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Finland's National Strategy for Adaptation to Climate Change

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Abstract	The Parliament's reply to the National Climate Strategy submitted to the Parliament in March 2001 identified the need to draft a programme for adaptation to climate change. The preparation of the National Strategy for Adaptation to Climate Change was started in the latter part of 2003. The work was coordinated by the Ministry of Agriculture and Forestry and representatives from the Ministry of Traffic and Communications, Ministry of Trade and Industry, Ministry of Social Affairs and Health, Ministry of the Environment, Ministry for Foreign Affairs, Finnish Meteorological Institute and Finnish Environment Institute took part in the preparation. Each Ministry was responsible for assessing the impacts and identifying adaptation measures in its own sector. The Adaptation Strategy was based on the available research information and expert assessments and judgements. A large number of leading Finnish researchers of climate change and its impacts, other experts and representatives of different sectors were involved in the preparation process. The comments sent by stakeholders were also taken into account in finalising the strategy. The increase in the greenhouse gas concentration in the atmosphere leads to global warming and changes in the climate systems. The Finnish Meteorological Institute compiled the climate change scenarios based on the existing international and national data. According to the estimates on the future climate change in Finland, by 2080 the average temperature could rise by 4 - 6°C and the average precipitation would grow by 15 - 25 %. Extreme weather events, such as storms, droughts and heavy rains, are likely to increase. The Government Institute for Economic Research drew up a background study on the long-term scenarios for the economy and the Finnish Environment Institute examined the future development trends in natural conditions. The strategy describes the impacts of climate change in the following sectors: agriculture and food production, forestry, fisheries, reindeer husbandry, game management, water resources, biodiversity, industry, energy, traffic, land use and communities, building, health, tourism and recreation, and insurance. The strategy describes the present sensitivity to climate change and outlines actions and measures to improve the capacity and to adapt to future climate change. The strategy aims at reducing the negative consequences and taking advantage of the opportunities associated with climate change. The Adaptation Strategy includes a proposal on starting a research programme. The Strategy for Adaptation to Climate Change was drawn up as a self-standing and comprehensive work. The main content will be included in the National Climate and Energy Strategy to be updated in 2005.	
Keywords	Climate change, scenarios, impacts, adaptation, agriculture and food production, forestry, fisheries, reindeer husbandry, game management, water resources, biodiversity, industry, energy, traffic, land use and communities, building, health, tourism and recreation, insurance	
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1. Background and objectives of the Adaptation Strategy

1.1. Background

The Finnish Government submitted a Government Report on the National Climate Strategy to the Parliament in March 2001. The Parliament stated in its response in June 2001 that the implementation of the National Climate Programme could be started but, in addition, there was a need to formulate a programme for adapting to climate change. Thus the Parliament's response required that the drafting of a programme for adaptation to climate change be started.

In early 2003 the Ministry of Trade and Industry together with other ministries prepared a progress report for the Parliament on the implementation of the National Climate Strategy. The progress report stated that a separate programme for adaptation to climate change will be included in the revised National Climate Strategy. It also stated that the following aspects should be taken into account when planning adaptation:

- Research should focus on acquiring the necessary knowledge basis on the impacts of climate change (both direct and indirect) affecting Finland. Uncertainty factors should also be taken into consideration. In the initial phase the adaptation programme requires the implementation of research aimed at this.

- The adaptation requirements in different sectors will be assessed. Critical sectors and impacts should be tentatively identified. Sectors that may require special attention include agriculture, forestry, nature conservation and tourism.[1]

- The extent to which there is a need to prepare for and adapt to adverse impacts in other parts of the world should also be considered.

The contact network assisting the Ministerial Working Group on Climate and Energy Policy decided that the Ministry of Agriculture and Forestry shall act as the coordi-

[1] These sectors were defined before the group started its work.

nating ministry for preparing an Adaptation Strategy.[2] For the preparation work of the Adaptation Strategy a task force was established with representatives from the Ministry of Agriculture and Forestry, Ministry of Trade and Industry, Ministry of the Environment, Ministry of Transport and Communications, Ministry of Social Affairs and Health, Ministry for Foreign Affairs, as well as the Finnish Meteorological Institute and the Finnish Environment Institute. Each ministry was responsible for its own sector-specific review. The Finnish Meteorological Institute compiled the climate change scenarios, which were partly based on the material produced by the FINSKEN project..[3] The Government Institute for Economic Research produced a background study on long-term economic scenarios. The progress of the preparation for the Adaptation Strategy was reported to the Ministerial Working Group on Climate and Energy Policy.

The preparation of the Adaptation Strategy began in the latter half of 2003. Seminars were held in different sectors with a two-fold goal: to outline the projected impacts of climate change and adaptation, and to outline the involvement in and views of different stakeholders on the preparation work of the Adaptation Strategy. The work relied on existing research data, expert assessments and views. It was a joint effort of both the stakeholders listed above and a large number of leading researchers on climate change and its impacts, other experts and representatives of different sectors. One of the research projects involved was the so-called FINADAPT[4], which is part of the Finnish Environmental Cluster Research Programme of the Ministry of the Environment and which is coordinated by the Finnish Environment Institute. The project assesses Finland's adaptive capacity to climate change. Worth mentioning in this context is also the comprehensive assessment "Arctic Climate Impact Assessment" (ACIA) of the impacts of climate change on the Arctic region, which was commissioned by the Arctic Council and completed at the end of 2004.

The proposal for Finland's National Strategy for Adaptation to Climate Change was presented at an open seminar in October 2004. The draft was sent to a number of

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[2] Parliament used the term *adaptation programme*, but due to the nature of the work, the work actually concerns a national adaptation strategy that does not include a detailed schedule of the proposed actions or any proposals for appropriations.

[3] The FINSKEN project (1999 to 2002) was part of the Finnish Global Change Research Programme (FIGARE) carried out by the Academy of Finland. The FINSKEN project produced consistent global change scenarios for Finland up to the year 2100 concerning issues such as atmospheric composition, acid fallout, climate change and sea level.

[4] Assessing the adaptive capacity of the Finnish environment and society under a changing climate (FINADAPT)

stakeholders for commenting. The general public was able to comment on the draft through the Internet. More than 50 comments were received from different parties or people, and these were taken account in finalising the Adaptation Strategy.

The National Climate Strategy will be revised during 2005. Finland's National Strategy for Adaptation to Climate Change was formulated as a separate and comprehensive report. Its central points will be included in the revised National Climate and Energy Strategy in 2005.

1.2. Starting points and scope of the Adaptation Strategy

Increased concentrations of greenhouse gases, especially carbon dioxide, in the atmosphere cause global warming. The human-induced (anthropogenic) change in the composition of the atmosphere will continue in this century and further accelerate global climate change. In Finland climate change is expected to increase the mean temperature and rainfall, especially in winter, as well as change the intensity and/or frequency of extreme climatic events. There are many uncertainties associated with the magnitude, timing and impacts of climate change, as well as the long-term development of society.

Adaptation to climate change refers to the adjustment in natural or human systems in response to actual or expected climatic stimuli or their impacts which moderates harm or exploits beneficial opportunities. Some key concepts associated with climate change and adaptation (applied in Finland's National Adaptation Strategy) are presented in Table 1.1.

The most important way to reduce the impacts of climate change, and thus the need for adaptation, is the global mitigation of greenhouse gases. The Adaptation Strategy does not assess the role which the potentially forthcoming mitigation measures may have in the climate change scenarios or in the future impacts of climate change and the necessary adaptation measures.

The impacts of climate change and the sensitivity and adaptive capacity vary in different parts of the world. Different sectors and target groups are exposed to a different extent to diverse impacts of climate change, and their vulnerability also varies. Climate change is expected to have clearly adverse impacts, but it may also benefit some sectors, at least in the short term. There are significant risks involved in the impacts of climate change. It is difficult to find a common metrics for the evaluation and comparison of the disadvantages, advantages or risks.

Table 1.1. Some key concepts used in Finland's National Strategy for Adaptation to Climate Change.

(Climate) Impacts
Consequences of climate change on natural and human systems. Depending on whether adaptation is accounted for or not, a distinction can be made between potential impacts and residual impacts.
* Potential impacts: All impacts that may occur given a projected change in climate, without considering adaptation.
* Residual impacts: The impacts of climate change that would appear after adaptation.
An impact may be an advantage or a disadvantage, direct or indirect.

Sensitivity
Degree to which a system is affected, either adversely or beneficially, by climate-related stimuli...

Adaptive capacity
The ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Vulnerability
The degree to which a system is susceptible to, or unable to cope with, adverse impacts of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Adaptation
Adjustment in natural or human systems to a new or changing environment. Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climatic stimuli or their impacts, which moderates harm or exploits beneficial opportunities. Various types of adaptation can be distinguished, including anticipatory and reactive adaptation, private and public adaptation, and autonomous and planned adaptation. The terms provision or adjustment are sometimes used in other contexts.

Mitigation
An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases. This is sometimes referred to as limiting climate change.

Because of the inertia involved in climate change, today's decisions and actions will have impacts far into the future. The Adaptation Strategy aims to provide an understanding of upcoming challenges until 2080 by means of long-term climate scenarios, scenarios describing economic development, and descriptions of natural systems.

Climate change cannot be solely regarded as an environmental issue; it is also broadly linked to our economic, social and cultural development, as well as security. It must also be taken into account in responsible global development. Climate change is a significant challenge to sustainable development, and the Adaptation Strategy is part of the work for this. Sector-specific reviews create prerequisites for integrating adaptation into sectoral development. At the same time they lay the foundation for evaluating any no-regrets measures whose implementation would benefit the sector or target groups regardless of climate change.

A conceptual framework of Finland's National Strategy for Adaptation to Climate Change is presented in Figure 1.1. Chapter 2 of the Adaptation Strategy presents climate change scenarios both for the world and for Finland. It also presents expected changes, economic, social and demographic development in Finland until 2080, as well as main trends in natural systems. This data is used to provide background information on future general changes against which the impacts of climate change and adaptation can be evaluated.

Chapter 3 presents an assessment of the impacts of climate change in different sectors internationally and in Finland, together with a survey of sector-specific sensitivity. The current adaptive capacity of sectors is described in chapter 4, which also presents measures for planned adaptation to climate change, as well as for strengthening and increasing adaptive capacity in order to avoid threats and utilise the opportunities that the changing climate entails.

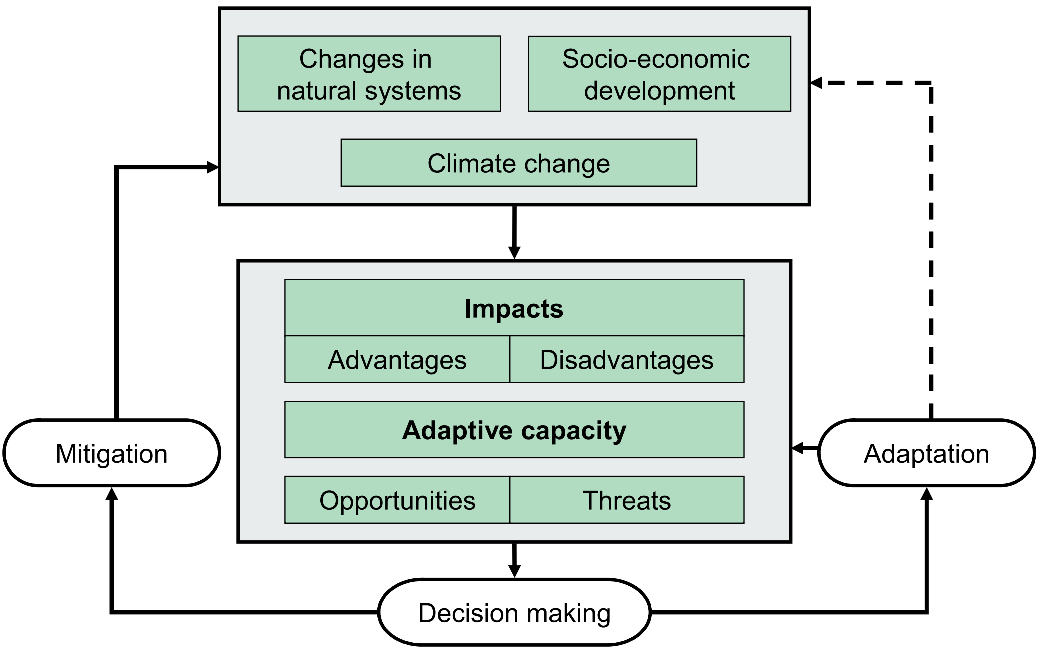

Figure 1.1. Conceptual framework of Finland's National Strategy for Adaptation to Climate Change.

Information on climate change and other changes needed for planning adaptation remains somewhat insufficient although research on the subject has been carried out for a long time, both in Finland and internationally. More research and development efforts are needed. In spite of the uncertainties involved, the Adaptation Strategy also presents policies for immediate action. In many cases these policies are connected with the increased frequency of extreme weather events. These measures ("win-win measures") will be beneficial independent of climate change. It is also justified to introduce certain measures at an early stage due to the long investment cycles. Sometimes mid-term and long-term policies are needed, which can be described as anticipatory and preliminary.

The climate change predicted for this century may gain in intensity later on and have significant impacts. Most of the Greenland continental ice sheet could melt within the next one thousand years, causing the sea level to rise by seven metres. The thermohaline circulation in the oceans, including the Gulf Stream, will probably weaken during this century, which will curb the climate warming in the North Atlantic region. In Finland, however, intense warming is expected. It is unlikely that the Gulf Stream will stop flowing during this century. Finland's National Strategy for Adaptation to Climate Change does not include measures required to address such changes of low likelihood or the impacts of events expected in a thousand-year time period.

1.3. Objectives of the strategy

The objective of the National Strategy for Adaptation to Climate Change is to strengthen and increase Finland's adaptive capacity. This is to be achieved by:

- Describing climate change and its impacts, as well as assessing the sensitivity of sectors.
- Assessing current adaptive capacity, vulnerability and opportunities associated with climate change; and
- Presenting actions that should be taken immediately (such as research and development) and policies for future actions.

2. Future scenarios

2.1. Climate change scenarios

2.1.1. Global changes

The third assessment report of the Intergovernmental Panel on Climate Change (IPCC 2001) states that most of the global warming that has taken place within the last 50 years is due to human activities. Increased concentrations of greenhouse gases, especially carbon dioxide, result in global warming. Natural factors (solar radiation and volcanic activity), and human-originated aerosols (airborne fine particles) have also influenced the transfer of solar radiation and thermal radiation in the atmosphere, but their effect alone is not enough to account for the observed changes in temperature. The change of atmospheric composition will continue during the 21st century, accelerating the global climate change which is already well under way.

The emission scenarios and models published by IPCC in 2001 (Appendix) have been used to estimate the changes in atmospheric greenhouse gas concentrations and quantities of aerosols, as well as the impact of these changes on the environment (IPCC 2001). Estimates of the future climate – created using climate models – take into account the impacts of experienced emissions and scenarios on future emissions. The global mean temperature is expected to increase by 1.4–5.8 °C from 1990 to 2100. The rate of warming is estimated to be substantially higher than that of warming observed in the 20th century. Warming will probably be even more rapid than at any time during the last 10,000 years. Land areas will warm faster than the globe on average, and the increase in winter temperatures of especially northern land areas will be considerable (*Figure 2.1*). A review of the results of one particular climate model (*HadCM3 climate model in Figure 2.1*) with different emission scenarios indicates that the intensity of temperature change towards the end of the century will depend on emissions. On the other hand, when examining a single emission scenario (*A2 emission scenario in Figure 2.1*), it can be seen that the results of different climate models differ from each other in details, but in general they include similar changes.

The sea ice extent of the Arctic Ocean is expected to diminish substantially during this century, making a large part of the sea open during the summer. This will have great impacts on the ecosystem, seafaring and the utilisation of natural resources.

Decline of the continental glaciers and snow cover in the Northern Hemisphere is also expected to accelerate. The average sea level in the oceans is expected to rise by 0.09–0.88 metres between 1990 and 2100. The water cycle will intensify, and mean precipitation will increase. However, regional variations in the changes will be considerable. The rainfall will probably increase the most in high latitudes (to the north of 60N), particularly in the winter. However, there will also be regions in both hemispheres where precipitation is likely to decrease, particularly between latitudes of 20N and 40N degrees (such as the Mediterranean region).

Fluctuation in Asian summer monsoons is expected to increase. Droughts and intense rain associated with the El Niño phenomenon[5] will probably become more extreme, which will increase the risk of drought and flood in many regions. The evaluation of changes in small-scale weather events with substantial local impacts (tornados, hail, lightning, etc.) remains inadequate.

Climate change and its impacts are not evenly distributed. No warming and its subsequent changes have been observed in certain regions of the world. For example, the sea ice extent of the Antarctic Ocean has not diminished in recent decades, while the sea ice extent of the Arctic Ocean has decreased by 15–20% during the last 30 years and the ice cover has become thinner. Natural climatic variation may suppress or intensify the change arising from increased levels of greenhouse gases regionally or perhaps even on the global scale. It is thus possible that in some regions climate change will be more intense and/or rapid than expected.

It is impossible to precisely forecast climatic conditions in the future. The anticipation of climate changes is involves with the following uncertainties, among others:

- It is impossible to precisely forecast changes in atmospheric composition. This is caused by a variety of processes that are difficult to anticipate (including methods of energy production, economic development, population) and affect the emissions of greenhouse gases, as well as the uncertainties associated with models (such as

[5] El Niño is caused by oscillation in the marine atmosphere system of the tropical Pacific. The coastal waters of Peru and Ecuador warm up substantially in the El Niño phase. The phenomenon occurs every four years on average. Warming causes torrential rain on the South American coast and a weak monsoon in India. It can cause severe crop failure. The effect on weather and the climate is greatest in the tropics, but also extends outside the tropics mainly in the Western Hemisphere.

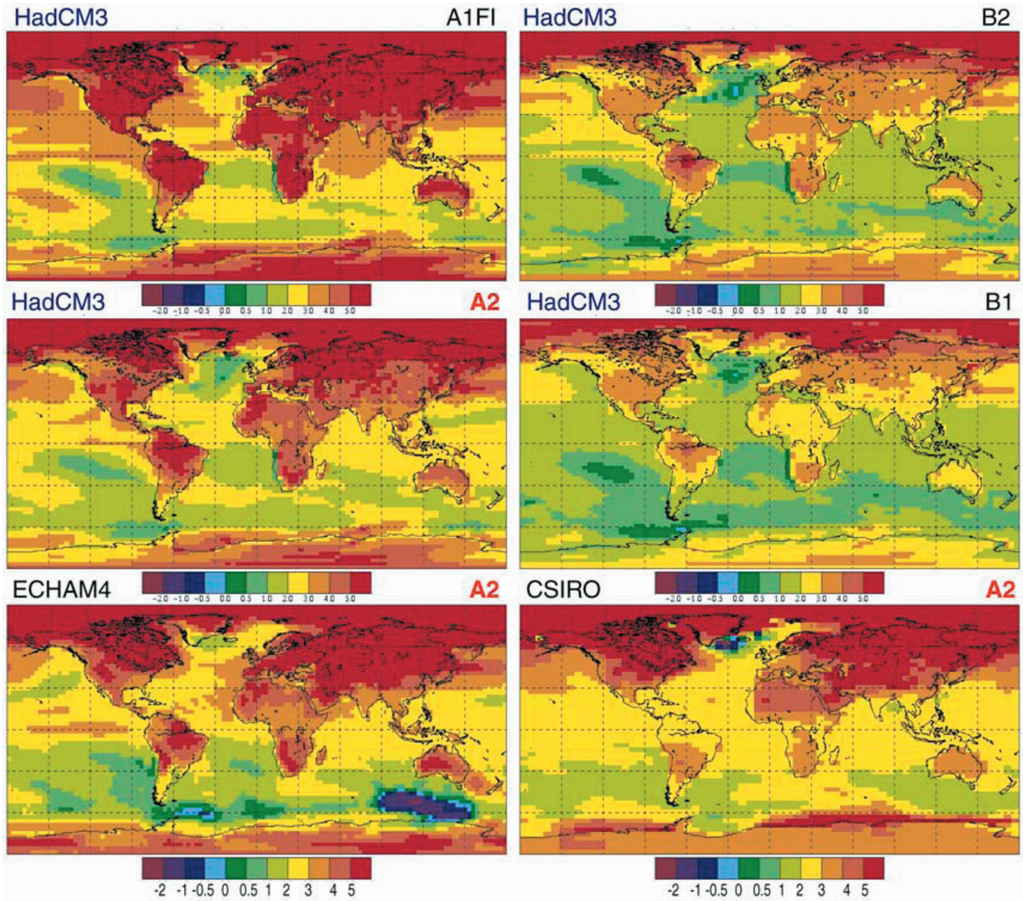

Figure 2.1. *Change in annual mean temperature (ºC) between 2070–2099 compared to the normal period 1961–1990 with different SRES emission scenarios (A1FI, A2, B2, B1; see Appendix) using the HadCM3 climate model, as well as change in accordance with the SRES emission scenario A2 in the ECHAM4 and CSIRO climate models. Source: http://ipcc-ddc.cru.uea.ac.uk/cgi-bin/ddcvis/gcmcf.*

description of the carbon cycle). The concentrations of many greenhouse gases can be fairly precisely estimated over the next few decades, but uncertainty increases towards the end of the century.

