Photo: iStock.com

6

Vulnerability assessment, climate change impacts and adaptation measures

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 a description of the framework for assessing risks and vulnerability to climate change. National adaptation policies and strategies as well as adaptation planning at sectoral and regional levels are discussed, together with progress of adaptation action. Finally, Finland's participation in international cooperation on adaptation is briefly discussed.

6 Vulnerability assessment, climate change impacts and adaptation measures

6.1 Climate modelling, projections and scenarios for Finland

Climate change projections have been derived from simulations performed with 28 global climate models. These models constitute a subset of the ensemble evaluated in the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2021). Using an ensemble of models to represent uncertainty in climate change projections is important, as the future climate cannot be predicted accurately due to uncertainties in future emissions and natural climatic variability, and the different representation of the climate system in the various models.

Figure 6.1 shows multi-model mean estimates for the future evolution of annual mean temperatures and precipitation rates in Finland for four forcing scenarios, with the SSP1-2.6 scenario representing small, SSP2-4.5 moderate, SSP3-7.0 large and SSP5-8.5 very large emissions. If the recent advances in global climate policy are realised in rapid and sustained mitigation, the two scenarios with the largest GHG emissions might be avoided.

According to the mid-level SSP2-4.5 scenario, the annual mean warming in Finland is expected to be 2.7 °C by mid-century and 3.7 °C by the end of the 21st century, i.e. about 1.6 to 1.8 times as large as the global mean warming. The projected increase in annual precipitation is also substantial, about 11 per cent under SSP2-4.5. Note that all the forcing scenarios lead to quite similar responses until the 2030s but start to diverge markedly thereafter.

Both the increases in temperatures and precipitation rates are likely to be larger in winter than in summer (Figure 6.2). If the SSP2-4.5 scenario were realised, the January mean temperature would increase by 2 to 7 °C and precipitation by 0 to 30 per cent by the end of the 21st century. In other SSP scenarios, the seasonal distribution of changes is qualitatively similar, but the amplitude of the change depends on the magnitude of forcing. An analogous seasonal distribution can be seen when studying less distant future periods.

Compared to the climate projections prepared with a previous model ensemble (which was used in the 5th IPCC Assessment Report) using a comparable forcing scenario, the present summer temperature projections are about 0.7

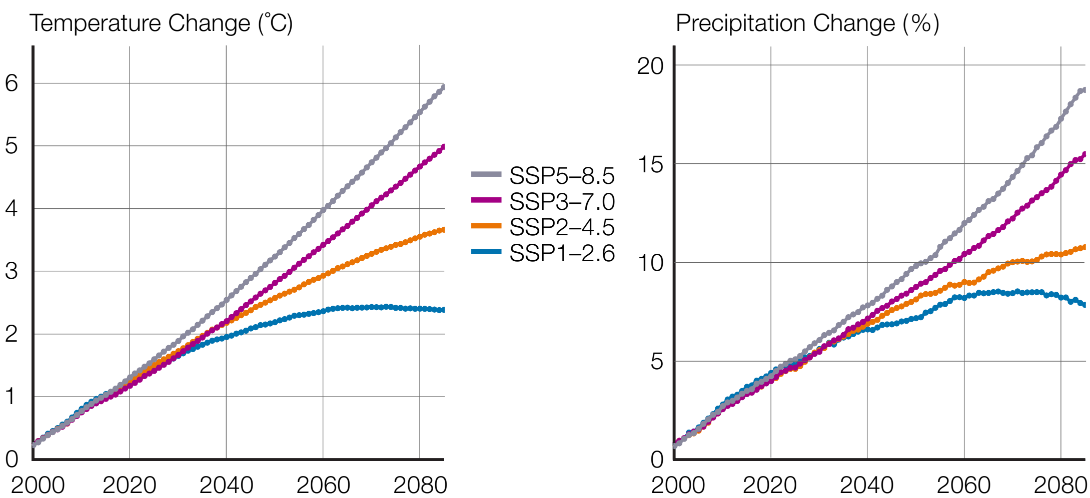
°C higher at the end of the century. Conversely, temperature projections for winter and precipitation scenarios for all seasons are fairly similar in both model ensembles.

These most recent temperature and precipitation projections were not published until early 2022, and hence most of the impact and adaptation research described in this chapter still makes use of older scenarios.

Other examples of projected climatic changes in Finland (mainly derived from older model generations) include the following:

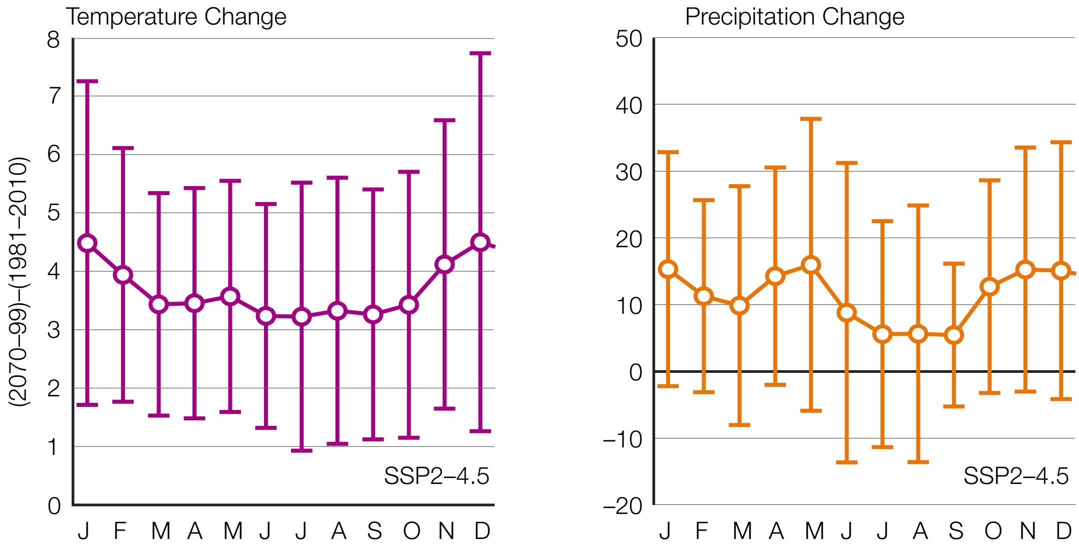
– Heatwaves become longer and more frequent, whereas severe cold spells gradually diminish.
– Heavy precipitation events intensify in summer.
– The number of days with precipitation increases in the winter.
– The snow season becomes shorter, and the average snow water equivalent decreases, particularly in southern Finland.
– The duration and depth of soil frost decreases, particularly in snow-free areas such as roads and airports. This also holds true for sea and lake ice cover.
– Winters become slightly cloudier, and solar radiation decreases. Conversely, summers and early autumns become slightly sunnier.
– For wind speeds, no significant changes are anticipated.

Figure 6.1
Projected temporal evolution of annual mean temperature (left, °C) and precipitation (right, per cent) in Finland by 2085, relative to the means for the period from 1981 to 2010; multi-model mean responses to four greenhouse gas scenarios: SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5.



Source: Ruosteenoja & Jylhä, 2021, the Finnish Meteorological Institute

Figure 6.2
Projected temperature (left, °C) and precipitation (right, per cent) changes in Finland for calendar months (J = January, F = February, etc.). The circles and the curve denote the multi-model mean projection. The 90 per cent probability interval for the change is denoted by the vertical bars. The changes are presented for the period 2070 to 2099, relative to 1981 to 2010, under the SSP2-4.5 scenario.



Source: Ruosteenoja & Jylhä, 2021, the Finnish Meteorological Institute

Climate monitoring and modelling framework

The Government research institutes, especially the Finnish Environment Institute (SYKE), the Finnish Meteorological Institute (FMI), the Finnish Institute for Health and Welfare (THL) and Natural Resources Institute Finland (Luke), all have activities linked to climate monitoring and modelling. The FMI is the main institute for physical climate variables, Luke focuses on effects related to renewable natural resources, SYKE on hydrology and water management as well as impacts on terrestrial and marine ecosystems and THL on human health. The Finnish Museum of Natural History (Luomus) plays a particular role in monitoring changes in species and biodiversity. Examples of the activities related to scenarios include the following:

- The FMI has constructed projections for the future climate at various temporal resolutions based on global (CMIP6) and regional (EURO-CORDEX) climate model simulations.
- SYKE has carried out joint work with other research institutes (Luke, FMI, THL) on the application of the SSP-based (formerly RCP-SSP) global scenario framework for Finland and specific sectors with national, sub-national and sectoral extensions (see Box 6.1).
- THL has participated in joint work carried out by SYKE on the application of the SSP-based framework for the health sector.

Box 6.1
Using shared socioeconomic pathways (SSPs) for defining future climate and socioeconomic development

There are five shared socioeconomic pathways (SSPs) that describe future socioeconomic development to the end of the 21st century. They are available as narrative descriptions, as well as quantitative projections of key socioeconomic variables. They are used in two ways for generating scenarios.

First, quantified SSPs can be used alongside shared policy assumptions about mitigation policy (SPAs) in integrated assessment models (IAMs) for generating pathways of greenhouse gas concentrations and radiative forcing of the atmosphere. These are inputs for global climate models for simulating the future climate. The most recent pathways used for climate modelling are labelled SSPs. The previous pathways, developed before SSPs were available, were labelled RCPs (representative concentration pathways).

Second, narrative SSPs can be used for co-creating with local experts and stakeholders' regional or sectoral socioeconomic narratives (SSP-extensions). These are richer and more detailed than the original global narratives. Quantified projections consistent with the narratives can also be developed.

Risk is a function of hazard, exposure and vulnerability. The SSP-based climates can be used to describe how the climate hazard may change in the future. The SSP-based socioeconomic narratives can help to define exposure and vulnerability. Combining these into integrated scenarios can allow an analysis of the relative effects of climate and socioeconomic development on elements of future risk.

Figure 6.3
Scenario matrix on the use of shared socioeconomic pathways (SSPs)

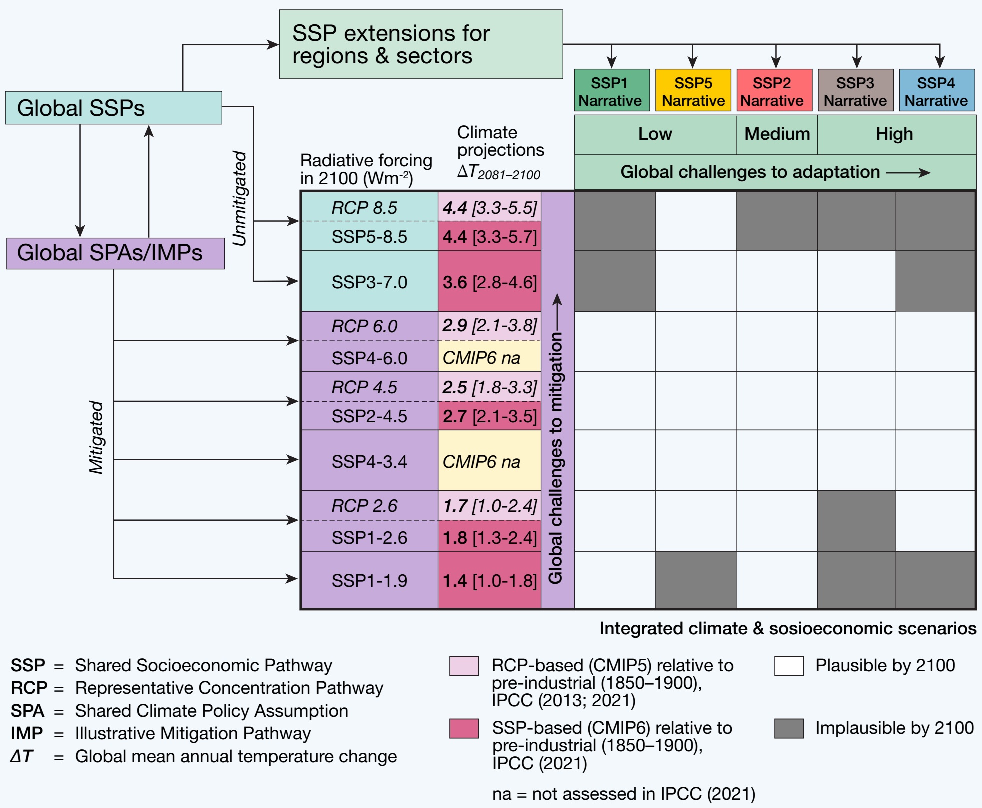


Figure 6.3 demonstrates how global shared socioeconomic pathways (SSPs) are applied in combination with shared climate policy assumptions (SPAs) to represent various mitigation levels (illustrative mitigation pathways – IMPs) used to define radiative forcing in models needed to project future climate (rows). Also shown are global mean temperature projections for 2081 to 2100 relative to pre-industrial times published by the IPCC based on two sets of climate model simulations: CMIP5 using RCPs in light pink (IPCC, 2013) and CMIP6 using SSPs and IMPs in dark pink (IPCC, 2021). Values are means (bold) and likely ranges (CMIP5) and very likely ranges (CMIP6). Global climate models also provide information on climate change for different regions of the world, including Finland.

Socioeconomic pathways can also be extended as SSP narratives describing socioeconomic conditions affecting exposure and vulnerability of regional systems and sectors at national and sub-national scale in Finland (columns). Information on future regional climate and future regional socioeconomic conditions for Finland can be combined into integrated scenarios at the intersection of the rows and columns (white cells in the figure). Note that not all combinations are regarded as physically plausible by 2100 (grey cells).

Source: Academy of Finland-funded FINSCAPES project[1]

1 https://www.syke.fi/projects/finscapes

Main approaches, methodologies and tools, and associated uncertainties and challenges

A basis for scenario work in recent years has been the global scenario framework organised around the shared socioeconomic pathways (SSPs). These are alternative descriptions of future socioeconomic development. The SSP-based climates can be used to describe how the climate hazard may change in the future. The SSP-based socioeconomic narratives can help to define exposure and vulnerability (Box 6.1).

