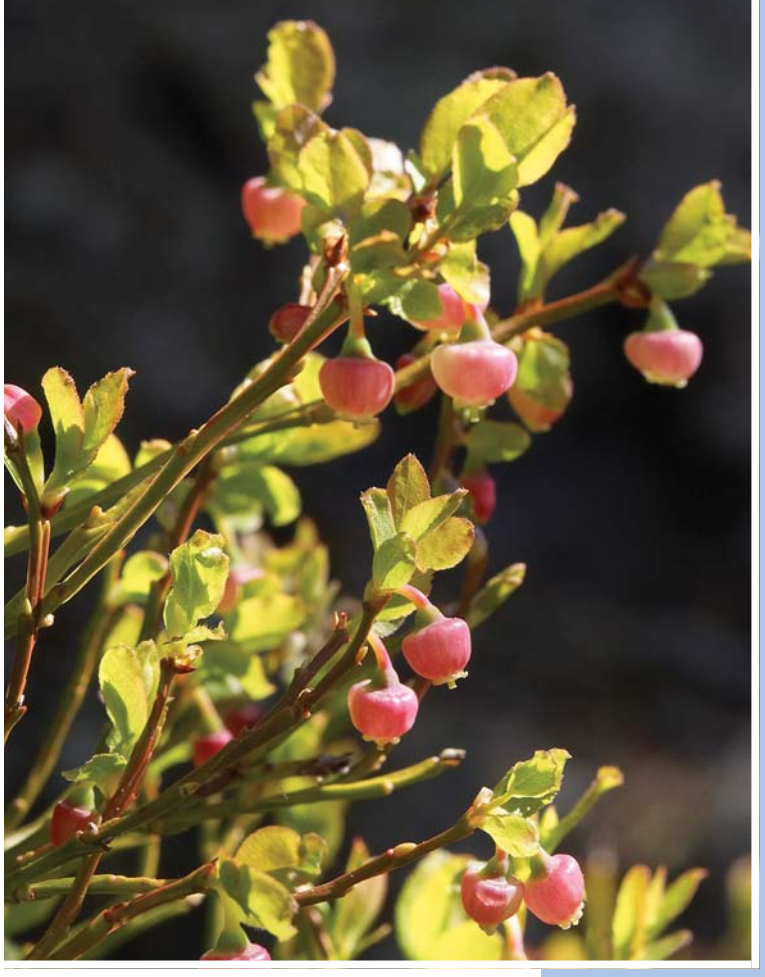


6 Climate change impacts, adaptation measures and vulnerability assessment

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

Photos

Marita Björkström/YHA kuvapankki, page 171
futureimagebank.com, pages 164, 184
iStockphoto, page 161
Jyri Juujärvi, page 163
Riku Lumiaro/YHA kuvapankki, page 191
Raili Malinen/YHA kuvapankki, page 177
Esko Kuusisto, pages 167,185
Erkki Oksanen/Metla, pages 157, 172, 175
Unto Tapio/YHA kuvapankki, page 166
Aarno Torvinen/YHA kuvapankki, pages 173, 175, 189

6 Climate change impacts, adaptation measures and vulnerability assessment

6.1 How is Finland´s climate likely to change?

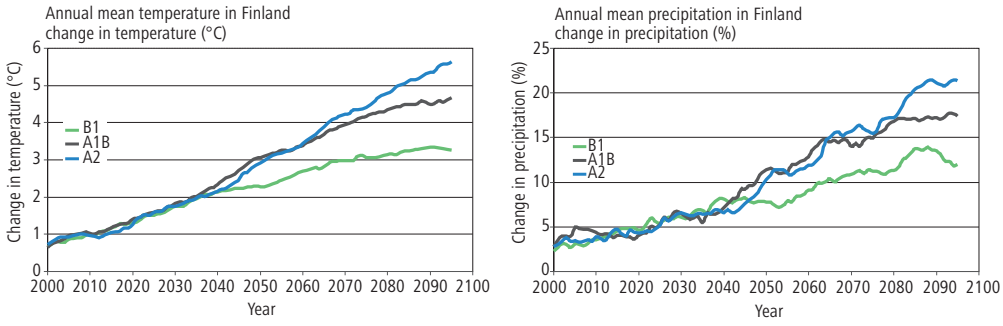
Climate scenario information for impacts and adaptation research as well as policy making has been produced as part of a climate scenario and information service project called ACCLIM, which is part of the Climate Change Adaptation Research Programme (ISTO, 2006–2010, see Chapter 8). Climate model simulations prepared for the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) together with regional climate model projections form the basis of the latest national climate scenarios. New, more comprehensive scenarios supersede earlier climate scenarios developed in the FINSKEN project 'Developing Consistent Global Change Scenarios for Finland'.

The future climate cannot be predicted accurately due to uncertainties in (i) future emissions of greenhouse gases and aerosols, (ii) natural climatic variability and (iii) imprecision of climate system models. Figure 6.1 shows the central estimates of the annual mean temperature and precipitation changes in Finland for three future emission paths, namely the high (A2), central (A1B) and low (B1) emission scenarios described in the Special Report on Emission Scenarios (SRES) of the IPCC. The range of the curves gives an uncertainty in projections due to emissions.

The temperature increase in Finland is expected to be about 1.5 times higher than the global average temperature rise (Table 6.1). The likely precipitation increase is also substantial. These increases will be larger during winter than summer. Different emission scenarios lead on average to quite similar changes in temperature and precipitation until about the 2040s. During the latter part of the 21st century climatic changes will depend strongly on the emission path. It is, however, very likely that there will be major climatic changes in northern Europe (Figure 6.2).

A new feature employed in the ACCLIM scenario development is a probability based approach to handle all sources of uncertainty. This approach demonstrates how rapidly relatively small changes in the mean val-

Figure 6.1
Projected changes in annual mean temperature and precipitation in Finland as deviations from the 1971–2000 average



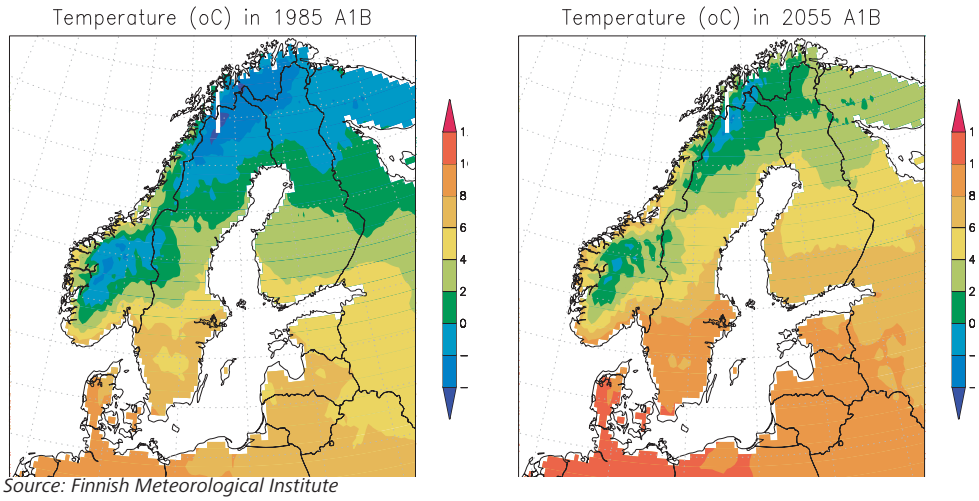
Source: Finnish Meteorological Institute

Table 6.1
Projected changes in the Finnish climate

Variable	Description
Temperature	Annual mean temperature increase of +3°C to +6°C between the periods 1971–2000 and 2070–2099. Greater increase in winter than in summer. Increase in mean minimum temperatures greater than increase in mean maximum temperatures. Decrease in number of frost days. Change in number and timing of days with temperatures around zero, depending on region and time interval considered
Precipitation	Increase of 10 to 25 per cent in annual precipitation between the periods 1971–2000 and 2070–2099. Greater increase in winter than in summer. Some models project no change in the summer. Increase in number of precipitation days in winter. Ratio of snow/rain decreases.
Ground frost	Less ground frost in snow-free areas (e.g. roads and yards). General decrease in number of ground frost days and depth of ground frost, modified regionally by snow cover changes.
Ice cover	Shorter ice period and decrease in ice strength.
Snow cover	Shorter and discontinuous snow season. Decrease in snow cover progressing from south to north.
Wind	Models give no clear indication of changes in mean windiness. Likely increase during wintertime over the Baltic Sea.
Cloud cover	Increase in cloud cover during winter.
Extreme events	Greater frequency and length of heat waves. Fewer and shorter periods of extreme cold. Greater intensity and frequency of heavy rainfall. No decrease in maximum snowfall. Longer periods of weak soil stability due to longer thaw. Risk of soil erosion.

ues can alter the probability of rare events. For example, according to statistics based solely on observations in Helsinki, the probability of exceeding the highest measured January mean temperature of +1.4°C during the coming five years due to natural variability is about 6 per cent. When the projected mean temperature changes are taken into account, the probability of setting a new record grows to 19 per cent. ACCLIM will continue

Figure 6.2
Present (1971–2000 average) and projected 2050s (central A1B emission scenario) annual mean temperature in northern Europe



Source: Finnish Meteorological Institute

developing better methods to estimate the probabilities of extreme weather and climatic events in the present and future climate.

To estimate the possible impacts in various climate scenarios, parameters are being developed with direct relevance to selected sectors. These include e.g. heating degree days in energy use, ground frost in road construction or snow cover in forestry. The new scenarios have already been used e.g. in hydrological modelling and considering agricultural potential.

6.2 Expected impacts of climate change and adaptation measures

The expected impacts described in this chapter are based on the results of various studies and research projects (see Chapter 8) or, in some cases, are based on expert opinions. They are followed by the adaptation measures which were identified in the evaluation of the national adaptation strategy (see 6.2.2).

6.2.1 General features of the impacts on Finland

Climate change has direct impact on nature, on industries dependent on natural resources, on the built environment and on human well-being. Knowledge of these impacts has increased in recent years.

The impacts of climate change create a range of different challenges for society and the economy. The FINADAPT research programme, has shown that there are still considerable uncertainties and information gaps in assessing the potential costs of the impacts and adaptation measures. Preliminary estimates of the economic impacts in this century suggest that they could be slightly positive. At the same time, climate-related risks are projected to increase. The extent to which benefits can actually be exploited and costs limited will in many cases depend on public and private policies other than climate policy, for instance agricultural, forest and urban and regional planning policies.

FINADAPT estimates that the forest and agriculture sectors could gain from climate change. Energy end-users may benefit from the reduction in demand for heating. The tourism sector might profit from warmer summers and from reliable winter snow cover in the north of the country, as this would increase the attractiveness of Finland as a tourist destination. However, these outcomes could change markedly if the negative consequences of extreme weather and climate events or volatility in world markets and trade reflected through foreign trade are included in the estimates. A sequence of negative climate change impacts within a short time span could test the resilience of several sectors of the economy or even the socio-economic system as a whole, locally or nationally. Furthermore, the global effects of climate change will be felt in Finland too (see Section 6.2.7).

In addition to direct impacts of climate change, mitigation and climate policy may have significant effect on the society and economy. Finland has challenging geographic con-

ditions and the economy relies on energy intensive industry. Both domestic and international mitigation policies will mean an increase in energy costs, and this will have major direct and indirect negative effects on the Finnish economy, including a need for structural change to a low-carbon economy. Information on the indirect impacts is still scarce, however.

For some sectors (e.g. energy production and manufacturing), climate mitigation policy is already firmly integrated with long-term public policy and business plans. Energy-intensive industry will face higher costs in the future because of emissions trading and rising energy prices. This will increase prices and reduce production and employment, and perhaps also lead to a relocation of some of the production to regions with a less ambitious climate policy.