- The modelling of climate change involves considerable inaccuracy, because the complex climatic system must be simplified in climate models. Simplifications are associated with issues such as the descriptions of cloud-related processes and the spatial resolution. Estimates regarding regional climate change are even more inaccurate than estimates on average global change. There are great variations between regional climate change estimates provided by different models within a time span of a few decades (Ruosteenoja et al., 2003).

- Climate varies in many time scales. This is caused by the existence of physical, chemical and biological interconnections between the different parts of the climate system (the atmosphere, seas and other liquid water on the globe, the cryosphere formed by snow and ice, land areas and the living environment). The magnitude of this so-called internal variability of the climate system can be estimated from observations and climate model simulations. However, the accurate forecasting of the natural variations is not possible over several years; for example, it is impossible to determine whether a certain winter will be colder or warmer than the average.

- Our knowledge on the climate system and the factors affecting it remains incomplete. This means that a factor previously unknown or considered negligible can turn out to be important in respect of climate change. For example, major changes are known to have occurred during the geological history of the world, but their reasons are not understood with certainty. Forecasts on climate change based on current knowledge are not accurate if the change is particularly significant or rapid.

The concentrations of atmospheric greenhouse gases will continue to increase. Climate change has already started and is expected to accelerate in the 21st century. Climate change caused by mankind will persist for several centuries.

More information on expected climate changes can be found in the following publications:

- *IPCC (2001), Third Assessment Report, Climate Change 2001, Working Group I, The Scientific Basis, pages 12–18. (http://www.ipcc.ch/pub/spm22-01.pdf)*
- *Article "Ten questions on the climate" (in Finnish) in Tiede magazine 18 May 2004*
- *Cubasch, et al., 2001. Projections of future climate change. In: Houghton J.T. et al. (eds.): Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, pp. 525-582. (http://www.grida.no/climate/ipcc_tar/wg1/338.htm)*

- *Ruosteenoja et al., 2003: Future climate in world regions: an intercomparison of model-based projections for the new IPCC emission scenarios. The Finnish Environment 644, Finnish Environment Institute, 83 pp. (http://ipcc-ddc.cru.uea.ac.uk/asres/scatter_plots/scatterplots_home.html)*

2.1.2. Changes in Finland

The Finnish climate is milder than that of most continental regions in the same latitude range (60–70N). The basic features of the Finnish climate also include variations between days, years and decades. Finnish nature has adapted itself to this variation in weather and climate. Modern society aims to control the risks caused by weather and climate variation through anticipation and planning. Indeed, adaptation to the variations of the present climate and preparation to climate change are in certain respects similar problems.

The annual mean temperature of Finland has increased by approximately one degree since the middle of the 19th century. Warming has been most intense in the spring months. The mean temperature in March, April and May is currently approximately two degrees higher than in the middle of the 19th century. Temperatures have rapidly increased since the 1970s, particularly in winter. The daily range of temperature variation has also become narrower, which is probably attributable to increased cloudiness. Trends have been observed in many other variables describing the climate (such as precipitation and wind), but these cannot be statistically distinguished from natural climatic variation.

The Finnish Research Programme on Climate Change (SILMU, 1990–1995) has prepared scenarios for climate change in Finland (Carter et al., 1996). These scenarios have been widely used when studying the potential impacts of climate change (Kuusisto et al., 1996). The most recent climate scenarios for Finland were prepared by the FINSKEN project[6], which used the latest emission scenarios and model tests (Jylhä et al., 2004).

Most climate scenarios are prepared on the basis of changes in mean temperature, mean precipitation, etc. (Carter et al., 1996; Jylhä et al., 2004). However, changes in the variance of climate variables may also have a great impact on the intensity and/or frequency of extreme situations (*Figure 2.2*), sometimes even greater than that of changes in the averages. Society and the environment may be particularly vulnerable to changes in extreme weather and climatic conditions, such as growing frequency of heavy rains.

[6] FINSKEN - Developing consistent global change scenarios for Finland, 1999–2002. Climate scenarios have been prepared for four SRES emission scenarios (Appendix 1) and cover the periods 2010–39, 2040–69 and 2070–99. http://www.ymparisto.fi/default.asp?contentid=90548&clan=EN

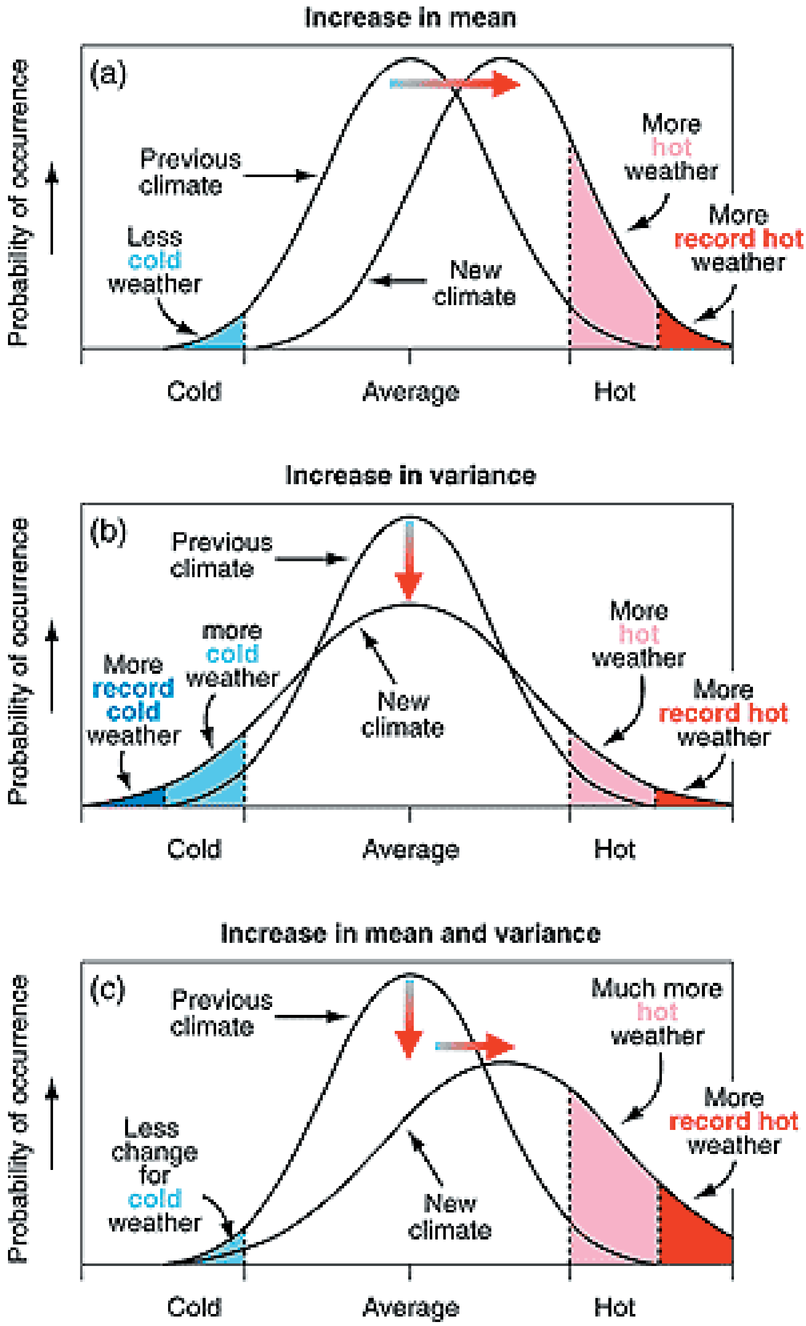

__Figure 2.2.__ Schematic showing the impact on extreme temperatures when: (a) the mean temperature increases, (b) the variance increases, and (c) when both the mean and variance increase.
Source: http://www.grida.no/climate/ipcc_tar/wg1/088.htm.

Some of the impacts of climate change appear in the short-term, some only after several decades. Due to the different time spans, mutually supplementary methods are required for the preparation of climate scenarios and forecasts. The accuracy of climate data available for different time spans varies, as do the factors causing inaccuracy.

Period 2005–2010

The greenhouse effect will only be slightly intensified over such a short time span, and any changes in Finland cannot be distinguished from natural climatic variation. Interannual variation of the weather and climate cannot usually be predicted[7]. The climate during this period can be best estimated by using climate statistics. Preparedness and risk management must be based on climate statistics calculated on the basis of empirical data (recurrences, regional distributions). It should be noted that many of the current societal calculations used within different areas of application (such as construction standards) are generally based on official climate data for the normal period 1961–1990, which apparently does not even match the current decade 2001–2010 too well in terms of for example, temperature conditions (Räisänen and Alexandersson 2003). Data describing the current climate and used for planning should be based on an appropriate normal period[8] and utilise the latest methods of observation and analysis.

Significant changes can be observed in the Finnish climate, and these are to some extent similar to the changes predicted by the models (Tuomenvirta 2004). Experienced climatic fluctuations, such as the mild winter temperatures of the 1990s, provide empirical data on how well or how badly we have adapted to climate changes and extreme conditions. This data should be used when preparing for expected greater changes in the climate.

Regardless of climate changes, the vulnerability of society to weather and climate factors may increase. For example, an increased amount of built-up land areas increases the risk of damage caused by short-term heavy rainfall. Increased traffic also increases vulnerability to interruptions and accidents caused by weather.

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[7] Climate forecasts covering several weeks or months are being prepared (for example, by NOAA and ECMWF), but their usability in Finland is limited for the time being. The forecasts are most often specified in terms of probabilities and intended for authorities or businesses, e.g. the energy sector.
[8] The Finnish Meteorological Institute has produced statistics also for the period 1971–2000. http://www.fmi.fi/saa/tilastot_100.html

Period 2010–2030

During this period, increased concentrations of atmospheric greenhouse gases will impose a constantly increasing warming impact on the climate. The temperature and precipitation scenarios (*in Figures 2.3 and 2.4)* differ from the climate of the 1961–1990 period (Jylhä et al., 2004). On the other hand, natural climatic variation remains in the same order of magnitude as the predicted changes (compare the scenarios with the bars representing natural variation in Figures 2.3 and 2.4). This means that during the 2010–2030 period in Finland, natural climatic variation may significantly suppress or intensify the background changes caused by the intensification of the greenhouse effect.

No scenario has been prepared in Finland for the climate of the next few decades, because methodological development is required before complex climate scenarios (describing several variables and their extremes) can be prepared. It is not self-evident how the distributions of climate variables describing the current climate should be modified to describe the climate of the period under review. The problem is slightly simplified by the fact that during this period the climate changes caused by different SRES emission scenarios are very similar to each other. The use of probabilities to describe the climate during this period could be a potential method applicable to the assessment of the impacts.

With different emission scenarios, the models produce a very similar development in mean temperature towards the 2030s (*Figure 2.3*). However, this does not mean that emission restrictions could safely be postponed until 2030; instead, restrictions must be initiated immediately if we want to mitigate the climate change expected in the latter half of the century.

Period 2030–2100

Increased concentrations of atmospheric greenhouse gases will significantly change the world's climate during this period. In this case, climate model simulations[9] are the best

[9] Simulations performed using climate models provide a versatile and physically uniform picture on climate changes (temperature, atmospheric pressure, precipitation, cloudiness, radiation, humidity, wind, snow cover). The use of regional climate models has become more common in recent years and produced more results with regard to changes

tool for estimating Finland's future climate. The FINSKEN project prepared a climate scenario for Finland using results from global climate models (Jylhä et al., 2004). Towards the end of the century, the average changes caused by different emission scenarios differ from each other (*Figures 2.3 and 2.4*). The greatest emissions cause the greatest changes in temperature and precipitation both in Finland and globally. Jylhä et al. (2004) have prepared scenarios for the changes in Finland's temperature and precipitation in different seasons. Temperatures will increase in all seasons, particularly in winter. Precipitation will also increase especially in winter. The total precipitation in summer will probably only change slightly and, according to some modelling results, may even decrease.

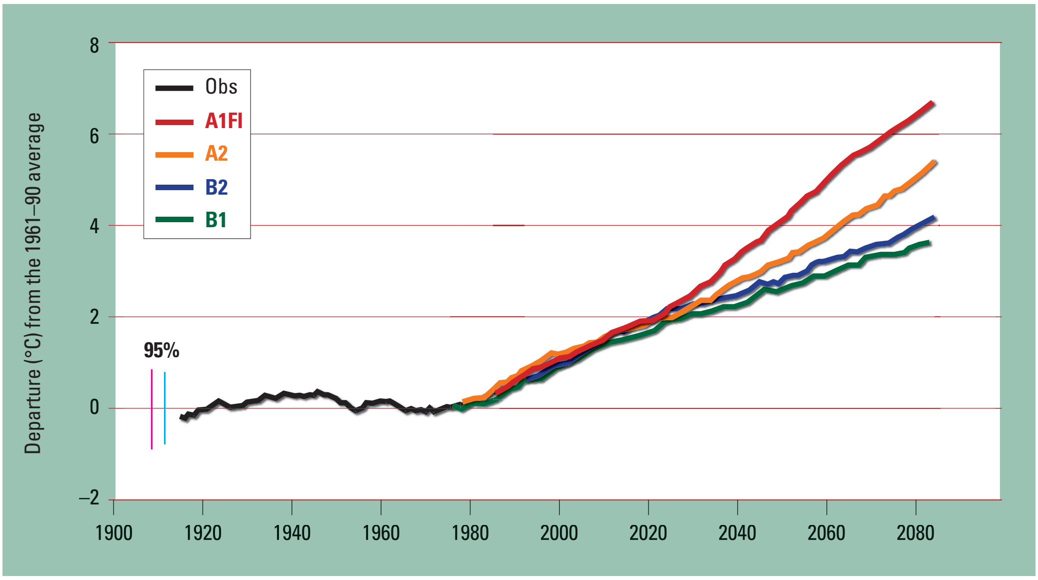

Figure 2.3. *Changes in Finnish mean temperature as deviations from the average in 1961–1990. The curves represent 30 year rolling averages.Observed changes (thick black curve) and the different FINSKEN scenarios (A1FI, A2, B2 and B1) as an average of four climate models. The vertical bars (purple and blue) represent natural climate change between 30 year periods, indicating the 95% range of variation in two different model tests. Note! The partially overlapping uncertainty ranges of the different scenarios are presented in Table 2.1.*

The trends of some climate variables observed in recent decades may even be opposite to the estimated changes caused by increases in greenhouse gases during the latter half of the current century. Differences between the observed changes and the climate scenarios may be due to the fact that trends caused by the intensified greenhouse effect remain fairly weak in comparison to natural climatic variation. All of the impacts will not necessarily be linear in time. For example, increased winter temperatures are estimated to cause reduced maximum spring runoff into water systems in the latter half of the current century even though precipitation is on the increase (Kuusisto et al., 1996). However, it is possible that increased winter precipitation in Northern Finland, combined with initially minor increases in temperature, could lead to an increased risk of spring flooding during the next few decades (Tammelin et al., 2002).

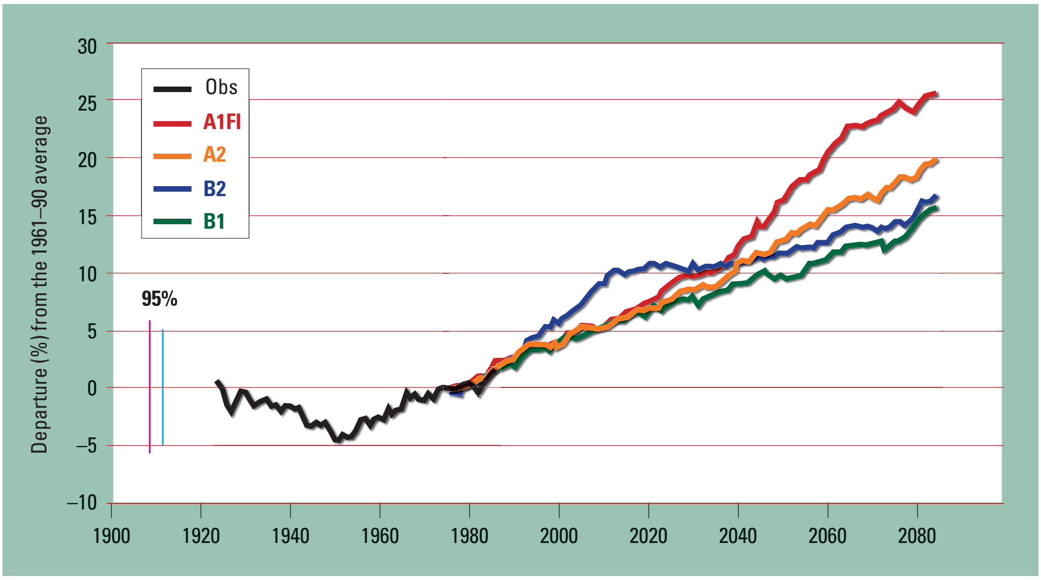

Figure 2.4. *Changes in Finnish mean precipitation as relative deviations from the average in 1961–1990. The curves represent 30 year rolling averages. Observed changes (thick black curve) and the different FINSKEN scenarios (A1FI, A2, B2 and B1) as an average of four climate models. The vertical bars (purple and blue) represent natural climate change between 30 year periods, indicating the 95% range of variation in two different model tests. Note! The partially overlapping uncertainty ranges of the different scenarios are presented in Table 2.2.*

More information on expected climate changes in Finland can be found in the following publications:

- *Jylhä et al. 2004, Climate change projections for Finland during the 21st century. Boreal Env. Res., 9, 127-152. (http://www.borenv.net/BER/ber92.htm)*
- *Räisänen, J., 2001: The impact of increasing carbon dioxide on the climate of northern Europe in global climate models (in Finnish). Terra, 113, 139-151. (http://www.helsinki.fi/maantiede/geofi/terra/terra113_3.html)*
- *Carter, T. R., Fronzek, S. & Bärlund, I. 2004: FINSKEN: a framework for developing consistent global change scenarios for Finland in the 21st century. Boreal Env. Res. 9: 91–107. (http://www.borenv.net/BER/ber92.htm)*
- *PRUDENCE, 2004: http://prudence.dmi.dk/index.html*

2.1.3. Changes in Finland in detail

This section provides more detailed information on climate change in Finland. The description is based on different studies, whose estimates are not completely mutually comparable or where the periods under review vary. The assessment of such inaccuracies is not systematic either. Most of the studies reported are based on a single emission scenario or model, or at most a handful of scenarios or models, except for Tables 2.1 and 2.2, representing the FINSKEN scenarios. They are backed by a multitude of climate models and a wide range of greenhouse gas and particle emission scenarios for the future.

Atmospheric temperature

One of the most obvious changes anticipated by the climate models is increasing temperature. This is also evident in the FINSKEN scenarios prepared for Finland: the climate will become warmer in all of the climate model tests and emission scenarios (*Table 2.1*). Natural climatic variation and differences between the models cause an uncertainty range of slightly less than two degrees in the annual mean temperature change predictions for the period 2010–39. Uncertainty increases towards the end of the century when the greenhouse gas concentrations resulting from different emission scenarios begin to deviate from each other.

Carter (1998) has calculated changes for the duration of the growing season[10] on the basis of SILMU scenarios. According to the SILMU central scenario, the growing season will be extended by some four weeks in Southern Finland by the middle of the century, slightly less in the north. Førland et al. (2004) estimate that the growing season in Finland will be extended by some 20 days between the periods 1961–1990 and 2021–2050. The effective temperature sum in Finland will probably increase by almost 25%. According to a study by Räisänen et al. (2004), if the A2 scenario is realised, the growing season in our country will be extended by some 40

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[10] The growing season begins when snow cover disappears from open areas, the mean daily temperature remains above +5 degrees for a minimum of five consecutive days and the sum of the mean daily temperatures in the following 5 day period is at least 20 degrees. The growing season ends when the mean daily temperature drops below +5 degrees or snow cover falls or temperatures below –10 degrees occur. In climate model studies, the growing season is usually defined only by means of the +5 degree limit.