Climate change projections for Finland have been mainly derived from the output of 28 global climate models. The rigour of the multi-model approach provides confidence that estimates for the inter-model spread of future climate changes in Finland and its sub-regions capture the major model uncertainties and are robust. The wide range of model outcomes associated with this approach presents some challenges for analysing climate change impacts (e.g. on water resources or agriculture) due to the large number of model simulations required. One approach to overcoming this challenge is to combine a sensitivity analysis of impacts to climate with the climate model projections presented probabilistically – the impact response surface approach. This approach also allows an estimation of likelihoods of exceeding certain pre-defined impacts.

6.2 Climate change impacts

Research, reviews and analyses provide a foundation for the assessment of the climate change impacts and related risks and vulnerabilities presented in this chapter. Research and assessments on climate impacts, risks and vulnerability have been carried out in national research efforts and as part of Nordic and European research efforts. Such knowledge is instrumental as a basis for adaptation measures, as is also called for by the National Plan for Adaptation to Climate Change 2022.

Examples of recent research and assessment efforts include the following:
- Overall Evaluation of the Implementation of the National Policy on Climate Change Adaptation (KOKOSOPU) – a project under the Government's analysis, assessment, and research activities between 2021 and 2022[2];
- Assessment of the Cost of Inaction Regarding Climate Change (KUITTI) – a project under the Government's analysis, assessment and research activities between 2020 and 2022[3];
- Report on the state of the research supporting adaptation to climate change by the Ministry of Agriculture and Forestry between 2021 and 2022;
- Climate change adaptation: regional aspects and policy instruments (SUOMI) – a project funded by the Finnish Climate Change Panel and coordinated by the Finnish Meteorological Institute between 2020 and 2022[4].

The list of references contains more examples of the research and assessments utilised in compiling this chapter. Section 6.2 of Finland's Seventh National Communication also provides various examples of relevant research in the recent past.

6.2.1 Impacts on environment and natural resource sectors

Natural environment and biodiversity

Different components of biodiversity will have different vulnerabilities depending on local conditions, species and habitats. The increase in mean temperature and annual heat summation and decrease in severe frost periods have already given rise to wide-ranging changes in the Finnish natural environment and biodiversity. Many native species in the south could find favourable living conditions further north in the warming climate. The prevalence of certain species of southern origin such as butterflies and birds has increased, and the distribution has moved northwards. At the same time, the number of species of northern origin has decreased in Southern Finland.

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2 Hildén et al. 2022a and 2022b http://urn.fi/URN:ISBN:978-952-383-118-6 https://tietokayttoon.fi/julkaisu?pubid=42102

3 Perrels et al. 2022 http://urn.fi/URN:ISBN:978-952-383-056-1

4 Gregow et al. 2021 https://www.ilmastopaneeli.fi/wp-content/uploads/2021/09/SUOMI-raportti_final.pdf

It has also been identified that changes in the ratio of abundance of certain species are reflected in the composition of species communities. For example, the average composition of communities of birds has moved towards the northeast during the last 20 years. In the future, a continued rise in mean temperate will lead to a continued decrease of numbers of species that have adapted to colder northern climates, and there is a risk that these species will largely disappear from Finland. On the other hand, southern-oriented species will increase in numbers and will partly replace species adapted to a cooler climate. In lakes, the spring peak of phytoplankton 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.

The effect of non-native species on the displacement of native species is currently most significant in Southern Finland, but the effect is predicted to strengthen and spread more broadly by the end of the century. Non-native species can already now displace native species specifically in human-influenced environments, and it is expected that the effect will also increase in waterbodies.

An increasing mean temperature also affects habitats across the whole of Finland. Habitats that are typically found in cooler climates, such as fjelds in Northern Finland, are especially vulnerable to climatic changes, and may completely disappear by the end of the century. Especially species that are limited to specific habitats (e.g. the Saimaa ringed seal and freshwater pearly mussel) are highly vulnerable to climate-induced changes in their habitats. Northern boreal species of forests, mires and Arctic mountain habitats are threatened and predicted to decline due to the warming climate. The most sensitive habitat types identified are coastal drift lines and the habitat types related to primary succession stages, snowbeds, mountain birch forests, mountain heaths, first-order streams, small inland waters in northern Lapland, traditional rural biotopes, southern aapa mires, springs and spring mires, and open and semi-open rock outcrops.

Increased precipitation induced by climate change is also projected to affect the natural environment. Open habitats are vulnerable to overgrowth due to mild rainy winters, increasing carbon dioxide content in the atmosphere, and nitrogen deposition. For example, taken together, these contribute to the growth of moss and trees in dunes, and accelerate overgrowth. The increase of precipitation during the winter also increases the washing away of nutrients in waterbodies. For coastal waters, this can be identified along the coast of the Baltic Sea as higher prevalence of reed beds, filamentous alga, and overgrowth. Increased runoff in winter will also influence the washing away of nutrients and solid matter into inland waters. It is expected that climate change will be a threat to more than 80 per cent of inland water and coastal habitats.

Protected area networks of natural habitats alleviate the negative effects of climate change and provide resilience in preserving declining species of conservation concern. However, recent studies have indicated that there is great variation in the growing degree days, the mean temperature in January, and the annual water balance across protected areas in Finland, and by the end of the century, significant changes to the microclimates of Finnish protected areas are expected. This calls for consideration and anticipation of changes in conservation planning.

Water resources

The most significant climate risks in the water resources sector are related to the increase of pluvial floods, changes in fluvial floods, and the increase in droughts. Other risks include increases in frazil ice and coastal floods, decreasing water quality, and increases in algal blooms. Of the above risks, increases in frazil ice floods have already occurred, and frazil-related problems will be common in the near future. The role of climate change in increasing flood risks and damage in Finland is expected to become more pronounced from mid-century onwards. This is especially the case for coastal floods, but continuous monitoring of the risk is required, as the potential effects of such floods can be significant.

Floods in Finland rarely have direct impacts on human health and security, but especially if floods become more widespread and enduring, these impacts will become more significant. Based on the EU Floods Directive[5] and the national Finnish Flood Risk Management Act[6], areas of potential significant flood risk are identified through preliminary flood risk assessments. Currently, 22 areas of significant flood risk have been identified in Finland – 17 of these are located inland, and five along the coast.

Occurrences of heavy rain are expected to increase due to climate change. Pluvial floods resulting from heavy rain and snow melting can generate considerable damage in urban areas, and anticipating these floods is challenging. Damage is usually incurred to property, human health, security, and the transport sector. The densifying trend in the built environment in urban areas is expected to continue for the next couple of decades, which increases the share of impervious surfaces. In turn, it increases the amount and intensity of surface runoff water. Due to denser and more technical construction, the vulnerability increases, and possible spillover effects become more complex.

The effect of climate change on fluvial floods varies across different waterbodies. The effect is expected to be greatest in central lakes and outlet rivers. The greatest risk of fluvial flooding is assessed to be in the City of Pori on the coast of the Gulf of Bothnia. Apart from damage to property, floods can have negative impacts on water quality, as they wash away debris, waste,

5 2007/60/EC

6 620/2010

sand, organic matter, nutrients, and acidifying compounds from fields, forests, and riverbeds. On the other hand, spring floods caused by melting snow are expected to become less frequent, except in the Lapland area. With spring floods currently the most common type of flood, this may signify an overall decrease in flood risks in many locations.

In the Baltic Sea, the effects of climate change can be identified as physical, chemical, and biological changes in the sea. An increasing water temperature enhances biological processes and may increase the intake of harmful substances in organisms. Studies have shown that the spring bloom of phytoplankton has been brought forward, and the length of the growing season has doubled. An increasing temperature probably also alleviates the spreading of non-indigenous species originating from more southern seas. Moreover, due to the increase in 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. The reduction of these habitat forming species will affect the structure and functioning of the ecosystems and may decrease the ecosystem services such as fish yield provided by these habitats.

Climate change has also been predicted to worsen the eutrophication of the Baltic Sea because of increasing nutrient runoff into the sea. As the temperature also rises, the decomposition of organic matter caused by microbes will accelerate, and especially in late summer, anoxia can increase. Cyanobacterial blooms are especially projected to increase, although this forecast is also subject to uncertainties. However, model studies have shown that direct human activity has a greater impact on the state of the Baltic Sea than climate change. A recent study has shown how climate change affects agricultural practices (crops, cultivars, land use), how climate affects the hydrological cycle, and how soils and lakes retain nutrients in a changing climate. The results show that climate change increases nitrogen loading into the sea, but that economic factors such as crop and fertiliser prices significantly affect the outcome, and that a significant reduction in nutrient loading can be achieved by farm-level adaptation to climate change.

Climate change and alien species pose new threats to the small waters of Finland, the status of which has been assessed as poor in the national habitat threat assessment. Small waterbodies, streams, and ponds are particularly sensitive to temperature stress. At worst, streams can dry out almost completely, which can damage their ecology. For example, changes in the hydrological seasonal rhythm have been found to affect the species composition of benthic organisms, especially in small waters.

Water supply

Droughts generate risks for agriculture, industry, and the water supply of communities and properties. Droughts in the summer are expected to increase in Southern and Central Finland due to earlier spring onset, less snow, and an increase in evaporation. Droughts give rise to water sufficiency problems, and the lowering of surface water levels creates water quality issues. For example, the summer droughts of 2018 and 2020 showed the need for preparedness in water supply management. Reduced groundwater levels may 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 the winter, increasing precipitation and snowmelt will produce fresh and oxygen-rich groundwater.

The expected increase in droughts, storms, and heavy rainfall can be identified in water supply as drying of smaller groundwater areas, lower quality of ground- and surface water stemming from washed away nutrients and pathogens in flood water and the limited capacity of wastewater networks. Storms and heavy rainfall and winds also increase water quality risks. Storms generate risks for the supply of electricity to water supply sites, especially peripheral regions and areas, thereby endangering both water distribution and treatment. It also remains necessary to prepare for larger power outages that affect larger regions.

In general, the Finnish water utility sector is in a good position to adapt to climate change. According to a recent survey conducted by the Finnish Climate Panel in 2019, water supply site actors are highly aware of climate change, seeing it as a general threat to water security in Finland. The survey results show that almost all actors find that their site can respond adequately to threats generated by weather variability. Some actors see that climate change threatens water security on their own sites. However, only less than half the survey respondents are prepared for heatwaves, prolonged droughts, mild winters, or floods. This finding can be explained by the fact that the respondents represent smaller groundwater sites that have yet to suffer from the aforementioned weather phenomena.

Different forms of floods, including runoff water and melted snow, can threaten the water quality of the inlet wells of urban areas and properties, which in turn generates risks to human health (e.g. waterborne diseases) and the reliability of water supply. These risks also affect about a quarter of a million Finnish households that rely on their own wells for the supply of water.

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. Due to the longer thermal growing season, higher accumulated temperature sum and milder overwintering conditions, the current cash crops are cultivated further north, and many novel crops may be introduced in cultivation.

However, possible increases in the variability of climatic conditions within and between seasons, more frequent extreme weather events, and increased risks of disease and pest outbreaks may cause uncertainties for agricultural production. Variation in precipitation within a growing season may further increase and cause substantial challenge for the sustainable development of agricultural systems. Early summer droughts may become more frequent and interfere with crop growth and yield formation, while increasing rains outside the growing season may put soils and their functionality at risk. It may also increase the leaching of pesticides and nutrients into the water systems, which are particularly vulnerable, as a third of the field parcels in Finland are 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 these potential changes call for early and powerful adaptation measures to reduce risks induced by climate so that society can benefit from the opportunities.

Forestry

Climate change affects forest ecosystems. The rise in average temperatures and atmospheric CO_2 levels has already accelerated the growth rate of trees, but the risk of more severe forest damage has increased simultaneously. Compared to Central and Eastern Europe, large-scale forest damage has been relatively rare in Finland, but this is likely to change due to climate warming. For Finland, the relevant risks are both abiotic (wind, drought, snow, etc.) and biotic (insects, diseases, wildlife, etc.), but as they also interact, the potentially negative effects on the forestry sector are complex. Yet it is noteworthy that tree mortality is always a natural and essential component of any healthy forest ecosystem. The management of forest damage is therefore never about suppressing it completely, but more about pre-emptive measures that can be used to prevent large-scale damage.

Wind and snow are amongst the most severe damage agents in Finland. Wind damage in the form of windthrow are predicted to increase in the future due to loss of ground frost, which makes trees more susceptible to wind damage – even though the winds themselves will not be any stronger. Snow damage is predicted to decrease in the southern parts of the country, but it is likely to increase in northern and eastern areas. Trees damaged due to wind or snow can increase the risk of cascading biotic damage.

Climate change increases the frequency ‘fire weather’, suitable weather for ignition and the spread of fire. In the long-term, the amount of burning material in forests is also expected to increase. Days with simultaneous high winds, high temperatures and low humidity increase the risk of fires spreading. However, most forest fires ignite due to human behaviour. In general, fires are not a major issue in Finland due to efficient fire monitoring and suppression work, and a dense forest road network that allows efficient fire suppression. The risk caused by droughts will therefore be more related to large-scale weakening of trees (esp. spruce), and how this increases the risks of insect damage.

Various biotic pest agents will benefit directly from climate warming, with more rapid development, a prolonged growing season, a further northward spread, etc. Yet they will also benefit from the increased number of weakened trees (e.g. due to wind or droughts) they use as breeding material. This is especially valid for the spruce bark beetle, which has caused unprecedented damage across Central and Eastern Europe, and the occurrence of damage is also becoming more common in southern Finland. Other bark beetles (such as *Ips acuminatus*) are also benefiting from warming, which may increase their future role as pests.

Decaying fungi such as the *Heterobasidion* root rot can remain active and produce spores for a longer time as the spring and autumn warm. Root rot also benefits from increased windthrow and diminishing snow cover, which often results in harvesting damage to unprotected tree roots: both phenomena result in cuts in the trees through which the spores can infect them. Here, Finland is also facing difficulties because of the increased use of spruce in forest regeneration: spruce is the tree species most susceptible to droughts and wind damage, while its main pests, the spruce bark beetle and root rotting fungi, benefit from warming. Here, forest management should emphasise mixed forests and the use of optimal tree species at any given site, but in certain areas, dense ungulate populations prevent the use of deciduous species to replace spruce.