Rising energy prices are distributed between companies in the emissions trading sector and sectors outside it (e.g. households, agriculture, transport and services). These rising prices may increase the living costs, which may, in turn, increase social inequity.

Mitigation measures and the need to save energy and improve energy efficiency require the development of new technologies. As indicated by the ClimBus research programme (see Chapter 8), this could bring many new business opportunities for Finland.

6.2.2 Adaptation measures and estimated level of adaptation by sector

The Ministry of Agriculture and Forestry published the National Strategy for Adaptation to Climate Change in 2005. The objective of the strategy is to reinforce and increase the adaptive capacity of society by minimising the negative impacts while taking advantage of any favourable impacts.

A Coordination Group for Adaptation to Climate Change has been set up to monitor and promote the implementation of the adaptation strategy. In winter 2008–2009 it steered an evaluation of the strategy implementation. The evaluation was based on a survey to establish whether and how the measures presented in the strategy have been launched in different sectors. The results were published by the Ministry of the Agriculture and Forestry in 2009 and are presented in this chapter under each specific sector.

In all sectors, decision-makers have at least some understanding of the impacts of climate change and recognise the need for adaptation measures. Practical adaptation measures have also been identified and plans have been made or even launched for their implementation. The most advanced sector is water resources management, where adaptation to climate change is already well integrated into decision-making. Good research on adaptation has been done in agriculture and forestry, but implementation of the measures is going to take some time. In fisheries, reindeer and game management, hardly any scenario-based research has been conducted, and adaptation measures are largely based on monitoring current climate conditions. Several research projects and strategy work have been started on biodiversity, but very few actual adaptation measures have been launched.

Ministry of the Environment launched in 2008 the environmental administration's action plan on climate change adaptation, defining adaptation measures concerning biodiversity, land use and construction, environmental protection and the use of water resources. The need to adapt to climate

change has been recognised and is being taken into account well in land-use and community planning, especially with regard to flood risks. In construction, planning the necessary adaptation measures calls for more research.

In the transport sector governmental agencies have conducted adaptation surveys concerning the different modes of transport. As for practical adaptation measures, the sector is already well prepared for weather-related disturbances in traffic safety and maintenance of the transport infrastructure. New adaptation measures concern long-term planning.

So far, the industrial and energy sectors have focused on climate change mitigation rather than adaptation to it. This is clearly reflected in the adaptation measures already launched, as well as in the number of measures proposed in the adaptation strategy. However, the views concerning the extent of adaptation measures in these sectors may be incorrect, because evaluation of the strategy implementation has not included measures in the private sector. The same applies to the tourism and insurance sectors. Private companies in these sectors are capable of adapting to the risks posed by the changing climate quite rapidly, even if less action were to be taken in the public sector.

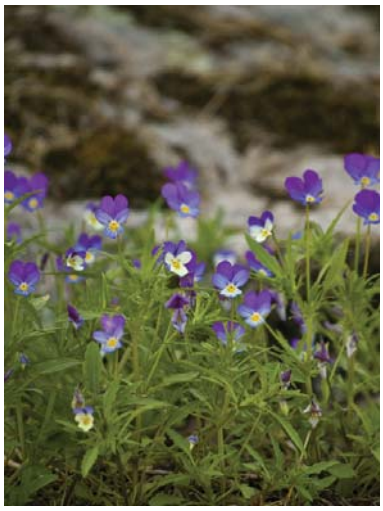
In the health and social services sectors the need for adaptation has been recognised only in certain circles and there has been little research on the health impacts of climate change. By contrast, the health impacts of air quality and, through this, the health risks associated with the mitigation measures, such as small-particle emissions caused by biofuels, are better known. During the preparation of the adaptation strategy a thorough risk assessment and institutional management review was carried out in relation to the challenges that climate change could pose to the health sector. The Ministry of Social Affairs and Health is updating its action guide on environmental health, which will prepare for extreme weather events (extreme temperatures and flooding), in particular by ensuring the functioning of health care.

In the adaptation strategy of 2005, national security was not addressed as a sector of its own. In 2006 and 2008 two Government Resolutions were adopted to prepare the national defence administration for the consequences of climate change.

6.2.3 *Impacts on nature and natural resources, and the related adaptation measures*

Biodiversity

Climate change will probably increase the total number of Finnish flora and fauna. However, some species characteristic to Finland, like relict cold water fish and other reminders of the ice age, may become extinct.



A longer growing season and milder winters may lead to the rapid proliferation of a number of southern species that thrive in a warm climate. In southern Finland, invading species could threaten the habitats of native species, and the population of invaders may expand rapidly if they lack natural enemies. On the other hand, many native species in the south could find favourable living conditions further north if the climate is warming. Northern species requiring cold conditions will suffer from the change as habitats suitable for them become rarer.

The impacts of climate change on vegetation and forest composition will occur more gradually. In the forests, the amount of decayed wood and forest litter is likely to increase, thus creating suitable habitats for a number of endangered species. Climate change will threaten the habitats of the fells area (e.g. palsa mires), especially those in which snow or ground frost is an essential factor.

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

Increasing temperatures and runoff into aquatic environments, and the resulting changes in nutrient loads, may have a profound impact on e.g. phytoplankton and zooplankton, benthic fauna, fish stocks and the number of species. The spring peak of phytoplankton in lakes will occur earlier and will be considerably more pronounced than today. The littoral zone is likely to be more sensitive to the effects of climate change than the pelagic ecosystem.

Snow and ice are essential for the Saimaa Ringed Seal

The warming climate is a serious threat to the endangered population of Saimaa Ringed Seals *(Phoca hispida saimensis)*. The only existing population of Saimaa Ringed Seal, about 260 individuals, is in Lake Saimaa, in eastern Finland.

The Saimaa Ringed Seal and its breeding are very dependent on cold winters, snow and ice cover. In February or March the female seal gives birth to its pup in a hollow lair built in snowdrift on ice. The risk of pup mortality increases if there are no snowdrifts by the shorelines or the temperature is not cold enough to prevent the collapse of the roof of the lair.

In winter 2006–2007 the pup mortality was exceptionally high, at around 30 per cent, compared with about 8 per cent in normal winters. The winter was warmer than usual. For a small population even a random variability in population size might be fatal.

Because of the threat which climate warming poses to the Saimaa Ringed Seal it is crucial to eliminate all other threats to the population. Voluntary fishing restrictions aim to prevent these seals drowning in fishing nets.

Summary of potential adaptation measures identified in the national adaptation strategy and measures already launched for protecting biodiversity in the context of climate change impacts and adaptation, and the preliminary timing of measures (*Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080).

		Anticipatory measures (A)	Measures launched
PUBLIC	Administration and planning	• Reducing human-induced stress on nature by controlling land use* (A)	• Government Decision of 13 November 2008 on the revision of the National Land Use Guidelines: preservation of ecological corridors between protection areas and, where necessary, other valuable nature areas is being promoted.
		• Evaluation, development and monitoring of the extent of the network of protected areas* (A)	• In 2007 Metsähallitus published a report on the state of the parks in Finland. The Government has approved a National Strategy and Action Plan for the Conservation and Sustainable Use of Biodiversity in Finland 2006–2016. In 2007 Finland reported to the EU on the implementation of the protection of habitats and species under the Habitats Directive in 2001–2006, especially as regards favourable conservation status (Natura 2000 network).
		• Maintaining original habitats* (A)	• Maintenance of original diverse habitats is to be furthered by an assessment of the above-mentioned conservation areas and restoration and management of areas, for which the main responsibility rests with Metsähallitus, with funding from the Ministry of the Environment. The Forest Biodiversity Programme for southern Finland (METSO) is contributing to the preservation and maintenance of valuable forest habitats (in 2008 about 1500 ha) by means of funding from the Ministry of the Environment. • Preparation of a national strategy for invasive alien species and a national strategy for mires and peatlands has been launched.
		• Changes in policy regarding the management and use of protected areas, where necessary* (A)	• Where necessary, outlines for the management and use of conservation areas are revised in the performance guidance of the Ministry of the Environment and in updating the management and use plans.
		• Taking valuable habitats into consideration in the management and use of forests* (A)	• Mainly implemented through the METSO programme. • The METE inventory of particularly important habitats in the Forest Act has been completed.
		• Conservation of valuable traditional farmland biotopes with the help of the agrienvironmental support scheme* (A)	• Management of traditional biotopes has been intensified in nature conservation areas through the work of Metsähallitus on about 3000 ha. • In 2008 management contracts for traditional biotopes under the agrienvironment scheme covered more than 22,400 ha.
		• Inclusion of an evaluation of the impacts of climate change in the ongoing planning and development projects for the promotion of biodiversity* (A)	• Report on endangered habitats published by the Finnish Environment Institute (SYKE) in 2008. • VACCIA project launched by the Finnish Environment Institute (SYKE) in 2009
		• Introduction of an information system for protected areas* (A)	• Development project on a database and information system for conservation areas steered by the Ministry of the Environment (2009–2010).
	Research and information	• Increasing cooperation, information and consultation between the different administrative sectors* (A)	
		• Information for forest owners and training for forest professionals* (A)	
		• Improving the monitoring, planning and information systems for biodiversity* (A)	• The environmental administration has prepared a survey on developing the follow-up systems relating to biodiversity.
		• Evaluation of the possibilities for ex situ protection with regard to climate change *(A)	
		• Studies of threatening factors caused by climate change at the ecosystem and species level (A)	
		• Carrying out general habitat-level follow-ups and supplementary species-level follow-ups (A)	
	Economic and technical measures	• Control and prevention of the spread of invasive alien species* (A)	• Ministry of Agriculture and Forestry has launched the preparation of a national strategy for invasive alien species, which is intended for completion in December 2010.
		• Restoration and management of valuable habitats* (A)	• A research project on the subject was completed in 2008.– In the forest sector, the METE inventory of particularly important habitats listed in the Forest Act has been completed.
		• Prevention of the extinction of species with the help of zoos and planting* (A)	
		• Reconstructing and restoring wetlands and mires* (A)	• Reconstruction and restoration of mires will be taken into account in the preparation of the national strategy for mires and peatlands.

	Anticipatory measures (A)	Measures launched
PRIVATE	• Reducing the pollution load on the environment and the atmosphere (A)	
	• Conservation of valuable traditional farmland biotopes* (A)	• In 2008 management contracts for traditional biotopes under the agrienvironment scheme covered more than 22,400 ha.
	• Taking valuable habitats into consideration in the management and use of forests* (A)	

Water sector

The most important effect of climate change on hydrological regimes is the change in seasonal distribution of runoff. Winter runoff is expected to increase considerably due to an increase in snowmelt and rainfall, while spring floods are estimated to decrease in southern Finland. In northern Finland spring floods may increase during the next few decades due to increased snowfall, but then decline as the warming increases.

Due to higher winter temperatures, there will be an increase in the frequency and intensity of winter floods from heavy rainfall and periods of thaw. Summer rainfall might decrease, though even if it were to stay at the present level, higher temperatures could cause fairly intense and prolonged drought periods. However, summer floods are also projected to be more frequent and severe due to increased extreme rainfall.

Changes in yearly runoff are estimated to be between –5 per cent and +10 per cent, depending on the catchment. Decreases are predicted for catchments with large lake surface areas, which enhance evaporation. Increases are predicted for catchments in which there is high winter runoff. This applies especially to large central lakes Saimaa, Päijänne and Näsijärvi, the levels of which may be very high in the winter.

Floods and droughts are potentially harmful to water quality. Low flows boost concentrations of bacteria, algae and toxins. High flows and intense rainfall increase erosion and leach of nutrients from catchments into watercourses and coastal waters.