Table 2.1. Changes in mean temperature (°C) in Finland in four FINSKEN scenarios compared to the normal period 1961–1990 (Jylhä et al., 2004). In addition to the average of the model results, the table presents the minimum and maximum change indicated by individual executions of the model in brackets. The rightmost column indicates the range of variation covered by all of the four scenarios combined.

DECEMBER-JANUARY-FEBRUARY

Period	A1FI *	A2	B2	B1 *	All
2010–39	2.7 (1.6–5.0)	2.2 (1.2–4.5)	2.6 (1.8–4.4)	2.5 (1.8–3.8)	(1.2–5.0)
2040–69	6.2 (4.2–7.8)	4.6 (3.4–6.0)	3.2 (2.0–5.7)	3.3 (2.3–4.8)	(2.0–7.8)
2070–99	9.1 (7.6–10.9)	6.8 (5.9–8.7)	5.1 (3.8–7.4)	4.9 (3.7–6.0)	(3.7–10.9)

MARCH-APRIL-MAY

Period	A1FI *	A2	B2	B1 *	All
2010–39	2.4 (1.1–3.7)	2.1 (1.1–3.4)	2.2 (1.1–4.2)	2.2 (1.3–3.7)	(1.1–4.2)
2040–69	4.8 (2.9–7.8)	3.6 (2.3–6.2)	3.0 (1.7–5.9)	3.2 (1.5–5.9)	(1.5–7.8)
2070–99	7.4 (4.4–11.7)	5.6 (3.5–9.4)	4.4 (2.8–8.1)	4.1 (2.2–6.9)	(2.2–11.7)

JUNE-JULY-AUGUST

Period	A1FI *	A2	B2	B1 *	All
2010–39	1.2 (0.7–1.6)	1.2 (0.6–1.6)	1.3 (1.1–1.5)	1.2 (1.0–1.5)	(0.6–1.6)
2040–69	2.8 (2.0–3.9)	2.1 (1.6–2.5)	1.9 (1.3–2.2)	1.8 (1.1–2.2)	(1.1–3.9)
2070–99	4.1 (3.0–5.5)	3.4 (2.4–4.3)	2.5 (2.0–3.2)	2.4 (1.6–3.1)	(1.6–5.5)

SEPTEMBER-OCTOBER-NOVEMBER

Period	A1FI *	A2	B2	B1 *	All
2010–39	2.2 (1.5–2.8)	1.8 (1.1–2.6)	1.7 (0.9–2.9)	1.8 (1.3–2.5)	(0.9–2.9)
2040–69	4.1 (3.5–5.2)	2.9 (2.1–4.0)	2.4 (1.5–3.6)	2.4 (1.8–3.0)	(1.5–5.2)
2070–99	6.4 (6.0–7.1)	4.5 (2.9–5.6)	3.3 (2.1–4.4)	3.0 (2.2–3.6)	(2.1–7.1)

ANNUAL

Period	A1FI *	A2	B2	B1 *	All
2010–39	2.1 (1.5–3.1)	1.8 (1.3–2.8)	2.0 (1.5–2.8)	1.9 (1.5–2.4)	(1.3–3.1)
2040–69	4.5 (3.8–5.2)	3.3 (2.9–4.0)	2.6 (2.1–3.7)	2.7 (1.8–3.5)	(1.8–5.2)
2070–99	6.8 (5.6–7.4)	5.1 (4.4–5.9)	3.8 (3.0–5.0)	3.6 (2.4–4.4)	(2.4–7.4)

* The estimates are based on a smaller number of climate model tests compared to the A2 and B2 scenarios.

days towards the end of the century, corresponding to approximately ten days per one degree of warming.[11]

One way of illustrating temperature changes in the late autumn and early spring, and in Southern Finland also in the winter, is by the change in the number of frost days. Days with temperatures below 0 °C (frost days) will become less common. The A2 and B2 model tests conducted in the PRUDENCE project[12] indicate that at the end of the century, Finland will have 40 to 80 frost days less than at present.

Kjellström (2004) studied the changes in temperature distributions in Northern Europe from the period 1961–1990 to the period 2071–2100. In summer, the mean temperature and temperatures above and below it will increase almost equally (*as indicated by Figure 2.2a*). In winter, however, warming will take place so that the coldest part of the distribution warms up more than the mean, moving the distribution to the right and shortening the "cold end". For example, when the median of winter temperatures in Finland increases by 6–8 °C, temperatures having a probability of occurrence of less than 5% will increase by at least 9–11 °C (thus the distribution will become narrower, contrary to Figure 2.2c).[13]

Water temperature

Climatic warming will naturally affect the temperature of inland waters as well. During the open water season, the impacts can be seen in the surface layers of waters, in water stratification, as well as in the hypolimnion. According to the results of the SILMU research programme, the mean temperatures of surface water, and in particular the highest temperatures, will increase. For some lakes, the highest temperatures may increase by more than 5 °C during the current century. The mean temperature of the epilimnion will increase almost as much as the atmospheric temperature.

[11] Descriptions of the current climate (1961–90) and future climate (2070–99) created by the Rossby Centre using a regional climate model (RCAO). The descriptions were created for HadCM3 and ECHAM4 climate simulations in which the atmospheric greenhouse gas and particle concentrations changed in accordance with the A2 and B2 scenarios. Reference: Räisänen et al. (2003)

[12] The PRUDENCE project simulated the atmospheric conditions of the periods 1961–90 and 2070–99 on the basis of scenarios A2 and B2 using several different regional climate models. The model tests by the Rossby Centre are part of the PRUDENCE project (Reference: http://prudence.dmi.dk/).

[13] The numerical values in the example are taken from a RCAO-ECHAM4 simulation of the A2 scenario (Kjellstöm, 2004).

Ice conditions

At present all Finnish harbours are frozen at least part of the time during normal winters. In front of Kemi the sea is frozen for the average of 183 days and in Kotka for 120 days ("ice-winter") (Meier et al., 2004). The entire Baltic Sea may be covered with ice during very severe winters.

The time series describing the greatest annual extent of Baltic ice cover starts in 1720. According to observations, the maximum extent of the ice cover has a strong correlation with atmospheric temperature and atmospheric flow conditions (for example, Omstedt and Chen, 2001). The first estimates on the expected changes in Baltic ice cover caused by increased greenhouse gases were prepared with the help of a model based on the statistical dependence between the ice cover and atmospheric temperature (Tinz 1996, Venäläinen et al., 1999). According to studies, the severity of winter periods with frozen sea will significantly decrease towards the end of the century. It has been estimated, on the basis of changes in the extent of ice, that the operating season of icebreakers will be shortened (Venäläinen et al., 1999). Räisänen et al. (2003) present the most recent estimates of the change in the extent of ice cover.[11] The maximum ice cover in winter will decrease to 54–80% of the present, depending on the model and scenario.

The extent of ice cover alone does not tell us everything about the impacts of ice conditions on navigation and marine ecology. Physical sea-ice models have been developed in order to provide a more detailed estimate of changes in the ice cover, and these are linked to a climate model (Haapala et al., 2001; Meier, 2002). In addition to the extent of ice, such models provide information on the duration of the ice-winter, the thickness of ice and its properties.

On the basis of climate simulations describing the end of the century[14], it is estimated (Tuomenvirta et al., 2000b) that the time of freezing will be postponed by less than one month in the northern part of the Gulf of Bothnia, and by approximately one month in the southern parts of the Finnish coast. The time of melting will be almost

[14] Ten-year climate descriptions for the present time and the end of the century conducted on a previous version of the Rossby Centre's regional climate model (RCA). The descriptions were carried out on the HadCM2 (and ECHAM4) climate simulations where the greenhouse gas concentrations in the atmosphere changed in accordance with the IS92a scenario. Reference: Räisänen et al. (2000)

one month earlier than at present in the southwest, and several weeks earlier than at present in the northern part of the Gulf of Bothnia. Towards the end of the century, the duration of the ice-winter will have shortened to one-half of the present on the southwestern and southern coasts of Finland, and to 70–80% of the present in the Gulf of Bothnia. According to simulations, the mean thickness of ice at Kotka, Oulu and Turku harbours will decrease by 10–20 cm, and the annual maximum thickness will decrease by some 30 cm. Meier et al. (2004) reported similar results. Simulations[11] indicate that the maximum thickness of ice in the middle part of the Gulf of Bothnia will decrease by 50% (60%) in scenario B2 (A2). Ice-winters will vary between different years also in the future, but severe winters by present standards will occur less frequently. Ice will probably be found in the eastern part of the Gulf of Finland and the northern part of the Gulf of Bothnia every winter. Because the modelling of different types of ice depends on wind conditions, among other things, it is difficult to estimate changes in the occurrence of heavy-pack ice or stacked ice that cause problems for navigation.

The period of ice cover on lakes will become shorter all over Finland. According to the results of the SILMU research programme, lakes will freeze a few weeks later than at present in the autumn at the end of the century, and ice cover will disappear a month or two earlier than at present in the spring. The ice conditions on large lakes in Southern Finland will become unstable in midwinter as well. The thickness of ice on lakes depends a great deal on snow cover.

Precipitation

Climate change is expected to increase precipitation. Table 2.2 presents changes in precipitation in different seasons, calculated by the FINSKEN project on the basis of four SRES scenarios and three 30 year periods. The greatest average increases in precipitation can be seen in the A1FI scenario, but random climatic variation is so extensive that it partly conceals the differences between the scenarios, particularly during the period 2010–2039. According to the estimates, rainfall will increase the most in winter. Some models actually predict that precipitation in the summer will slightly decrease.

Table 2.2. Changes in precipitation in Finland under four FINSKEN scenarios compared to the normal period 1961–1990 (Jylhä et al., 2004). In addition to the average of the model results, the table presents the minimum and maximum change indicated by individual executions of the model in brackets. The rightmost column indicates the range of variation covered by all of the four scenarios combined.

DECEMBER–JANUARY–FEBRUARY

Period	A1FI *	A2	B2	B1 *	All
2010–39	16 (5–36)	9 (-1…32)	11 (1–26)	11 (4–23)	(-1…36)
2040–69	31 (18–57)	20 (7–44)	13 (4–32)	13 (5–27)	(4–57)
2070–99	43 (23–76)	28 (14–60)	20 (7–49)	22 (12–40)	(7–76)

MARCH–APRIL–MAY

Period	A1FI *	A2	B2	B1 *	All
2010–39	4 (-1…16)	6 (-2…16)	12 (2–25)	10 (1–14)	(-2…25)
2040–69	18 (7–37)	14 (2–29)	12 (1–27)	13 (1–26)	(1–37)
2070–99	28 (11–56)	21 (8–44)	17 (5–31)	16 (4–34)	(4–56)

JUNE–JULY–AUGUST

Period	A1FI *	A2	B2	B1 *	All
2010–39	9 (4–13)	4 (-5…12)	4 (-7…17)	5 (2–9)	(-7…17)
2040–69	11 (41–9)	7 (31–4)	4 (-14…18)	7 (1–10)	(-14…19)
2070–99	11 (6–13)	3 (-8…12)	5 (-3…14)	12 (7–17)	(-8…17)

SEPTEMBER–OCTOBER–NOVEMBER

Period	A1FI *	A2	B2	B1 *	All
2010–39	7 (2–15)	6 (1–14)	7 (3–15)	5 (0–-13)	(0–15)
2040–69	16 (8–29)	12 (6–23)	8 (4–18)	8 (2–-16)	(2–29)
2070–99	26 (14–35)	15 (8–28)	15 (3–31)	15 (8–-25)	(3–35)

ANNUAL

Period	A1FI *	A2	B2	B1 *	All
2010–39	9 (4–14)	6 (2–13)	8 (3–16)	7 (3–14)	(2–16)
2040–69	18 (9–28)	12 (7–21)	9 (1–20)	10 (4–17)	(1–28)
2070–99	26 (14–37)	15 (8–29)	14 (6–28)	16 (8–22)	(6–37)

* The estimates are based on a smaller number of climate model tests compared to the A2 and B2 scenarios.

The warmer atmosphere of the future may contain more humidity than at present, which will allow for increased heavy rain. According to climate models, the intensity of rain will increase in extensive areas, and torrential rain will become more common. Calculations on the changes have been conducted in several studies presented below.

- Tuomenvirta et al. (2000a) studied changes in major precipitation in Finland for the purpose of designing dams. By the end of the century, the 1, 5 and 14 day regional maximum precipitations[15] will increase by 35–65% in regions corresponding to the grid square of the climate model test (180 x 280 km^2), in smaller regions even more so. The calculations are based on a simulation performed using a single climate model during the mid-1990s, which did not account for the effect of, for example, particle emissions.
- Räisänen and Joelsson (2001) studied changes in major precipitation using a regional climate model[14] with a grid square of 44 x 44 km^2. The greatest daily precipitation during a year increased by almost 20% on average in Northern Europe in the latter half of the century. The greatest accumulated precipitation in six hours increased by more than 20%. In a corresponding study based on the most recent regional model results[11], annual precipitation increased by 13–31%, while the differences between different models were greater than the differences between different emission scenarios (Räisänen et al., 2003 and 2004). The number of rainy days (precipitation >1 mm/day) increased by 5–18%. The greatest daily precipitation during a year increased by 13–19%, and increases were shown in all the model tests and for all seasons (J. Räisänen, personal communication).
- The PRUDENCE project[12] calculated 5 and 15 year return periods for 5 day aggregate rain under several climate simulations with the A2 scenario (Beniston et al., 2004). The present 15 year return periods in winter in Northern Europe were similar to 5 year return periods at the end of the century. The intensity of rain will increase also in the summer season. For example, the greatest daily accumulation of rain will increase by 10–20%, in some experiments by more than 30%.

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[15] Maximum regional precipitation is used to assess dam safety. It is a calculated figure determined on the basis of research data, in this case a 30 year climate simulation. It represents precipitation with a local recurrence frequency of 10,000 years. (Dam safety, 1997).

The PRUDENCE project also examined changes in the duration of rainless periods. In many experiments, increased precipitation in Finnish winters is also associated with an increased number of rain days, which reduces the duration of rainless periods. The research results are conflicting in spring and summer seasons. In some model tests, dry periods become shorter, but in most tests there is no significant change or dry periods become longer. When taking into account the fact that increased temperature increases evaporation, it is possible that periods leading to intensive drying of the soil will become more common.

Estimates of the change of precipitation involve a lot of uncertainty. The rain processes are not described in detail in the numerical models, and natural variation of precipitation is high, which obscures the signal caused by climate change. The results obtained for Finland are similar in different studies, but the numerical values vary between model simulations.

Snow cover and ground frost

Warming in the winter season leads to reduced snow cover in the Northern Hemisphere. The climate experiments of the PRUDENCE project[12] show that the number of days with annual snow cover will decrease by 20–40% in the second half of the century when examining Finland as a whole. There are regional variations in the changes depending on temperature and changes in precipitation. In regions where the present mean temperature of winter months is higher than approximately minus 5 degrees, such as Southern and Southwest Finland, the changes in the duration and thickness of snow cover are great. On the other hand, snow cover in Northern Finland in midwinter is more sensitive to changes in precipitation than temperature. Despite increased winter rain, the period of snow cover in Northern Finland will shorten by more than one month due to warmer autumns and springs, according to Räisänen et al. (2003), and snow depth in midwinter will decrease by some 30% towards the end of the century.[11] Changes will be greater in Southern Finland, because a substantial amount of precipitation will be in the form of water also during winter months. The period of snow cover will be shortened by some two months, and snow depth in midwinter will reduce to about one-third of that at present. Venäläinen et al. (2001b) arrived at similar results when examining a separate model describing the soil and snow cover in addition to climate simulations[14].

Venäläinen et al. (2001a) studied expected changes in the thickness of ground frost in the latter half of the century on snow-free surfaces such as roads and the built-up environment where the formation of ground frost decreases with increases in temperature. The experiments[14] indicate that the annual maximum depth of ground frost on snow-free surfaces will decrease by 30–50% in Southern and Central Finland and 50–70% in Northern Finland by the end of the century.

Snow cover is an efficient thermal insulator that retards ground frosting. Venäläinen et al. (2001b) estimated changes in ground frost in forests at the end of the century.[14] The combined effect of reduced snow cover and increased temperature has different impacts on ground frost in different parts of Finland. The increase in temperature will be so great in Northern Finland in the winter that ground frost will clearly decrease even though snow cover will also become thinner. At present, snow cover significantly restricts ground frost in Eastern Finland. A scenario test in this region indicates that the decrease in snow cover will almost counterbalance the impact of increased temperature on ground frost. The result is only a slight decrease in ground frost thickness. As the mean temperature increases, the current continuous period of snow cover in Southern and Western Finland will turn into a series of consecutive short periods of snow cover. The probability of a period with subzero temperatures coinciding with a period with no insulating snow cover on the ground will also increase. According to model results, the mean ground frost layer in Southern and Western Finland will become only slightly thicker, but frost may penetrate deeper than present during severe winters.

Windiness and solar radiation

Cubash et al. (2001) note that in several model simulations of the future the occurrence of cyclones will become more common. However, the results vary substantially between climate models. Estimates on the change of mean wind velocity in Finland depend on the model, and even the direction of change varies (Räisänen et al., 2003 and Tammelin et al., 2002). Regional climate models indicate that in the Baltic Sea region the wind velocity in winter will increase as the extent of ice on the sea is reduced.

The assessment of changes in solar radiation reaching the Earth's surface requires data on changes in cloudiness. For the time being, the description of cloudiness in climate models involves a great deal of uncertainty (McAvaney et al., 2001).

2.2. Socio-economic scenarios in Finland

2.2.1. Introduction

Climate change will affect the economy in many ways and present various needs for adaptation. The costs of adaptation will crucially depend on economic development, the prosperity of the economy and its ability to adapt to climate change on the one hand, and on the mitigation of climate change on the other. One of the central issues for the Finnish economy over the next few decades will be the development of its population structure, which will affect productivity and economic growth as well as the costs of attending to the population's welfare. Climate change will modify the general preconditions under which the economy functions. However, the direct impacts of climate change will vary by industry. Some sectors in Finland are estimated to benefit from climate change, while other sectors will face new expenses. Some of the impacts of climate change are difficult to allocate to any specific industry.

Climate change could affect Finland through the global economy in two ways. The intensity of climate change as such depends on the development of the global economy, but if climate change starts to affect the global economy, the impacts will also be reflected in Finland. On the other hand, actions to prevent climate change may limit economic growth but might also create new opportunities for Finnish industry.

No comprehensive assessments on the economic impacts of climate change adaptation in Finland have been prepared yet. The SILMU programme assessed the impacts of climate change on some sectors. The costs of adaptation to climate change and the combined impacts of adaptation and limiting emissions in order to prevent climate change have not yet been assessed.

A separate study by the Government Institute for Economic Research reviews the long-term development opportunities of Finland's economy starting from crucial structural factors.[16] The primary purpose of the study is to combine existing estimates on the impacts of climate change and structural development factors of the economy into coherent compilations that can be used as a reference point in further studies assessing adaptation to climate change and the costs of prevention, rather

[16] A separate study will be published in early 2005 in the VATT publication series.

than producing estimates on the costs of adaptation. The study also provides background information for assessing the combinations of adaptation measures directed at different sectors. The calculations do not assume any active adaptation to climate change or assess the significance of mitigation measures.

2.2.2. Alternatives under review

Economic development is primarily assessed from the viewpoints of the global economy, Finland's population development and the development of employment and productivity. The starting point of the review is the WM scenario (With Measures scenario), assessing the development of the economy until 2025. The WM scenario has also been used as the basis for the national plan for distributing greenhouse gas emission rights prepared in August 2004. The basic alternative in this review assumes that the economy will follow the WM scenario until 2025. After this, economic development will be largely dictated by the development of export demand, employment and productivity. The differences in productivity between different sectors are assumed to become more balanced after 2025, but in the basic alternative, it is assumed that the global market, employment and growth of productivity will remain at a high level.

Economic starting points for the WM (With Measures) scenario

- The WM scenario assumes that the national economy will grow at an average rate of 2%
- Growth will be faster in the beginning of the period and slow down towards the end.
- The national economy will become increasingly service-oriented.
- The industrial structure will become lighter as the process industry grows more slowly than other industries.

In the two alternative scenarios, employment and productivity are allowed to vary in comparison to the Basic scenario. The scenarios also differ from each other in terms of the rate and impacts of global economic development and climate change. The scenarios can be briefly described as follows:

- Basic scenario: the development of the global economy and exports is a continuation of the WM scenario, productivity development by age group is rapid, employment rate will increase to 75% by 2020.
- Regressive Finland: the development of the global economy and exports slows down after 2025 in comparison with the WM scenario, employment rates by age

group will remain at the current level by 2020, productivity development will be mediocre.
- Alternative Finland: the global economy and exports develop favourably, technology and consumption are focused on less energy-intensive products and services, employment rates will regain the pre-recession level by 2020, the growth of productivity will remain lower than in the Basic scenario but will be more rapid than in the regression scenario.