In addition to the native pests, climate change and global trade will bring new species into Finland. Insect species such as the nun moth (*Lymantria monacha*) have become increasingly abundant in the 2000s. Similarly, a new fungal pathogen, *Diplopia sapinea*, was confirmed to cause mortality to Scots pines in the record-hot summer of 2021 – something researchers assumed the fungus could not do in Finland. While the spread of these two species is natural, global trade is a pathway for invasive alien species. Climate change is not a direct factor here, but the Finnish climate will also become more suitable for various invasive pests because of it. The increasing global trade and current legislative restrictions in controlling the spread of exotic pests and pathogens will unfortunately ensure that the risks of invasive alien species will remain topical, regardless of the progress of climate change.

Fisheries and game

The effects of climate change on aquatic ecosystems are especially strong with extreme weather events such as prolonged hot summers. In general, there is variation in how well fish species can tolerate the changing conditions, with some species and life-stages more vulnerable than others.

An increasing water temperature generally benefits fish species that prefer warmer and more nutrient-rich waters, and this has improved the reproduction of many spring and summer spawners. However, the dissolving of oxygen from the air into the water is weaker as the air temperature increases. During extreme warm temperatures, this can result in oxygen deprivation, and the consequences can be severe. During hot summers, the stratification of water can be strong, resulting in a layer of warm water in which oxygen dissolving from the air is poor, and fish that cannot tolerate warm surface waters move deeper. Simultaneously, various other species benefit from the warming, and as their activity increases, they consume oxygen from within lakes, including from the bottom. This causes difficulties for bottom-dwelling fish, but also to those that have moved to deeper waters to escape the warm surface waters. An increasing water temperature also affects the spatial distribution of fish species.

Eutrophication is coupled with climate-induced impacts in aquatic systems. An increasing water temperature exacerbates eutrophication. With more eutrophied conditions, additional risks of anoxia and widespread algal blooms emerge, as the decaying algae consume oxygen from the bottom areas and further increase the dissolving of nutrients from bottom sediments. This results in 'internal' load, a state in which the eutrophication process continues even though no nutrients flow into the waters from any external sources. This process concerns the Baltic Sea, as well as Finland's isolated small ponds and inland waterbodies.

Aquaculture facilities with flow-through water intake will suffer from increasing water temperatures, which have already led to widespread fish deaths in the hot summers of 2014, 2018 and 2020, for example. Similarly, increasing eutrophication also has negative effects on aquaculture production, both inland and in coastal waters, through potentially more strict environmental licensing.

Commercial fishing is affected directly by what happens to fish stocks, but also by changing environmental conditions such as ice conditions. While prolonged ice-free periods may lengthen the season for marine trawling fishing, other winter fishing will suffer from a shortage of ice.

Invasive alien species will remain highly relevant for aquatic ecosystems, as Finland has already seen the establishment of several alien fish species in coastal waters (for example, the round goby, *Neogobius melanostomus*), as well as in inland waterbodies (for example the pumpkin seed *Lepomis gibbosus*). While climate change does not itself cause the relocation of these species, it may make the Finnish climate more suitable for certain invasive species that might not otherwise survive.

Climate change affects the abundance, species composition and distribution of game populations in Finland. Southern species and certain invasive species are benefiting and becoming more abundant, and the range of species adapted to winter conditions is narrowing. Climate change will affect all levels of the food web and change the relationships between species. Changes in snow and ice conditions can drive certain species into crowded conditions, increase winter predation or loss of breeding habitat for cubs.

Reindeer husbandry and herding

Reindeer herding is a large-scale Arctic subsistence livelihood based on both the reindeer's ability to obtain food and survive on natural pastures and reindeer herders' traditional knowledge of reindeer and the grazing environment. Reindeer husbandry is a traditional livelihood of the indigenous Sámi people and is therefore an integral part of the Sámi culture.

Reindeer herding is vulnerable to the negative effects of climate change. Climate change is expected to be particularly severe in the northern regions where the Sámi homeland and the reindeer husbandry area are located. Climate change and changing weather conditions directly affect reindeer food supply, health and wellbeing, as well as practical reindeer husbandry activities. Climate change also has indirect effects through changes in the grazing environment. Regional and annual variations in weather and snow conditions and their changes have a significant impact on the ability of reindeer to obtain food from the wild and on the quality of the food, as well as on the prevalence of parasites and diseases.

In addition to the industry's own activities and weather variability and climate change, the ecological, social and economic sustainability of reindeer husbandry is influenced by many local, regional and global factors. The effects of the changes caused by reindeer grazing, forestry, and a range of other land uses, such as gold mining, tourism development and tourism services accumulate. At the same time, interlinked changes have degraded, reduced and fragmented reindeer pastures.

Changing conditions due to weather variability and climate change, combined with land-use changes, create economic uncertainty for reindeer herders. The consequences of significantly variable weather conditions result in disadvantages for reindeer husbandry, increase costs, reduce income for reindeer herders, and cause a significant reduction in wellbeing.

Natural Resources Institute Finland regularly assesses the quantity, quality and availability of reindeer grazing resources through reindeer pasture inventories. Based on the reindeer pasture inventories for 2016 to 2018, the lichen biomasses in the experimental areas are most significantly influenced by the seasonal timing of grazing with lichens and the reindeer densities on areas covered by lichens, as well as by changes in forest structure and old-growth forest in the reindeer herding cooperatives. The extent of other land uses in the cooperatives and probably ecosystem changes caused by climate change have contributed to the condition of lichen pastures and changes in plant species.

Adverse changes in the reindeer grazing environment have gradually altered reindeer management and increased the need for additional winter feeding and the use of feeding enclosures. The reduction and fragmentation of pastures have created conflicts and problems between reindeer husbandry and other livelihoods. In areas covered by lichens that have not been grazed for a long time, the impact of forestry on the amount of lichen was much lower. In recent decades, changes in the structure of commercial forests have been more favourable to reindeer grazing. The limited possibilities to control the pressure of other land uses make it difficult to organise and develop reindeer management in a controlled way, to regulate the use of pastures, and to respond to changes in climate.

6.2.2 Impacts on infrastructure and other economic sectors

Energy

Weather-related hazards like wind and snowstorms, lightning strikes and floods are the major source of weather and climate risks for the energy sector in Finland. Challenges to energy production and distribution are also created by some enduring weather episodes often coinciding with relatively high energy demand and demanding conditions for the maintenance of power systems, such as long periods of extreme cold, long-term snowfall, and snow load. Storms and heavy snow loads on tree crowns have caused power outages for customers. Nuclear power plants have had issues with seawater being too warm for optimal cooling, leading to part-load operation and with stormwater levels. Long periods of very low precipitation causing hydrological drought reduce hydropower production. This matters in Finland, because hydropower plays a central role as a regulating power source, and more widely, because Scandinavian precipitation largely determines the electricity price on the Nordic power exchange.

The renewal of the energy infrastructure is slow due to long-term investments. Therefore, for example, electricity blackouts caused by weather events will also be experienced in the future, although investments in the electricity network are increasing its resilience to weather events.

There are opportunities to reduce CO_2 emissions with renewable energies. Especially wind but also solar energy production is increasing (see Section 2.6), which also increases weather-related variability in production. Weather risks to wind turbines, e.g. due to icing, seem manageable. Bioenergy production and harvesting face risks due to climate change: in the winter, long warm periods and frost delay may hinder access to remote sites on soils with a low bearing capacity.

Energy systems need to be resilient and not under-dimensioned, because very cold winter episodes will remain possible during the latter part of the century, leading to high demand for heating capacity, especially in Eastern and Northern Finland. On the other hand, due to warming summers, heatwaves which increase the need to cool buildings can affect the country in any location.

Future impacts of climate change will partly depend on how the energy system changes as a result of the ongoing green energy transition. The impacts are likely to affect both energy production, transmission, distribution and consumption.

Land-use planning and buildings

In the land-use and building sectors, the impacts of climate change are fairly well known, and the need for adaptation measures is commonly acknowledged. The main climate-related risks to land-use planning and buildings are related to a shifting temperature, rainfall, floods, rising sea levels and droughts. Climate change presents complex challenges to the built environment in Finland due to variability across regions and seasons. For example, there is a need to prepare for both increased snow loads in some regions and humidity risks to buildings caused by increased precipitation in the form of rain in others.

Climate change gives rise to moisture risks, which affect all the buildings in every part of Finland. Moisture risks generated by precipitation are already currently significant, and these risks are expected to grow in the future due to increased rainfall. The increase in mean temperature also converts snow into rain, which further increases buildings' moisture risks. Increasing humidity and a rise in temperature intensify the growth of mould and microbes in building structures. The most risk-prone structures among the current building stock are poorly ventilated wooden frame constructions and brick-clad structures.

Prolonged heatwaves increase the risks of heat-related sickness and residents' mortality if the buildings cannot be ventilated and the room temperature cannot be lowered.

Concrete structures are susceptible to frost shattering during the winter due to increasing wind-driven rain load in the form of water and sleet. Buildings along the coast are currently the most vulnerable to such risks. In the future, the current coastal climate conditions are expected to spread to inland Finland, where risks of frost shattering have been lower. High wind speeds are increasingly causing material damage to buildings, e.g. through the detachment of surface structures and trees falling nearby.

The main flood risks to the built environment are related to pluvial and fluvial floods, which place burdens on urban sewer networks and cause significant economic damage. Pluvial flood risks are greatest in the most densely populated areas like the Uusimaa region. In recent decades, the share of impervious surfaces in the built environment has increased sharply, which in turn intensifies pluvial floods.

The largest risks related to the rise in sea level affect the existing building stock. In coastal areas, the risk of flooding due to the sea level rise is relatively low so far, especially in areas where the land uplift is the most significant. In the long term, the risk of coastal floods is expected to increase, as the average rate of sea level rise exceeds the speed of land uplift. The most problematic areas on the Finnish coast are those where coastal and fluvial floods coincide – the best known of these areas is Pori.

Cultural heritage

Cultural heritage sites – or the 'cultural environment' as they are called in Finland – are places and environments created by human activity and through interaction between humans and the natural environment. The sites include the built and natural environments, cultural landscapes and archaeological sites, typically with elements of historical significance.

Climate change has a tangible impact on the preservation of cultural heritage and the cultural environment. Cultural heritage sites are strongly influenced and damaged by climate change. According to the Cultural Heritage Barometer (2021), 51 per cent of the respondents to the survey estimated that climate change posed a threat to the preservation of cultural heritage.

Increasing humidity and rising temperatures, eutrophication and constipation, the acidity of air and rain, freezing and melting cycles and extreme weather phenomena such as storms, flooding, erosion, heavy rains and thick snow may damage the landscape and other cultural heritage places and objects on land, underground, or in the water. The degradation of biodiversity and loss of natural habitat affect cultural landscapes and semi-natural habitats by threatening traditional biotopes and impoverishing the natural heritage.

The impacts of climate change are more severe, and global warming is faster in the Arctic than elsewhere in the world. Therefore, for example, the Sámi indigenous people are facing drastic changes in the Sámi homeland in Finland, Norway, Sweden and Russia. The traditional livelihoods of the Sámi, such as fishing, gathering, and reindeer husbandry, as well as the traditional knowledge associated with them, are especially vulnerable to climate change (see Section 6.2.1 for reindeer herding). Traditional knowledge of nature is subject to change. The intangible cultural heritage is disappearing and will no longer be passed on to future generations.

Industry and commerce

Finnish industry is energy-intensive, and the need to mitigate climate change has been a focus in the industrial sector. The effects of climate change and the need to adapt to its effects have not had a central role in the discussion. However, climate change does cause varying risks to industrial operations in Finland. For example, disruptions in industrial production caused by floods and storms may be significant, and rare major floods may pose major risks to some industrial operations, especially if the disruptions in operations are prolonged.

However, the most significant impacts of climate change on industrial operations and commerce in Finland are most likely to be indirect. Such indirect risks result from the global impacts of climate change or in other sectors within Finland. The relevant risks vary, depending on the industry sector, value chains, and the location of operations. For example, the effects of climate change on the Finnish transport and energy sectors may indirectly affect industrial operations and commerce through logistics and power outages. The challenges to wood harvesting posed by the worsening and longer thaw weakening period may affect industries reliant on wood supply. The effects of climate change and the natural phenomena related to it, such as floods, storms, and droughts, may pose risks to industries requiring an industrial water and cooling water supply.

Value chains are in a key position when considering the vulnerability of Finnish industrial sectors to the indirect effects of climate change. The industries most vulnerable are those with critical points in the value chain in areas outside Finland. For example, if the operations at these critical points are sensitive to extreme weather events, the effects may be serious. Such disruptions may affect the price and availability of raw materials and thus affect both industrial operations and commerce. For example, supply chains relevant for agriculture or the food industry in Finland are affected by weather and climate events related to crop failures and supply chain logistics and the availability of fertilisers. Although cross-border impacts are considered a very relevant category of climate change impacts, they have been little addressed thus far (see Section 6.7 for cross-border effects in general).

Mining

The most significant climate impacts on the mining sector are related to water management. In particular, with the increase in heavy rainfall, the risks of water management in mines may increase. Historical data show that roughly half the documented exceptional situations in mines have been caused by water management problems. In turn, more than half of these were related to dams. A Mining Environmental Safety Report published in 2014 emphasised the significance of design floods stemming from sudden and/or large amounts of excess water. However, the report does not examine the potential impact of climate change on these specific floods or on mining in general.

Climate change needs to be addressed when planning overall water management. With cold winters, recycling of process water is restricted, while large amounts of frozen water from tailings is added to the water management system in the spring with ordinary snowmelt water. A sudden and very warm spring can cause melting to be extremely quick, so facilities need the capacity to address this. So in some sense annual water management can be more evenly distributed if winters get milder, with less snow and freezing. Long dry periods and warmer summers require increased attention to management of dusting, as dust from mines can contain harmful particles.

Securing energy supply is crucial, as processes are controlled or operated by electric technologies and machinery. Typically, water management is based on collecting water and steering waterflow by pumping. If pumping is prevented, control of water masses can become impossible. A longer power blackout may cause various environmental and health risks and endanger the whole operation. Steering the process at the plant can be endangered if power is cut. This can create a risk of unexpected emissions.

Access to and from a mining area must be secured, even in unusual weather conditions. Critical points can be bridges and low-lying areas, which are sensitive to flooding. Buildings and constructions on a mine site should be placed and planned so that rainwater has natural ways and places to gather and be absorbed without mixing with process water that requires more treatment. Otherwise, the capacity of water treatment can occasionally be overloaded.