Groundwater is classified as high-quality household water. If dry periods become longer in the summer in southern Finland, groundwater discharges will be reduced. That may also lead to a shortage of dissolved oxygen, high concentrations of dissolved iron, manganese and metals in the groundwater. Shortage of dissolved oxygen may generate ammonium, organic matter, methane and hydrogen sulphide gases causing bad taste and smell. In wintertime, increasing precipitation and snowmelt will produce fresh and oxygen rich groundwater.

The changing climate is not likely to introduce new types of threats for the water supply and wastewater systems. However, the present problems related to climate will become more frequent. Small water utilities and wastewater systems with combined sewers are the most vulnerable to climate-related problems.

As to the safety of dams, very intense rainfall is estimated to increase by up to 40–60 per cent, which would cause problems for dams

particularly in small rivers. Increased monthly or seasonal precipitation together with winter snowmelt are reasons for considering the safety of dams in larger rivers. However, major problems look unlikely in this respect, because most dams have quite large spillways.

Frequent winter floods and a smaller amount of snow will mean a greater storage capacity requirement in the winter and less storage capacity in the spring in southern Finland. In northern Finland storage capacity will still be needed for snowmelt floods.

Milder winters will increase non-point source loading from catchments dominated by agriculture and forestry. According to recent modelling results of the EURO-LIMPACS project, the annual export of inorganic nitrogen will increase between 10 and 70 per cent, depending on the location and land-use patterns of the catchments. Warmer, wetter conditions are also likely to result in higher concentrations of dissolved organic carbon. Changes in stratification patterns and considerably shorter duration of the ice cover period in lakes were also predicted. These have implications for water quality management.

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning the use and management of water resources, and the preliminary timing of measures (*Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080).

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Administration and planning	• Planning of water services* (A)	• Municipal and regional planning of water services a regular activity.
		• Surveying of risk sites and preparation of general plans for risk sites* (A)	• Mapping of flood risk sites in 2009–2011. Flood hazard mapping has been carried out for about 60 significant flood risk sites, and flood risk mapping has been started on a small number of sites.
		• Acquisition of temporary flood control structures* (A)	• Responsibilities relating to temporary flood control structures have been clarified and a proposal made that the matter be included in flood risk management plans and building permits.
		• Emergency preparedness planning* (A)	• Regulations on the emergency preparedness planning of water services was examined by the working group on the revision of the Water Services Act.
		• Land use planning to reduce flood risks and especially to avoid construction in flood areas* (A)	• ISTO and environment cluster projects on land use planning and flood risks. • Flood risk management has been taken into account in the revision of the national land use objectives. • See 'Land use and community planning'.
		• Taking rain-induced floods into account in zoning and urban planning* (A)	• Research projects on heavy rainfall and urban floods and warning about these, e.g. RATU and RAVAKE • The Finnish Meteorological Institute will start warning about heavy rainfall in summer 2009.
		• Flood forecasts (A)	• The Finnish Environment Institute is responsible for operative flood forecasts and for developing these forecasts in conjunction with the Finnish Meteorological Institute.
		• Planning of trenching and storm water services (A)	• A guide on storm water/urban runoff is being prepared, and there are research projects on sufficient drainage for runoff water.
		• Operational flood prevention (R) • Cooperation between authorities (R)	• Working group set up to investigate the responsibilities and tasks of authorities involved in flood risk management and flood prevention.

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Research and information	• Surveying the quality requirements for water at cattle farms and dairy farms* (A)	
		• Improvement in the predictability of floods (heavy rainfall): weather forecasts, weather radar, follow-up of soil dampness and snow/satellites and observation (A)	• Research projects relating to improving flood forecasts have been launched, e.g. OST-K, FloodFore, RATU and RAVAKE
		• Studying the impacts of rain-induced floods* (A)	• In e.g. ISTO project case studies on impacts of heavy rainfall.
		• Surveying the need for temporary flood protection structures, their acquisition and the responsibilities associated with their use* (A)	• Regional survey of temporary flood protection structures and their usability.
		• Information about flood hazards (A)	• Regional communication has been enhanced e.g. by informing about flood maps.
		• Information provision in flood and drought situations (R)	• Project of the Finnish Environment Institute (SYKE) and the, Finnish Meteorological Institute on the development of operative warning systems
		• Instructions from the authorities for reducing flood damage (R)	• Instructions on preparing for special water service situations and emergencies have been published.
		• Restrictions on water use (R)	
	Economic and technical measureS	• Raising of flood banks (A)	• Flood banks are being increased and reinforced in e.g. Pori and Lapland (Kittilä, Ivalo). To prepare for sea flooding, flood protection banks are being planned, e.g. in Helsinki.
		• Construction of reserve water intake plants* (A) • Interconnection of the networks of water supply plants* (A) • Investments in projects that improve preparation for exceptional situations and regional cooperation* (A) • Expansion of water supply and sewerage networks* (A) • Supporting the construction of irrigation systems for agriculture* (A)	• State-supported continuous investment in reserve water aquifers, joining of networks, preparing for special and emergency situations, regional cooperation and expanding of networks.
		• Compensation for damage caused by exceptional flooding of water systems (R)	• Proposal on revising the compensation system for flood damage has been prepared.
		• Use of temporary flood protection structures (R)	
		• Use of reserve systems at water supply plants, disinfection (R)	• Disinfection preparedness requirement prepared at the Ministry of Social Affairs and Health.
		• Transportation of water, water pickup points, bottling of water (R)	• Water services pool is planning the acquisition of a reserve water system.
		• Purchasing water from another water services company (R)	
		• Distribution of lower quality water (R)	• No further work on this since the long purification process following the water crisis in the town of Nokia,
	Normative framework	• Changes to regulation permits (A)	• Functioning of regulation in view of climate change adaptation studied in 2009 in respect of the Rivers Kokemäenjoki and Lapuanjoki.
		• Implementation of building regulations (R)	
		• Changes to regulation permits (R)	• Research projects on possible needs for change in regulation permits.

	Anticipatory (A) / Reactive (R) measures	Measures launched
PRIVATE	• Taking out insurance* (A)	• Proposal on revising the compensation system for flood damage has been prepared.
	• Construction of properties farther away from flood areas* (A)	• Land use objectives have been revised and the matter is taken into account in land use planning and building permit procedures.
	• Construction of irrigation systems* (A)	
	• Joining the network of a water services company / choosing the location for a well and maintaining its condition (A)	• A place for a well – guide published in 2008.
	• Protection of properties against flood (R)	• Use of temporary flood protection structures has been studied, and incentives continue to be provided for this, which is partly a regular activity of properties.
	• Saving and recycling water, use of lower quality water (R)	
	• Increasing the discharge capacity of dams (R)	• Research projects to assess the need to change the discharge capacity of dams.

The Baltic Sea and its coastal areas

Based on available regional models, a warming of the mean annual air temperature in the order of 3°C to 5°C is projected for the Baltic Sea area during this century. Most of the warming is likely to occur in the eastern and northern parts of the sea during winter months and in the southern parts of the sea during summer months. The annual precipitation would increase especially in the northern parts of the Baltic Sea basin, with more of the increase being in winter than in summer. The changes in precipitation will affect the runoff into the Baltic Sea, with potential increases in mean annual river flow from the northernmost catchments and decreases in the southernmost catchments.

There has also been a general tendency toward milder ice conditions in the Baltic Sea. The largest change has been in the length of the ice season, which has decreased by 14–44 days over the past century, mainly due to earlier ice break-up. The mean sea surface temperature of the Baltic Sea is projected to increase. As a result, the projected decrease in the ice cover by the end of the century is dramatic. The Bothnian Sea, large areas of the Gulf of Finland and the Gulf of Riga, and the outer parts of the southwestern archipelago of Finland will become, on average, ice free.

Although the mean sea level of the oceans is rising, this effect is partially balanced by the land uplift in the Baltic Sea. The calculated rate of sea level rise is estimated to be about 1.7 mm per year in the southeastern Baltic Sea, which reverses to –9.4 mm in the northwestern Gulf of Bothnia. By the year 2100, many parts of the Baltic Sea currently experiencing a relative fall in sea level would instead have a rising relative sea level.

Regional wind changes in the Baltic Sea may have an additional impact on sea level surge heights. In several regional scenario simulations, extreme sea levels are projected to increase significantly more than the mean sea level. The combination of high sea levels induced by storm surges, ice-free seas, and unfrozen sediments would enhance erosion and the transport of sediments.

Pristine peatlands

Changes in temperature, precipitation and evapotranspiration may have a considerable impact on the hydrology of wetlands and, consequently, the load of organic and inorganic matter from catchments. Furthermore, the continued increase in atmospheric CO_2 and N_2O might affect the quantity and quality of surface vegetation in peatlands.

Climatic warming will probably cause mire vegetation zones to move further north, i.e. raised mire vegetation will take over parts of the current low 'aapa' mires. It is estimated that peatlands may become drier than at present, especially in the summertime. Drier conditions will lead to barrenness of some peatlands and overgrowth of Sphagnum peat. It has been suggested that the drying of peatland surfaces may lead to carbon losses in the short term, but changing vegetation patterns may increase the long-term carbon sequestration, especially in northern Finland. Decreased water levels will also increase tree growth and, accordingly, lead to higher level of carbon storage in biomass.

In northernmost Lapland the Palsa mires (frozen mound bogs) are in danger of thawing with the warming climate, which would mean changed hydrological conditions and vegetation communities. Consequently, methane production would increase, but the higher carbon sequestration rates in the long term may compensate for the climatic impact.

Agriculture

Agricultural production in Finland is primarily limited by temperature. Other factors restricting production include solar radiation, precipitation and soil properties. The thermal growing season is estimated to lengthen by three to four weeks by 2050. However, the effective growing season will be prolonged by only about two weeks, mainly at the beginning of the season, because the low solar radiation and increasing rainfall prevent taking advantage of warming autumns.

Crop productivity will increase and the current main field crops could be cultivated further north. In the next few decades autumn-sown crops will become more common. However, the predicted increase in the variability of growing conditions is likely to increase production risks. In the early growing season, the risk of night frosts will remain and problems with drought will become more severe, increasing the need for irrigation.

Extreme weather events may become more frequent and bring heat waves and more heavy rainfall during the growing season, i.e. precipitation may be distributed more unevenly. As the temperature and precipitation in the autumn and winter increase, the decomposition of organic material will accelerate. The risk of erosion and leaching of nutrients will increase. The overwintering of plants may be hampered in southern Finland if the snow cover decreases. Also, the compaction of clay soil may increase and cultivation may become more difficult if the ground frost period shortens. The alternation between melting and freezing caused by mild winters may cause plants to suffer from anoxia beneath a forming ice cover.

Noxious insects will benefit from a warmer climate and longer growing season. The risk of plant disease epidemics may increase and disease outbreaks may occur earlier. Climate change will improve the living conditions of vectors, such as plant lice, that spread viral diseases.

Farm animals will have a shorter indoor feeding and longer grazing season. Increased grazing may, however, enhance the leaching of nutrients to water. The risk of animal diseases may increase, although the risk is expected to be very low. The possible spreading of the vector-borne disease bluetongue is being followed closely and a contingency plan has been made. Diseases associated with the quality of water and feed may become more common. If the temperatures in sheds housing cattle and poultry rise very high, this would lead to a reduction in the milk yield of dairy cattle and in the growth of beef cattle and poultry.

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning agriculture, and the preliminary timing of measures (*Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080).