The scenarios are combinations of assessments of the development of the global economy, the climate, as well as Finland's economy and population. These background factors are described in more detail in the following.

Assumptions regarding the international economy

Several studies have provided different kinds of estimates on the long-term development of the global economy. These studies have assessed the development of factors such as energy consumption, security of supply or the energy system (for example, studies by the International Energy Agency – IEA), but also other issues crucial to sustainable development (for example, studies by the International Monetary Fund – IMF). The EU has also provided estimates on the development of the economy and energy consumption over the next few decades. The IPCC has compiled general economic scenarios for different groups of countries. The applicability of the scenarios presented in the literature with regard to studies concerning Finland is somewhat limited, because of their partly qualitative nature, but they can be used to support the estimates of the development of export demand. The assumptions regarding the development of the global economy used in this study are based on the IPCC scenario families (Appendix). The development of the global economy is reflected in Finland above all through the development of export demand, which differs between the IPCC scenario families. The IPCC scenario families are also useful for estimating the connection between economic development and climate change. Climate change is experienced differently in the different economic scenarios of the IPCC, depending on economic growth and technological development.

The essential differences between the IPCC scenarios arise from the assumptions made with regard to the openness of global trade and the possibilities of technology transfer, the distribution of prosperity between countries and groups of countries, and ultimately the compatibility of the global economic trend with sustainable development. Different combinations of these characteristics underlie the four IPCC scenario families, which include:

A1 – An open global economy with rapid technological change.
A2 – A world of blocs with haphazard resistance to change.
B1 – A consciously eco-efficient high-tech world.
B2 – A world of local communities and selective technological development.

This study examines the first three scenario families. Climate change is experienced differently in each scenario, but the differences emerge slowly and only become clearer after 2050. The scenarios are described in more detail below.

A1 – An open global economy with rapid technological change

This scenario mostly corresponds to the Basic scenario of this study. In this scenario, all countries take part in economic cooperation, resulting in the rapid development of the global economy and the diffusion of economic efficiency through cooperation also for developing countries. The distribution of prosperity leads to a slowdown in population growth on a global scale after 2060. Technology will develop rapidly and innovations will be distributed quicker than at present. Technology is mainly used to respond to the requirements of sustainable development. This scenario has the greatest rate of growth in the gross domestic product per capita. The development of greenhouse gases varies strongly between scenario variants. The emissions of greenhouse gases could remain relatively low if technological development improves eco-efficiency. However, this scenario family does not assume eco-efficiency to be a crucial political objective, and thus it is possible that emissions will be higher than in the B1 scenario and climate change will be more rapid.

A2 – A world of blocs with haphazard resistance to change

This scenario mostly corresponds to the Regressive Finland scenario of this study. In this scenario family, the development of the global economy is not as favourable as in the A1 scenarios. The main reason for this is the division of the world into trading blocs, each promoting their own particular interests, which will retard economic development and the increased prosperity of developing countries. The diffusion of technology is not as rapid as in the A1 scenarios either. Slow improvement in prosperity will lead to a higher rate of population growth compared to the A1 scenarios, which will be reflected in higher emissions than in the B1 scenarios and, in general, higher burden on the environment.

B1 – A consciously eco-efficient high-tech world

This scenario mostly corresponds to the Alternative Finland scenario of this study. In this scenario family, economic cooperation is intense, which creates the prerequisites for economic growth and the diffusion of technology, but clear environmental objectives are set for technological development. Economic growth will lag behind the A1 scenarios, and this is also the case with increased prosperity and narrowed margins between the prosperity of developing and industrialised countries, but technological development will also take an environment-friendly direction. However, the rate of economic development in this scenario family is ranked second among the scenario families, which means that the development of the global population is similar to that of the A1 scenarios. The emissions of greenhouse gases are under control in these scenarios, and climate change is not as rapid as in other scenarios.

Assumptions on the structural factors of the Finnish economy

In addition to the global market, factors essential to the development of the Finnish economy include the development of the population, employment and productivity, as well as consumer demand. The assessments of the development of the population, welfare costs and employment are based on an earlier study by the Government Institute for Economic Research VATT (Parkkinen, 2004), evaluating the possibilities of economic growth on the basis of the development of productivity, employment rate by age group, as well as welfare costs.

Population development

The population growth forecast follows the population forecast of Statistics Finland until 2030 and its continuation calculation until 2050. After 2050, the forecast is based on the assumption that trends will continue. During the first decades of the 21st century, until 2030, the population will grow by some 200,000, but will follow a slight downward trend after that. The population will be back to the current level by 2050. The calculations do not assume any strong increase in migration compared to the current level.

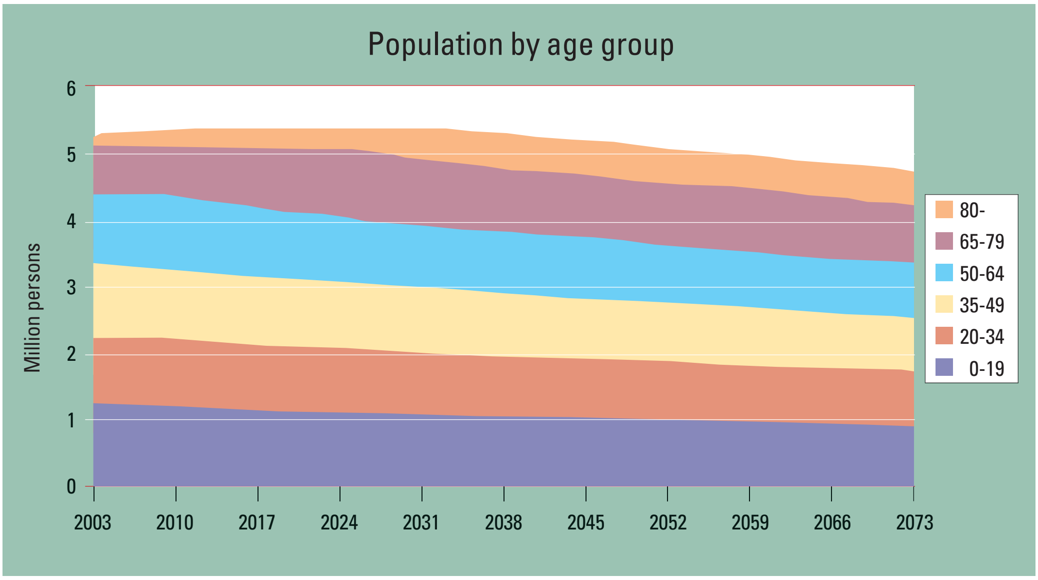

Figure 2.5. *Population forecast by age group 2003–2080.*

Employment

The starting point for employment development scenarios is the current situation. Employed labour in 2002 totalled 2.37 million people. According to a labour survey, the employment rate of 35 to 45 year olds was 85%, while the employment rate of the entire working-age population, from 15 to 64 years of age, was 67.7%. In the early 1990s, before the recession, the number of employed Finns was 2.5 million, which means an overall employment rate of 74% and a rate of more than 90% for the group at the peak working age (35 to 45 year olds). On the other hand, the employment rate was only 60% in 1994, at the time of worst unemployment, and employed labour numbered 2.05 million. There were also great differences in employment between age groups at that time.

The employment scenarios in this study are comparable to this history. The weakest employment alternative assumes that the employment rates by age group would remain at the 2002 level (Regressive Finland). In this case, the number of employed people would decrease by almost 150,000 by 2020 and by as much as 500,000 by 2050. The Alternative Finland scenario assumes that the employment rates by age group will return to the pre-recession level, which means that the number of employed people will remain unchanged until 2020 but will subsequently decrease by

250,000 by the year 2050. In the best case, the employment rate will increase to 75% by 2020, and the number of employed people increases until then, followed by a decrease to 2.2 million by 2050 (Basic scenario), representing a decrease of about 150,000 compared to the present.

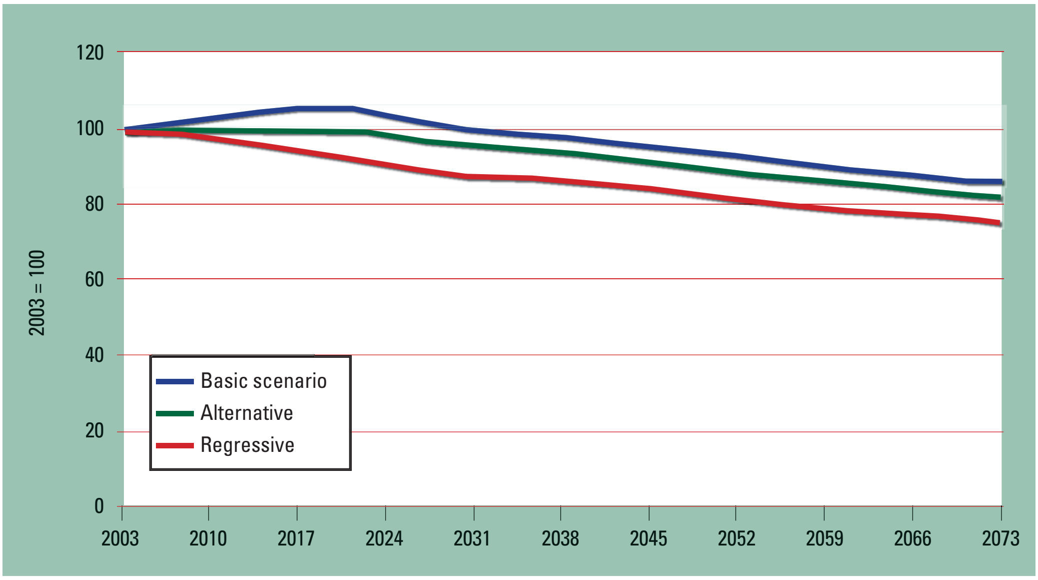

Figure 2.6. *Relative development of the employment rate 2003–2080.*

Parkkinen (2004) has also provided scenarios on the development of overall productivity. In the case of weak productivity development, the productivity of work would increase by 1.3% per year, which is slower than ever before since the last war. In Parkkinen's basic case, the productivity of work increases by 2% each year, which is a fairly slow rate in historical comparison. In the best alternative, the productivity of work is assumed to increase by 2.7% each year.

Among the scenarios of this review, overall productivity in the Regressive Finland alternative is assumed to increase slightly faster than in Parkkinen's study, amounting to some 1.6% per year during the first decades of the millennium. The average growth of productivity is initially assumed to be 2% in the Basic scenario and the Alternative Finland scenario, but after 2025, the average growth of productivity is assumed to be 2.7% in the Basic scenario and 2.4% in the Alternative Finland scenario.

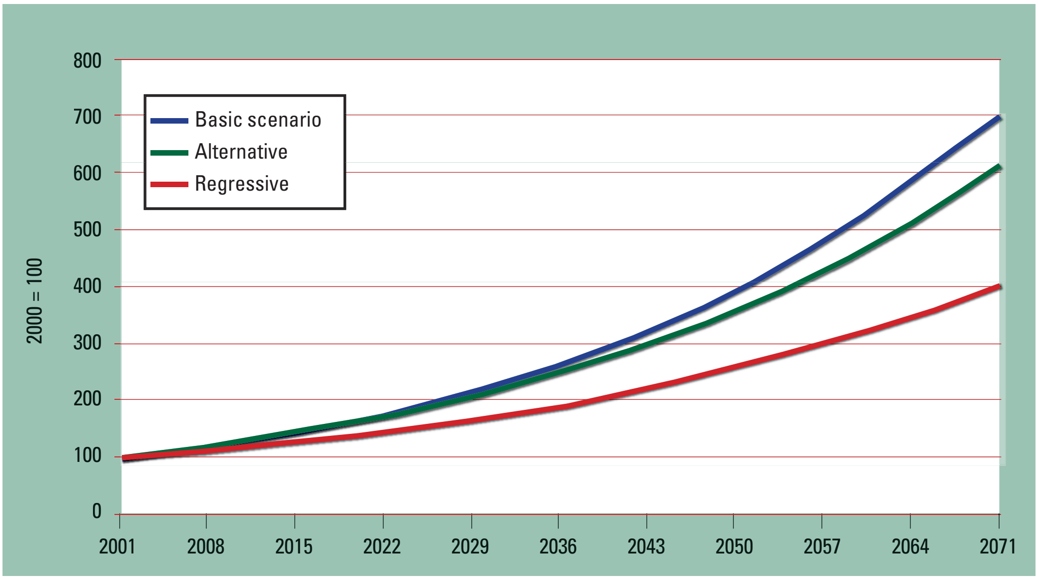

Figure 2.7. *Relative development of the productivity of work 2000–2080.*

Parkkinen (2004) also assessed the development of pension and welfare costs. The growth of these costs quite closely follows the ageing of the population. This review takes into account the effect of an ageing population on both welfare costs and taxation. However, it is possible that the increased standard of living will improve health and postpone the increase in welfare costs – people will only require health care services at a slightly older age. In this review, this alternative has been combined with the Alternative Finland scenario, where a positive connection is assumed to exist between public health and a proportionally better state of the environment.

Impacts of climate change

The review has also utilised estimates on the impacts of climate change. The estimates are based on calculations made in the SILMU research programme regarding the changes caused by climatic warming in sectors of the economy which are sensitive to climate change (Kinnunen, 1992, Kuoppamäki, 1996). The calculations only address the sectors of industry where the impacts of warming had been quantified. Potential changes in the global economy are not assessed either. This means that the assessments made in SILMU include many factors of uncertainty but are still the most comprehensive economic assessments of the impacts of climate change in Finland. In this respect, the FINADAPT research project started recently will considerably improve the knowledge base.

SILMU estimated that the warming of the Finnish climate would settle in the range of 0.1 to 0.6 degrees in a decade. The assessments of the impacts of climate change assume that climatic warming in Finland will settle at the middle of the estimated range, 0.4 degrees per decade. Estimates of more rapid warming have been presented later on, and therefore the study at hand assumes that the impacts might be greater or smaller than Kuoppamäki's estimates, depending on the development of the global economy and the associated environmental pressure originating in the economy. However, it seems clear that the impacts of climate change will not be so linear but might vary greatly depending on the intensity of warming. The assessment of the impacts obviously requires further methodological development, which is partly carried out within the FINADAPT research project.

According to Kuoppamäki's estimates, in some respects Finland is very different from other industrialised countries with regard to the impacts of climatic warming. This is based on the northern location of Finland; warming will extend the growing season, which will have a positive impact on agriculture, and the timberline will move farther north, which will probably be a benefit to forestry. The need for heating will also be reduced. The negative trends include the increased occurrence of various kinds of pests. However, biodiversity may suffer, and storminess may also increase, which increases the risk of damage to trees and various types of structures. Climate change will have quite conflicting impacts on some other sectors as well. With regard to agriculture, Kuoppamäki estimates that, in addition to the extended growing season, the increase of arable land areas in the north, due to warming, will increase the harvesting potential. This increased harvesting potential will vary by type of crop, with a 40% average. In addition to this, animal husbandry would benefit from warming as the grazing season will become longer (feed costs, animal health). Pest damage is estimated to double. However, the net benefit to Finnish agriculture would be in the order of FIM 1 to 3 billion per year at the level of 2050, based on the value of money in 1993.

With regard to forestry, warming will lead to increased growth and changes in the structure of forests. Birch is estimated to become more prevalent. The impact of warming is due to the obvious increase in growth, and Kuoppamäki estimates the total annual impact of warming to be FIM 4.4 billion, based on the value of money in 1993.

Benefits in the energy sector derive from the decreased need for heating and the increased availability of hydroelectric power. The first will probably be more significant, because the share of hydroelectric power in the total energy supply is relatively small. The decreased need for heating will lead to decreased consumption of electricity and fuels. Annual electricity consumption is estimated to be 1.5% lower in 2025 and 4.6% lower in 2100 due to warming. The overall annual impact on the energy sector is estimated to be FIM 700 million, based on the value of money in 1993.

Kuoppamäki's study does not address any other sectors. For example, warming may have very conflicting impacts on construction. Warming will decrease the requirements for thermal insulation, but increased rainfall and storminess will impose new requirements on construction. The traffic sector involves great technological uncertainties, and it is not clear whether the impacts of warming on winter maintenance are foreseeable with any significant degree of certainty. Warming can be both an advantage and a disadvantage for the tourism industry as well. The overall impact of warming on tourism would probably be negative.

Climate change can also result in increased migration, and the study estimates that an increased number of "climate refugees" would cause costs to Finland as well. The study at hand does not address this alternative.

In this review, the estimates of Kinnunen and Kuoppamäki have been used to describe the impact of climate change so that the estimated impact is introduced to the model framework as a change in productivity. This change is assumed to be experienced gradually so that the annual impacts will reach the level estimated by Kuoppamäki in 2050. However, the overall impact of climate change on the calculations remains low, as macroeconomic factors receive more emphasis in the long-term. The impact on the annual growth of the gross domestic product would be positive, but remain in the order of fractional percentages. The impact on agriculture, forestry and the forest industry would be somewhat greater, but no more than 0–0.2%.

2.2.3. Scenario calculations

This chapter reviews the development of the national economy in the different scenarios. The review is based on calculations made using an equilibrium model describing the Finnish economy. The equilibrium models are based on detailed descriptions of production, consumption and the public sector, and provide information on the reaction of the economy to different changes in the boundary conditions. In scenario use, the models can be utilised to review the growth generated by changes in different structural factors over time, as well as the changes in the structure of production and consumption. The hypotheses underlying the calculations are described in more detail in a separate research report of the Government Institute for Economic Research.

The central characteristics of the scenario calculations are described above. The scenarios will be introduced to the model calculation as follows:

- The growth of the population and labour force, as well as pension costs, is assumed to be in line with the population scenarios.
- The growth in employment and productivity is allowed to vary by scenario.
- Demand in the global market varies by scenario.
- The volume of welfare costs follows the population scenarios.

Certain assumptions on the determination of costs must be made in the calculations. The most important ones are:

- Unit costs of welfare expenses depend on the model.
- Unemployment benefits are tied to the income level index.
- Unit costs of other income transfers are tied to the income level index.
- The volume of other income transfers is tied to the population.
- The volume of education expenses is tied to the school-age population.
- Unit costs of education expenses depend on the model.

Following assumptions are made concerning the public sector:

- Public expenses independent of the scenarios (expenses other than welfare and education) increase on a par with the WM scenario.
- The relation of public debt to GDP is kept fixed by adjusting value-added tax.

The model determines economic growth limited by factors of supply (employment, productivity) and demand (global market) that vary by scenario. Similar to the long-term growth scenarios, the development of productivity plays a crucial role in these scenarios as well. High growth in productivity will enable strong economic growth. As the labour force ages and the number of employed people follows a downward trend through the 21st century, the structure of the economy will start to become more service-oriented, and the strong development of productivity may accelerate this trend.

Economic development in the Basic scenario

Figure 2.8 illustrates the development of the national economy in the Basic scenario. In this scenario, the growth of GDP continues at a relatively rapid rate during the first decades of the 21st century and starts to slow down towards 2050. However, the growth of GDP is still almost 2% in 2050. Consumption per capita increases more rapidly than GDP. Export demand is estimated to increase by 3–4% in the entire review period.

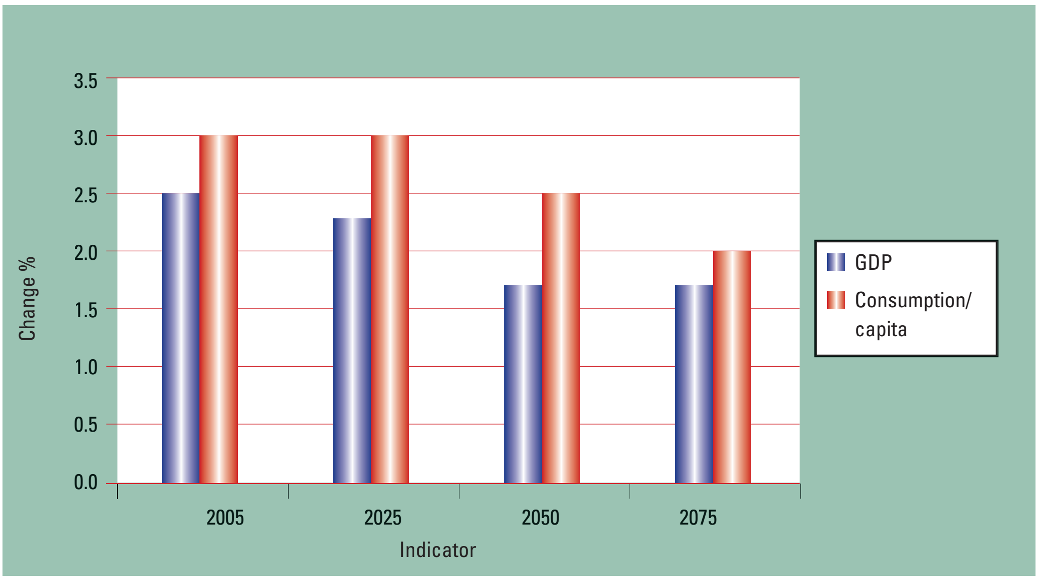

Figure 2.8. *Indicators of macroeconomic development in the Basic scenario.*

Figure 2.9. illustrates the development of the structure of the national economy through the creation of added value in the Basic scenario. Rapid growth of productivity will release factors of production to the service sector, and the economy will start to become more service-oriented in the 2030s. Among the industrial sectors, the growth of the forest industry will remain in the order of a couple of per cent, while the growth of the metal and metal products industry will initially be faster, more than 3% annually, but it will slow down to 2% on average starting in the 2030s. The growth of other sectors will be clearly slower. The growth of exports and telecommunications will maintain the growth of the communications industry above the average growth of GDP. The share of public services will gradually begin to diminish, as their growth falls short of the growth of GDP.