In the mine planning stage, all aspects of risks caused by climate change must be addressed and considered. Risks and threats to mining operations are analysed in the mining safety permit required from all operating mines according to the Finnish Mining Act[7]. A mining safety permit requires that all risks that the operation can face are identified, and that the risks and any consequences are mitigated and avoided. The mining operator is responsible for the internal rescue plan. The rescue plan specifies how to manage possible incidents, and how environmental and human accidents are prevented.

Transport and communications

The transport and communication sector and its infrastructure are highly vulnerable to changeable weather conditions, and disturbances in the transport sector affect other sectors. Due to weather conditions (e.g. heavy rain and snowfall), accidents and/or delays in the transport chain may occur which mean that goods are not delivered on time, commuters cannot rely on timetables and businesses suffer from loss of earnings. Besides rain

7 621/2011

and snow, roads, railways, ports, airports and communication networks in Finland are occasionally subjected to other weather conditions such as storms, floods, extreme cold, and heatwaves. However, conditions vary within and tend to affect different parts of the country, as well as transport modes, in different ways, e.g. due to the population distribution and the condition of road network.

Key climate risks in the transport sector include complications in seafaring and shipping due to ice conditions, difficulties in air traffic due to storms and increased rainfall, challenges in the road and railway network due to erosion, changes in ground frost and poor weather conditions, and problems in conveyance dependability. Changes in ground frost, soil moisture, groundwater level and snow cover cause problems to the road, railway, and airport infrastructure. The transport of raw materials from forests will get more difficult as the period during which the ground is frozen shortens, and changes in the load-bearing capacity of roads may have significant cost impacts as the repair and maintenance costs of the road network rise. In road traffic, road closures remain the most significant vulnerability. A reasonable amount of natural resources (aliments, soil and forest industry raw materials) in Finland is transported by way of the minor road network, which is mainly gravel and sensitive to rainy winters and dry summers. Road and railway infrastructure and traffic are affected by frost heave, which also occurs during the winter, not only in the spring. The surface structure of roads and bridges is damaged by icing-melting periods occurring more often and weakened by hot and dry periods, which also cause dusting problems. Heat may also cause problems to rollingstock. Floods, which may be stronger due to climate change, can cause breakages in roads and railway banks and bridges.

The risks vary depending on the season, the section of the transport sector, and the region of the country. In sea areas, ice cover in the Gulf of Finland and the Sea of Bothnia will continue to form in winters, but it will happen increasingly later. Strong winds can cause packing of ice, which increases the need for icebreaking. Rising sea levels will change the location of sediment layers and shallows. All these will make navigation more demanding and expose safety equipment to a strong weather burden. These in turn will increase transport time and costs. For rail, wind impacts, causing e.g. the falling of trees (during the autumn) are expected to cause harm more often. Fog with increases in humidity and freezing rain are risk factors for aviation. Winter conditions will cause challenges to air traffic and airports and their safety in Finland. De-icing of planes and removing snow from runways will take more time. In telecommunications, the aerial cables network may be especially vulnerable to storms and icy rain. Sea cables may be damaged by packed ice causing problems to electric and communication networks, which in turn causes power outages, leading to delays and cancellations. Power outages affect traffic control and electric traffic. Challenges in energy supply increase energy costs. Lightning can cause disturbances and harm hardware and equipment. Heat may cause overheating of data centres and affect information systems.

Tourism and recreation

Finland is an attractive destination for tourists mainly because of its nature. Dependence on nature and seasonal variation makes 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 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. Awareness of climate change and the capacity to adapt to it are improving among tourism enterprises, but many regional differences remain. The type of tourism and its economic importance in the region, the image of tourism, and the region's social and community characteristics 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 reduce the attraction of such activities in the summer.

The impacts of key changes have already been observed: snow conditions have weakened, including the number of snow cover days, which is especially seen in the delay of the arrival of snow cover in the early season. This is already affecting winter tourism, especially in southern parts of the country.

In the future climate, snow cover days will decrease even further in the season, particularly at the beginning of the season. They will decrease by at least 30 per cent by the end of the century, which is, however, less than in other winter tourism areas in Europe. Long delays to the onset of winter are expected to become more common in the future, posing challenges for Christmas and other Arctic nature-based tourism, including downhill skiing and other winter sports. Average winters will become shorter. The magnitude of the change will vary according to the climate scenario and time horizon.

Winter tourism is vulnerable to the changing climate, as it is highly dependent on reliable winter conditions. Adaptive measures such as snow storage and snowmaking can be too costly or create greenhouse gas emissions, depending on the energy sources. Other strategies include alternative activities and technical solutions like indoor sports arenas.

Finance and insurance

In Finland, bank loans are often secured by real estate. Population and economic activity, and thus also properties used as loan guarantees, are mainly located in coastal areas, and the share is increasing. This exposes the collaterals to increasing coastal flood risks, amounting to hundreds of millions of euros of collateral exposed to climate risks if no further protection measures are taken.

Climate change is likely to increase damage caused by extreme weather, and indemnities for damage are thus also 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 insurance premiums and available coverage. Climate change will affect insurance companies directly in three different ways: through claims; their investments; and the terms of trade of reinsurance. Growing risks and changing attitudes will also affect who will be insured in the future; many investors have already withdrawn their investments in companies that create a heavy environmental load.

Forests are insured by private insurance companies in Finland. Private forest owners have little by little insured more of their forests: some 50 per cent of private forest owners are now insured against forest damages, while twenty years ago, only 30 per cent of private forests were insured. Forest insurance products offered by insurance companies provide variable cover against damage caused by storms, snow loads, forest fires, floods, pests and fungal diseases, for example. On average, some 60 to 70 per cent of forest insurance compensations are paid for storm damages, making annual compensation highly dependent on storm activity in each year. For example, in December 2011, the Boxing Day storm alone led to compensations totalling nearly EUR 30 million. Between 2012 and 2021, insurance companies paid storm compensation amounting to EUR 139 million.

Weather episodes favourable for forest fires are becoming more common due to higher temperatures increasing potential evaporation and the drying of the soil surface layer. When high temperatures, strong winds and low humidity coincide, they increase the risk of forest fires igniting and spreading. By the end of this century, the average number of forest fire warning days per year will probably be five to ten days larger than currently. The growth in the forest fire risk will be stronger in southern Finland. Despite the effectiveness of forest fire prevention in Finland, the cost of large fires can rise to tens of millions of euros.

6.2.3 Impacts on health and welfare

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

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

In future, milder winters will probably lead to lower cold-related mortality from cardiopulmonary diseases. On the other hand, because of the large winter climate variability, society and individuals will also have to be prepared for cold spells in future. During the winter, darkness and icy walkways and roads cause health risks. The number of days when the temperature hovers around 0 °C will increase and may lead to an increased number of slipping injuries and traffic accidents. Thinner ice and the shorter duration of ice cover on waterways will be a safety risk. Darker winters, caused by a shorter snow cover period, increased precipitation, and cloudiness, may also increase cases of winter blues or seasonal affective disorder and related medical conditions. In part of the population, climate change causes environmental or climate anxiety.

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

Changes in hydrology such as an increase in heavy precipitation events and winter flooding may increase water epidemics in the future. The leaching of nutrients into waterways due to increased precipitation, with higher summertime temperatures, increases the risk of blue-green algae blooming. A warming climate may also increase the risk of infectious diseases spreading via swimming water and introduce new infectious species such as *Vibrio cholerae*.

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; more effort is needed to prevent health risks related to mycotoxins in crops. The same changes in climate will also increase the risk of moisture damage in buildings, which may further aggravate microbial indoor air problems. Finally, climate change may lead to increased exposure to allergenic pollen and therefore severer symptoms via e.g. changes in the distribution of plant species and increased amount of pollen.

In Finland, socioeconomic health inequalities are already relatively large, so as the possibilities for adaptation vary depending on socioeconomic status, these differences may also increase health inequalities. For example, a stable financial position facilitates adaptation to extreme weather phenomena such as making energy-efficient and cost-effective air conditioning decisions in households. At worst, climate change adaptation will increase societal division, as different types of climate-friendly housing and mobility are available for some of the population, while some will have to settle for old technology. If the structural change in society continues to mean the destruction of jobs in industrial and old technologies, attitudes may become even less favourable to policies promoting adaptation. At worst, strong societal divisions may lead to the strengthening of 'identity politics' if, for example, vegetarian food and cycling are strongly linked to a certain urban lifestyle in which there is no desire to participate. The regional perspective should be considered to reduce inequality. In addition, consideration of different population groups in both social welfare and healthcare should be kept in mind, considering especially children and young people and the indigenous Sámi people.

In adapting to climate change in healthcare, changes affecting the need for health services or counselling in the population should be considered. These changes may be caused by e.g. the spread of vector-borne diseases and increased risk of weather-related accidents. On the other hand, the need for services may also reflect changes in the living conditions of different population groups, caused by climate change adaptation actions in other sectors and the impacts of these actions on the operating environment of healthcare. Most phenomena related to climate change are progressing slowly and can be at least partly anticipated. It is therefore possible to prepare for changes in the long term. The potential impacts of climate change on healthcare may be complex, and they also involve issues in other sectors and society in general. The general requirements for improving efficiency in the use of resources and energy are also reflected in the adaptation of healthcare, which is responsible for a significant part of the total production of societies and the use of resources.

6.2.4 Economic impacts

According to a recent national study, climate change can be expected to have slightly negative effects on the Finnish economy as a whole, expressed as a percentage change in gross domestic product (GDP) over the period between 2020 and 2070 (Table 6.1). In a scenario with higher greenhouse gas concentrations (RCP4.5), and hence more global warming, the percentage change in GDP is larger than in a scenario with less global warming (RCP2.6). The study was unable to account for all potential economic impacts, but the results are sufficiently indicative for the period covered, and somewhat beyond, provided global warming pathways exceeding three degrees can be avoided globally.

In the study, climate change scenarios RCP2.6 and RCP4.5 were combined with socioeconomic scenarios. RCP2.6 is combined with SSP1[8], which represents a cooperative sustainable development-oriented world in which innovations spread quickly. RCP4.5 is combined with SSP3, which represents a divided world inclined to defend current interests, and in which innovations spread more slowly and only within certain regions.

Considering the uncertainties and incompleteness of the collection of included effects, the study's most important message was that a proactive adaptation approach was clearly more beneficial for the economy than a reactive approach. A proactive approach entails adaptation in which public and private actors concertedly make timely use of risk projections and act accordingly, aiming to avoid the occurrence of major damage. In a reactive approach, emphasis on certainty postpones serious action until significant damage occurs. Even for a country like Finland, with a considerably more modest expected value of climate change damage than the global average, the cumulative benefit of proactive adaptation over the period between 2020 and 2070 was estimated to be between EUR 5 and 8 billion (present value at 2 per cent discount rate), depending on the scenario. The model exercise included differentiation of results at provincial level, which showed that some provinces, with overrepresentation of vulnerable economic sectors, were expected to suffer more than others, even though disparities did not rise to very high levels.

Table 6.1

Estimated changes in Finnish GDP at national level and indications of regional variability in different climate economy scenarios by 2070 due to climate change while distinguishing between a proactive and a reactive adaptation approach*

	SSP1-RCP2.6		SSP3-RCP4.5	
	Proactive, %	Reactive, %	Proactive, %	Reactive, %
GDP: percentage change from baseline	−0.05	−0.11	−0.10	−0.26
GDP: regional variability of change in GDP	−0.4 ~ +0.2	−0.6 – 0	−0.5 ~ +0.1	−1.0 – 0

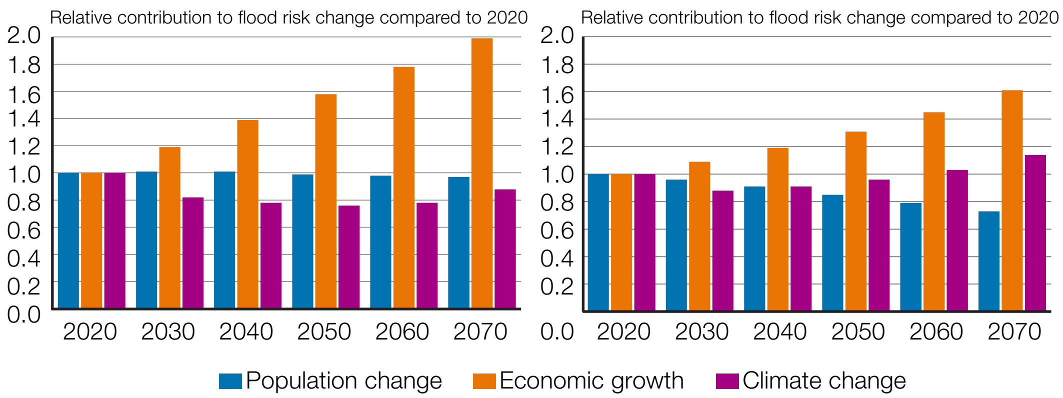
*) Only a selection of effects could be accounted for. Not included are international logistic disruptions (however, these are temporary), effects of increased heat stress, part of the biotic risks for humans, agriculture, the forest sector, land-based and marine ecosystems, or possible surpassing of climate tipping points.

In contrast to the macro-economic results, results become often less clear-cut when measured in absolute monetary terms at sectoral level. An important reason for this complication is that stronger economic growth in a sustainability driven world as represented by SSP1 with less global warming

8 SSP=Shared Socioeconomic Pathway

(RCP2.5) creates more asset value that can be damaged compared to a divided world as represented by SSP3 with less economic growth and more global warming (RCP4.5). For example, as illustrated in figure 6.4, in the case of coastal and riverine flooding in Finland, the changes in expected damage value in the absence of further adaptation are dominated by the effects of economic growth and associated changes in the value of real estate. On top of the economic growth effect, the climate change effects on flood risks do start to kick in after 2060 in the scenario with more global warming (RCP4.5) because of changes in river discharge and stronger storm surge risks along the southern coast. The economic risks of flood nonetheless remain very moderate by international standards. When the current flood risk management plans are all realised, the residual economic risks will remain small.

Figure 6.4
Relative contributions of changes in population, economic growth, and climate change effects on water levels to the development of the expected monetary value of flood damage in SSP1-RCP2.6 (left) and SSP3-RCP4.5 (right) starting from reference year 2020 (=1).