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Administration and planning	• Attention to production methods adaptable to climate change, production structure and locations in support policy*** (A)	• In the context of the mid-term review of the EU's common agricultural policy (CAP) a decision to increase measures under Rural Development Regulation, incl. measures concerning climate change adaptation.
		• Development of animal disease monitoring systems** (A)	• Finland has prepared a contingency plan for bluetongue disease, a catarrhal fever in ruminants spread by midges.
		• Development of plant disease and pest monitoring systems* (A)	
	Research and information	• Development of new technologies and cultivation methods and providing information on them** (A)	• Research project on impacts of climate warming on the health of reindeer.
		• Conceptualisation of climate change and its risks* (A)	• One of the ISTO research projects investigates the risks of a changing climate.
	Economic and technical measures	• Integration of changed climatic conditions and plant protection requirements into plant improvement programmes* (A)	• A joint Nordic plant breeding project has been launched.
		• Minimising the disadvantages of the potentially increasing use of pesticides** (R)	• National action programme required under the framework directive on sustainable use of pesticides is being prepared.
	Normative framework	• Assessment of the revisions to water protection guidelines** (A)	

	Anticipatory (A) / Reactive (R) measures	Measures launched
PRIVATE	• Introduction of new cultivation methods, cultivated crops and technology** (A)	• Raisio plc and Boreal Plant Breeding Ltd are contributors to the funding of the ILMASOPU research project. • Action on farmers' own initiative.
	• Extending the farm animal grazing period*** (R)	• For the animal welfare payments, 550 farms have selected grazing during the growing period as the additional measure.
	• Increasing the control of pests and diseases** (R)	• The ILMASOPU research project has noted an increase in prevention.

Fisheries and game

The warming climate may have a significant impact on the state of waters, fish stocks, fishing and fish farming. Changes in precipitation and temperature will probably affect the numbers, distribution and mutual relationships of fish populations both directly and through other changes in the ecosystem. Cold water species may decline particularly in small and shallow waters in southern Finland, while warm water species will benefit and spread further north. Changes in the salt concentration of the Baltic Sea could also have a great impact on its fish populations.

In most cases, young fish will benefit from the warming of waters, with longer growing periods in the spring and autumn. This may increase the abundance of plentiful age groups, also increasing the amount of prey available for predatory fish. It is estimated that climate change will increase leaching of nutrients into waters. This will increase eutrophication, which has already affected fish stocks in coastal waters. Generally, eutrophication increases the total fish biomass, but decreases species richness; cyprinid species thrive, but species requiring clear and well-oxygenated waters become scarce.

In the winter a shorter ice period and thinner ice will favour the most important mode of professional catching, trawling. On the other hand, it will hamper the wintertime seine catching of vendace as well as coastal net fishing. In summer, longer and more intense heat waves may increase fish diseases and parasites and make cultivation of fish more difficult. The most important cultivated fish is the rainbow trout, for which warming could be more a disadvantage than an advantage. If the climate warms significantly, there might be a need to farm a different fish species.

Moose, the most important game species in Finland, may first benefit from a warmer climate due to an increase in food resources. On the other hand, the heat physiology of the moose is not adapted to a temperate climate. Reduction in snow cover in southern and central Finland will contribute to the northward spread of roe deer and white-tailed deer.

The warming climate will increase the diversity of small game prey and predatory species and should stabilise the present strong population fluctuations. The abundance of medium-sized predators will increase. A decrease in snow cover and an increase in the frequency of freezing of snow may also be harmful for game birds which use snow for shelter.

Fisheries
Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning fisheries, and the preliminary timing of measures (*Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080).

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Administration and planning	• Improvement of monitoring in order to assess the state of fish stocks, and development of cooperation between different parties* (A)	• Climate change taken into account in the overhaul of the Fishing Act. Test fishing register established for monitoring the management of waters facilitates follow-up of fish stocks.
		• Prevention of water pollution, fishing pressure and the deterioration of fish habitats* (A)	• Carried out as part of the regular planning of measures.
	Research and information	• Assessment of the ability of different species and age groups to adapt to the impacts of climate change* (A)	• ISTO research project launched in 2009.
		• Investigation of interdependencies between species and ecosystems* (A)	
		• Monitoring the development of the sector* (A)	
	Normative framework	• Consideration of the locations of new fish farming facilities with regard to climate change* (A)	

	Anticipatory (A) / Reactive (R) measures	Measures launched
Private	• Regulation of waters and diversion at power plants* (A)	• Support for the construction of passes for fish.
	• Increasing buffer zones around small waters* (A)	
	• Coordination of the temperature cycles important to the life cycle of fish at fish farming facilities to match natural cycles* (A)	
	• Investments in aeration and oxygenation equipment at fish farming facilities* (A)	
	• Change in fishing practices (for example, partial replacement of ice-fishing with open water fishing)*** (R)	• Changes in fishing practices taken into account in the overhaul of the Fishing Act and in the activities of the organisations involved.
	• Increased purification of discharge water from fish farming facilities in order to reduce feed and excrement* (R)	

Game management

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning game management, and the preliminary timing of measures (*Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080).

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Administration and planning	• Preparation of management plans for game stocks* (A)	• Management plans prepared for wolf, lynx, bear, wild forest reindeer, seal and partridge populations; preparation of management plans for wolverine and grouse populations under way. • National moose programme and wetland strategy are being prepared.
		• Guidelines for forest management and care should recommend that the living conditions of grouse be taken into account* (A)	
	Research and information	• Development of game management methods, i.e. measures directed at the habitats of game* (A)	• Several studies and projects of the Finnish Game and Fisheries Research Institute (FGFRI), the Finnish Forest Research Institute (Metla) and game management districts.
		• Continuing development of the game richness index, triangular game surveys and other methods of stock assessment* (A)	• The Finnish Game and Fisheries Research Institute (FGFRI) monitors and develops the game richness index and assesses the abundance of game.
		• Information about hunting and protection decisions* (A)	• Information on hunting and protection decisions is communicated in the relevant media. Organisations in the game sector also disseminate information on decisions.
		• Study on the response and adaptation of game species to climate change* (A)	
	Economic and technical measures	• Development of game management methods, as well as methods and equipment intended to prevent damage and support for their use.* (A)	• The Hunters' Central Organization acquires equipment to prevent damage with the aids of funding from the Ministry of Agriculture and Forestry and tries to find the best methods and equipment together with the manufacturers. Game management districts distribute equipment to potential damage sites.
		• Prevention of forest damage, agricultural damage and road accidents using suitable means (such as fences, mineral stones, repellents)* (A)	• Management plan for grouse populations is being prepared, communication to land and forest owners and hunters on taking grouse habitats and nests into account in the treatment of forests; 'Capercaillie Parliament of Central Finland'; Metsähallitus monitors game populations and manages game habitats constantly to ensure sustainable hunting. Note: connected to the previous measure.
	Normative framework	• Legislative regulation of game stocks (hunting and protection decisions)*** (A)	• Ministry of Agriculture and Forestry issues annual regulations on allowable game bags in order to steer the hunting of large carnivores. Game management districts may protect e.g. grouse in certain areas by their own decisions.

	Anticipatory (A) / Reactive (R) measures	Measures launched
PRIVATE	• Construction of game fences, use of repellents, restriction of stock by hunting or expansion of stock by restricting hunting* (A)	• See above. • Hunting is coordinated by the Ministry of Agriculture and Forestry, game management districts and Metsähallitus. Game management associations function as local experts and assess the damage. • Moose population has been reduced by hunting to prevent damage to forests, agriculture and traffic, and the population is now at the level of the mid-1990s.
	• The living conditions of game should be favoured in forest management* (A)	• Forest management guidelines, etc.
	• The growth of small predator populations should be controlled by hunting* (A)	• Continuous action by hunters. Intensified hunting in e.g. the archipelago with good results.
	• Regulation of hunting in accordance with game stocks (hunting clubs, hunters)* (R)	• Quotas of hunting clubs or associations, protection decisions and restrictions relating to the sex or age of game animals.

Forestry

Climate change will have an influence on the distribution and growth of boreal forests in Finland, where forests are one of the key sources of income. The natural regeneration of trees is mainly limited by low summer temperatures. Increases in temperature, carbon dioxide concentration and precipitation together with a longer growing season are likely to increase tree growth especially in northern Finland. According to some scenarios, the annual growth of forests (in cubic metres) is estimated to increase by one-third by the year 2100.

The timberline is expected to move slowly further north, with the two most important coniferous trees in economic terms, the Scots Pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*), in the front line. Although deciduous trees would naturally gain ground in a warmer climate in southern Finland, the composition of tree species is mostly affected by forest management.

Climate change is a risk for forest health, productivity and biodiversity. Some typical boreal forest species and habitat types may decline or disappear. The forest health risks can be reduced, to some extent, by forest management. Risk of forest fires may increase in southern Finland if drought and heat waves become more common in summer. Periods of drought may also decrease tree growth. In autumn and winter, strong winds will increase wind damage to trees, especially if the period of ground frost shortens, as this will weaken the anchoring of trees to the ground. After such damage forests will be more vulnerable to pests. The shorter ground frost period and increased precipitation will also cause problems in forest management and harvesting.

The risk of snow damage to trees could decrease in southern and central Finland, because a smaller share of the wintertime precipitation is predicted to fall as snow. In northern Finland, however, an overall increase in precipitation and possibly wetter snow may increase snow damage.

Insect pests will benefit from increased temperatures and the longer growing season. This may increase the number of insect generations each year. One such species is the spruce bark beetle, the worst pest affecting spruce. An increase in minimum temperatures in the winter could facilitate the spread of pest species in Finland from south to north and from central Europe to southern Finland (e.g. the Gypsy and Nun moth).

The risk of fungal diseases may also increase in a warmer climate. For example, the economically most significant fungal disease, root rot caused by Heterobasidion spp., may spread further north, but will also cause more damage within its current range.

The changing climate will affect also forest berries. Cowberry (*Vaccinium vitis-idaea*), bilberry (*Vaccinium myrtillus*), and cloudberry (*Rubus chamaemorus*) are economically the most significant berry species. The flower buds of bilberries can be damaged by severe frost in the absence of insulating snow cover in the winter. As the growing season will start earlier, the berries will also ripen earlier. On the other hand, berries will be vulnerable to cold weather spells during flowering in the early summer.

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning forestry, and the preliminary timing of measures (*Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080).

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Administration and planning	• Inclusion of climate change aspects in the National Forest Programme* (A)	• Finland's National Forest Programme 2015, which was approved in 2008, contains measures related to adaptation.
		• Revision of forest management recommendations to incorporate climate change** (A)	• Forest management recommendations were revised in 2006.The specific recommendations for the management and use of peatland forests were published in 2007.
		• Protection of gene pools of forest trees* (A)	• Network of gene reserve forests set up in Finland: 42 forests, a total of about 7 000 ha. European gene reserve forest network is being created under the EUFOR-GEN programme.
	Research and information	• Development of forest management to adapt to climate change and to mitigate it* (A)	• Six ISTO research projects and the MIL research programme produce basic data on forest management methods that contribute to climate change adaptation and mitigation.
		• Development of a system for anticipating and monitoring damage* (A)	• Anticipation of damage investigated in two ISTO research projects. • National Storm Damage Contingency Plan (2007) extended in 2009 to cover other sudden forest damage. Forestry Centres drew up regional storm damage contingency plans in 2007 and they organise e.g. storm damage preparedness exercises with rescue authorities. • Further development of the follow-up system for damage as a joint project of the Finnish Forest Research Institute (Metla) and Forestry Development Centre Tapio.
	Economic and technical measures	• Development of harvesting* (A)	• Several ongoing surveys and development projects concerning harvesting equipment.
		• Tree improvement* (A)	• Forest tree breeding programme 2050 takes account of climate change. • Adaptation, especially of pine, to climate change investigated in an ISTO research project.
		• Control of pests and diseases*** (A)	• Preventing pests and diseases is taken into account in the budget, and the Finnish Forest Research Institute (Metla) is monitoring the pest and disease situation. Crisis contingency plan for pine wood nematode is being updated.
		• Maintenance of forest roads* (A)	• Exceptional weather conditions and periods of frost and other damage to roads taken into account in road maintenance. The objective set in National Forest Programme 2015 is to halve the length of roads with restrictions due to frost damage over the period 2006–2015.
		• Rapid harvesting of wind damaged trees in order to prevent consequential damage** (R)	• Harvesting of wind damaged trees takes place in accordance with the national and regional (Forestry Centres) forest damage contingency plans. A Contingency Manager appointed in all Forestry Centres.
		• Selection of the origin of artificial regeneration material** (R)	• Climate change taken into account in selecting the origin of forest reproductive material. Further information produced in e.g. the Forest Tree Breeding 2050 programme and ISTO research projects.
	Normative framework	• Assessment of the need for change in forest legislation in changing climatic conditions**/*** (A)	• Revision of Forest Act initiated in 2008. In this context it will be assessed whether adaptation and e.g. preparing for forest damage calls for changes in the legislation. • Crisis contingency plan for pine wood nematode is being updated.
		• Potential bans on wood imports from areas most badly contaminated by pests*** (A)	• Import restrictions have been imposed on coniferous plants and timber to prevent the spread of pine wood nematode.