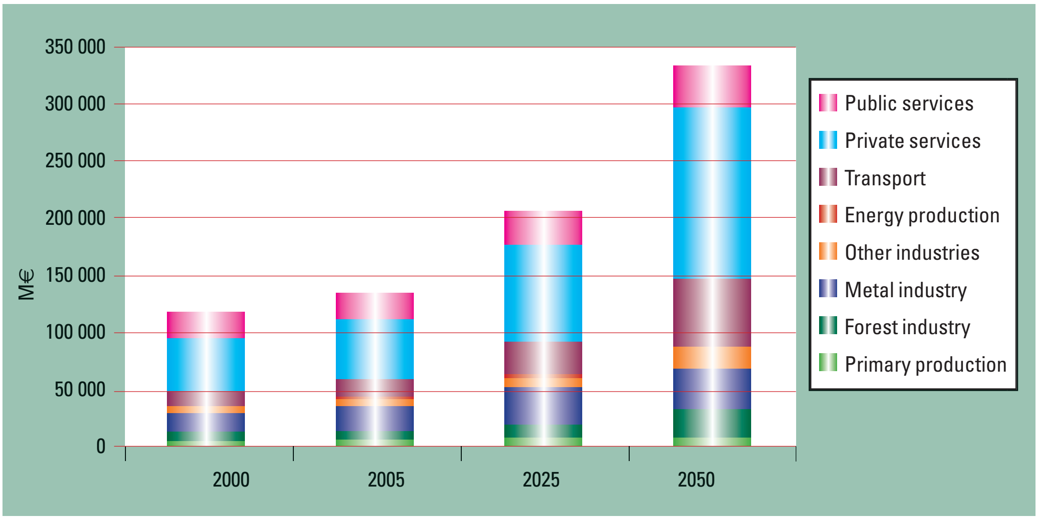

Figure 2.9. *Added value in the Basic scenario.*

Economic development in the Regressive Finland scenario

Figure 2.10 illustrates the development of the national economy in the Regressive Finland scenario. The development of employment is the weakest in this alternative, and as the growth of export demand and productivity are also assumed to be weaker in this scenario compared to the Basic scenario, the growth of GDP will clearly fall short of the Basic scenario. The growth of consumption will also be relatively weak.

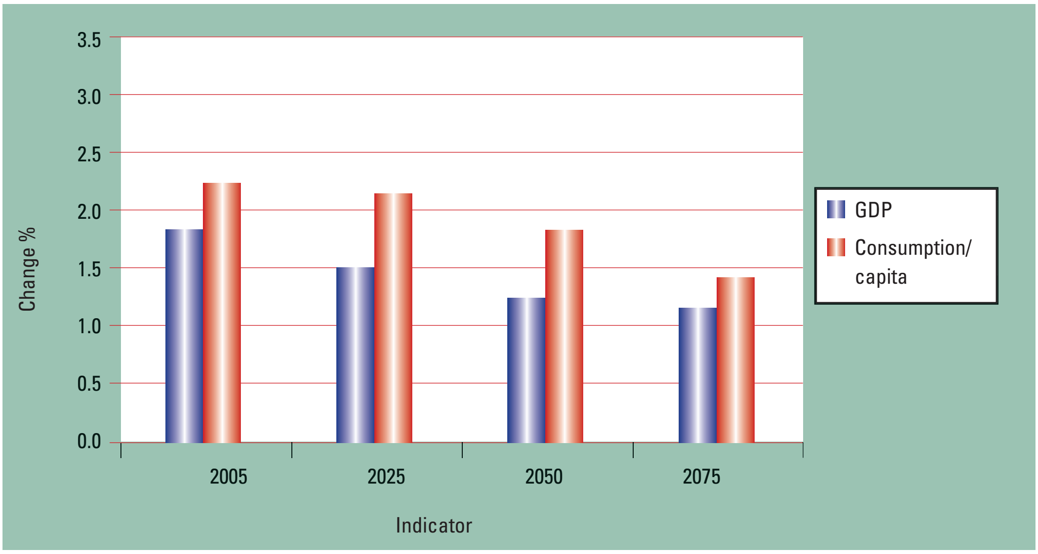

Figure 2.10. Indicators of macroeconomic development in the Regressive Finland scenario.

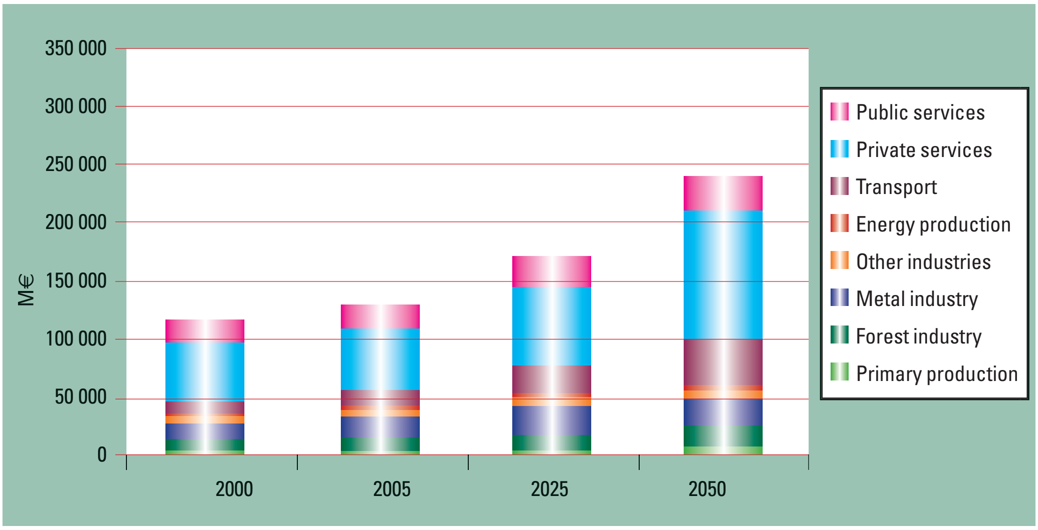

Figure 2.11. Added value in the Regressive Finland scenario.

Figure 2.11 illustrates the development of the structure of the national economy in the Regressive Finland scenario. The value of production will clearly fall short of the Basic scenario. The growth of production slows down especially after 2025. Industrial production will slow down as a result of the slow growth in export demand and productivity. Furthermore, weaker development of productivity will result in slower growth in private service sectors compared to the Basic scenario.

Economic development in the Alternative Finland scenario

Figure 2.12 illustrates the development of the national economy in the Alternative Finland scenario. This alternative assumes that employment and productivity will increase more rapidly than in the Regressive Finland scenario, but not as rapidly as in the Basic scenario. The growth of export demand is assumed to be rapid, with the annual average at 3%. However, weaker development of productivity will result in lower growth in production compared to the Basic scenario. The growth of GDP will be close to the Basic scenario until 2025, after which it will remain below 2%. Industrial growth will be slightly weaker than in the Basic scenario, but the rate of growth in private services will be in the same order as in the Basic scenario, with the annual average at 2.2–2.3%. This means that the economy will gradually become more service-oriented.

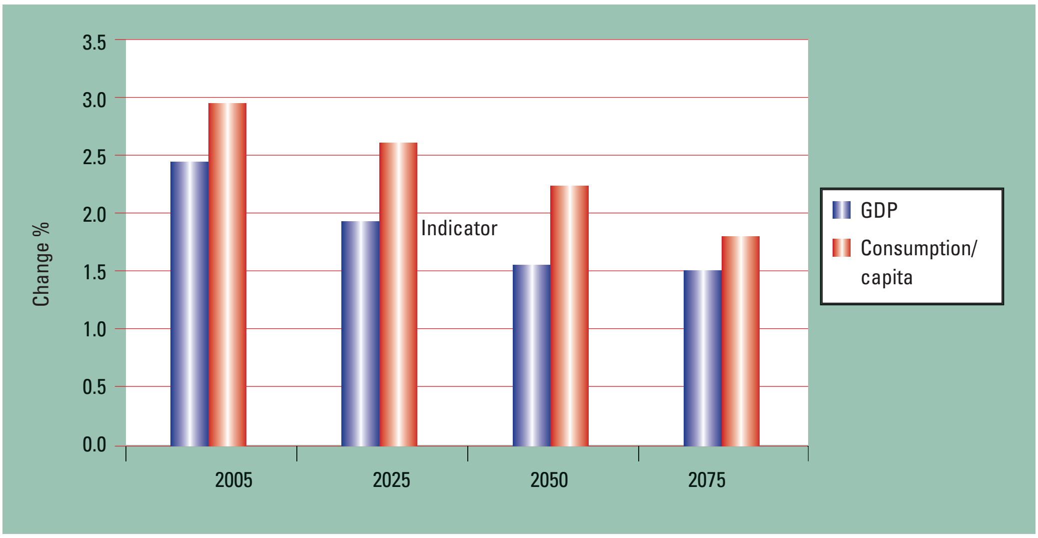

Figure 2.12. *Indicators of macroeconomic development in the Alternative Finland scenario.*

Figure 2.13 illustrates the development of the structure of the national economy in the Alternative Finland scenario.

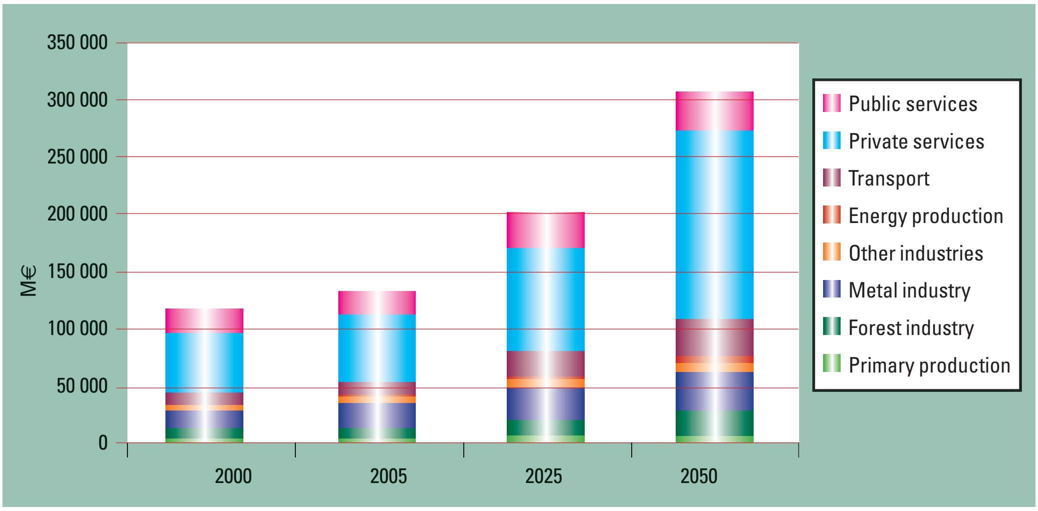

Figure 2.13. *Added value in the Alternative Finland scenario.*

Summary of the scenarios

The chapters above present a review of the long-term growth scenarios for the Finnish national economy on the basis of the estimated development of crucial structural factors. These include population growth and the development of employment and productivity. The scenarios may be compared to the global market development alternatives described by IPCC.

The scenarios differ considerably from each other. The Basic scenario is characterised by a rapid rate of growth in the global markets and strong development of employment and productivity. In this scenario, the rate of industrial growth is rapid until the 2030s, but the economy will become more service-oriented after this. GDP and consumption will remain high. The estimated growth of the global market is slower in the Regressive Finland scenario than in the Basic scenario. This scenario represents the weakest development of employment and productivity. In this scenario, growth is clearly weaker than in the Basic scenario, but growth of GDP and consumption are at fairly high levels when compared historically. The Alternative Finland scenario assumes that the growth of the global market will be rapid but directed towards non-traditional activities. However, the growth of employment will be better than in the Regressive alternative. In this alternative, GDP and consumption will remain lower in the long-term compared to the Basic scenario. This is primarily due to the weaker growth of productivity.

Figure 2.14 illustrates the added value generated by the economy. Growth will slow down in all of the scenarios starting in the 2030s. The structural change in the economy towards a more service-oriented model becomes evident quite quickly but will not actually be experienced until after a few decades.

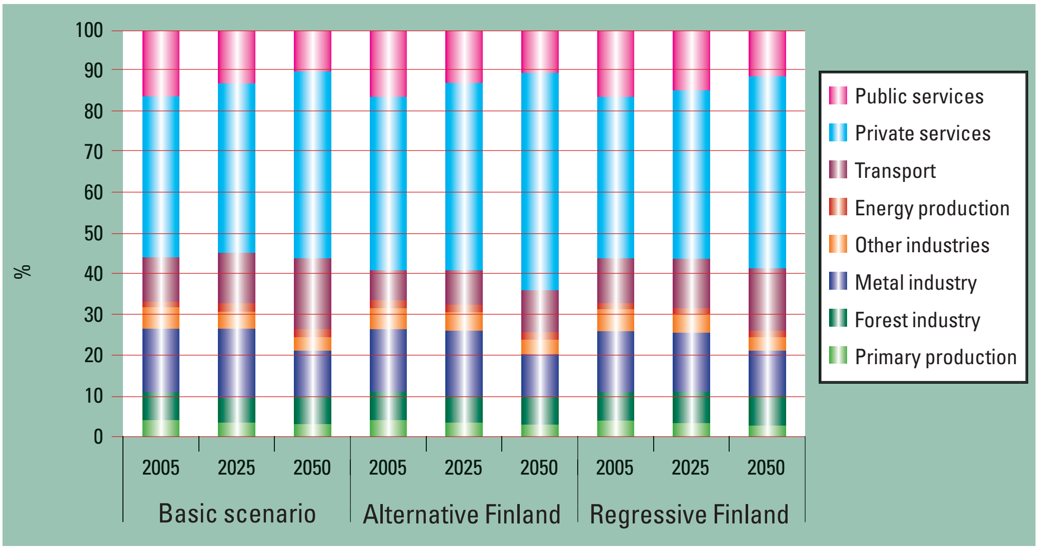

Figure 2.14. *Development of added value in different scenarios.*

Figure 2.15. illustrates the structural change in the economy, through the added value by sector in 2005, 2025 and 2050.

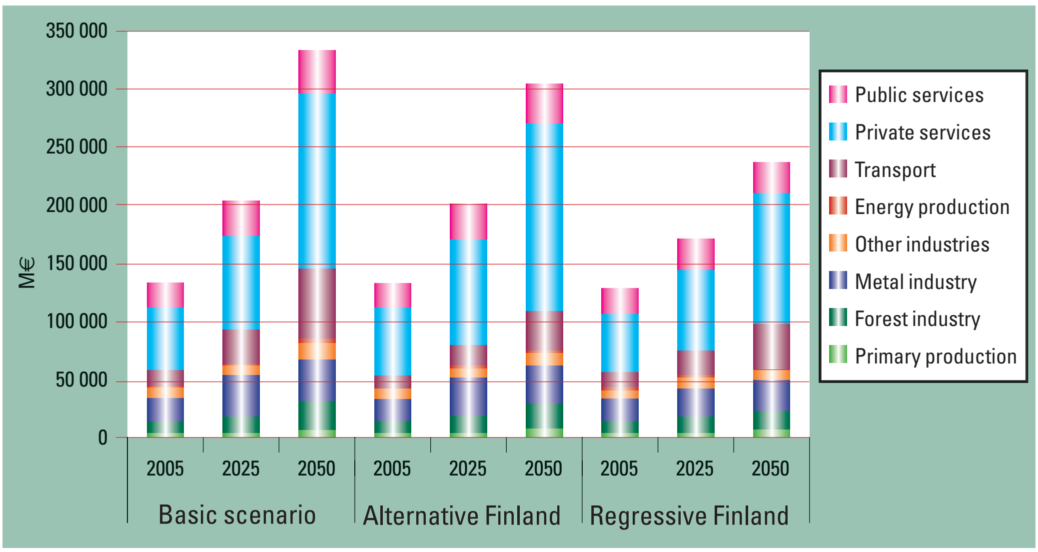

Figure 2.15. *Development of the shares of added value in different sectors and scenarios.*

The calculations evaluate the economic impacts of climate change on the basis of sector-specific impact assessments conducted in the SILMU research programme. The assessments only cover some sectors. Impacts calculated on the basis of the available assessments remain small in all of the scenarios at the level of the national economy as a whole, even though they are clearer particularly in agriculture and forestry. However, the calculations presented here do not look into any sharp changes in the climate, global economy or technology. On the basis of the available assessments, climate change will not become an obstacle to securing welfare in Finland during the next few decades, but it is clear that further studies may reveal significant impacts and shed more light on the uncertainties that were not reviewed in the SILMU programme.

2.3. Natural systems

The impacts of climate change to the society are propagated through natural conditions. In addition to the climate, crucial natural conditions include the properties of soil, the quantity and quality of water, as well as the properties of air. When the climate changes, changing natural conditions also affect the natural development of flora and fauna.

2.3.1. Soil

The most important properties of soil that climate change is estimated to affect include the amount of nutrients available, dampness, structure and frost. Changes in different parts of Finland mainly depend on regional differences in climate change, but also on the location of soil types susceptible to each change.

The release of nutrients from dead parts of plants into the consumption of other plants will be accelerated as the warming of the climate speeds up decomposition in the soil. This facilitates the nutrient intake of plants and promotes their growth. On the other hand, the risk of nutrients leaching into water systems may increase if plants do not use all of the released nutrients. These changes in the nutrient economy of plants and the risk of nutrient leaching will affect agriculture, forestry and water systems.

Increase in annual rainfall increases the average moisture of the soil. This will decrease the rigidity of soil as a base for buildings at least to some degree, which may have to be taken into account in the design of foundations for new buildings. Existing buildings will generally not be endangered if they have been built correctly and in compliance with prevailing standards. Only buildings located on fine-grained banks and precipices, and maybe railway lines, could be endangered if erosion and landslides become more common as the moisture of soil increases.

Despite increased annual precipitation, it is possible that extended dry spells will become more common. It is possible that, as large occasional rainfall becomes more common, this will also be the case with extended rainless periods. This could hinder the growth of trees in infertile habitats that are the most sensitive to aridity. However, the ability of forested soil to retain water will improve with climatic warming as more organic matter is accumulated. This will reduce the sensitivity of woodlands to aridity, and the growth of forests is not estimated to be significantly hampered by aridity. The accumulation of organic matter in forested soil is possible despite the acceleration of decomposition, because the growth of forest vegetation and the production of forest litter are estimated to accelerate even more.

The structure of clay soil will become even denser as annual precipitation increases and the ground frost period becomes shorter, and this will impede cultivation.

Reduced ground frost will cause problems outside agriculture as well. It will impede harvesting of forests in the winter and weaken the anchoring of trees in the soil, exposing forests to storm damage. In the construction sector, reduced ground frost could reduce the need for ground frost protection in principle, but protection of the present type will also be required in the future as ground frost periods similar to the present will continue despite the decrease of average ground frost. All in all, the occurrence of ground frost depends on several different factors, including winter temperatures, the thickness of snow cover and the length of the snow-covered period. Climate change has an indirect impact on ground frost, which is why the occurrence of ground frost will probably change in different ways in different parts of Finland.

2.3.2. Water

Climate change is expected to cause changes in water quantities, water quality and the sea level. Climate change will make extreme events such as floods, heavy rain and drought more common. Annual precipitation will increase, but rain will become more common particularly in winter, and summers may become drier than at present. Changes in the quantity of water will affect water supply, energy production, industry, water traffic, construction and agriculture. Instead, changes in water quantities are not expected to have any significant impact on the growth of forests.