The study also indicated that permanent changes in the operating environment of various economic sectors, e.g. related to average temperature trends, development in average precipitation, typical duration and thickness of snow cover, etc., will eventually be more important for economic development than damage caused by extreme events, even though the latter may cause significant disturbance for a limited period. This is summarised in Table 6.2. It should be noted that the first two items, floods and power disruptions, are expressed in terms of rising costs. In contrast with the forest[9] and agriculture sectors, the effect is expressed in terms of change in earnings, and hence the effect is negative, as earnings go down compared to the reference development.

Proactive adaptation with respect to these gradually progressing changes in operating environments can significantly reduce the negative effects of climate change and enhance the positive effects of new opportunities, either created

9 In this case the forest sector encompasses both the forest product industry and forest resources management.

through adaptation-aware innovation efforts or resulting from climate change as such. An example of the former is innovations in forest management and the cultivation of subspecies, while an example of the latter is the relative improvement of the tourist amenity value of the Finnish summer climate. Generally, these notions are especially relevant for sectors strongly dependent on ecosystem services such as agriculture and the forest sector (Table 6.2). The same notions apply also to tourism and urban planning and architecture, as these largely determine working conditions in service sectors, as well as for daily life in general.

Table 6.2
Expected risk developments in terms of extra damage or reduced earnings in selected sectors associated with climate change in two socioeconomic climate scenarios for the period between 2041 and 2070 compared to the current levels of expected damage*

	SSP1-RCP2.6		SSP3-RCP4.5	
	Proactive	Reactive	Proactive	Reactive
Sectoral effects – extra costs or production loss (EUR million/year)				
Built environment – floods	decreasing**	+6	decreasing**	+16
Households – Electricity distribution disruptions	stable/decreasing**	+9	stable/ ecreasing**	+20
Forest sector (output value)	–450	–600	–550	–800
Agriculture (farm income)***		–180		–290

*) Only a selection of effects could be accounted for. Not included are international logistics disruptions (however, these are temporary), effects of increased heat stress, part of the biotic risks for humans, agriculture, the forest sector, land-based and marine ecosystems, or the possible surpassing of climate tipping points.

**) For both coastal and inland flooding and electricity distribution, disruptions apply that, if existing adaptation plans are completed, the expected cost levels of these hazards are projected to decrease or at least stabilise in the case of electricity, as the significant cost of underground cabling is eventually borne by consumers.

***) The change (loss) in farm income in the reactive approach is expressed as the difference with the proactive approach.

The cost figures presented above are mostly based on physical damage and production losses. These are referred to as 'tangible cost'. Costs can also be 'intangible', referring to a reduction in levels of wellbeing and non-monetisable environmental changes. Examples of intangible costs are extreme weather-related disruptions in electricity distribution to households (which also include tangible costs) and the loss of wellbeing associated with the temporary or permanent health effects of vector-borne diseases. A crude guideline for inferring the cost of non-pecuniary welfare losses (i.e. net of actual expenditures) is that these add between 100 and 200 per cent to the original – pecuniary – cost levels. The resulting cost figures can be used to assess justifiable investment levels for adaptation plans. On the other hand, such compound cost figures should not be used for macroeconomic comparisons or the assessment of public budget developments without recourse to their foundation. Part of these welfare effects may later nevertheless result in tangible costs.

Availability of sectorial impact data is essential for efficient adaptation planning and implementation. Physical impact data tend to be better available than economic impact data, but significant impediments exist for both categories. Problems with missing or poor economic impact data are partly caused by the lack of (exact) physical data. Furthermore, private ownership of data and absence of damage prices for nature, and various health effects add to the availability problems of economic impact data.

The regional economic impacts vary by region due to regional differences in climate change and the shares of climate change sensitive economic activities. For example, analysis of ski lift ticket sales data across Finland has shown that the number of visitors to ski centres in Southern and Central Finland are about twice as sensitive to adverse snow conditions than ski centres in Northern Finland. Furthermore, a lack of snow in Southern and Central Finland tends to increase ski lift ticket sales in Northern Finland. Given the gradual reduction in the duration of the ski season, especially in Southern and Central Finland, where these durations are already shorter than in the north, an inter-regional rebalancing of visitor numbers can be foreseen to the benefit of Northern Finland, which may also face a growth in foreign visitors. Overall, at a national level the turnover of ski centres may therefore grow moderately over the next few decades, even though this also depends on the effects of mitigation policies on long-distance travel. The impact of climate change becomes more visible and diversified when zooming in to the regional level. This notion underlies the regional variation summarized in Table 6.1. Regions in Finland with higher shares of agriculture and forest sector in their regional product tended to face stronger setbacks owing to effects of climate change.

6.3 Assessment of risks and vulnerability to climate change

6.3.1 Methodological approaches for assessing risks and vulnerability

In the context of climate change, risk is often defined arising from dynamic interactions among hazards, exposure and vulnerability. Here, hazard refers to climate-related events and trends that may induce adverse impacts such as losses or damages to livelihoods and environmental resources. Exposure is described as the presence of people, livelihoods, species or resources in places and settings that could be adversely affected by the hazard. Vulnerability is defined as the propensity or predisposition of the exposed entity to be adversely affected. It encompasses concepts such as sensitivity, susceptibility and lack of capacity to cope and adapt[10].

10 IPCC (2022)

To improve the efficiency of disaster risk management and climate change adaptation, a government funded research project proposed a governance model to produce sector-specific risk assessments from inter-operable basic data, ultimately combining them cost-effectively into a national climate risk assessment at regular intervals, has been proposed.[11] It can also guide regional and municipal risk assessments. It is suitable for assessing the consequences of harmful weather events, emerging risks, and cross-border effects.

The proposed operating model consists of 1) cross-sectoral, joint monitoring, and anticipatory work that monitors and anticipates hydro-meteorological and climate hazards, and general societal development with the help of scenarios; 2) sector-specific risk assessments in which exposure, vulnerability, and risk realisation and management are assessed; and 3) a joint, synthesising, climate risk assessment that merges sector-specific risk assessments into a national climate risk assessment.

The climate risk assessment is linked to the preparation and evaluation of policy measures. It utilises societal development scenarios for exposure and vulnerability assessments and provides a knowledge base for developing climate change adaptation measures and governmental security and foresight activities.

The governance model requires nationwide coordination with a wide range of expertise, e.g. key ministries, research institutes, and other stakeholders. Each sector would be responsible for its own risk assessments, but the model would ensure that the monitoring, forecasting, and scenario information of risk management was common across sectors.

The model suggests an update of the national climate risk assessment every six years. It is thus possible to integrate the climate risk assessment with the National Risk Assessment, which is carried out every three years in accordance with the national Security Strategy for Society.

A multi-sectorial climate change risk assessment was undertaken in 2018, and the results were used in the national risk assessment[12]. The climate change risk and vulnerability assessment was updated in 2022 as part of the development of the second national climate change adaptation plan. Assessment included three different perspectives: 1) national risk and vulnerability assessment with a focus on sectorial and cross-sectorial risks and vulnerabilities, 2) regional vulnerabilities, and 3) national and local level institutional vulnerabilities.

11 https://tietokayttoon.fi/documents/113169639/113170760/23-2018-Assessing+and+monitoring+hydrometeorological+and+climate+risk.pdf/67449197-bb59-439c-a96f-6d7d507bfa20/23-2018-Assessing+and+monitoring+hydrometeorological+and+climate+risk.pdf?version=1.0&t=1536559699000

12 National Risk Assessment 2018, https://intermin.fi/julkaisut/julkaisu?pubid=URN:ISBN:978-952-324-249-4

The results will also be used as an input to the update of the national risk assessment. In addition, a government funded project assessed institutional vulnerabilities, with a particular focus on regional and local level[13].

The operating model also provides an input for other reports and assessments that are required by the Climate Act, the Energy Union Governance Regulation of the EU, reporting on the planned implementation mechanism of the Sendai Framework, the EU Civil Protection Mechanism, the National Rescue Service Reform, and the UN Framework Convention on Climate Change, for example. The model has yet to be put fully into practice but forms a framework for ongoing development work within and across sectors. The revised National Climate Change Adaptation Plan 2030 aims to develop means to implement the proposed model.

Work is also ongoing to test a model-based response surface approach for a national-scale climate change impact and adaptation assessment, applying impact models across sectors within a standard analytical framework. This seeks to represent three aspects potentially relevant for policy: (i) sensitivity – examining the sensitivity of the sectors to changing climate for readily observable indicators; (ii) urgency – estimating risks of approaching or exceeding critical thresholds of impact in alternative scenarios as a basis for determining the urgency of response; and (iii) response – determining the effectiveness of potential adaptation and mitigation responses.

6.3.2 Assessment of disaster risks

In Finland, extreme weather events include low-pressure storms, thunderstorms, hot and dry spells, frosty periods, heavy rain and heavy snowfall. Climate change will affect their likelihood and thus alter the associated risks. Climate change will also increase the risk of large-scale forest fires. As the climate warms, days with simultaneous high winds, high temperatures, and low humidity will become more frequent and increase the risk of fires spreading. The risk of flooding, for example, from the sea, watercourses and stormwater, will also change as the climate warms. Sea levels will rise in the Gulf of Finland, and storms may intensify, increasing the risk of marine flooding. Exposure will depend significantly on where you are on the coast. Similarly, the change in the risk of watercourse flooding will depend on location: in some places, it will decrease due to there being less snow, but in large central lakes and their estuaries, for example, the risk of flooding will increase.

Extreme weather events can pose immediate risks, for example, to human health and safety, and damage or disruption to infrastructure in a region. For example, storms can cause electricity supply disruptions when trees fall on power lines. In turn, electricity supply disruptions can cause further disruption

13 Hildén et al. 2022a and 2022b http://urn.fi/URN:ISBN:978-952-383-118-6 https://tietokayttoon.fi/julkaisu?pubid=42102

to infrastructure and critical functions in the area through cascading effects. However, in global comparison, extreme hydro-meteorological events do not generally create disasters in Finland.

6.4 Domestic adaptation policies and strategies

6.4.1 National adaptation policy framework

In publishing its first National Strategy for Adaptation to Climate Change in 2005, Finland was among the first countries in the world to produce such a strategy. The current national adaptation policy framework is described in the Government Resolution of the National Climate Change Adaptation Plan 2022 (Nov 2014)[14].

The aim of the adaptation plan is that Finnish society has the capacity to manage the risks associated with climate change and adapt to changes in the climate. Three objectives were set to be achieved by the end of 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 of climate change adaptation.

The first objective highlights the approach of mainstreaming adaptation, i.e. integrating the perspective of managing climate risks and adaptation needs into regular activities in different sectors. Following this, further identification and definition of more detailed adaptation measures has been tasked to each sector ministry for their areas of responsibility.

Implementation of the NAP has been supported and monitored by a broadly based Monitoring Group for Climate Change Adaptation since 2015. The group is chaired by the Ministry of Agriculture and Forestry, 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.

14 https://mmm.fi/documents/1410837/5120838/MMM-_193086-v1-Finland_s_National_climate_Change_Adaptation_Plan_2022.pdf/582041ee-3518-4a63-bf60-7133aed95a9c/MMM-_193086-v1-Finland_s_National_climate_Change_Adaptation_Plan_2022.pdf?t=1507187377000

Between 2018 and 2019, a mid-term evaluation was carried out to assess progress in the implementation of the NAP. In the lead up to updating the National Adaptation Plan, a final evaluation of the NAP was carried out between 2021 and 2022.

National adaptation planning has been stipulated as part of Finland's Climate Act since 2015. The law provides a framework for planning, implementing, and assessing climate policies and improves cooperation among government offices in mitigation and adaptation. According to the Climate Act, the Government approves and presents to Parliament long-term and short-term strategic mitigation and adaptation plans. According to the Climate Act, a national adaptation plan should be approved at least every ten years. Between 2020 and 2022, the Climate Act was revised, and the updated Climate Act[15] entered into force on 1 July 2022. In the future, a National Adaptation Plan will be adopted every other electoral period (essentially every eight years). The revised Climate Act further stipulates that an evaluation will be carried out halfway through the NAP's implementation period to assess progress and needs for additional measures.

The Climate Act stipulates that each ministry is responsible for implementing and monitoring the progress of the climate plans included in the climate policy planning framework defined by the Act. In essence, this means that while the Ministry of Agriculture and Forestry is responsible for coordinating overall national adaption policy, each ministry has the responsibility to ensure and follow up its implementation within their own areas of responsibility. The current NAP includes a measure that detailed climate risks and vulnerability assessments, as well as the identification of measures needed to manage them, should be undertaken by each sector ministry. Where required, sectoral adaptation (action) plans should be developed to guide more detailed adaptation actions in different sectors. Currently, sectoral adaptation plans have been developed by the following sector ministries (further information in Section 6.4.2):

- The Ministry of the Environment's Action Plan (2008, revised in 2011 and 201616). The environmental administration's sectoral adaptation action plan includes measures for biodiversity, land use, buildings and construction, environmental protection, and the use and management of water resources.

- The Ministry of Agriculture and Forestry's Adaptation Action Plan (2011, revised 202217). The sectoral adaptation action plan includes measures for

15 423/2022

16 Adaptation to Climate Change in the Administrative Sector of the Ministry of the Environment Action Plan 2022, http://urn.fi/URN:ISBN:978-952-11-4736-4

17 https://mmm.fi/en/adaptation-in-the-ministry-of-agriculture-and-forestry-administrative-branch

agriculture, forestry, fisheries, game management and reindeer husbandry, water supply, and flood risk management.

- The Ministry of Social Affairs and Health's Adaptation Plan (2021[18])

Furthermore, adaptation has been integrated into broader climate/ environmental policy programmes in other sectors, including transport and communications, and defence. In 2022, work is underway in the Ministry of Defence to develop a dedicated sectoral climate change adaptation plan.

Adaptation to climate change has been recognised in National Energy and Climate Strategies (2005, 2008, 2013, 2016, 2022). Climate change adaptation has been further integrated in various national policies, such as Finland's Strategy for Arctic Policy adopted in June 2021 where mitigation and adaptation to climate change is one of the strategy's four priorities (further information in Section 6.7).