	Anticipatory (A) / Reactive (R) measures	Measures launched
PRIVATE	• Preparation of forest plans on the basis of new management recommendations**/*** (A)	• No systematic approach to adaptation in forest planning and proposals for management measures of private forests.
	• Rapid harvesting of wind damaged trees in order to prevent consequential damage** (R)	• Harvesting of wind damaged trees coordinated in accordance with the national and regional (Forestry Centres) storm damage contingency plans (see public measures above). On private lands the forest owner decides who removes storm-damaged trees.

6.2.4 *Impacts on industries, infrastructure and human well-being, and the related adaptation measures*

Energy

Climate change affects the demand for electricity and heating. Demand for heating can be expected to decrease and demand for cooling to increase. The production of combined heat and power (CHP) may be reduced because of decreased demand for district heating. Warming will also affect the temperature of cooling water, reducing the efficiency of condensing power plants. The reliability of energy distribution and transmission will probably weaken, because the frequency of extreme weather conditions is likely to increase.

Hydropower resources and wind energy potential are likely to increase. Hydroelectric power generation is estimated to increase by 0–10 per cent up to the 2030s, mainly due to large winter discharges. Part of the increase will be caused by decreased spill-off in spring, with smaller floods. Some estimates suggest that solar energy may be reduced as a consequence of increased cloudiness. Biomass supply is expected to grow due to a longer growing season and improved potential productivity, hence increasing the amount of available bio energy. Climate change will have only minor direct impacts on the exploitation of fossil fuel and nuclear energy resources.

The potential for peat production is estimated to increase, mainly due to a longer harvesting period. However, higher summer rainfall would significantly reduce peat production, because this is very sensitive to weather conditions. Estimates concerning increased precipitation in the summer and the duration of dry periods are uncertain, however. Therefore, the overall impacts on peat production cannot be clearly deduced.

Climate change will have a great effect on the electricity network business. Increases in snow loads, floods and storms may affect the functioning of the energy supply network, due to falling trees, for example.

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning the energy sector.

		Anticipatory (A) measures	Measures launched
PUBLIC	Administration and planning	• Inclusion of adaptation to climate change in the long term planning and strategies of the energy sector. Progress will be gradual as necessary information is being accumulated. (A)	
	Research and information	• Research and development on adaptation will be expanded in order to continue and supplement the research on climate change mitigation (A)	• Studies on the functioning of low-energy building and on the impacts of improving the energy efficiency of structures on the functioning of the moisture technology of structures were published in 2008.
	Economic and technical measures	• More detailed examination of the need, quality, design and possible realisation times for concrete adaptation measures (A)	
		• Using suitable means of preparation for an increased need for repairs in some sectors (A)	
	Normative framework	• Surveying the potential need to change standards, etc. as necessary (A)	

	Anticipatory (A) measures	Measures launched
PRIVATE	• Adaptation surveys specific to each branch of energy (A)	
	• Systematically introducing adaptation to climate change as part of long-term planning and strategies in branch organisations and large enterprises of different energy branches (A)	

Land use planning and construction

The expected changes in precipitation and snow loads, wind velocity and temperature are a challenge for the construction sector. These stress factors are already having an impact on construction, because buildings have a long life cycle. It is expected that the number of freeze-thaw cycles on the exterior surfaces of buildings will increase considerably.

The most important impacts of climate change on land use are changes in flood risks, extreme weather events and groundwater conditions. The impacts will vary regionally. Changes in flood risks will mainly be caused by melting snow, heavy rainfall, the rise in sea level and changes in storm winds. This will create challenges for land-use planning, especially in the vicinity of rivers and lakes, in coastal areas and other areas vulnerable to floods.

Increased heavy rainfall will be a challenge for storm water management, especially in areas where most of the ground surface is covered with impermeable materials.

Dry summers and lower levels of groundwater may reduce the carrying capacity of soil and cause more settlement.

Ground frost conditions will also change, making it more difficult to build ice roads.

Land use and communities

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning land use and community planning.

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Administration and planning	• Evaluation of the impact of climate change will be included in the long term planning of regional and urban structures (A) • Town planning processes will be associated with a requirement to carry out additional investigations on adaptation to climate change in particularly vulnerable areas (flood risk areas, attention to the microclimate, terrain and soil, conduction of rainwater and surface waters, construction in shore areas, potential increase in windiness, protective city block areas, avoidance of hollows) (A)	• Government Decision of 13 November 2008 on the revision of the National Land Use Guidelines. (Objectives laid down in the Land Use and Building Act must be taken into account and their implementation must be promoted in regional land use plans, local plans and activities of State authorities.) • Life+ project CCCRP ''Climate Change Community Response Portal'' (Finnish Meteorological Institute) has been launched.
	Research and information	• Flood-sensitive areas and structures will be surveyed (A) • Anticipatory systems and warning systems for extreme events will be developed (A) • Regional and local impacts and means of adaptation will be investigated (A)	• The Finnish Environment Institute (SYKE), Regional Environment Centres and Ministry of Agriculture and Forestry map/survey risk areas. • R&D projects (2009, 2010): flood risks in land use, geographic information analyses of flood risk areas. • Proposal on flood risk management (Ministry of Agriculture and Forestry) • Guide to preliminary assessment of flood risks, draft of 24 September 2008. • Steering of land-use planning, training and communication, incl. regional examples. • Life+ project SNOWCARBO "Monitoring and assessment of carbon balance related phenomena in Finland and northern Eurasia", Finnish Environment Institute(SYKE).
	Economic-technical measures	• The conduction of rain and surface waters will be improved (R)	• Proposal to include management of storm water/urban runoff in amendments to the Water Services Act (Ministry of Agriculture and Forestry). • Guide on storm water/urban runoff is being prepared (Association of Water and Sewage Plants (VVY), Association of Finnish Local and Regional Authorities, Ministry of Agriculture and Forestry, Ministry of the Environment).
	Normative framework	• The need to amend the Land Use and Building Act and Decree and municipal building codes will be investigated (A)	• Needs for change surveyed during 2009, draft Government proposal in December 2009.
		• Recommendations will be issued at different levels of planning as necessary (A)	• Commitment to adaptation in land use under Government Decision on the revision of the National Land Use Guidelines. Steering of land use planning, training and communication.

	Anticipatory (A) / Reactive (R) measures	Measures launched
PRIVATE	• The conduction of rain and surface waters will be improved (R)	

Buildings and construction
Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning buildings and construction.

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Administration and planning	• Climate change will be included in long-term planning and research activities in the construction sector (A)	• Government Decision of 13 November 2008 on the revision of the National Land Use
	Research and information	• Surveying the local impacts and spheres of influence of climate change (A) • Surveying flood-sensitive areas (A) • Anticipatory systems and warning systems for extreme events will be developed (A) • The need to rebuild rainwater drains in built-up areas and the scope for impregnating soil with water or directing it to basins will be studied (A) • The impacts of a potential increase in wind velocity will be taken into consideration with regard to the existing building stock and new construction (A) • Revision of existing structures (A)	• EXTREMES project (Natural hazards to infrastructure in a changing climate II). • Life+ 2007 project ''Climate Change Response through Managing Urban Europe-27 Platform'' (Union of Baltic Cities) launched on 1 January 2009. • The Ministry of Agriculture and Forestry, the Finnish Environment Institute (SYKE) and Regional Environment Centres map/survey flood risk areas. • RATU project (Heavy rains and urban flooding); publication Finnish Environment 31/2008 • Wind load study • Pre-study on the physical behaviour of buildings and the durability of building envelopes.
	Economic-technical measures	• Guidelines will be prepared for the treatment of storm water and the design of drainage systems (A)	• Proposal to include management of storm water/urban runoff in amendments to the Water Services Act (Ministry of Agriculture and Forestry). • Guide on storm water/urban runoff is being prepared (Association of Water and Sewage Plants (VVY), Association of Finnish Local and Regional Authorities, Ministry of Agriculture and Forestry, Ministry of the Environment).
		• Repair of storm damage to buildings will be further developed (R)	
		• Different repair measures (R)	
	Normative framework	• Potential revision of design standards, instructions and regulations based on research information (A)	
		• Potential issue of recommendations in accordance with local stress conditions (A)	

	Anticipatory (A) / Reactive (R) measures	Measures launched
PRIVATE	• Different repair measures (R)	

Manufacturing

The indirect impact of climate change through mitigation measures and greenhouse gas reduction targets will be much more important to industry than direct impacts.

Direct impacts have two main pathways. Firstly, in some sectors available raw materials may change. This can have implications for processing methods, for product assortments and perhaps even for the factory location. For example, changes in growing conditions may affect the chemical and structural properties of wood for the forest industry. In addition to the possible increase in annual growth, rising temperatures may increase the overall wood density, due to thicker fibre cell walls, and may also increase fibre length. Further, enhanced growth may improve branch growth, increasing knots in the wood and causing reduction in the quality and mechanical strength of sawn wood. The food processing industry may also face changes if regional shifts take place in crop production or if milk production moves further northwards. Secondly, the transport of industrial raw materials and products may become more vulnerable to adverse weather conditions. In the forest industry, this may also include seasonal shifts in the supply of roundwood if the duration of difficult road conditions in the spring increases. Severe storms may also induce peaks in the supply of roundwood.

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning manufacturing industry.

		Anticipatory (A) measures	Measures launched
PUBLIC	Administration and planning	• Inclusion of adaptation to climate change in the long term surveys of different industrial sectors. Progress will be gradual as the applicable information is accumulated. (A)	
	Research and information	• Sector-specific surveys of the information and research needs of adaptation and their focusing (A) • More detailed investigation of the economic impacts of adaptation specific to sector (A)	
	Economic and technical measures	• Sector-specific, detailed examination of the need, quality, design and possible realisation times for concrete adaptation measures (A)· • Systematic survey of industries located in flood-sensitive areas and consideration of the required adaptation methods as necessary (A)	• See table on Land-use and community planning.·
	Normative framework	• Surveying the potential need to change standards, etc. as necessary (A)	

	Anticipatory (A) measures	Measures launched
PRIVATE	• Sector-specific surveys of adaptation needs (A)	
	• Systematically introducing adaptation to climate change as a part of long-term planning and strategies in the branch organisations and large enterprises of different sectors (A)	

Transport and communications

Climate change is likely to affect the transport infrastructure and all modes of transport. Floods and heavy rainfall will increase erosion and risk of landslides along roads and railways. Temporary flooding of underpasses will become more frequent. The net change in maintenance costs of roads and highways over the entire cold season will probably be small.

Sea transport may benefit from climate change. The ice season is expected to shorten considerably in the Baltic. On the other hand, the heaviest storms often occur in winter months, and if the sea is open, waves may be very high. If there is ice, storms can create thick ice belts and high ridges on shipping routes and at harbour mouths.