Changes in rain conditions will also affect the quality of water. Floods and more abundant rain will increase the drainage of water from land to water systems and groundwater, which will increase the burden on water systems and groundwater caused by nutrients and harmful substances. Drought will weaken the quality of groundwater by increasing the concentrations of iron and manganese, among other things. Drought could also lead to oxygen depletion in shallow lakes. Changes in the quality of water will affect the water supply, fishing and the recreational use of waters.

The change in sea water in relation to Finland's ground surface depends on two issues: the rise in the sea level due to climate change and land uplift in Finland since the most recent glacial period. Until now, land uplift around the coasts of Finland has been greater than the rise in the sea level, with new land appearing. The sea level is expected to rise by 5–30 centimetres during the next 50 years and by 10–90 centimetres by the end of this century due to glacial melting and the thermal expansion of water.

North Atlantic Oscillation (NAO)[17] also affects the sea level in the Baltic Sea. It caused the relative decrease in the sea level in the Gulf of Finland to stop 30 years ago. The impact of NAO will cease in the long-term, but the rise in the sea level will also be reflected in the Baltic Sea. Due to this, the sea level in the Gulf of Finland will remain roughly at the present level until the end of the century. According to extreme forecasts, the mean water level could either increase or decrease by almost half a metre. The sea level in the Gulf of Bothnia will continue to decrease in relation

[17] North Atlantic Oscillation (NAO) is a statistical index describing the intensity of the westerly flow of atmospheric mass in the North Atlantic region. The NAO index value varies on a daily and annual basis, but has mostly been positive during the last couple of decades. This period has been characterised by mild and humid winters caused by westerly flows. This was the case in Finland, for example, in the 1990s.

to the ground surface due to more rapid land uplift, but the relative rate of decrease will probably remain smaller than has been prevalent for 30 years. According to an extreme forecast, land will again be covered by sea particularly in the southern part of the Selkämeri region, but the present level will not be exceeded to any significant degree in the northern part of the Gulf of Bothnia.

2.3.3. Atmosphere

In addition to greenhouse gases that change the climate, air pollutants (solid fine particles and gaseous chemical compounds) impose a burden on the atmosphere. The issues of climate change, greenhouse gases and air pollutants are interlinked in many ways. Climate change will change the tolerance of ecosystems to air pollutants. Climate change will also affect the conversion of air pollutants in the atmosphere and their migration. Some air pollutants have direct impacts on the climate; for example, sulphate aerosols and fine particles have direct and indirect climatic impacts. Efforts to reduce greenhouse gas emissions in order to mitigate climate change will also reduce the concentrations of air pollutants. The most significant air pollutants affecting human health and the functioning of ecosystems include ozone in the lower atmosphere, sulphur and nitrogen compounds, and fine particles.

Carbon dioxide

Carbon dioxide is the most important greenhouse gas after water vapour[18], and its increased atmospheric concentration will accelerate the growth of plants particularly in dry conditions. This may be significant for agriculture and forestry.

Carbon dioxide is efficiently miscible in the atmosphere so that its concentration is almost the same all over the globe despite the uneven geographical distribution of emission sources and carbon dioxide sinks. The increased concentration of carbon dioxide in the atmosphere due to human activity will depend especially on the usage of fossil fuels, including coal, oil and natural gas. The atmospheric concentration of carbon dioxide has increased from 280 ppm (parts per million) in the pre-industrial period to the present 367 ppm and is estimated to further increase to 550–950 ppm by the end of this century, depending on the usage of fossil coal.

[18] The most important natural greenhouse gases include water vapour (with an approximate contribution of 60% to the natural greenhouse effect), carbon dioxide (approximately 26%) and ozone. However, the amount of water vapour in the atmosphere is not directly dependent on human activity. Anthropogenic emissions of carbon dioxide and other greenhouse gases increase atmospheric temperature, which increases the evaporation of water from the soil, vegetation and seas. Thus the increased temperature caused by human activity increases the amount of water vapour in the atmosphere, and the greenhouse effect becomes intensified.

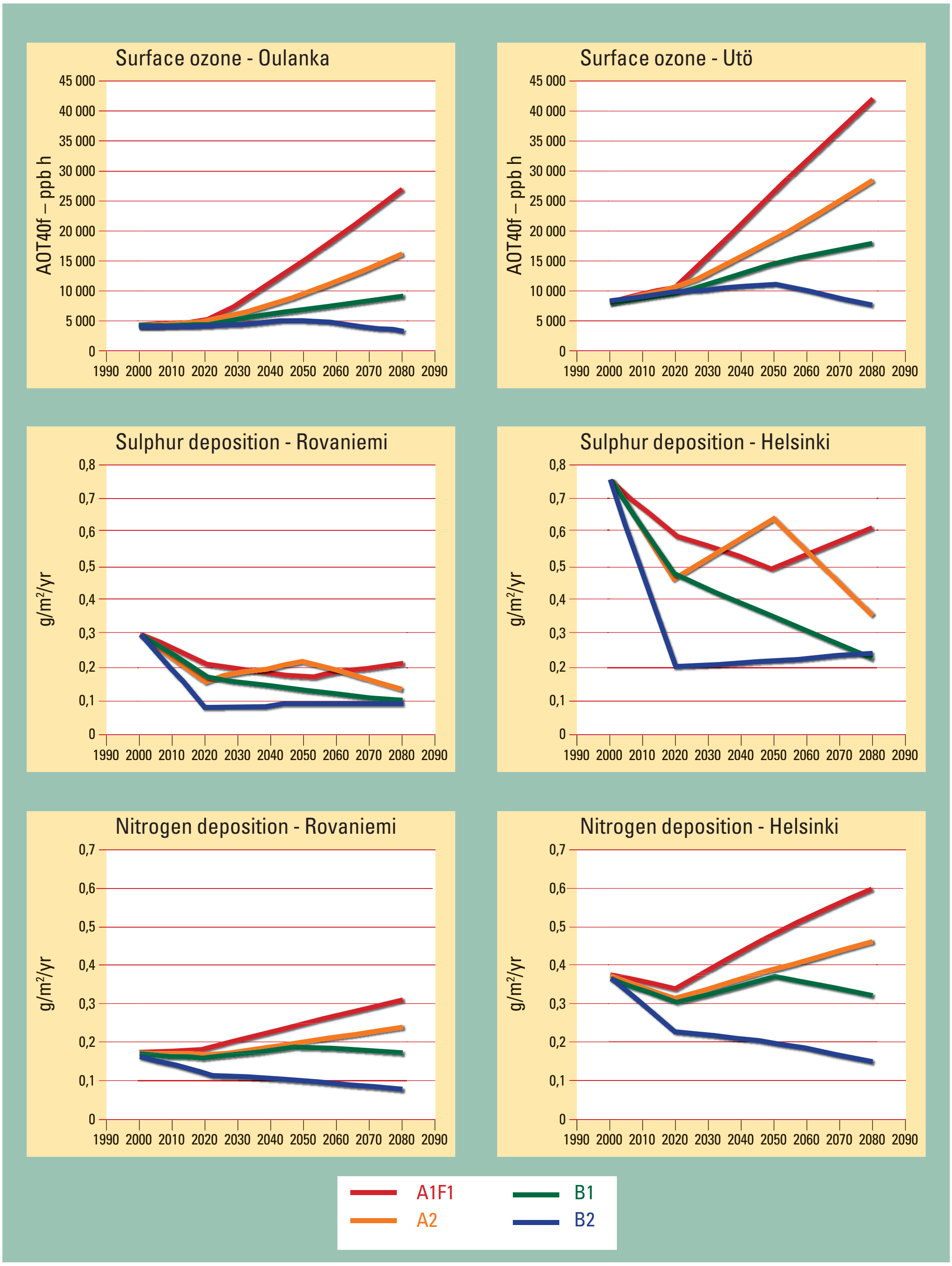

Figure 2.16. Future trends in quantities describing air pollution in Southern and Northern Finland on the basis of the different IPCC and FINSKEN scenarios. The scenarios are explained in the Appendix.

Ozone

High concentrations of ozone in the lower atmosphere will damage plants and human health. Ozone is formed through photochemical reactions in the atmosphere, and its formation requires nitrogen oxides and a precursor substance, for example, methane. The ozone concentration in a certain location depends on the global quantities of airborne precursor substances, the long-range transport of ozone and local emissions of nitrogen oxides. The overall quantity of ozone in the lower atmosphere is increasing, because the quantity of atmospheric methane is increasing and emissions of nitrogen oxides are growing particularly in Asia, Latin America and Africa. In addition to the increased concentration of background ozone, local emissions of precursor substances and nitrogen oxides may result in high local concentrations of ozone.

Ozone concentrations in the lower atmosphere are estimated to increase in Finland during this century unless future emissions of air pollutants follow the most environment-friendly IPCC trend (*Figure 2.16*). In Southern Finland, the concentrations will exceed the limit considered harmful for trees before 2020, and the increase will continue after this[19]. In Northern Finland the limit will be exceeded in the middle of the century if air pollutant emissions develop in accordance with the two most extreme forecasts.

Ozone is not only an air pollutant but also a greenhouse gas, and in the upper atmosphere it protects life on the globe from harmful ultraviolet radiation. Among other things, excessive ultraviolet radiation increases the risk of skin cancer and eye diseases. However, the most significant factor affecting human exposure to UV radiation is human health behaviour (use of protection). Ozone depletion in the upper atmosphere has been particularly evident above the Antarctic, where the ozone layer has thinned by as much as 60%. Cooling of the upper atmosphere and warming of the lower atmosphere due to climate change may result in ozone depletion similar to the Antarctic in the Northern Hemisphere as well. The emissions of freons and halogen compounds containing chlorine and bromine are regarded as the greatest causes of ozone depletion. When observing changes in the ozone layer in the upper atmos-

[19] The limit harmful for trees is based on the total amount of high concentrations of ozone during the growing season from May to September (AOT40f = 10 000 ppb h, AOT40 refers to the sum of daytime hourly average ozone concentrations to the extent that they exceed 40 parts per billion from May to September).

phere, one should keep in mind that there is also natural variation in the thickness of the layer. For example, in Finland the ozone layer is approximately 30% thinner in the autumn than in the spring in Finland.

Deposition of sulphur and nitrogen

The deposition of sulphur dioxide and nitrogen oxides acidifies water systems and forest soil. More than half of all European ecosystems are estimated to be affected by the eutrophication impact of nitrogen deposition. The emissions of sulphur dioxide and nitrogen oxides originate from the combustion of fuels in energy production, industry and traffic. Sulphur and nitrogen deposition in Finland originates from both our own emissions and long-range transport.
The elimination of sulphur dioxide from combustion emissions has become quite efficient during the last couple of decades, which is why sulphur deposition has been significantly reduced despite an increased use of fuels. The downward trend is expected to continue during this century thanks to the development of emission purification technology (*Figure 2.16*). According to the most extreme forecast regarding the use of fossil coal in Finland and neighbouring areas, sulphur dioxide deposition will not be decreasing during the whole century, but the downward trend would continue until 2010, after which the level would stay the same. According to the lowest forecast of fossil coal usage, sulphur emissions will decrease to a very low level by 2020 and remain low after that.

The deposition of nitrogen oxides has also decreased, but not as much as that of sulphur dioxide. This is due to the fact that it is more difficult to remove nitrogen than sulphur from emissions. The nitrogen deposition constitutes a common type of diffuse pollution, while sulphur deposition is point source pollution. According to most forecasts on fossil fuel usage, nitrogen deposition is expected to continue to decrease during this century (*Figure 2.16*). However, nitrogen deposition decreases more slowly than sulphur deposition, and according to the two most extreme forecasts on fossil fuel usage, nitrogen oxide deposition will regain an upward trend.

Restriction of the use of fossil coal in order to mitigate climate change will also reduce atmospheric emissions of sulphur dioxide and nitrogen oxides, and the deposition of these compounds.

Fine particles

Atmospheric fine particles are harmful to human health, causing cardiovascular diseases and respiratory disorders. However, the impact mechanisms are not known in detail. Atmospheric emission of fine particles originates in the combustion of fuels and natural processes, and other air pollutants form fine particles in the atmosphere.

There are no forecasts on the quantity of fine particles in Finland which would cover the entire century. According to fine particle emission forecasts extending to the year 2020, Finland's emissions will be reduced in comparison with the present level in all of the energy production alternatives studied. In addition to Finland's own emissions, the concentration of atmospheric fine particles depends on long-range transport.

2.3.4. Flora and fauna

Human activity changes the natural development of flora and fauna. Natural change in flora and fauna occurs through changes in habitats and living conditions, as well as through succession. Climate change, pollutant deposition, changes in land use and, particularly in Finland, the management of forests, are factors affected by man that change the natural development of flora and fauna. The development of flora and fauna depends on the combined impact of natural and anthropogenic factors, and it is often difficult to distinguish the impact of any single factor, at least very precisely.

Northern ecosystems are not typically rich in terms of biodiversity. Such ecosystems are generally regarded as sensitive to environmental changes, and are not believed to possess a particularly good capability to adapt to changing conditions. However, it is not self-evident whether this generalisation can be applied to all northern ecosystems. In fact, northern animals and plants already need to survive in highly variable conditions in terms of temperature and humidity.

More significant changes from the viewpoint of flora and fauna include the warming of the climate on average, extension of the growing season particularly in the spring, increased occurrences of temporary periods of drought, as well as shortening and increased irregularity of the periods of snow and ice cover. On the other hand, due to increased winter precipitation, snow cover could become thicker than at present in regions with subzero winter temperatures.

A warmer climate may create preconditions for the distribution of several species of flora and fauna to extend hundreds of kilometres to the north. In practice, distribution will depend on the migration ability of the species and the use of land, i.e. the management of forests, agricultural areas and water systems. As the climate changes, species currently found in Southern Finland will migrate to Northern Finland, and new species will spread to Southern Finland from regions south of the country. Broad-leaved trees, birch in particular, will become more common in forests, and the timberline will rise. Arctic species that have adapted themselves to the coldest conditions of Northern Finland will recede and their areas of distribution will become smaller. The increased occurrence of drought periods and reduction in snow cover may be harmful to vegetation growing in locations susceptible to drought, such as on cliffs and ridges. Finland's current forest vegetation zones are presented in Figure 2.17.
Plant and animal communities do not migrate as such, but the proportions of different species change. New species will migrate to the location, some of the original species gain more benefit from climate change than the others, and some species will suffer. The overall number of species found in Finland is expected to increase. Climate change is expected to cause a disadvantage to some coldwater species characteristic of Finland, such as salmonoids as the spread of new species and new conditions may become a threat to these.

Climate change will increase the productivity of northern ecosystems. This will be an advantage to agricultural production and forestry. Increased productivity is both an advantage and disadvantage in terms of biodiversity. Original ecosystems will change and many species will decline. Abnormal weather conditions and the improved living conditions of pests and diseases will increase the risk of plant and forest damage, and impose uncertainty on productivity forecasts.

The adaptation of flora and fauna to climate change can be promoted by sustained management and use of natural resources, avoiding other disadvantages imposed on flora and fauna by human activities, and ensuring that genetic variation, which constitutes basis for the adaptive capacity of organisms, will remain as extensive as possible.

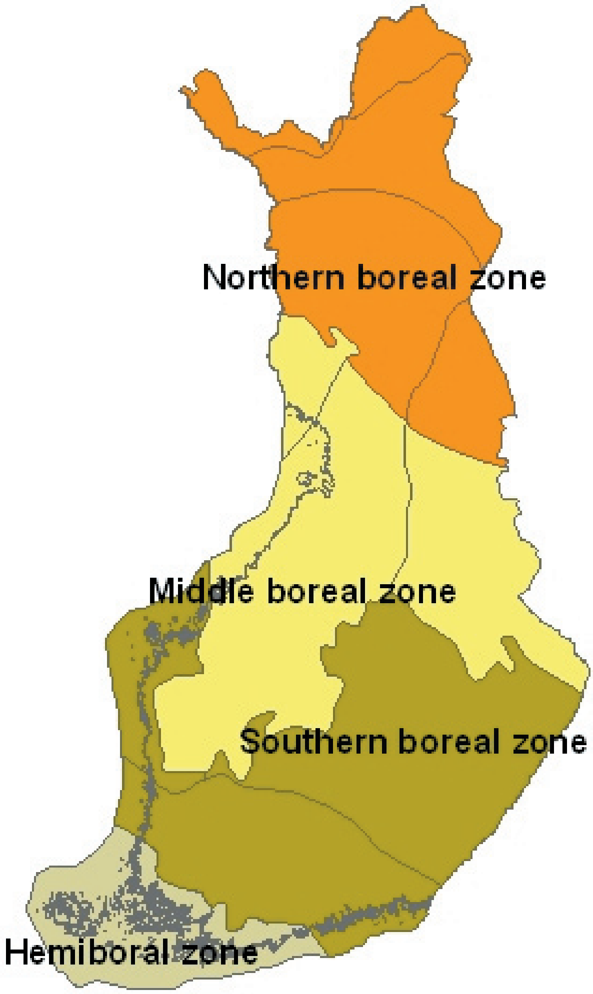

Figure 2.17. The current forest vegetation zones of Finland. Finland is located in the boreal forest belt. The Finnish territory is divided into four sub-zones, whose boundaries are determined by differences in vegetation caused by the thermal climate. Source: SYKE and MML.

3. Impacts of climate change

3.1. Global and European impacts

Climate change will have global impacts on many of the basic living conditions of humankind, including food production, availability of water, health, as well as the conditions regulating the existence and location of human communities. Harvests are expected to increase in northern regions as the climate warms, but decrease in the subtropics and tropics due to drought. Drought is also expected to make less water available for drinking and irrigation in these southern areas. Diseases spread by insects, such as malaria, and communicated through water, such as cholera, are likely to become more common, but the estimates involve a great deal of uncertainty. More common, longer and hotter heat waves will increase mortality due to heat. Floods caused by heavy rain and an increased sea level are expected to damage human communities in different parts of the globe.

Climate change will affect human living conditions as well as natural systems. Climate change will be intense in Arctic regions, and the impacts are estimated to be significant, because many Arctic natural systems and organisms are considered particularly sensitive to changes in climate.

Climate changes and their impacts have been evaluated in detail, by continent, in the third assessment report of the Intergovernmental Panel on Climate Change, IPCC. The report is available on IPCC's web site[20], and the associated summaries for policymakers are available in Finnish on the Finnish Environment Institute's web site.[21]

The impacts of climate change in Europe are in general expected to be similar to those around the globe. The climate will become warmer, extreme weather conditions such as storms, floods, drought and heat waves will become more common, and drought will become a problem particularly in Southern Europe. Drought and heat waves are going to affect agriculture and cause crop damages in Southern Europe, but a few degrees of warming in Northern Europe may improve the growth of plants and increase harvests. Such changes would move the key areas of European food produc-

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[20] www.ipcc.ch
[21] www.ymparisto.fi > Ympäristön tila > Ilmastonmuutos > Hallitustenvälisen ilmastonmuutospaneelin (IPCC) arviointiraportit

tion farther north. Hotter, longer and more common periods of hot weather will decrease the interest in southern holiday resorts, and more uncertain snow conditions will cause problems for ski resorts.

Europe should be able to adapt to climate change and its impacts better than poorer regions of the globe. Despite this, southernmost Europe and European Arctic areas are considered to be sensitive to damage.

Climate change will have unequal impacts on different parts of the globe. Even though the warming of the climate is estimated to be most intense in Northern latitudes, the greatest disadvantages caused by climate change will be experienced in developing countries in tropical and subtropical regions. The harmful impacts of climate change will be the most intense in these regions, and poor countries cannot adapt themselves to climate change. In the least developed countries, the poorest people will suffer the most. They cannot afford the costs of preparation against the impacts of extreme weather conditions that are becoming more common, such as floods, periods of drought and hurricanes, or to repair the damage caused by these events. The harmful impacts of climate change are estimated to worsen the development problems of poor countries, such as the lack of food and spread of diseases.

Climate change is estimated to increase differences in well-being between developed countries and developing countries. An increase in temperature by some degrees, and the associated impacts of climate change, will result in economic losses in developing countries, but besides these disadvantages, such climate change could cause advantages to many developed countries located farther north. Any greater climate changes are estimated to cause disadvantages in developed countries as well. However, current economic estimates on the impact of climate changes should be viewed cautiously. The estimates do not account for rapid variation in weather or extreme weather events. Furthermore, they only include partial consideration of products and services for which no global market exists. This is why the IPCC estimates that current economic reviews mostly underestimate the disadvantages and overestimate the advantages of climate change.