6.4.2 Sectoral adaptation planning

Water resources and water supply

In the water resources sector, climate change has been integrated into the implementation of the EU's water framework and flood directives, national dam safety legislation, water supply site risk assessment, and the review process of watercourse regulation permits. The selection and prioritisation of measures presented in the 2nd flood risk management plans and 3rd river basin management plans include the estimation of climate resilience of different strategies and measures. The Finnish Environment Institute has produced preliminary stormwater flood maps for municipalities' stormwater risk assessments and regional Centres for Economic Development, Transport and the Environment (ELY Centres) have prepared flood maps to enhance preparedness and to be considered in land-use planning. A national drought risk management strategy is under development. A pilot for a regional drought management plan was carried out in 2020, and a national drought risk analysis is in progress. Indicator-based drought early warning systems are also under development. Watershed regulation and permits require reassessment due to seasonal changes in water levels and discharges. Adaptation may require changes in the regulation permits. Dam safety legislation requires the estimation of design floods for classified dams. Climate change affects the magnitudes of the design floods, and this should be considered in the estimation of the design floods in the watersheds where floods are expected to increase. The new Water Resources Management Strategy 2030[19] also

18 Climate change in the healthcare and social welfare sector: Climate change adaptation plan of Ministry of Social Affairs and Health (2021–2031), http://urn.fi/URN:ISBN:978-952-00-8424-0

19 http://urn.fi/URN:ISBN:978-952-366-185-1

emphasises climate change adaptation and mitigation in the management of water resources.

Agriculture

Adaptation measures for agriculture are included in the Ministry of Agriculture and Forestry's sectoral adaptation plan for 2022 to 2027. Guidelines for water management in agriculture and forestry in a changing environment (2020)[20] set out objectives and measures for sustainable water management in agriculture and forestry, including in the light of changing climate conditions. A work programme has been published to support the guidelines' implementation. In addition, emergency plans and risk assessments for various existing and emerging pests and diseases are discussed in Section 6.6.2.

Forestry

Adaptation measures for forestry are included in the Ministry of Agriculture and Forestry's sectoral adaptation plan for 2022 to 2027. The Forest Damages Prevention Act[21] took effect in 2014, and it was altered most recently in 2022 to decrease the risk of extensive forest damage caused by insects or root rot due to climate change.

Climate-resilient forestry is an integral part of the National Forest Strategy 2025. The main goal is to maintain and improve the resilience of forests by integrating climate change considerations into forest management. This is achieved by improving knowledge of and practical tools for the enhancement of carbon storage and sequestration in forests, as well as on the impacts of forests and forest management on climate change adaptation. The preparation of the new Strategy is underway and will be finalised by the end of 2022. Increased financing for research and development, as well as updated legislation and guidelines on forest management and climate change, also contributes to improved risk management carried out by forest owners, operators and the authorities. The updating of the state financing scheme for sustainable forest management in private forests is also underway. One of the main goals is to promote management practices that enhance forests' resilience.

Reindeer husbandry and herding

In 2021, the Ministry of Agriculture and Forestry established a working group on the future of reindeer husbandry with the aim of 1) promoting active, sustainable and progressive reindeer husbandry, 2) developing the subsidy system and securing investment support for reindeer husbandry, and 3)

20 Maa- ja metsätalouden vesitalouden suuntaviivat muuttuvassa ympäristössä - Valto (valtioneuvosto.fi)

21 1087/2013

promoting the development of reindeer husbandry as a profitable, sustainable, and culturally significant livelihood. The working group's first task is to prepare a working model for reindeer pasture management plans for each reindeer herding cooperative, which will ensure the sustainable use of reindeer pastures in accordance with the reindeer numbers stipulated in a government decree[22]. The working group's work will also include the sector's work on anticipating the effects of climate change and planning adaptation measures.

Fisheries and game

Commercial fishing is steered by the Fishing Act[23]. The Fishing Act provides for national fisheries management plans to ensure the sustainable use and management of fisheries resources. Climate change plays a marginal role in policymaking and commercial fishing documents.

Finnish hunting legislation and hunting activities are based on the principle of sustainable use. Sustainable use is determined by estimates of the size of animal populations and species-specific management plans. The impact of climate change on the success of animal populations has not been considered in recent management plans.

Energy

Adaptation measures in the energy sector are included in the National Climate and Energy Strategy published in 2022.

In energy distribution the Act on Electricity Markets[24] requires the network operators to prepare for extremes and also to compensate users for failures to maintain distribution of electricity. This has made network operators invest in ways to reduce the risk of distribution failures due to for example storms.

Act on Peak Load Reserve[25] secures a balance between electricity production and consumption. Amendments in 2021[26] make it possible to secure supply of electricity also in abnormal situations and disturbances. In the future, the need for and volume of peak-load capacity would be assessed at least every two years. Participation in peak-load reserve would be extended when necessary.

Transport

The Ministry of Transport and Communications is responsible for adaptation planning in the transport and communications sector at national and strategic

22 414/2020
23 379/2015
24 588/2013
25 117/2011
26 1239/2021

levels. Adaptation is part of standard sectoral policies, plans, and programmes in the transport sector.

In 2021, the Government adopted the National Transport System Plan for 2021 to 2032, which is a strategic plan for the long-term development of the entire transport system. The plan includes an action plan and brings together the measures taken by central and local government. The plan notes that climate change is changing the transport system's operating environment. According to the plan, adaptation to climate change will require transport system operators to be more aware of weather and climate risks, for example. There is a need for measures in the planning of both the rail and road networks and especially in the winter maintenance of the networks. Sustainability is one of the key goals of the plan, and the plan's measures will increase opportunities for climate change adaptation policies in the sector.

In March 2022, the Government adopted a new Transport Safety Strategy[27]. The strategy notes that acknowledging the needs of climate change adaptation throughout the transport network is key to the improvement of traffic safety. All the authorities responsible for the transport network's maintenance must ensure that changing conditions and increasingly extreme weather are considered in the maintenance and development of the transport network. The plan also includes policy measures on the better collection and communication of meteorological information.

The Finnish Transport Infrastructure Agency (FTIA), which operates under the Ministry of Transport and Communications, is responsible for road, railway, and waterway construction and maintenance and operates in close cooperation with the regional Centres for Economic Development, Transport and the Environment (ELY Centres). According to the steering contract between the Ministry and the Agency, as part of its continuous tasks, the Agency produces information regarding adaptation.

Built environment, natural environment, and biodiversity

In the built environment sector, the legislative steering of adaptation to climate change is based on the Land Use and Building Act[28]. Another important method for steering land use regarding adaptation has been the national land-use guidelines (Government Decision 2008), one of the focus areas of which is adaptation. According to the Land Use and Building Act, the national land-use guidelines must be taken into account in regional planning, municipal land-use planning and in the operations of the authorities. In 2014, the Land Use and Building Act was amended with provisions on stormwater management. Increasing rain levels have been considered through the issuing

27 https://www.lvm.fi/-/government-resolution-transport-safety-strategy-aims-to-improve-the-safety-of-all-modes-of-transport-1703498

28 132/1999

of a decree on the preparation of moisture control plans in construction in 2014. Urban flood management is also covered by the Flood Risk Management Act[29]. A reform of Land Use and Planning Act is currently ongoing, and its main targets are the mitigation and adaptation of climate change.

Adaptation actions in the built and natural environments are included in the Action Plan for the Adaptation to Climate Change of the Environmental Administration 2022[30], adopted in 2016. Progress of the plan's implementation from 2016 to 2019 was reported in 2020 (for further discussion see Sections 6.6.1 and 6.6.2).

Cultural heritage

The Ministry of the Education and Culture, with other ministries, agencies, and third sector actors, prepares the first national cultural heritage strategy. The Cultural Environment Strategy from 2014 to 2020, which was completed under the leadership of the Ministry of the Environment, will continue to direct the work on the cultural environment. In addition, the Ministry of the Environment is currently preparing the definition of landscape policy. In all these strategies, climate change is a key theme.

Industry and commerce

The most significant risks caused by climate change to the Finnish industry and commerce are indirect and closely connected to other sectors within Finland as well as to global developments. Because of the cross-sectoral nature of the risks, no specific adaptation plan has been prepared for Finnish industrial operations or commerce[31]. The adaptation planning is carried out through cross-sectoral work in which the adaptation needs of the Finnish industry and commerce are taken into consideration.

The mitigation and adaptation needs caused by flooding, droughts and other extreme weather conditions are researched and implemented in connection with the ongoing reform of the Land Use and Building Act. Climate change mitigation and adaptation as the main objectives of the reform improve the ability of the Finnish industry and commerce to adapt to the direct effects of climate change.

Research has identified problems in logistics caused by climate change as a potential indirect risk to Finnish industrial operations. In March 2021, the Finnish National Emergency Supply Agency under the Ministry of Economic Affairs and Employment of Finland started the implementation of the Logistics 2030 programme. Logistics 2030 programme takes into account

29 620/2010

30 http://urn.fi/URN:ISBN:978-952-11-4736-4

31 No specific plan for adaptation has been prepared for mining either. As for the built environment in general, securing the function of infrastructure is essential.

the impacts of climate change on the logistics sector and aims to strengthen the operating conditions and operational capacity of critical logistics infrastructure.

Indirect risks caused by disruptions in the energy supply are addressed as part of the Finnish Climate and Energy Strategy prepared by the Finnish Ministry of Economic Affairs and Employment. Energy security and security of supply play a major role in the Finnish approach to climate change adaptation and as such support the ability of the Finnish industry to adapt to problems in the energy supply.

Tourism

Adaptation measures for the tourism sector are an integral part of Finland´s tourism strategy 2019–2028 and action plan 2022–2023. The updated strategy will be finalized by autumn 2022. The strategy 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 strategy calls for new, innovative solutions for sustainable tourism products and experiences.

According to the strategy, proactive adaptation measures and successful green transition are a prerequisite for ensuring the profitability and social acceptability of tourism business activities. The tourism sector needs investments in measuring and reducing carbon dioxide emissions, reforming operating practices and in-creasing cooperation. These all actions are included into the Finland´s tourism strategy. In addition, in June 2022, 60 tourism businesses, destinations and associations together with Visit Finland signed Glasgow Declaration for Climate Action in Tourism. By signing the organizations commit to halve emissions by 2030 and reach Net Zero as soon as possible before 2050.

Tourism is a horizontal sector and many adaptation planning described in this chapter has direct or indirect impact on the tourism sector. Especially transport is an essential part of the tourism sector.

Health and welfare

Adaptation actions for health and welfare sectors are included in the Climate Change Adaptation Plan for the Social and Health Sector[32] published by the Ministry of Social Affairs and Health in 2021. The aim of the sectoral Adaptation Plan is to assess the current state of adaptation and the structures supporting it, identify current and new adaptation measures in the health and wellbeing sector, and translate the measures into more concrete terms within the administrative branch of the Ministry of Social Affairs and Health.

32 http://urn.fi/URN:ISBN:978-952-00-8424-0

The intention is to introduce the Adaptation Plan to healthcare and social welfare operators and to increase risk awareness in the healthcare and social welfare sector. The Adaptation Plan contains 43 objectives and 92 recommendations for measures. The measures cover areas related to environmental health, health, and social services (incl. occupational safety and health), social effects, and mitigation measures and repercussions. The Ministry of Social Affairs and Health is responsible for implementing, monitoring, and assessing the Adaptation Plan. The Drinking Water Directive[33] (EU) on the quality of water intended for human consumption to ensure healthy drinking water is being implemented. Planning on legislative amendments across several branches of government, particularly in the administrative branches of the Ministry of Social Affairs and Health, the Ministry of the Environment, and the Ministry of Agriculture and Forestry, is currently ongoing.

6.4.3 Disaster prevention and management

There is no single national disaster risk reduction strategy in Finland, but there are legislative government resolutions, various strategies and programmes that together form the necessary preparedness of the society to various disasters. The legislation includes the Emergency Powers Act[34], Rescue Act[35], and Act on Security of Supply[36].

The Security Strategy for Society 2017[37] is a government resolution that harmonises national preparedness principles and guides preparedness in the various administrative branches. The first part of the strategy presents a cooperation model for comprehensive security, based on which preparedness measures and other actions are taken concerning a range of incidents in Finland. The principles of the Security Strategy for Society cover preparedness in different types of incidents and emergencies. The strategy lays out seven vital functions in society, i.e. the basic functions that must be safeguarded in all conditions and at all operative levels. The second part of the strategy outlines the tasks and areas of responsibility of the Government's ministries pertaining to preparedness. They are the starting point for preparedness planning at all activity levels. To safeguard the vital functions, the Security Strategy for Society 2017 defines 57 tasks and areas of responsibility for the Government's ministries pertaining to preparedness.

The Report on Internal Security assesses the state of internal security in Finland, and the national and global drivers of change affecting it. It defines the internal security objectives and the direction of development until 2030.

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33 Drinking Water Directive (EU) 2020/2184

34 1552/2011

35 379/2011

36 1390/1992

37 https://turvallisuuskomitea.fi/wp-content/uploads/2018/04/YTS_2017_english.pdf

It aims to ensure the further development of internal security so that Finland will be an even safer country for all people and population groups in the future. Climate change was identified as one of the drivers affecting internal security.

The statutory tasks of the Regional State Administrative Agencies include coordinating regional preparedness and organising the related cooperation, which includes cooperation with the various authorities in the region, as well as with non-governmental organisations and the private sector. The Regional State Administrative Agencies organise large-scale preparedness exercises to promote a common regional risk management capability between actors. Regional risk assessments are actively used for preparedness exercises and for general preparedness planning and training activities.

In 2018, climate change impacts were included in the National Risk Assessment by describing the diversity of weather and climate risks and the challenges posed by growing risks to society. Ministry of the Interior re-established the National Sendai Network in 2021 to offer a common national podium for the relevant 26 different stakeholders. The Network consists of ministries, research and development, central national agencies and non-governmental organisations, all having responsibilities in implementing the Sendai Framework. This Network strengthens national and international cooperation, forms the audience for better information sharing and enhances implementing national strategies within the Disaster Risk Reduction (DRR) issues.

6.4.4 Sub-national and local adaptation plans

A significant share of adaptation measures is implemented at the regional and local levels. Various measures promoting preparedness for climate change, such as flood protection, have already long been implemented at regional or municipal level. Adaptation measures are included in many recent programmes and strategies at the regional and local levels, but the dominant focus of climate action has been on climate change mitigation.

The need for systematic implementation of adaptation measures has been widely recognised in municipalities, and regional climate risk knowledge and awareness have increased. This has led to active development efforts and collaboration with different actors. Typical adaptation measures focus on improving preparedness for climate risks, such as flood risk mapping or emergency planning related to water management and storms.