Air traffic will suffer from heavy storms and lightning. Maintenance costs of airports and the use of de-icing chemicals may increase in mid-winter.

In telecommunications, the networks relying on cables may be vulnerable to storms and icy rain. The same applies to the automatic safety systems of different modes of transport. Ice and wind loads on telecommunications masts may also become heavier.

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning transport and communications, and the preliminary timing of measures (*Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080).

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Administration and planning	• Inclusion of climate change in the transport sector's long-term planning* (A)	• Survey on climate change adaptation conducted by the Finnish Road Administration in 2007, by the Rail Administration in 2008 and by the Finnish Maritime Administration in spring 2009. • Life+ project JULIA "Mitigation of and Adaptation to Climate Change in the Helsinki Metropolitan Area – From Strategy to Implementation" (Helsinki Metropolitan Area Council (YTV)) has been launched.
		• Securing the functionality of telecommunications networks (wired networks)** (A)	• The Finnish Rail Administration studies the improvement of redundancy in communication networks to remove accuracy problems, which has indirect impacts on ensuring the functioning of wire networks.
	Research and information	• Surveying of flood sensitive areas* (A)	• The Finnish Rail Administration has inventoried sensitive areas as regards flood risks in southern Finland in connection with preparedness exercises and preparedness plans. • The Ministry of Agriculture and Forestry, the Finnish Environment Institute (SYKE) and Regional Environment Centres map/survey flood risk areas.
		• Anticipatory systems and warning systems for extreme events** (A)	• The Finnish Meteorological Institute maintains and develops several observation and warning systems relating to weather and wind information.
		• Assessment of the ice situation in the Baltic Sea* (A)	• The Finnish Maritime Administration has participated in research on trends in the ice conditions of the Baltic Sea.

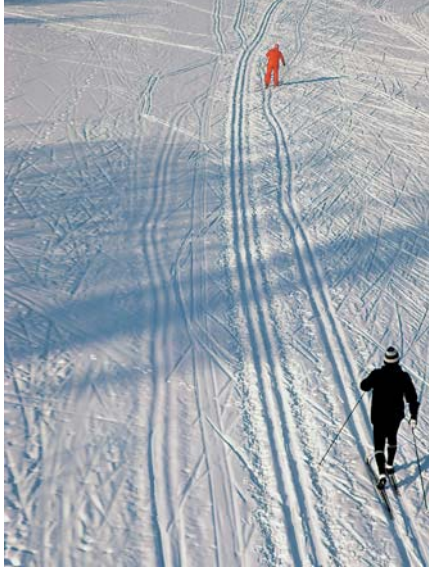
		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Economic and technical measures	• Maintenance of the structures (road, ditches, bridges and culverts) and condition of road network, particularly on smaller roads and gravel roads as floods and rainfall increase and ground frost diminishes** (A)	• Anticipatory action: as far as possible the matter is taken into account in new investments. • Reactive action: structures are maintained and managed within the budget appropriations for basic road maintenance.
		• Maintenance of the structures (track beds) and condition of railways while floods and rainfall increase and ground frost diminishes** (A)	• Anticipatory action: as far as possible the matter is taken into account in new investments. • Reactive action: structures are maintained and managed within the budget appropriations for basic railway maintenance.
		• Minimising the environmental hazards caused by antiskid treatments (alternatives to salt, planning of groundwater protection)** (A)	• The Finnish Road Administration has tested potassium formiate in deicing of roads in winter in Suomenniemi; implementation of the theme programme on groundwater protection is proceeding at a pace of about 3 km a year.
		• Taking more difficult traffic conditions into account in planning and schedules (R)	• Report of the Finnish Maritime Administration on Climate Change and Adaptation, publication 3/2009
		• Repair of storm damage to overhead cables (R)	• Removal of problem trees included in the present management contracts. The Finnish Rail Administration is responsible for the repair of damage.
		• Increase of winter traffic in the Baltic Sea (R)	• The Finnish Maritime Administration has prepared a forecast for maritime transport in 2030.
		• Antiskid treatment of roads and airports (R)	• The winter management guidelines of the Finnish Road Administration will be introduced on 1 October 2009 for main roads throughout the country, and for new work started on other roads.
		• Repair of storm damage to the road and rail networks (R)	• Within the budget framework.
	Normative framework	• New planning norms and guidelines for road and railway construction**/*** (A)	
		• Guidelines and definition of tolerances for the duration and disturbances (R)	• The Finnish Rail Administration has updated the disruption and response times in its new maintenance contracts.

	Anticipatory (A) / Reactive (R) measures	Measures launched
PRIVATE	• Maintenance of the structure and condition of the private road network as floods and rainfall increase and ground frost diminishes** (A)	
	• Taking more difficult traffic conditions into account in planning the schedules and timing (R)	
	• Salting and antiskid treatment of roads (R)	

Tourism and recreation

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

Snow-based activities such as cross-country skiing, alpine skiing, riding snowmobiles and ice-fishing are vulnerable to climate change. Increased uncertainty of snow conditions has already been a problem for winter tour-



ism and recreation, particularly in southern Finland. However, ski resorts in the north may benefit in the future from their relatively good snow conditions compared to other resorts in Europe or southern Finland.

The short summers are a major obstacle to the further development of summer tourism and recreation. A warmer and longer summer season would thus improve the conditions for summer sports and many water-based recreation activities (e.g. boating, swimming and fishing). On the other hand, algal blooms in warmer waters, increased summer precipitation or extreme weather events may lower the attraction in summer time. Changes to the flora and fauna could also have an impact if a particular species is an important attraction in the area (e.g. the Saimaa ringed seal is an important part of the positive image of the lakes region).

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning tourism and the recreational use of nature, and the preliminary timing of measures (*Immediate: 2005–2010, **short- term: 2010–2030, ***long-term: 2030–2080).

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Administration and planning	• Integration of adaptation to climate change with tourism strategies* (A)	• Improving snowmobile routes in the national inventory of snowmobile routes in 2009.
		• Taking into account the increase in hiking outside the cold season in the planning and use of recreation areas*** (A)	• The revision of the Off-road Traffic Act in 2009 takes into account the development of off-road traffic during the period with no ground frost.
		• Development of other attractions besides those related to snow for winter tourism to reduce the dependence on snow* (A)	• Classification of hiking routes under way.
	Research and information	• Increased research both on the impacts of and adaptation to climate change* (A)	• Adaptation of tourism and outdoor and other recreation services has been studied e.g. under the FINADAPT research project.
		• Communicating research results to private actors* (A)	
	Economic and technical measures	• Development of artificial snow* (R)	

	Anticipatory (A) / Reactive (R) measures	Measures launched
PRIVATE	• Development of other attractions in winter tourism to reduce the dependence on snow* (A)	
	• Improving the economy of artificial snow on ski slopes and investigating the possibilities of its use in cross-country skiing* (R)	
	• Change of tourism patterns*** (R)	
	• Change in patterns of recreational use of nature*** (R)	• Lengthening the boating and camping season.

Opportunities for cross-country skiing will decrease

Skiing has been a popular physical activity and part of the Finnish way of life for generations. According to nationwide surveys, almost half of the population engages in either cross-country or alpine skiing at least once a year and over 90 per cent say that they have adequate cross-country skiing skills.

Fewer skiing days per season is the first consequence of a warmer climate. Fewer skiing opportunities close to home will have a negative impact on skiing frequency of those who are unable to travel to areas with guaranteed snow. The absence of cross-country skiing opportunities will reduce the chances for children to learn this traditional winter activity. This impact will be strongest for people living in southern Finland.

Skiers in southern Finland will thus become more interested in ski tourism to areas with guaranteed snow, where more opportunities will open to develop new services. At the moment, tourism enterprises do not see the shortened winter season as an immediate threat to their business, even though cross-country skiing and riding snowmobiles and dog-sleds are more sensitive to natural snow conditions than alpine skiing.

Insurance

Climate change is likely to increase the damage caused by extreme weather. Insurance companies face higher uncertainties in their risk estimates, which may be reflected in the insurance premiums and coverage. At present, the companies offer good insurance coverage for forests, for instance against fire, storms, floods, heavy snow, insects or pathogens. On average, some 70–80 per cent of annual compensation in forest insurance is paid for storm damage. This figure has remained unchanged over the last 5–6 years, i.e. over EUR 2 million, or 2,000 payments, annually. The figure includes also forest fires.

Home and property insurance policies do not cover damage caused by heavy rainfall or floods. However, if a flood from a river or lake is considered exceptional (i.e. it has a return period of over 20 years), it is possible to obtain compensation from the government. The average yearly compensation in this category has been less than EUR 1 million, but occasionally the amount has been higher, for example in 2004 it was EUR 7 million. The current system for compensating flood damage does not include floods caused by sea-level rise or storm water/urban run-off. This is one of the reasons why the system for compensating flood damage is under revision. An insurance -based system has been proposed.

The government also compensates agricultural operators for damage caused by adverse weather conditions if this exceeds 30 per cent of the value of a normal harvest. The annual budgeted sum for this compensation is EUR 3.4 million for harvest damage and EUR 0.8 million for flood damage. The average annual figure has risen because there have been a few years with exceptionally high compensation.

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning insurance, and the preliminary timing of measures (*Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080).

		Anticipatory (A) measures	Measures launched
PUBLIC	Administration and planning	• Integration of climate change adaptation with tourism strategies* (A)	
		• Development of an insurance pool jointly with insurance companies* (A)	
	Research and information	• Modelling and study of risks utilising existing climate change scenarios* (A) • Development of precautions to avoid damage* (A)	• Research project under way on weather-induced risks in the management of climate risks in agriculture.
	Economic and technical measures	• Development of technology to reduce risks* (A)	
	Normative framework	• Development of insurance legislation* (A)	

	Anticipatory (A) measures	Measures launched
PRIVATE	• Clarifying insurance policies and responsibilities* (A)	
	• Proactive planning and modelling* (A)	
	• Development of private insurance systems to take climate change into consideration* (A)	
	• Development of new products to control economic risks* (A)	
	• Diversification of risk with the help of bonds and derivatives* (A)	

Health

Increased intensity and frequency of extreme weather events may cause additional pressure in the health sector, particularly as the population ages. High temperatures will increase heat-related mortality and morbidity in the summer. There is a clear increase in mortality in Finland when the daily average temperature remains at about +20°C or more for 1–2 weeks. On the other hand, with milder winters the risks of additional mortality from cardiovascular and pulmonary diseases as a result of an extremely cold spell are likely to decrease. Darker winters, caused by a shorter snow cover period, increased precipitation and cloudiness, may increase cases of seasonal affective disorder. The number of days when the temperature hovers around 0°C will also increase. This may increase the risks of slipping injuries and traffic accidents. In addition, thinner and shorter duration of ice cover on waterways will be a safety risk.

Warming will contribute to the northward spread of ticks and the tick-borne diseases such as Lyme disease (borreliosis) and tick-borne encephalitis. A warmer climate will also stabilize the population fluctuations of small rodents, which will reduce the overall incidence of several rodent-borne diseases (e.g. Puumala hantavirus and tularaemia). The probable increase in density of medium-sized predators (red fox, raccoon dog) will increase the risk of rabies and alveolar echinococcosis spreading to Finland.

A warmer climate and longer growing season may favour the pollen production of certain plants and the occurrence of cyanobacteria in waters, which may cause allergic reactions. If forest fires become more common, airborne particulates may have an adverse health impact.

Storms, floods and intense small-scale wind phenomena may cause accidents and create health hazards. Floods may also induce large-scale health risks, particularly through contamination of the water supply.

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning social services and health care, and the preliminary timing of measures (*Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080).