The local impacts of climate change are reflected in large regions. The worsening of living conditions causes pressure to migrate to other regions and may lead to unrest when people have to struggle for insufficient supplies of food and water. This may lead to global security risks. Economic impacts will be reflected everywhere due to the present global economy. The reflection of the harmful impacts of climate change outside the regions actually impacted may reduce the advantages that a slight change in climate would otherwise have in northern developed countries such as Finland over the next few decades.

3.2. Impacts in Finland

3.2.1. Use of natural resources

3.2.1.1. Agriculture and food production

Agriculture and food production in Finland

Finland is the world's northernmost agricultural country. The growing season – which refers to the period during which the average daily temperature exceeds 5 degrees – varies from less than 100 days in the north to 180 days in the south. In Central Europe, the thermal growing season lasts for 280 days. The temperature sum the growing season, or the sum of average temperatures in the growing season, varies from 760 degrees in Sodankylä to 1,400 degrees in Southern Finland.

There are 2.2 million hectares of arable land in Finland, which is 6.5% of the country's land area. In 2003 some 1,982,000 hectares were cultivated and more than 220,000 hectares were set aside. The total number of Finnish farms with more than one hectare of arable land was about 72,000 in 2003. Finnish agriculture is based on family farms. Most farms engage in production activities eligible for agricultural support, and the average arable area is 31 hectares. During the EU membership, the average arable area has increased by some 45 per cent and the number of farms has decreased. Active farms have often specialised in a particular sector of production or developed into diversified part-time enterprises.

The structure of agricultural production in terms of the number of farms has changed considerably during the EU membership. The share of livestock farms decreased from 52% to 39% between 1995 and 2003, and the share of plant farms increased from 39% to 57%. However, the share of animal husbandry in agricultural production measured by market prices has remained almost unchanged, standing at 82% in 2003. Compared to other European Union countries, the average unit size of Finnish livestock farms is relatively small.

Climatic conditions influence the regional distribution of production and use of arable land. Plant farms are mainly located in Southern Finland, while cattle farms are found in central, eastern and northern parts of the country. Milk is produced all over the country, up to the northernmost Lapland. However, the main production regions are in Ostrobothnia, North Savo and North Karelia, whose production represents more than half of the total. Pigmeat and poultry production is located in western and southern parts of the country. Bread cereals are mostly cultivated in Southern and Southwestern Finland. Fodder cereals can be cultivated all over Finland, with the exception of the northernmost parts of the country. The location of cattle farms, dairy farms in particular, is strongly reflected in the use of arable land. For example, the share of fodder grass in the total cultivated area is more than 90% in the Province of Lapland and 60% in Eastern Finland, while its share is only a little over 20% in Southern Finland.

The total return on agriculture and horticulture amounted to four billion euros in 2003. Agriculture employed 118,900 people in 1999. If the entire food industry is included, the number of people employed is approximately 163,000.

The objective of Finnish agricultural policy is to maintain an inhabited countryside and self-sufficient agriculture. Even though its significance to the national economy has diminished, agriculture remains the most important source of livelihood in the countryside. The common agricultural policy of the European Union steers Finnish agricultural policy. The support systems will be reformed next year to respond to challenges imposed by the enlargement of the EU and changes in international trade.

Impacts of climate change on agriculture and food production

Changing climatic and soil conditions

The potential of agricultural production in Finland is primarily limited by temperature. Other factors limiting production include solar radiation and precipitation, either directly or through the availability of nutrients and water. Soil factors also affect production. The growing season is estimated to become three to five weeks longer by 2050. With the exception of Northern Finland, the growing season will extend particularly in the autumn.

The impacts of increased temperature and precipitation in soil will appear as changes in the nutrient economy and structure. As temperature and moisture increase, the decomposition of organic material becomes accelerated. The risk of erosion, as well as that of nutrient release and leaching into waters, will increase. Compaction of clay soil, which is particularly common in Southern Finland, may increase and cultivation may become more difficult if the ground frost period shortens. The need for irrigation water will increase, and the availability of water may become a problem. Climatic warming may increase stress arising from dryness and heat during the growing season.

Increased concentrations of greenhouse gases will affect the physiological functions of plants. Increased carbon dioxide concentrations will promote photosynthesis, improve the efficiency of water use in plants and impose changes on the distribution of photosynthesis products between different parts of plants, as well as on the density and quality of plant tissue. The combined impacts of air pollutants (ozone) and UV radiation on ecosystems may become intensified.

Impacts of exceptional weather in summer 2004 on the quality of crops

The current extreme phenomena are not necessarily caused by climate change, but the future impacts of climate change can nevertheless be estimated on the basis of the extremes of the current climate. Dry periods in the beginning of the growing season in spring 2004 dried the lands up quickly, and seed could be sown early. The wet spring made new crop yellow, and part of the malting barley crop was lost at an early stage. However, a record-breaking harvest was still anticipated in the latter half of July 2004. The harvest expectations plummeted after the heavy rains in August. Barley stands suffered the most. Rye was flattened at many places, and turnip rape suffered from water on the fields. Heavy rainfall caused severe damage in potato plantations as well. The risk of crops flattening was further increased by humid weather in the spring and early summer, which made the stands exceptionally luxuriant. The stands were also threatened by plant diseases and weeds, because the poor carrying capacity of the land made it impossible to spread pesticides in many places.

The overwintering of plants in Southern Finland may become increasingly difficult when the depth of snow decreases. The alternation between melting and freezing caused by mild winters is most harmful for the overwintering of plants, which may suffocate beneath the ice cover. However, the overwintering of perennial plants may also be improved as the period of snow and ice becomes shorter. The risk of spring frost may also increase.

Pests, plant diseases and weeds

Insect pests will benefit from a warmer climate and longer growing season. Their overwintering and reproduction will be more successful, and they will have time to produce more generations for each phase of the host plant's exposure. Sufficient temperatures and humidity are essential for the spreading of fungal diseases. The risk of plant disease epidemics, particularly various types of fungi and moulds, as well as potato blight may increase. They may also occur earlier. Climate change will not have any direct impact on the spreading of viral diseases, but the living conditions of vectors spreading them, such as plant-lice, will improve.

Other examples of potential new pests include the spreading of the Colorado beetle and the potential spreading of carrot psyllid to Northern Finland. New combinations of pests, as well as combinations of pests and natural enemies, may lead to severe problems in the short-term, because there will not be enough time for communities to adapt themselves. In addition to pests and diseases, weeds will probably become more common.

Cultivation of arable crops

The area suitable for the cultivation of cereals will move farther north. Thus Finnish agriculture would be practised in a climate that is currently prevailing south of Stockholm in Sweden or in the southern part of the Baltic States. Finnish agricultural production will probably not develop to resemble these regions, because it is influenced by domestic consumption needs, the economy of cultivation and the soil. Therefore, the focus will probably stay with cereal cultivation in Southern Finland and fodder grass production in the north.

The production of cereals and grass is currently limited by the short growing season, occasional frost and drought early in the summer. The harvest potential is estimated to increase, but it is difficult to estimate changes in harvests without knowledge on the varieties that will be used in the future. If the cultivation of new varieties spreads to the north, the length of the day will impose a challenge on plant breeding.

Potential drought early in the summer in Southern Finland may affect the growth of spring cereals in the future. However, the most important factor weakening the quality of the harvests of cereals, grass and root plants, is wetness at the time of harvesting. It causes sprouting in the ear and lodge of cereal crops. Stagnant water in fields can also make harvesting more difficult. Increased extreme events may weaken the quality of cereal crops in the future. Studies have shown that the protein content of grains will decrease with the increased concentration of carbon dioxide, but the protein content will also be affected by several other factors, including fertilisation, soil moisture and temperature.

Perennial grasses will benefit from increases in temperature and carbon dioxide content. For example, the yields of meadow fescue are expected to improve. Yields could increase particularly in Northern Finland. Potato and sugar beet will also benefit from a longer growing season.

The potato crop

The potato crop may increase by 20–50% by 2050, but potato blight will cause a similar loss without additional preventive measures. The distribution of the worst pest affecting potatoes at present, the potato nematode, is currently limited to Southern and Central Finland, but climate change is estimated to move the northern limit of its distribution to Lapland by 2050. The root cyst nematode is a serious problem in the United States, for example, but its migration to Finland has been successfully prevented until now. If it migrated to Finland, it could probably produce two generations each year in Southern and Central Finland, at least in theory under the changed circumstances, and could occur in the entire country.

Horticultural production

Horticultural production is expected to benefit from climate change. The cultivation of apples can be expanded, and pear, plum and cherry may become increasingly important. The harvests of crop under glass will increase, and costs will decrease. However, the risk of diseases and pests will increase. The harvests of outdoor vegetables will probably increase. In berry production, the overwintering of raspberry and strawberry in particular may become more secure, which will probably increase the average harvest. Landscape development is expected to gain significant benefits from climate change.

Animal husbandry

The indoor feeding season of farm animals will be shorter and the grazing season will be lengthened. The well-being of animals will improve if outdoor grazing is increased, but increased grazing may cause greater burden on water systems. The need to store feedingstuffs will be reduced. The risk of animal diseases may increase, even though the risk is still believed to be very low. Diseases associated with the quality of water and feed may become more common. The yields of dairy cattle and growth of beef cattle and poultry may be reduced if temperatures in barns housing cattle increase to very high levels.

Global impacts on food production

Among the global factors affecting agriculture, climate change is considered one important factor, in addition to environmental pollution, liberalisation of trade and competition. Climate change could cause increased drought in traditional food-producing areas, sudden intense variations in weather, and major crop failures. Global production problems may cause severe shortage of food and conflicts over the availability of food. The greatest problems for food production are expected in developing countries, particularly Africa. This could cause global disturbances in the trade of agricultural products, which may be reflected in Finland as well.

Table 3.1. *Summary of the anticipated impacts of climate change on agriculture and food production in Finland. The impacts are not commensurable, in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant.*

Disadvantage	Advantage
– Increased erosion and risk of nutrient leaching – Compaction of clay soil may hamper cultivation if ground frost is reduced – Combined impacts of air pollutants (ozone) and UV radiation on ecosystems will become intensified – Risk of insect damage and plant diseases will increase – Overwintering of plants may become more difficult – Need for irrigation water may increase – impacts of increased extreme events on the quantity and quality of the harvested crop	+ Production potential of plants will increase + Plant cultivation boundaries will move farther north + Horticultural production will benefit + Outdoor grazing can be increased + Overwintering of perennial plants will probably become easier

3.2.1.2. Forestry

Forestry in Finland

A major part of the surface area of Finland is influenced by forestry activities. Finland's land area is 31 million hectares, of which 26 million hectares (86%) is forestry land, and 20 million hectares is forest. Finland possesses 0.5% of the world's forest resources, and 1.5% of global felling takes place in Finland. Some 20 species of trees are found in Finland, but the most significant ones for forestry are pine, spruce and birch. Pure pine forests grow in fairly dry habitats, while spruce is found in more fertile locations and birch mostly in mixed forests. More than half of all forests are mixed forests.

Finnish forest industry is characteristically an export industry: the average share of exports in annual production is more than 70 per cent. Forest industry accounts for approximately one-third of Finland's net export income. 5% of the world's forest industry production takes place in Finland, and Finnish exports represent about 10% of global exports. Forestry and forest industry combined employ directly some 95,000 people, three quarters of these in forest industry.

The National Forest Programme 2010 defines the objectives of forest policy for the next few years. The programme is intended to guarantee work and livelihood based on forests, the biodiversity and vitality of forests, as well as the recreation provided by forests to the entire population. In comparison with previous forest programmes, the current programme includes more extensive consideration of ecological, social and cultural sustainability and forest-related competence. In addition to national needs, it responds to the crucial needs of international forest policy.

The administration of forestry is divided among several parties. The Ministry of Agriculture and Forestry steers and develops the Finnish forest policy. The Forestry Development Centre Tapio is a forestry development and expert organisation promoting sustainable forestry by providing services to assist in practical problems related to forestry. The thirteen regional forestry centres constitute a regional system of forest administration, supervising compliance with forest legislation and promoting sustainable management and use of forests, as well as the preservation of their biodiversity and environmental protection associated with forestry.

The Finnish Forest Research Institute operates under the Ministry of Agriculture and Forestry. Forest-related research is also carried out at universities and the Finnish Environment Institute. Metsähallitus is a State enterprise whose task is to manage the government's forest assets. The regional environment centres also carry out tasks associated with environmental protection and the biodiversity of forests. Other important actors in forestry include forest owners and forest industry enterprises. Private forest owners own almost 60% of the total forestry land and 68% of the growing stock. Forest management associations promote the interests of private forest owners and operate as advisory organisations for forest owners.

Forest management in Finland is founded on the forest and nature conservation legislation reformed in 1997. The aim of the Forest Act is to secure the economic, social and ecological sustainability of forestry. The Forest Act includes provisions on the preservation of habitats of special importance, and the Nature Conservation Act includes an obligation to preserve protected habitat types and provisions on the conservation of species, including species under strict protection. On the basis of the Act on the Financing of Sustainable Forestry, a private forest owner may receive financial support from the government for forest management and improvement work, as well as for the harvesting and transport of wood sold for energy production purposes in association with the management of young forests.

The Forestry Development Centre Tapio has issued forest management recommendations for private forests. In addition to legislation, these are based on the National Forest Programme 2010, research results, the profitability of forestry, and practical experience. The purpose of the recommendations is to improve the efficiency of wood production in harmony with the objectives of nature management. Guidelines are issued for essential activities, such as forest regeneration, seedling stand management, intermediate felling and ditch cleaning and supplementary ditching. Metsähallitus has produced its own environmental guide for forestry, and a revised version of this was completed in the spring of 2004. Both guides go beyond the statutory minimum level for forest management. Furthermore, other forestry organisations have their own forest management guidelines, quality management systems and environmental management systems.

21.9 million hectares of Finnish forestry land are certified under the FFCS (Finnish Forest Certification System), which belongs to the Pan-European PEFC system

(Programme for the Endorsement of Forest Certification Schemes). The FFCS system fulfils the requirements laid down by legislation and international treaties on the management and utilisation of forests, the verification of the origin of wood, and the implementation of external audits.

Impacts of climate change on forestry

Changing climatic and soil conditions

The increase in temperature, carbon dioxide concentration and precipitation caused by climate change will boost the growth of trees in the boreal forest belt, and the timberline is expected to move north. Climate change will lead to changes in soil and vegetation. The climatic zone suitable for boreal vegetation is expected to move 150–550 km farther north during this century. However, boreal vegetation cannot migrate at such a rapid pace, at least not naturally, because the natural rate of migration for trees is only 20–200 km a century.

The mineralisation of nitrogen will accelerate, because the amount of forest litter will increase and it will decompose faster at higher temperatures, provided that the litter is sufficiently moist. The amount of water available for plants may decrease if precipitation only increases by the minimum quantities indicated in climate forecasts. On the other hand, increased precipitation will compensate for some of the increased evaporation caused by warming, but in regions where snow cover diminishes, soil water reserves will not be replenished in the spring as before. However, drought is not believed to restrict the growth of forests as the increased concentration of carbon dioxide will compensate for the potential impacts of drought. Changes in snow conditions will be reflected as changes in ground frost, which will have a particular impact on the temperature of the root layer of trees in the spring season.

Climatic warming will probably cause mire vegetation zones to move in the same way as forest zones. This would mean that raised mire vegetation will take over parts of the current low "aapa" mires. This development has already started as a consequence of ditching during the last few decades. In Fell Lapland, the topography of the terrain in relation to precipitation limits the emergence and size of mires. Changes in the water conditions of the soil may change the need to drain mires, but it is very difficult to predict the impact of climate change on peatland and mires. It is estimated that mires may become drier than at present, especially in the summertime. Drier conditions will lead to the barrenness of some mires and overgrowth of sphagnum peat. Decreased water levels will allow the growth of trees to increase.

The longer growing season may delay the hardiness of trees, and warming may cause premature degradation of frost resistance. However, experiences have shown that, for example, in the exceptionally warm autumn of 2004 the frost resistance of pine was –25 to –30 degrees at the beginning of November. The risks caused by late and early frost vary by species. Scenarios describing climate change suggest that risks of forest fires may increase in Finland because of longer summers, a warmer climate and increased evaporation. Even though increased one-time precipitation decreases the risk of forest fires, it is possible that the occurrence of dry periods will become more common and add to the risk.

Climate warming could increase damage to trees by autumn storms in two ways. Ground frost improves the anchoring of trees to the soil, which reduces the risk of wind damage. As the climate warms, the frost-free period that imposes risks on trees becomes longer, and milder winters increase the probability of a weather type that causes storm damage. On the other hand, increased temperature may increase the number of local thunderstorms, thus adding to the risk of wind damage.

The combined impact of ozone, UV radiation and carbon dioxide is not completely known. Increased ozone concentrations in the lower atmosphere will reduce the growth of trees. It exposes forest trees to oxidising stress, which will probably reduce the growth of trees to some degree, because the impacts of chronically continuing ozone exposure, even in small concentrations, will accumulate over the years. This will probably cause loss of increment, which may weaken the condition of trees or further expose them to other damage (diseases and insect pests). There are differences in ozone resistance both between species and between genetically different individuals of the same species. UV radiation and ozone also have some combined impacts. However, increased carbon dioxide concentrations will compensate for the loss of increment caused by ozone.

Growth of trees and composition of stand

The improved growth of forests is one significant, positive impact of climate change. Low summer temperatures impose the greatest limiting factor on forest regeneration in northern habitats. Climate change may improve the seed yield of trees, which facilitates regeneration in Northern Finland and makes it possible farther north. However, the natural regeneration of trees in nutrient-rich sites is limited by ground vegetation.

The most recent national estimates on forest growth and changes in the proportions of tree species were prepared in connection with the SILMU study. The research methods used at that time involve some uncertainties, but there are no more recent forecasts covering the entire country as yet. The SILMU research results regarding the growth of trees and changes in the composition of stand are described below.

According to the estimates, climate change will probably improve the growth of all tree species all over the country, more so in Northern than Southern Finland. The growth of tree stand is expected to increase by 40% and annual felling opportunities on mineral soil to increase by 22% during this century. The forecasts account for increased temperatures, carbon dioxide concentration and precipitation. However, the increase in growth depends on the soil. Trunk volume will grow proportionally less in Vaccinium site types compared to fresh mineral forest soil sites. However, more recent estimates at the forest stand level indicate that the acceleration of growth will be less intense, some 10–15% in Southern Finland and 25–35% in Northern Finland.

Even though climate change will modify the composition of stand, the forest management methods will play a greater role in determining the future proportions of tree species. According to the SILMU study, birch will be the winner in climate change, and the proportion of coniferous trees will become significantly lower especially in Southern Finland, unless the composition of stand is steered by means of forest management. If the development of the stand composition is steered by forest management, pine and spruce will also thrive in Southern Finland. According to the most recent estimates, the growth of spruce will probably not decline, because the increased concentration of carbon dioxide will compensate for the impacts of potential drought.

Pests and pathogens in forests

The populations of insect pests in forests are estimated to increase during this century, but it is difficult to say how natural enemies will be able to control them. Species that currently cause occasional forest damage may become major pests. Insects will benefit from increased temperatures and a longer summer. Particularly the two species of pine sawflies, the European and the common, will benefit from dry summers, and the damage they cause is expected to increase if summers become dry.

The distribution of black arches may move north of the current latitude of 60 degrees. Other potential species with an increased risk of damage include the pine bark bug, the pine shoot beetle, the bordered white moth, the winter moth and the pine beauty moth. Other species that may become more common include the elm bark beetle, the web-spinning sawfly and the gypsy moth.

Climatic warming and the associated migration of new species from outside our country can bring new types of risks. The spread of new species (such as the pine wood nematode) will be fostered by international wood trade, the transport of wood products and packages, as well as the mobility of people. Coexistence of several species is another risk. Furthermore, forests weakened by potentially increasing storms will be more vulnerable to pests.

Our most important pests are currently able to produce one generation of progeny during the summer. The longer growing season and increased temperatures may lead to the birth of two or more generations of progeny each year. This would significantly increase the potential of insects to regenerate, and therefore the risk of forest damage. The worst pest affecting spruce, the spruce bark beetle, is one example of such a species.

The crucial factors for fungal diseases are precipitation and humidity rather than temperature. Extensive mycosis epidemics causing severe damage have been quite rare in Finland until now. The risk imposed by climate change on tree species important to forestry does not seem too high. The greatest risk would be that damage caused by annosus root rot spreads farther north and the pest becomes more common in Southern Finland. Warmer winters will also increase the risk of scleroderris canker. In addition, the risk of damage caused by lophodermella needle cast, pine needle cast, phacidium disease and honey fungus may increase, and Dutch elm disease may spread to the Finnish territory. If precipitation increases, leaf spot fungus on broad-leaved trees may also increase.