Bigger cities and municipalities have been especially active in developing and implementing adaptation policies and actions. In 2021, the Helsinki Region Environmental Services Authority (HSY) finalised their Sustainable Urban Living Programme, which includes new measures for climate change adaptation in the metropolitan area. The programme supersedes the metropolitan region's adaptation strategy adopted in 2012. Individual cities in the metropolitan region have since engaged in more detailed adaptation planning, and the focus of measures at the metropolitan region level have therefore shifted to common learning, supporting awareness raising, networking, and monitoring and evaluation. Some larger cities are involved in the Covenant of Mayors for Climate and Energy, which requires cities to prepare risk and vulnerability assessments and plan adaptation measures as part of their climate action plans.

Finland's Regional Councils established a collaboration network in 2020 to improve knowledge sharing and cooperation in relation to climate issues, including adaptation to climate change. The regional Centres for Economic Development, Transport and the Environment (ELY Centres) have carried out a systematic assessment of the current and future needs of adaptation action in their areas of work. ELY Centres are active across the country, and through the ELY Centres' internal network on climate change issues, the Centres collaborate on national-level actions. Many regions are also proactive in promoting regionally important adaptation action and creating adaptation plans in collaboration with other regional actors.

6.5 Monitoring and evaluation framework

National adaptation actions are guided by the National Adaptation Plan (NAP) of 2014. A mid-term evaluation of the NAP was published in the spring of 2019, and a final evaluation of the plan was carried out between 2021 and 2022. Annual monitoring of the NAP has focused on tracking the progress of the actions included in the plan. Efforts to monitor adaptation more broadly are ongoing. Some sectoral adaptation plans have also included efforts to follow up their implementation: for example, the Ministry of the Environment has monitored its own adaptation programme by systematically tracking the actions and identifying progress and challenges. Evaluations of the Ministry of Environment's adaptation plan were published in 2013 and 2020.

The final evaluation of the current NAP (2014 to 2022) focused on assessing the success and challenges of the plan's implementation, as well as identifying needs for further adaptation efforts. The evaluation approach combined multiple methods. Policy and legislation documents were assessed to identify, inter alia, the state of climate adaptation in different policy fields and the policy coherence of adaptation across fields. Three workshops involving public officials working at the regional level across Finland were organised, in which the participants provided inputs on the current state, challenges, and knowledge gaps of climate adaptation work in their respective regions. Two national-level workshops involving representatives from multiple ministries were organised to discuss how to better concretise adaptation work within the next 10 years and to present objectives and actions to achieve them. A survey was sent out to all Finnish municipalities to gain a better understanding of the current state of climate adaptation at the local level. Interviews with regional and national public sector actors were conducted to assess the level of both human and economic resources dedicated to adaptation measures. In addition, various adaptation policy development paths were identified through a literature review of reports across EU countries.

Prior to the recent final evaluation of the NAP, a mid-term evaluation was carried out between 2018 and 2019, in which a two-phase process applied. In the first phase, a facilitated self-evaluation process was carried out with sectoral administrations at the national level, consisting of group interviews with representatives of ministries and associated agencies and national research institutes in eight sectors, as well as key regional and local level representatives. The second phase focused on engaging stakeholders beyond the national-level administrations. Regional and local stakeholders from 11 different sectors were consulted via an online survey, and five regional stakeholder workshops were organised around the country to discuss the progress of adaptation work from a regional perspective.

Further to periodical evaluation efforts, more regular monitoring of the implementation of adaptation policies is undertaken by the National Monitoring Group for Climate Change Adaptation. The monitoring group brings together a broad range of stakeholders from both the national and regional levels. As part of this work, key indicators for monitoring climate impacts, risks and adaptation were compiled between 2015 and 2017 in dialogue with stakeholders. The further development, application and communication of adaptation indicators is an ongoing process led by the national adaptation monitoring group. In 2022, work is ongoing with Finland's national Climate Change Panel to identify indicators suitable for monitoring adaptation, especially in the human health and water services sectors.

The Helsinki Metropolitan Area had formulated a regional adaptation strategy for 2012 to 2020 focusing on urban adaptation. In 2021, the implementation and effectiveness of the strategy, coordinated by the Helsinki Region Environmental Services Authority (HSY), was assessed by an external evaluator. According to the assessment, the strategy was most influential in the first years of its implementation, because the concept of adaptation was still novel, bringing a new perspective to urban planning. The strategy was considered useful for recognising climate hazards and vulnerabilities. What added most value to the adaptation planning during the strategy period was the development of fruitful cooperation and knowledge exchange between the cities in the Metropolitan Area. During the strategy period, the need for the cities' own adaptation measures gained more attention, and some of the measures of the regional strategy were exported in the cities' adaptation action plans.

6.6 Progress and outcomes of adaptation action

6.6.1 Progress of national adaptation plan

A mid-term evaluation of Finland's National Adaptation Plan 2022 was carried out in 2018–2019. Results of the evaluation were used to steer and strengthen the Plan's implementation. In August 2022, a final evaluation of the progress of Finland's national adaptation policy was published. Results of the final evaluation have informed preparation of Finland's next NAP that looks to the year 2030.

According to the final evaluation, climate change impacts are receiving increasing attention in all administrative sectors in Finland. This is evident in references to climate change in the development of regulation and other policies. It is assessed that the NAP has positively contributed to goal setting and increasing general awareness of the need for adaptation. Sectors have, however, progressed at a different pace in terms of actions and guidelines that would concretely strengthen adaptive capacity. For example, advances have been made in construction, infrastructure maintenance, water management, and the use and protection of water bodies. These are typically sectors in which weather and climate fluctuations have long been relevant for normal operations. In other fields, such as game management, fisheries and healthcare, climate change has only recently gained attention as a concrete phenomenon that requires action.

Finland has maintained R&D activities that support the development of adaptation measures and the preparation of policies promoting adaptation. Until recently, R&D activities have focused either on short-term examinations on the one hand or long-term academic research. However, there is also a need for applied R&D projects, in which joint development methods would be created using tools such as checklists and guides for different sectors to implement concrete adaptation measures.

In Finland, monitoring the state of the environment has developed over a long period of time, and the data has also been used to verify and assess climate change impacts. Adaptation measures are reported nationally in connection with the Annual Climate Report to Parliament. Policy measures promoting adaptation are also regularly reported to the EU and the UN Paris Climate Agreement. Monitoring of individual adaptation measures at the regional and local level is developing, but monitoring is still fragmented. Moreover, there is no unified data base which could be utilised to develop adaptation planning measures and activities and to share good practices of actions taken.

In addition to evaluations of the NAP, progress in the implementation of certain sectoral adaptation plans has also been assessed. In 2020, Progress in the implementation of the Action Plan for the Adaptation to Climate Change of the Environmental Administration from 2016 to 2019 was reported.

The results show that the implementation of almost all measures described in the Action Plan for which a timetable had been set has progressed as planned, and they have been completed. In terms of the steering instruments, progress has been made in considering the needs for adaptation, but the consistency of the guidance should be further improved. Further details on the progress of actions are described in Section 6.6.2 below.

6.6.2 Progress of sectoral adaptation actions

Natural environment and biodiversity

The Action Plan for the Adaptation to Climate Change of the Environmental Administration 2022 was adopted in 2016. The Action Plan contributes to the implementation of the National Climate Change Adaptation Plan 2022 (Government Resolution of 20 November 2014).

The Finnish Nature Conservation Act is one of the key instruments to ensure the biodiversity of the Finnish natural environment. The act has recently been revised. Compared to the Conservation Act of 1996, in the revised version, adaptation to climate change-induced impacts is more clearly integrated into the aim of the act, and the need for identifying interdependences between climate change and biodiversity measures has been acknowledged. As the need to consider climate change impacts has become part of the proposed new law, the linkages between conservation and climate change adaptation are therefore further strengthened.

The protection of habitats takes a major leap forward in the new Act. The protection of certain habitat types that are already protected will be further strengthened. In addition, the Act provides the statutory framework for the protection of threatened habitat types and imposes a prohibition on degrading strictly protected habitats. The protection of species will also be intensified and clarified, which, with the protection of habitats, will significantly promote the protection of biodiversity in Finland. The Act also promotes the rights of the Sámi people by taking their rights as an indigenous people into account in the implementation of the Nature Conservation Act more strongly than before. The new Act includes a prohibition on weakening traditional Sámi livelihoods and culture.

Worldwide and in Finland, invasive alien species constitute one of the leading threats to biodiversity. Climate change is anticipated to substantially increase the number of alien species in Finland and the damage they cause. Climate change also affects the relationships between plants and plant diseases. The EU Regulation on Invasive Alien Species, Finland’s national legislation on Invasive Alien Species, and related national management plans will increase preparedness to react to changing circumstances, as climate change increases the potential for invasive alien species to spread northwards and thus extends their range, as well as their invasiveness. The more tangible actions are used to address the negative effects by invasive alien species, the more biodiversity will be maintained and adapted to the climate.

Water resources

Adapting to the impacts of climate change has long been important for the water sector. The current water conservation enhancement programme (2019 to 2023) funds projects that support adapting to climate change and prevent biodiversity loss in different sectors. For example, the programme is expected to generate and develop measures to prevent nutrient runoffs in the agricultural sector and manage rainwater in an integrated fashion (incl. nature-based solutions). The water conservation enhancement programme also funds studies and assessments of the state of the Baltic Sea and inland lakes, which supports adaptation to climate change. In addition, the new Programme of Measures of Finland's Marine Strategy from 2022 to 2027 deals with anthropogenic stress factors, as well as the impacts of climate change, which can aggravate other problems and thus call for more effective measures. In addition, the flood risk management plans for 2022 to 2027 for significant flood risk areas were updated in 2021. The objective of the plans is to develop measures to minimise flood damage and flood risks, such as flood forecasting and flood warnings. In 2022, new river basin management plans and action programmes were adopted for 2022 to 2027 to achieve and sustain the good state of waters.

Water supply

In the new Programme for the National Water Services Reform, attention has been paid to securing the undisturbed operation of water supply management and improving the management of risks, including climate risks. The Water Resources Management Strategy 2030[38] lists key change factors to the operating environment, such as the use of water resources, management of risks and self-sufficiency, and adaptation to climate change, by utilising nature-based solutions, for example. The goal of the strategy is to support and enable the supply of clean water, the reliability of water supply, and the water-related wellbeing of society and nature. Additionally, water responsibility and security are given more attention, and these will also be advanced at an international scale.

Agriculture

Further development of cultivation methods and systems is required 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 advisory services help 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. Research on climate change impacts and

38 http://urn.fi/URN:ISBN:978-952-366-185-1

available adaptation means has thereby already provided useful information for farmers and agricultural entrepreneurs. In the agricultural sector, measures for adaptation to climate change often also work as climate change mitigation measures. Adapting to a changing climate is also instrumental in achieving the climate mitigation targets set for the agricultural sector.

The adaptation measures include developing risk profiles and emergency plans for various existing and emerging pests and diseases. Although 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 where relevant. Finnish plant breeding has expanded the breeding strategies to cover novel crops that will probably 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 the future adaptive capacity of Finland's agriculture.

The EU's Common Agricultural Policy (CAP) provides many tools for the abovementioned adaptation needs. Diversified production, the stability of the business economy, and the management of the growing condition of the field and water management play a key role in adapting to climate change. Organic production also promotes biodiversity and thus helps farmers adapt to climate change. Investment subsidies, advice services and various data transfer projects have helped develop production and modernise the equipment base. Adaptation to climate change in livestock farming is strongly linked to animal welfare and production hygiene. In Finland, animal welfare and hygiene are at a high level, and measures to promote them are well funded by the Rural Development Programme. Measures related to adaptation are included to the Finnish national CAP plan for the new CAP period from 2023 to 2027.

An indication of farmer's readiness to adapt to climate change is that they have already adopted later-maturing cultivars and crops, and they have started sowings earlier than a couple of decades ago. Since 1995, there has been a significant shift to the cultivation of more diverse cash crop choices in larger field areas. The warming climate has been the primary driver, but such a change has been possible only when supported by well-adapted cultivars, active markets and financial compensation. Cultivation methods and systems have been further developed to reduce risks and increase the resilience and competitiveness of agricultural production in a changing climate. These include sustaining soil structure and conditions by diversifying crop rotations, applying measures that increase soil organic content, increasing the period with soil cover by using autumn-sown and cover crops, and developing warning systems for the occurrence of pest and disease epidemics. However, farmers have prioritised the maintenance of subsurface drainage over the future use of irrigation. Farmers hesitate to adopt irrigation because of uncertainties in future precipitation, crop prices, irrigation costs, and thus whether investment pays back, and how long it will take. Adaptation measures on farms have been supported and monitored by several recent or ongoing research projects in collaboration with farmers, advisory services, farmers' unions, policymakers and private companies. To enhance adaptation to exceptional weather conditions, measures to improve and increase farms' energy self-sufficiency and energy security of supply have been promoted and implemented.

Forestry

The Forest Damages Prevention Act[39] took effect in 2014, and it was altered most recently in 2022 to decrease the risk of extensive forest damage caused by insects or root rot due to the changing climate.

Finnish forest administration has prepared contingency plans for extensive storms and other damage in forests. The plans cover storm damages, forest fires, snow damage, drought and frost damage, air pollution carried over a distance, and pests previously unobserved in Finland. The authorities have also started to draft contingency plans for various invasive alien species, as well as domestic pests such as the spruce bark beetle, which are expected to cause more damage in the future.

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. Next generation seed orchard programme is being prepared during 2022. 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.

Energy

Finland has taken measures to adapt to the changing climate conditions, especially to the severe winter and summer storms that cause extensive and long-lasting power outages. Energy utilities have replaced a significant amount of the overhead electricity lines with underground cables. This has drastically decreased the number of blackouts throughout the country compared to the situation in 2011, when a major storm caused a blackout for more than 500,000 households. After the storm, the new requirements of a weatherproof network were introduced to the Electricity Market Act[40]. Among other things, the Act sets time limits for power outages beyond which compensation must be paid and includes measures for increasing the security of supply.