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Administration and planning	• Securing the capacity of health care to correspond to changing climatic conditions* (A)	
		• Cooperation between climate researchers and health care and social services* (A)	• Networking has been launched and know-how enhanced especially on infectious diseases.
		• Supplementing of the guide for special circumstances by the Ministry of Social Affairs and Health with regard to hot periods (A)	• Guide on emergency situations in environmental health, which should be completed in 2009, offers a comprehensive account of emergency situations related to weather events.
		• Energy policy must aim to secure the distribution of electricity (A)	
	Research and information	• Information about the dangers of the changing climate, such as heat waves* (A)	• The Finnish Meteorological Institute has plans for warning systems for heat and cold. Criteria for the heavy rainfall warning system take account of the risk of water-borne epidemics.
		• Studies related to special circumstances, monitoring them and organising reporting on them (A)	• Generic action models have been prepared on research activities relating to emergency situations.
		• Information on the dangers of algal blooms* (A)	• The Ministry of Agriculture and Forestry, the Finnish Environment Institute (SYKE) and Regional Environment Centres issue weekly reports on algal blooms in summer.
		• Information about the increased risk of infectious diseases* (A)	
		• Studies related to special circumstances and organising reporting on them (R)	• Research and communication is carried out on all emergency situations where significant numbers of people are at risk of falling ill.
	Economic and technical measures	• Development of urban planning with regard to the control of the urban heat island phenomenon* (A)	
		• Preparedness planning must pay attention to backup systems for the distribution and production of electricity (A)	• The Ministry of Social Affairs and Health is updating the guide on emergency situations in environmental health, including risk management relating to power cuts.
		• Ensuring air conditioning and sufficient ventilation in retirement homes and hospitals, for example, by means of quality recommendations* (R)	• Classification of indoor air was revised in 2008.

	Anticipatory (A) / Reactive (R) measures	Measures launched
PRIVATE	• Increased air conditioning*** (R)	• Guide on the ventilation of residential buildings will be published during 2009.

Cultural environment

Climate change can affect the cultural environment and it may pose a threat to the preservation of the cultural and natural heritage. More research is urgently needed on the impacts of climate change in order to evaluate them comprehensively.

Cultural landscapes and traditional rural biotopes will be affected as changes are expected in biodiversity and in the distribution of species. As environmental conditions of the soil change, archaeological heritage will be endangered and stability of the soil as a foundation for buildings will weaken. Wood is also sensitive to changes in humidity. Wooden buildings are typical in Finland and, therefore, measures will be required to control decay and fungi growth even without flooding problems. The old town in Rauma and the Petäjävesi wooden church on the UNESCO World Heritage List represent Nordic wooden architecture. Extreme weather phenomena such as storms and flooding have an impact, for example, on the Suomenlinna Sea Fortress also listed on the World Heritage List.

Adaptation to climate change leads to an increased need for safety repairs at restoration and conservation sites. Climate and energy policies, like the increasing use of renewable energy sources, and energy-saving goals, like improving energy efficiency of buildings, may also have significant effect on the cultural environment.

6.2.5 *Impacts of climate change in Finnish Lapland, and the related adaptation measures*

In Finnish Lapland, the observed climatic changes have so far been relatively small. Exceptional snow conditions have occurred though, varying from record late arrival in some years to record high accumulations in late winter in others. In spring 2005, severe floods caused considerable damage in some communities.

The projected climate change in Lapland indicates a particularly large warming trend, and a considerable increase in precipitation. The changes are likely to have pronounced effects on the distribution and productivity of boreal forests and arctic vegetation. Forests will spread into the tundra, which may also produce a feedback effect on the regional climate by reducing the albedo and thus causing additional warming.

The shortening of the snow season has become very evident in recent years, threatening particularly the important Christmas tourism season. Tourism is the main industry in many communities in Lapland. During seven months of the year, tourism has been based on snow and winter conditions. For this reason, some municipalities in Lapland have begun to look ahead to the consequences of climate change.

Reindeer husbandry is important in Lapland, particularly in small communities. Reindeer are also of great cultural value because many of their

owners are indigenous Sami people. The impacts of climate change on reindeer populations are expected to be mainly unfavourable. If winters get milder and precipitation increases, snow may be thicker and icy layers may form inside the snow cover. This would make it difficult for reindeer to dig for lichen and their need for supplementary food will increase. The northward advance of the tree line and gradual replacement of lichens with vascular plants may also affect reindeer pastures.

Almost half of Finland's hydropower is generated in Lapland. Increased precipitation and more even discharges (smaller spring floods and bigger discharges in winter) will be beneficial for hydropower production. It is likely that additional capacity will be built alongside existing hydropower plants.

Summary of climate change adaptation measures (potential measures identified in the national adaptation strategy and measures already launched) concerning reindeer husbandry, and the preliminary timing of measures (*Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080).

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Administration and planning	• Coordinating the interests of reindeer husbandry and forestry* (A)	• The need to reconcile the interests of reindeer husbandry and forestry will become even more important as climate change alters the circumstances.
		• Development of aerial supervision in order to reduce the risk of large fires* (A)	
		• Comprehensive planning of different forms of land use through the development of planning systems* (A)	• Different forms of land use should be taken into account in natural resource planning by Metsähallitus.
	Research and information	• Studying the long-term changes experienced in the state of pastures and the impacts of climate factors** (A)	• The Finnish Game and Fisheries Research Institute (FGFRI) monitors and reports to the Ministry of Agriculture and Forestry. Maximum allowable reindeer numbers will be determined on the basis of the proposals of a working group to be set up (proposal to be based on the state of pastures).
		• Providing information on the most critical pasture areas* (A)	• Communicated on the basis of the above-mentioned reporting by the Finnish Game and Fisheries Research Institute (FGFRI).
		• Study of the adaptation of reindeer to climate change**(A)	• Ongoing study on reindeer forage and supplementary feeding.
		• Study on the ecophysiological impacts of environmental changes on plants and soil, particularly on horsehair lichen, mosses and lichen in northern regions** (A) • Development of planning systems for different forms of land use** (A)	• Studies by the Finnish Game and Fisheries Research Institute (FGFRI) on the amounts, state and productivity of pasture areas and changes in pastures and their causes. Research on the impacts of grazing reindeer and other land uses on pastures.
	Economic and technical measures	• Separation of winter and summer pastures by fences* (A)	

		Anticipatory (A) / Reactive (R) measures	Measures launched
PUBLIC	Normative framework	• Prescription on the maximum number of reindeer** (A)	• Number of reindeer established for 10 years (next time in 2010) based on the state of pastures, taking account of social and economic impacts.

	Anticipatory (A) / Reactive (R) measures	Measures launched
PRIVATE	• Development of pasture rotation systems (including rotation fences)* (A)	• Pasture rotation systems constantly developed by herding cooperatives. Research at the Finnish Game and Fisheries Research Institute (FGFRI) on e.g. the impacts of different reindeer herding methods on output and costs.
	• Arrangement of additional feeding** (R)	• Additional feeding of reindeer depending on the natural conditions and state of pastures.

6.2.6 *National security and the related adaptation measures*

The adaptation strategy of 2005 did not address national security as a sector of its own. A better understanding has since been developed of the impacts of climate change on societies and how the climate change related problems in some other parts of the world may be reflected in Finland through the global economy and via migration and environmental refugees. The Government Resolutions on the Internal Security Programme (Ministry of the Interior 2008) and Strategy for Securing the Functions Vital to Society (Ministry of Defence 2006) deal with the preparations within the national defence administration for the consequences of climate change.

Administrative sector of the Ministry of Defence
Summary of climate change adaptation measures already launched concerning the administrative sector of the Ministry of Defence.

		Measures launched
PUBLIC	Administration and planning	• According to the report on national security and defence policy (Finnish Security and Defence policy 2009: Government Report, 23 January 2009), the future development of national security must take into account the threats caused by climate change and adaptation to it, e.g. by means of land-use and other community planning, education and training and acquisition of rescue equipment.
		• In the Strategy for Securing the Functions Vital to Society (YETT Strategy, Government Resolution 2006) climate change is considered the most serious global environment threat.
		• According to the Ministry of Defence strategy 2025 'Securely into the Future', climate change is a factor that influences the security situation and it must be taken into account in the activities of the defence administration.
		• A study on the needs for adaptation and impacts of climate change on the activities of the defence forces has been launched based on the survey 'Defence Administration and Climate Change' (2008).
		• Planning of the military actions of the Defence Forces (Operative and development planning of garrisons, VARSU) also takes account of flood risk areas, norms for energy planning, energy efficiency of buildings and structures and environmental protection.

Administrative sector of the Ministry of the Interior
Summary of climate change adaptation measures already launched concerning the administrative sector of the Ministry of the Interior.

		Measures launched
PUBLIC	Administration and planning	• In the 'Safety First – Internal Security Programme' (2008), climate change is recognised to have on impact on security e.g. because of extreme weather events and increasing number of refugees.
		• In the administrative sector of the Ministry of the Interior, climate change mitigation and adaptation have been taken into account e.g. in the acquisition of equipment. It is considered particularly important to obtain research information on the security impacts of climate change in order to prepare for the future.
		• Preparing for the potential impacts of climate change on internal security, illegal immigration, smuggling and human trafficking.
		• Preparing for the growing frequency of storms and extreme weather events in rescue operations.

6.2.7 *Global impacts of climate change reflected in Finland*

Changes taking place in other parts of the world will create a need for adaptation in Finland, too. The IMPLIFIN project ('Implications of international climate change impacts for Finland') concludes that climate change impacts on the world economy and on the development of poorer countries could have important repercussions for the Finnish economy and for Finland's international relations in general. Furthermore, international climate policy and especially EU regulations will have implications for Finnish policy making.

In the early stages of warming, the impacts on the Finnish economy are not expected to be very large, with beneficial impacts compensating to a large extent for detrimental impacts. Moreover, the near-term adaptive capacity of Finland appears to be quite high, especially when compared to poorer countries. However, effects can be mixed and benefits could occur in some periods and disadvantages in others.

Finnish agriculture, forestry, energy, tourism and transport are sensitive to the international impacts of climate change. The impacts will also have consequences for Finland's international development cooperation.

Over the next few decades a slight change in the climate would have advantages for a northern developed country like Finland. However, the advantages may be reduced when the harmful impacts of climate change outside Finland are taken into consideration.

In the long run, external impacts could prove to be more significant for policy makers than domestic concerns (Table 6.2).

Table 6.2
Climate change impacts in other countries reflected in different sectors in Finland

Sector	Link between global events and adaptation need in Finland
Agriculture and food production	Agriculture, food prices and availability may be affected by: • Uncertainty concerning preservation of levels of production in present major production areas • Changes in demand for agricultural products • Implications of mitigation measures such as increased demand for bio-energy crops • A possible increase in the demand for Finnish food products.
Development cooperation	Finland's international development cooperation policies and practices need to be modified to take climate change into account.
Economy	Effects on the economy and foreign trade can be mixed and benefits could occur in some periods and negative effects in others. Extreme weather events could increase costs significantly.
Energy	EU energy policies create a need for restructuring Finland's energy production. Hydropower production is expected to increase in the Nordic countries, which have a common energy market. Energy infrastructure, and particularly transmission networks and pipelines, are likely to be vulnerable to climate change and extreme weather events. Climate change could affect the reliability of energy distribution and therefore energy supply in Finland.
Forestry	Diminishing non-boreal, but increasing boreal forest reserves may increase the importance of boreal forests as a carbon sink. Policy measures in other EU countries on renewable energy may reduce the effectiveness of national policies in Finland. Demand for bio-energy may lead to increased exports of forest-based biofuel and know-how from Finland.
Health	Forest fires in neighbouring countries may worsen air quality and cause negative health impacts.
Security	Resource scarcity could cause conflicts and forced migration. Opening of new sea routes in the Arctic also has a military and strategic dimension, which could alter the world's geopolitical balance.
Tourism	Regional climate effects in the Mediterranean and the Alps, for example, may affect tourists' preferences in ways which will affect Finnish tourism.
Transport and communications	Opening of the Northwest Passage and Northern Sea Route could mean substantial savings in transportation costs, as well as savings in time and energy costs. Opening of the Arctic Sea routes could mean increased transportation through northern Finland and Lapland and possibly also changes in marine transportation in the Gulf of Bothnia or in the Baltic Sea in general.