The Government is currently introducing new measures to the Electricity Market Act to enable the energy transition and help consumers better manage

39 1087/2013

40 Electricity Market Act 588/2013

their consumption and deliver energy-efficient solutions. New provisions allow consumers to save money. They contribute to the overall reduction of energy consumption. New types of services will enable more efficient system use. Intelligent electricity networks will work as a service platform in the transition to a more decentralised and carbon-neutral electricity system. Almost all users of electricity in Finland have smart meters that allow customers to participate in a variety of markets, improve security of supply, and cost-effectively create new business opportunities for companies. The smart meters provide network companies with online information about the network status, including detailed geographical information about disturbances caused by trees that have fallen on overhead lines, for example. This enables network companies to quickly restore the electricity supply and minimise the duration and consequences of events.

To fully use the demand side response and optimise the system, distribution network companies must also prepare a network development plan explaining how to employ demand response and storage and energy efficiency measures as an alternative for network investments for more efficient system use.

Land-use planning and buildings

In the land-use planning and building sectors, climate change and its impacts present significant challenges, which are also commonly recognised. In the currently ongoing reform of the Land Use and Building Act (2021 to 2022), one of the central goals is to better take climate change into account. The ambition is to make changes to the existing land-use planning system so that planning can better contribute to climate change mitigation and adaptation.

The Action Plan for the Adaptation to Climate Change of the Environmental Administration 2022 was adopted in 2016. The Action Plan contributes to the implementation of the National Climate Change Adaptation Plan 2022 (Government Resolution of 20 November 2014).

Cultural heritage

The major legal basis for protecting cultural heritage sites and the environment is the Land Use and Building Act. The national land-use guidelines also contribute to the efforts to adapt to climate change and extreme weather events and their consequences. Cultural environments are among the guidelines' themes.

The Constitution defines nature and its diversity, as well as the intrinsic value of cultural inheritance intrinsic. Furthermore, the Sámi indigenous people have the right to maintain and develop their own language and culture. According to the Act on the Sámi Parliament[41], the Sámi indigenous people have

41 1727/1995

autonomy over their own language and culture in the Sámi homeland. The new Climate Act (2022)[42] contributes to ensuring the ability of the Sámi to maintain and develop their own language and culture.

The Cultural Environment Strategy from 2014 to 2020, completed under the leadership of the Ministry of the Environment, pointed to the recognition of how the cultural environment helps in mitigating climate change and adaptation to it. However, the measures focused mostly on the impacts of the management of the built heritage in the mitigation of climate change. The Ministry of the Environment is to update the 'Climate Change and the Cultural Environment – Recognised Impacts and Challenges in Finland' report (2008). The threats to cultural heritage caused by climate change and related mitigation and adaptation measures will be discussed in the revised report.

A practical tool to assess the impact of floods on the built heritage and landscape is the flood map service of the Finnish Environment Institute. It can be used to map risks to the cultural environment.

The national cultural heritage strategy, which is under preparation, will propose measures related to adaptation and mitigation to climate change. For example, cultural heritage should be included in climate change mitigation and adaptation plans, and the impacts of climate change on cultural heritage and the cultural environment should be monitored.

Finland actively participates in international networks that promote the adaptation of cultural heritage to the effects of climate change. The Finnish Heritage Agency is part of the international Climate Heritage Network that seeks solutions for the tensions between the protection of cultural heritage and climate change mitigation and adaptation. In 2021, The Nordic and Baltic countries arranged a forum, called Cultural Heritage in a Changing Climate, in which Finnish delegates participated. Cooperation is also active at the European Union level.

Industry and commerce

The need for risk management due to weather variability and extreme weather conditions has been obvious in some weather-sensitive industries, and the general ability of the Finnish industrial sector to adapt to the direct effects of climate change is good. Adaptation measures for the direct and indirect risks in the industrial sector have been mapped.

Contingency plans, the development of supply routes and methods and increasing the flexibility of the energy supply have been suggested as suitable adaptation methods for the direct effects of climate change. Adaptation measures to the indirect effects of climate change can include the strengthening

42 423/2022

of value chains and networks with alternative supply areas and routes, as well as with the addition of new export markets. A more demanding way is to help improve the resilience and adaptive capacity of the most vulnerable parts of the value chain.

Studies on adaptation needs for industry suggest that adaptation to climate change presents an opportunity for the industry sector. For example, new products, processes, technologies and expertise 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 only recently been introduced to the wider discussion. Such new opportunities are also available outside the industrial sector, as the shift in commerce from goods to services presents new opportunities for innovation. For companies in technical trading, the role of services is already central. Additionally, the growing importance of services mitigates the indirect effects of climate change on commerce and therefore improve its adaptability.

Mining

A new Mining Act is currently under preparation. One of the goals of the new Act is to enhance the level of the environmental protection of mining, which indirectly strengthens the linkages with climate change adaptation. In the future, risks induced by climate change may increase in certain regions and thereby have impacts on the secure operation of the mining sector, such as water balance management in mining areas. In the preparation of the new Mining Act, the need to coordinate and accommodate different concerns, including biodiversity and the protection of waters, has been acknowledged.

Transport and communications

Adaptation is part of standard sectoral policies, plans and programmes in the transport sector. Real-time traffic and weather information and the situation picture assist operators, traffic control, and the whole traffic system to adapt. In the revision of the Road Traffic Act[43], the effects of changing winter conditions have been considered, and meteorological research has been utilised.

The Finnish Transport Infrastructure Agency (FTIA) has considered adaptation to climate change when updating guidelines and policies for the drainage of roads and railways (2018), the dimensioning of culverts, bridge arches and sewers, the winter maintenance of roads (2018), and the maintenance of gravel roads (2022). The flood risk areas, alternative routes, drainage and culverts of roads have been inventoried regionally. The lack of alternative routes increases the vulnerability of railways. Risk trees alongside the railways have been harvested. Reserve power equipment has been renewed, and its use has been further developed. Maintenance contracts have been

43 729/2018

developed to take risks caused by climate change into account. The need for adaptation in the planning, design and building of railways is recognised. Ensuring adequate financing of the maintenance and repair of infrastructure is essential in adaptation to climate change.

Awareness of climate change and its predictions have been recognised as risk management means for seafaring. The service reliability of safety equipment and different systems has and is being improved by adding e.g. remote control. The safety and serviceability of seafaring is secured by preparing for various disturbances and exceptions and practising with seafaring actors.

The effects of climate change on runoff water and adaptation to flooding in airports have been studied. Research needs on de-icing means and the durability of airport structures have been identified. Good adaptability/ resilience is essential for airports, because the effects of climate change are realised over a long period.

To decrease the risk of damage to the networks, aerial cables are being replaced with ground cables when legacy copper networks are dismantled, especially in sparsely populated areas. The Finnish Transport and Communications Agency Traficom's regulation on the resilience of communications networks and the regulation of the electrical protection of communications networks define obligations concerning preparedness for and adaption to normally expected climate conditions. Telecommunications operators are obliged to implement measures defined in regulations to protect their networks against possible climate impacts such as power cuts, cooling system failures, cable cuts and damaged hardware, as well as overvoltage and overcurrent of climatic origin, such as lightning strikes. Detailed requirements for communications networks hardware redundancy, reserve routes and the resilience of cooling systems, as well as power supply obligations and the resilience of the power supply, have been defined in the regulations. Provisions on electrical safety, grounding and overvoltage and overcurrent protection have also been provided. The purpose of regulations is to improve reliability and the resilience of communications networks and services in challenging weather conditions and in normal operation, as well as to prevent the communications network causing danger in any expected conditions. Traficom coordinates and monitors telecommunications operators' compliance with obligations.

Tourism and recreation

Finland's Tourism Strategy from 2019 to 2028 and action plan from 2019 to 2023 react to climate change. The strategy states the role of tourism as a cross-sectoral industry and its potential to enhance a shift to cleaner and more sustainable lower-carbon economic growth to minimise the effects of climate change. At the same time, the strategy calls for innovative solutions for sustainable tourism products and experiences. The update of the action plan from 2022 to 2023 is almost finalised.

Finance and insurance

The financial industry in Finland overall considers climate change in its operations and as part of its risk management. Finland's earnings-related pension sector's responsible investments were analysed for the first time in 2021. According to the analysis, 49 per cent of Finnish overall pension assets are invested in alignment with Finland's goal of being carbon neutral in 2035.

An 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 insurance that covers damage caused by exceptional floods and severe weather events. The great majority of households and property owners have this insurance. Between 2018 and 2020, Finnish insurance companies paid EUR 7.2 million in flood compensation. The Flood Centre operated by the Finnish Environment Institute (SYKE) and the Finnish Meteorological Institute (FMI) offers an early warning system for floods, including daily watershed forecasts and online flood warnings, and provides estimates on the exceptionality of flood and weather events.

The Government compensation scheme for crop damage ended at the end of 2015, but some private insurance products that cover risks of extreme weather conditions have since been introduced to the market by private insurance companies. The Government introduced a tax exemption for insurance products covering crop damage, plant pests, and animal health in 2019. The exemption lasts until the end of 2027.

Health and welfare

An increasing number of adaptation measures has been taken to reduce the risk of the adverse health effects of climate change. The Ministry of Social Affairs and Health published a climate change adaptation plan for the social care and healthcare sector in 2021, which recommends adaptation measures in multiple health and welfare fields.

Multiple research projects, funded by the Academy of Finland and the Government's analysis, assessment and research activities, are ongoing in the field of climate change and health, healthcare and adaptation. In these projects, the health effects and questions on adaptation and cross-sectoral impacts in healthcare with ecological healthcare are identified and assessed.

Furthermore, communication and raising risk awareness is becoming an increasingly important part of climate change adaptation. The Finnish Institute for Health and Welfare (THL) communicates on, e.g. slipping accidents, water quality issues, and preparedness for heatwaves and infectious diseases.

THL recently published an overview of the health effects of heat in Finland and the measures taken to mitigate them, as well as recommendations for improving heat preparedness. New information has been produced on the health effects and vulnerable population groups and heat preparedness in the healthcare sector. Research projects are ongoing to provide national guidance on the heat-related burden of disease and the cost-effectiveness of mitigation scenarios. An update to the government decree on housing and health is underway, including a health-based evaluation of the upper-limit values for the indoor temperature during the summer.

The main effort to prevent water-borne epidemics in future has been the recent implementation of the Drinking Water Directive[44] on the quality of water intended for human consumption, which aims to ensure healthy drinking water. Additionally, water epidemics are monitored by a municipal investigation team in the event of an epidemic, and water epidemics are reported to the reporting system for food and waterborne epidemics.

6.7 International cooperation on adaptation

Climate resilience is one of the crosscutting objectives of Finland's development policy and development cooperation. The aim is to enhance climate change adaptation, reduce vulnerability, and strengthen the resilience of people, ecosystems and societies to climate risks and the impacts of climate change. The integration of the crosscutting objectives in all development cooperation activities is a binding obligation, either through mainstreaming or targeted action. In addition, climate change and natural resources 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 advancing the integration of these goals into partner countries' own development planning. Particular attention is paid to the roles people in vulnerable positions play 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). Internationally, Finland is a forerunner in building resilience to weather- and climate-related disasters, having financed the improvement of the weather and climate services of more than 50 national meteorological and hydrological services (NMHS) around the world in the past decade.

Recognition of the cross-border impacts of climate change is an additional justification for international cooperation to address the consequences of

44 (EU) 2020/2184

climate change wherever significant adverse impacts occur. Several different cross-border impact chains have been identified for Finland, concerning trade, infrastructure, finance and insurance, human mobility, ecosystems, geopolitics and cognitive changes (see Section 6.4. in Finland's NC7). Some of the effects are also discussed in the sectoral sections in this chapter. Recently, the global trade effects, among others, of the covid-19 pandemic and Russia's attack on Ukraine have emphasized the link between adaptation to the climate change and factors unrelated to the climate. As an example, weather-driven crop failures in the main areas of cereal production lead to more serious cross-border effects when the pandemic and the war have reduced availability of production inputs to the agriculture and industry and increased prices. There are also recent and ongoing assessment efforts related to cross-border effects, such as one funded by the Nordic Council of Ministers[45].

The Council of the Baltic Sea States (CBSS) has established an Expert Group on Sustainable Development. The group is made up of officials from relevant ministries of the CBSS Member States. Together, the Expert Group has gained more than 20 years of experience in working on sustainability policies within the Baltic Sea Region through knowledge-sharing, outreach and project work. One aim is to share responsibility and participate in finding sustainable solutions on all levels of the society. Therefore, the Experts Group continuously builds purpose-oriented partnerships, commissioning studies, conducting trainings, facilitating projects and providing policy input to strengthen sustainability practices and climate adaptation processes.

Climate change mitigation and adaptation is one of the four priorities of Finland's Strategy for Arctic Policy adopted by the Government in June 2021. According to the strategy, all activities in the Arctic must be based on the carrying capacity of the natural environment, the protection of the climate, sustainable development principles, and respect for the rights of indigenous populations. International agreements, the cooperation of the Arctic Council and the Barents Euro-Arctic Council, and EU policy programmes will support the development of solutions to halting climate change, safeguarding biodiversity, and addressing other environmental issues in the Arctic.

The Arctic Council's Working Groups produce information on the warming of the Arctic region, the state of biodiversity, and the impacts of climate change on snow, water, ice and permafrost, the acidification of the seas, ecosystems, and land and marine species. Action plans have been prepared to support adaptation, and a framework programme has been drawn up to strengthen resilience. This information has an extensive impact on decision making, both at the level of the Arctic region and globally. In 2017, the Arctic Council adopted a collective aspirational goal of reducing black carbon emissions by between 25 and 33 per

45 Report "Nordic Perspectives on Trans-boundary Climate Risk" in 2022
https://www.norden.org/en/publication/nordic-perspectives-transboundary-climate-risk

cent by 2025. The Arctic Council also works to prevent environmental pollution, forest and grass fires, and marine litter, as well as to improve waste management.

The Barents Euro-Arctic Council has drawn up an Action Plan on Climate Change, which was updated in 2021. Implementation of the Action Plan was launched during the Finnish Chairmanship of the Council between 2021 and 2023. National funding has been granted to support international collaboration and capacity building between practitioners, academics, and civil servants on Arctic adaptation for implementation of Finland's Arctic Strategy and strategies of the Arctic Council and the Barents Euro-Arctic Council. In 2020 and 2021 activities focused on connecting actors from different countries and sharing adaptation knowledge and best practises across countries.

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