6.3 *Vulnerability assessment*

In comparisons of the vulnerability of different countries to climate change, the Nordic countries, including Finland, have been among the least vulnerable. The conclusion is the same when world-wide maps of various vulnerability indicators are examined.

So far, there have been few risk analyses concerning the impacts of climate change in Finland. In some sectors, the results of climate change research have included aspects of vulnerability assessment. In the European Environment Agency report 'Vulnerability and adaptation to climate change in Europe', agriculture and forestry are the only sectors for which Finland has specified some vulnerabilities.

Implementation of Finland's adaptation strategy requires that risk assessment methods applicable to the impacts of climate change must be developed and applied further. Moreover, assessments that integrate different risks, such as climate, environment, economy, health and insurance, will be needed. These will require precise information about the expected impacts and uncertainties of climate change.

In January 2009 a major project concerning vulnerability assessment was started. This MAVERIC project ('Map-based assessment of vulnerability to climate change employing regional indicators') has six objectives:

- To identify relevant climate variables for selected human activities and to use observations and model-based future projections of these variables to describe the exposure to climate change.
- To examine alternative impact models for evaluating sectoral or system sensitivity to climate change, and to analyse their suitability for application at a municipal level.
- To define appropriate indicators of adaptive capacity to climate change based on the modification of existing sustainability indicators and scenarios, a literature review and discussions with representatives from selected pilot study regions.
- To finalise a set of vulnerability indicators for Finland as a whole and develop web-based methods to map these interactively.
- To report results at stakeholder workshops to obtain feedback and facilitate refinement and nationwide application of the vulnerability indicators.
- To publish the results in peer reviewed literature.

The project is scheduled to end in December 2011. The research team is interdisciplinary and multi-institutional. The work will focus on three sectors: agriculture, tourism and recreation, and water resources. Other sectors are also under consideration.

Another major project VACCIA (Vulnerability of ecosystem services for climate change impacts and adaptation), started in January 2009, will make a detailed assessment of the vulnerability of main ecosystem services in Finland and collect information on possible adaptation measures.

Literature

Berghäll, J. & Pesu, M. (2008) Climate Change and the Cultural Environment. Recognized Impacts and Challenges in Finland. The Finnish Environment 44en/2008, Ministry of the Environment, Helsinki, Finland http://www.ymparisto.fi/default.asp?contentid=318369&lan=en

Carter, T.R. (ed.) (2007) Assessing the adaptive capacity of the Finnish environment and society under a changing climate: FINADAPT. Finnish Environment, 1/2007, Finnish Environment Institute, Helsinki, Finland http://www.ymparisto.fi/download.asp?contentid=64914&lan=en

Case Studies on Climate Change and World Heritage (2007) UNESCO World Heritage Centre, Paris, France http://unesdoc.unesco.org/images/0015/001506/150600e.pdf

Climate Change and World Heritage. Report on predicting and managing the impacts of climate change on World Heritage and Strategy to assist States Parties to implement appropriate management responses (2006) World Heritage Reports 22, UNESCO World Heritage Centre, Paris, France http://whc.unesco.org/uploads/activities/documents/activity-474-1.pdf

Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007), Cambidge University Press Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B., Averyt, M., Tignor M.M.B. & Miller H.L. (eds.) Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.ipcc.ch/ipccreports/ar4-wg1.htm

Futter, M., Forsius, M., Holmberg, M. and Starr, M. (2009) A long-term simulation of the effects of acidic deposition and climate change on surface water dissolved organic carbon concentrations in a boreal catchment. Hydrology Research Vol. 40 No 2–3 pp 291–305

Jylhä K., Ruosteenoja K., Räisänen J., Venäläinen A., Tuomenvirta H., Ruokolainen L., Saku S. & Seitola T. (2009) Changing climate in Finland: estimates for adaptation studies. ACCLIM project report 2009. Finnish Meteorological Institute, Report 2009:4, (in Finnish, extended abstract and figure captions in English)

Kankaanpää, S. & Carter, T.R. (forthcoming) IMPLIFIN -report (Implications of international climate change impacts for Finland).

Kankaanpää, S., Carter, T.R. & Liski, J. (2005) Stakeholder perceptions of climate change and the need to adapt. FINADAPT Working Paper 14, Finnish Environment Institute Mimeographs 344, Helsinki, Finland http://www.ymparisto.fi/download.asp?contentid=45376&lan=en

Kellomäki, S., Strandman, H., Nuutinen, T., Peltola, H., Korhonen, K.T. & Väisänen, H. (2005) Adaptation of forest ecosystems, forests and forestry to climate change. FINADAPT Working Paper 4, Finnish Environment Institute Mimeographs 334, Helsinki, Finland http://www.ymparisto.fi/download.asp?contentid=45301&lan=en

Kiander, J. (2008) Ilmastopolitiikka ja tulonjako. Selvitys Vanhasen II hallituksen tulevaisuusselontekoa varten. Ilmasto- ja energiapoliittisen tulevaisuusselonteon taustajulkaisu (Climate policy and income distribution. Background report for the government's foresight report on climate and energy policy) Yliopistopaino, Helsinki, Finland (in Finnish)

Kirkinen, J., Martikainen, A., Holttinen, H., Savolainen, I., Auvinen, O. & Syri, S. (2006) Impacts on the energy sector and adaptation of the electricity network business under a changing climate in Finland. FINADAPT Working Paper 10, Finnish Environment Institute Mimeographs 340, Helsinki, Finland http://www.environment.fi/download.asp?contentid=45340&lan=en

Lepistö, A., Kortelainen, P. & Mattsson, T. (2008) Increased organic C and N leaching in a northern boreal river basin in Finland. Global Biogeochemical Cycles Vol 22, GB3029, doi: 10.1029/2007GB003175 http://www.agu.org/pubs/crossref/2008/2007GB003175.shtml

Ministry of Agriculture and Forestry (2005) Finland's National Strategy for Adaptation to Climate Change. Publication 1a/2005, Helsinki, Finland www.mmm.fi/attachments/ymparisto/5kghLfz0d/MMMjulkaisu2005_1a.pdf

Ministry of Agriculture and Forestry (2008) Greenhouse impacts of the Use of Peat and Peatlands in Finland. Publication 11a/2007, Vammala, Finland http://www.mmm.fi/attachments/mmm/julkaisut/julkaisusarja/2008/5BKZGKG1a/MMM11a2007_nettiversio_turve.pdf

Ministry of Agriculture and Forestry (2009) The Evaluation of the Implementation of Finland's National Strategy for Adaptation. Publication 4a/2009, Helsinki, Finland www.mmm.fi/attachments/mmm/julkaisut/julkaisusarja/2009/5IEsngZYQ/Adaptation_Strategy_evaluation.pdf

Ministry of the Environment (2008) Adaptation to Climate Change in the Administrative Sector of the Ministry of the Environment, An Action Plan to Implement the National Strategy for Adaptation to Climate Change. Reports of the Ministry of the Environment 20en, Helsinki, Finland http://www.ymparisto.fi/print.asp?contentid=313737&lan=fi&clan=en

Ministry of the Environment (1995) Valtioneuvoston periaatepäätös maisema-alueista ja maisema-alueiden kehittämisestä. (Decision in Principle of the Council of State Concerning the Landscapes and Developing of the Landscapes.) (In Finnish) http://www.ymparisto.fi/download.asp?contentid=28080&lan=fi

Nakicenovic, N., et al. (2000) Special Report on Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, U.K., www.grida.no/climate/ipcc/emission/index.htm

Peltonen-Sainio, P., Rajala, A., Känkänen, H. & Hakala, K. (2009) Improving farming systems in northern European conditions. Crop Physiology. Applications for Genetic Improvement and Agronomy. Elsevier B.V.

Pouta, E., Neuvonen, M. & Sievänen, T. (2009) Participation in cross-country skiing in Finland under climate change: Application of multiple hierarchy stratification perspective. Journal of Leisure Research 41(1), 91–108, National Recreation and Park Association, Ashburn, VA, USA.

Rankinen, K., Valpasvuo-Jaatinen, P., Karhunen, A., Kenttämies, K., Nenonen, S. & Bärlund, I. (2009) Simulated nitrogen leaching patterns and adaptation to climate change in two Finnish river basins with contrasting land use and climatic conditions. Hydrology Research Vol 40 No 2–3 pp 177–186

Räisänen, J. & Ruokolainen, L. (2008) Ongoing global warming and local warm extremes: a case study of winter 2006–2007 in Helsinki, Finland. Geophysica Vol. 44, Nos.1–2 pp 45–65, Geophysical Society of Finland, Helsinki, Finland http://www.geophysica.fi/pdf/geophysica_2008_44_1-2_045_raisanen.pdf

Saarinen, J. & Tervo, K. (2006) Perceptions and adaptation strategies of the tourism industry to climate change: The Case of Finnish nature-based tourism entrepreneurs. International Journal of Innovation and Sustainable Development 2:2, 214–228, Inderscience publishers, Geneve, Switzerland

Saloranta, T. M., Forsius, M., Järvinen, M. & Arvola, L. (2009) Impacts of projected climate change on thermodynamics of a shallow and deep lake in Finland: Model simulations and Bayesian uncertainty analysis. Hydrology Research Vol. 40 No 2–3 pp 234–248, http://www.iwaponline.com/nh/040/nh0400234.htm

Sievänen, T., Tervo, K., Neuvonen, M., Pouta, E., Saarinen, J. & Peltonen, A. (2006) Nature-based tourism, outdoor recreation and adaptation to climate change. FINADAPT Working Paper 11, Finnish Environment Institute Mimeographs 341, Helsinki, Finland http://www.ymparisto.fi/download.asp?contentid=45369&lan=en

Uudenmaan liitto (2007) Uudenmaan rannikkoalueiden yleispiirteinen tulvakartta (Flood map of the coastal areas of the province of Uusimaa). Uudenmaan liiton julkaisuja E 96 – 2007, Uudenmaan liitto, Helsinki, Finland (in Finnish) http://www.uudenmaanliitto.fi/modules/publishbank/julkaisupankki_files/364_E%2096%20Uudenmaan%20rannikkoalueiden%20yleispiirteinen%20tulvakartta.pdf

Vajda, A. (2007) Spatial variation of climate and the impact of disturbances on local climate and forest recovery in northern Finland. Doctoral dissertation, University of Helsinki, Department of Geography. Finnish Meteorological Institute, Contributions 64, Helsinki, Finland https://oa.doria.fi/bitstream/handle/10024/13149/spatialv.pdf?sequence=1

Internet links

ACCLIM Programme, http://www.ilmatieteenlaitos.fi/research_climate/climate_2.html

Climate Change Adaptation Research Programme ISTO, www.mmm.fi/ISTO/eng

ClimBus Programme, http://akseli.tekes.fi/opencms/opencms/OhjelmaPortaali/ohjelmat/ClimBus/en/etusivu.html

EURO-LIMPACS project, www.environment.fi/syke/euro-limpacs

FINADAPT Programme, http://www.environment.fi/syke/finadapt

Ministry of the Agriculture and Forestry, http://www.mmm.fi/en/index/frontpage.html

Ministry of the Environment, http://www.environment.fi

National Board of Antiquities, http://www.nba.fi/en/

Nationwide Outdoor Recreation Demand Study by the Finnish Forest Research Institute, Metla, http://www.metla.fi/metinfo/monikaytto/lvvi/ (in Finnish)

VACCIA project, www.environment.fi/syke/vaccia (in Finnish)