The moose population will benefit from reduced snow cover in Southern Finland. Damage to winter pastures will decrease, but greater mobility will lead to increased moose damage in larger areas. The roe deer population has rapidly increased in Southern Finland in recent years, and the damage caused to agriculture and forestry is anticipated to increase in the future. Climate change will improve the roe deer's success at overwintering and accelerate the growth of the population.

Biodiversity in forest

Changes caused by climate change will lead to an increased abundance of grasses and herbs and the decline of shoots, mosses and lichens. Vegetation will become more diverse as the share of southern species increases. On the other hand, northern species of plants may decline and partly disappear. The success of heterotroph species depends on changes in vegetation. Increased broadleaf litter will be able to maintain a more diverse range of soil species. The increase of forests dominated by broad-leaved trees will also add to the diversity of plant-eating insect species. Oak in particular attracts a wide range of insect species. The numbers of mammals, such as the bank vole, moose and reindeer, will be affected by changes in the amount of snow. Among birds, taiga species and northern species will decline and make room for species living in broadleaf-dominated mixed forests.

Forest harvesting and utilisation

Decreasing ground frost will make forest work and harvesting more difficult in winter. On the other hand, the thickness of ground frost may increase if the snow cover remains clearly thinner, even if the weather is not at its coldest extreme. Thinning snow cover will facilitate forest harvesting in winter. The spring thaw period will be longer, which will impose additional demands on machine capacity and storage, as well as cause additional costs. Stands marked for cutting in the summer may become less common if precipitation increases in the autumn. Harvesting damage suffered by growing stock could increase in connection with thinning if the period when there is no ground frost becomes longer and precipitation increases. The structure of forest roads may also have to be improved.

If the radial growth of pine increases, the usability of pine logs in the sawmill and carpentry industries may weaken. The emergence of pine branches may increase, but this will happen in proportion to trunk growth, which means that the relative amount of branches will not increase. The possibilities of utilising spruce fibre are threatened by the risk of damage to spruce forests due to dry periods, vulnerability to harvesting damage in years of short ground frost and little snow, as well as the high energy requirement of the mechanical pulp process. However, economic and technological development is estimated to impose more rapid changes in global wood production and the forest industry compared to the changes caused by climate change.

There is not much information on the long-term impacts of climate change on the properties of wood material yet. According to estimates, growth processes will begin earlier in the spring, and diameter growth can also begin as much as a couple of weeks earlier than in the current climate. However, the growing period of trees will not be lengthened in proportion to the thermal growing season. The length of the growing period of present trees is an adaptation to the current climate, heavily dictated by genetic factors. Experiments indicate that in a higher temperature growth will also stop much earlier than in the current climate.

The impacts of carbon dioxide on the chemical composition of wood vary between different species of trees. With regard to broad-leaved trees, an increased concentration of carbon dioxide has decreased the concentrations of lignin and cellulose in the wood. Particular attention must be paid to these issues in the future in order to avoid quality defects during the processing of wood material, such as blue stain and damage from mould fungi. On the other hand, in conditions corresponding to the changed climate, increases in lignin and decreases in cellulose have been observed in pine, simultaneously with increased density and length of fibres in the wood material.

Other products from forests

The impact of climate change on forest products other than wood products has not been extensively studied yet. Annual variations in the flowering time of forest berries such as bilberry may be great, and flowering may occur extraordinarily early for several consecutive years. Long time series (100 years) of bilberry flowering times do not indicate any systematic trend towards earlier flowering. If this happened, the probability of frost damage would increase because, depending on the weather conditions, there may be occasional frost as late as at present. Mushroom harvests are expected to increase as a consequence of climate change.

__Table 3.2.__ Summary of the anticipated impacts of climate change on forestry in Finland. The impacts are not commensurable, in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant. Some of the impacts are clear advantages or drawbacks but the direction of some impacts is still unclear or the direction of the impact depends on the intensity of climate change.

Disadvantage	Direction of the impact unclear or simultaneous disadvantage and advantage	Advantage
– Increased risk of nutrient leaching – Increased risk of wind damage and weakened anchoring of trees to the soil as ground frost declines – The combined impacts of air pollutants (ozone) and UV radiation on ecosystems will become intensified due to climate change – The risk of pests and forest pathogens will increase – Potentially reduced ground frost will make forest harvesting more difficult – Longer thaw period in spring will impose additional demands on machine capacity and wood storage – The quality of coniferous wood may suffer	• The proportions of tree species will change • The tree line will move farther north	+ Increases in carbon dioxide concentration, temperature and precipitation will add to the productivity of the boreal belt + Felling opportunities will increase + Plants will have access to more nutrients + The seed yield of trees will improve and natural regeneration in Vaccinium site types in Northern Finland will become easier.

3.2.1.3. Fisheries

Fisheries in Finland

Finland possesses excellent conditions for fishing, because fishing waters are abundant. Ninety-eight species of fish have been identified in Finland. Among these, 45 are freshwater or migratory species, and 23 are saltwater species. There are 17 transplanted foreign species and 20 species that are occasionally found in the Finnish sea area. The number of naturally regenerating crayfish species is three.

Fisheries can be divided into two parts: the fisheries industry and recreational fishing. The fisheries industry includes professional fishing, fish farming, fish processing and fish trade. The combined value of production is more than 336 million euros per year. The employment effect of fisheries, including all multiplicative effects, is estimated at about 20,000 man-years. The total catch of professional fishing in the sea area amounts to more than 100,000 tonnes and is worth almost 20 million euros calculated at prices paid to the fishermen. In addition to Baltic herring, sprat and cod, species currently important to professional fishermen in the sea area include powan, pike-perch, perch and salmon. The catch of professional fishing in inland waters amounts to some 4,500 tonnes and is worth almost 6 million euros. From 1980 to 2000, the total catch of professional fishing has increased by almost half, but fishing income has halved, just like the number of professional fishermen. The total number of professional fishermen operating in the sea area has decreased to less than 1,000 full-time professionals. There are approximately 1,000 professional fishermen in the inland waters, and less than one-third of them get 30 per cent or more of their income from fishing.

Recent developments have lead to a reduced number and increased unit size of fisheries enterprises, as well as an increase in the average age of professional fishermen. Very few new people enter the industry. The number of professional fishermen will probably continue to decrease if the current fishing restrictions continue. The total number of fishing vessels is also expected to decrease, as the number of fishermen is declining.

There were a total of 568 fish farming facilities operating in Finland in 2003, of which a little under 300 used natural feed ponds. Slightly more than 100 facilities were involved in hatchery. Fish farming produces fish and crayfish for consumption, further farming or planting. Approximately 15 million kilograms of edible fish is farmed in Finland every year, almost exclusively rainbow trout. The production of powan, trout and Arctic charr is minor. In 2003 the value of production was about 36 million euros.

Almost two million Finns are involved in recreational fishing. In 2002 the catch of recreational fishing was approximately 39,000 tonnes, which was worth almost 50 million euros at prices paid to the fishermen. Most of this, almost 80 per cent, was caught from inland waters. The most important species in the catch of recreational fishermen include perch, pike, roach and many other species of freshwater and migratory fish.

The nature of recreational fishing has transformed from fishing for household consumption towards recreational fishing. This is reflected, among other things, in the decline of net fishing and the increased use of rod fishing equipment. The total value of catch from recreational fishing has decreased in recent years. However, the economic significance of recreational fishing derives mainly from the demand for fishing-related services. Tourism income generated by fishing tourism, including multiplicative effects, is estimated at 300 million euros. There are currently more than 1,000 tourism entrepreneurs in Finland who get at least some of their income from fishing tourism, and approximately 70–90 entrepreneurs whose primary source of income comes from services sold to fishing tourists.

The regulation of fishing is based on the Fishing Act. The Ministry of Agriculture and Forestry is responsible for the general implementation of the Act. The Employment and Economic Development Centres (T&E Centres) act as the Government's regional administrative authorities. The T&E Centres include Fisheries Units, which constitute the regional organisation for fisheries administration subordinate to the Ministry of Agriculture and Forestry.

Fisheries in Finland's sea areas fall under the EU's common fisheries policy. The Act on Implementing the Common Fisheries Policy of the European Union (1139/1994) provides for the implementation of the policy in Finland. Fishing is also restricted by a Government Decree (258/1996) and the fishery rules of the International Baltic Sea Fishery Commission (IBSFC), which are included in Council Regulation (EC)

No 88/99 laying down certain technical measures for the conservation of fishery resources in the waters of the Baltic Sea, the Belts and the Sound, as well as the frontier river agreement between Finland and Sweden and the associated fishery regulations. The International Baltic Sea Fishery Commission issues recommendations for fishing quotas, and the contracting parties either confirm their quota or may indicate their opposition to some of the recommendations. The EU confirms the recommendations by means of a specific quota regulation approved by the meeting of the Council of Fisheries Ministers. Since the spring of 1996, salmon fishing in Finland's territorial waters and fishing zone using nets and fykes has been restricted by means of a Government Decree (258/96), imposing limitations on salmon fishing in the Baltic main basin, in the Gulf of Bothnia and in the River Simojoki (Salmon Decree). Following the reform of the EU's common fishing policy, a maximum limit on the size of fleets has also been imposed on the Member States.

The quotas and fishing restrictions concern salmon, Baltic herring, sprat, cod and flatfish species.

Impacts of climate change on fish stocks and fisheries

Climate factors such as the temperature of the air and water, rainfall and wind conditions have a strong direct or indirect global impact on the health, productivity and distribution of fish. Changing distributions of fish, increased or decreased growth, increased susceptibility to communicable diseases, new diseases and parasites, and changing ecosystems have an impact on fisheries. In some regions, fisheries may already have been influenced by climate change. For example, climate change has been identified as one of the potential factors affecting the decline of salmon stocks on Pacific coasts. Changes in the runoff of water systems and rivers have also been found to have impacts on fish populations.

In Finland, the impact of climate change on professional and recreational fishing and fisheries as a whole will be reflected through the impact on fish stocks. In the long run, climatic warming may have a significant impact on the state of waters, fish stocks, fishing and fish farming, but in the short run, other factors such as market conditions, fishing restrictions, increase of the grey seal population, reduced fishing capacity, and natural variation of fish stocks will have a significantly greater impact on professional and recreational fishing than climate change.

The composition of Finland's fish stocks may change either directly or indirectly as waters become warmer, but also through the natural routes of distribution and through human activity in the form of active planting. Coldwater species may decline particularly in small and shallow waters in Southern Finland, while warmwater species will benefit and spread farther north.

Impacts of increased temperature on fish

The impacts of climate change on fish production depend on the proportions of fish species in a particular water area, the reaction of different species to change, as well as changes in the general productivity of waters. Increased temperature is expected to boost the growth of fish, thus increasing fish production. However, this will require that factors currently limiting growth or mortality do not occur.

Fish stocks in minor rivers and lakes are more sensitive to changes in temperature and precipitation than the stocks of major rivers and lakes. Changes in precipitation and temperature due to climate change will probably affect the numbers, distribution and mutual relationships of fish populations both directly and through other changes in the ecosystem.

High water temperatures will accelerate fish metabolism and increase the need for nutrition, but the cycle of nutrients will become correspondingly accelerated also in other parts of the ecosystem. Changes in the ecosystem may be reflected in competition situations between species, as well as the proportions of predatory fish and their prey.

The potential increase of basic production and the consequent sinking of organic material to the hypolimnion will reduce the oxygen concentration in cold hypolimnion in late summer and autumn. This will weaken the living conditions of species requiring cold, oxygen-rich water. However, the extent of the impact depends on the volume, area and nutrient content of the lake, among other things.

In most cases, the early stages of a young fish's development will benefit from the warming of waters, which may increase the amount of plentiful age groups in several species, further increasing the amount of prey available to predatory fish. On the other hand, the warming of waters may result in prey species being hatched at a different time than previously, which may cause problems for nutriment supply to fry. However, it is probable that predatory salmonoids in their early stages, as well as those living in brown-water river habitats (trout in particular, also salmon and lake trout), will have to live in temperatures clearly above the optimum temperature for the species, causing problems to the natural production of their fry.

Changes in areas of distribution

The present distribution of each species of fish has been determined on the basis of climatic and hydrological factors (temperature, windiness, runoffs, water level, precipitation), the availability of suitable nutrition, and the presence of predators, competing species and dispersion barriers. However, the most important factors that have affected the distribution of fish stock in northern regions are temperature, in the sea both temperature and saltiness, as well as dispersion barriers. Climatic warming will move both the southern and northern limits of distribution towards the north. In places, the relocation of distribution in Finnish inland waters is hindered by the lack of natural dispersion opportunities. Dispersion of fish towards the north in inland waters requires that in addition to temperature, the habitat must be suitable for the species. For example, cyprinid fish from the rich lakes of Southern Finland would not be successful in Lapland even if it was warmer, because the waters there are far too infertile.

Of the hydrological changes, the increase in sea level is estimated to be too small to have any significant impact on the success of the spawning of most fish or their spawning locations, because upheaval will partly compensate for the impact. On the other hand, a potential change in the salt concentration of the Baltic Sea due to an increased sea level may cause substantial changes. The present salt concentration only limits the distribution of a few freshwater species in our coastal waters but is the most essential factor for saltwater fish. Any increase in salt concentration, no matter how minor, could have great impacts on the fish populations of the Baltic Sea and on the improvement of living conditions for saltwater species. Fish may spread to new areas in the sea if the environmental conditions allow this. It is possible that an increased salt concentration could allow completely new species of fish to migrate to our waters from more southern parts of the Baltic Sea. However, it is uncertain whether the saltiness of the Baltic Sea will increase even if the sea level increased, because saltiness depends on the relation between precipitation and inflow. Observations have indicated that a variation as minor as 10 per cent in the amount of river water entering the Baltic Sea has a significant impact on saltiness. Increased precipitation may also make the inflow of salty water from the straits of Denmark to the Baltic Sea less frequent. This would lead to longer periods with a lack of oxygen in the deep bottoms, the release of nutrients, and potential acceleration of the eutrophication of the Baltic Sea. Both the lack of oxygen and eutrophication will have unfavourable impacts on economically valuable species of fish.

Table 3.3. Examples of the impact of climate change on individual species of fish.

Species	Impact
Coldwater fish	
Arctic charr	• May lose ground to competitors that favour warmer water • The production of fry by the endangered Saimaa charr may suffer
Burbot	• Will decline in numbers or their distribution will be reduced
Powan Trout	• Success in lakes in Southern and Central Finland may be hampered
Grayling	• Southern populations spawning in rivers or lakes may decline
Vendace	• May decline in the lakes of Southern Finland
Warmwater fish	
Cyprinids (roach, bream, ide) Pike-perch Perch	• May spread towards the north
Crayfish	
River crayfish Signal crayfish	• May spread towards the north

Impacts on professional fishing

The increased production of fish, the appearance of new species of prey, and the decline or disappearance of fish stocks will require adaptation by fishermen and those managing fishing waters. Professional fishing will also have to adapt to problems that have significantly clearer impacts but are independent of climate change, including profitability problems, fishing regulation and dioxin problems. The impact of climate change on fisheries depends on changes in fish stocks and their relative abundance. The most significant impact on fishing will probably come through changes in species.

Even though the natural production of fry by salmonoids is estimated to suffer from the warming of waters, one must bear in mind that a significant part of the salmonoid catch is currently based on planting, particularly in the sea. This means that any downswing in the production of fry by salmonoids in natural waters does not automatically lead to a significant diminishing of salmonoids in the catch.

Professional fishing may benefit from changes in the distribution of pike-perch and its success in warmer waters. The demand for pike-perch is already high. Annual imports of pike-perch from Estonia to Finland are approximately equal to the catch from Finnish professional fishing. Pike-perch is also among the species from which fishermen get the best price per weight. An increase in temperature may be beneficial to pike-perch in rich coastal waters, for example, but any potential benefit could be lost partially or entirely if fishing is not carried out under reasonable regulations. The significance of scaled fish to professional fishing has been predicted to increase in the future in any case.

Even a minor increase in salt concentration would probably have a great impact on the fish populations of the Baltic Sea, thus affecting professional fishing in particular through the improved living conditions of saltwater species (Baltic herring, sprat, cod, flatfish). For example, the improved growth of Baltic herring alone could have significant impacts on the usability of the fish as food, as well as on the dioxin content. Lower dioxin levels attributable to accelerated growth could be a decisive factor for professional fishing.

In the next one hundred years the ice cover of the Baltic Sea is estimated to become 20–30 centimetres thinner, and the annual greatest extent is estimated to diminish by 30–40 per cent compared to the present extent. Shortening of the ice-winter and thinning of ice will favour our most important mode of catching, which is trawling, but it would hamper the wintertime seine catching of vendace. Milder ice-winters have been considered an impact of climate change that will facilitate navigation, but even so, uncertainty exists with regard to changes in windiness and storminess. The mild but windy winter of the future will not necessarily be an easy ice-winter for navigation, because windiness may cause the ice on the sea to move more easily and become packed, causing a hindrance to navigation. Windiness and storms are also associated with intensified waves. Humidity and rain will increase the formation of fog, impair visibility at sea and increase the risk of icing on vessel structures.

Impacts on recreational fishing

Populations living close to the northern border of their area of distribution will increase and become more common in the catch of fishermen. Such species include pike-perch, bream, asp and ruff. The increased productivity of waters may also lead to higher catches to increase; on the other hand, the increased abundance of cyprinids may increase the proportions of low-value fish stock. From the viewpoint of fishermen, many fish with a high temperature optimum are generally less desirable species. Because an increase in temperature will be the most harmful for salmonoids spawning in streams, their significance as a catch for fishermen will diminish. However, the probability of this is largely dependent on planting, because a large part of the salmonoid catch is currently based on planting.

With regard to recreational fishing, the shortening of the ice-winter will improve the possibilities of lure fishing and reduce ice-fishing.

However, it is probable that the impacts of changes in fish populations will have only minor impacts on recreational fishing. The changes will be slow in proportion to one's lifetime, and in the case of a recreational activity, expectations can be quite flexible. Recreational fishing as such is quite rapidly developing and changing. New modes of catching fish come into fashion all the time (today's trolling trend, for example), while the commercialisation of the hobby and even aspects related to the protection of animals may significantly affect the nature of recreational fishing in the future.
Impacts on fish farming

The potential impacts of climate change on the prerequisites for fish farming will essentially depend on the temperature tolerance of the cultivated species. Our most important cultivated fish is rainbow trout, for which warming could be more a disadvantage than advantage. The warming of waters may increase the production of fish farming facilities if the temperature increases at a time favourable for growth. However, the annual added growth of production is limited by licence conditions. This means that improved individual growth cannot increase total production by any significant amount unless the cultivation cycle becomes shorter over entire growing seasons. Extended heat waves have been observed to weaken the growth results.

In theory the production of a fish farming facility producing salmon smolts could at best be doubled. However, this would mean that it should be possible to increase the amounts of water used. On the other hand, an excessively warm summer could cause death to salmon fry if no cold groundwater was available at the facility.

In the case of aquaculture, warm summers have imposed problems on cultivation, including production breaks, retardation of fish growth and impaired product quality. Climatic warming may increase the problems of fish farming. The expected outlook includes reduced appetite, increase in diseases and parasites, and the added difficulty of caring for cultivated fish (for example, bathing becomes more difficult in warm conditions). The impacts will be similar in inland waters and the sea and affect the cultivation of edible fish as well as the production of fish for planting.

Indications from the cultivation of female fish and production of spawn suggest that in the case of coldwater fish, this essential primary production is quite sensitive and hard to predict after warm growing seasons.

Uncertainties

Even though the impacts of climate change on fisheries have been studied to a certain extent, there are deficiencies associated with assessing the state of fish stocks. A crucial problem is that there is quite intense natural variation in fish stocks. Furthermore, the vast number of bodies of water in Finland imposes its own limits on research. The catch is affected by many other factors besides climate change. If catches increase, this can also be attributed to the successful management of fishing waters, increased catching efforts and eutrophication. It is difficult to distinguish the impacts of climate change from other anthropogenic impacts when observed by means of conventional ecological criteria regarding the abundance, growth and catches of different species.

Table 3.4. *Summary of the anticipated impacts of climate change on fisheries in Finland. The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant. Some of the impacts are clear advantages or drawbacks but the direction of some impacts is still unclear or the direction of the impact depends on the intensity of climate change.*

Disadvantage	Direction of the impact unclear or simultaneous disadvantage and advantage	Advantage
– Coldwater species will decline in the waters of Southern Finland – Oxygen concentration in waters will decrease – Production of fry by salmonoids will suffer – Significance of salmonoids as a catch will diminish (dependent on the extent of planting) – In fish farming, warm summers may cause production breaks, retarded growth and impaired quality – Caring for cultivated fish will become more difficult	• Runoff of water systems and rivers will change • The composition of fish stocks will change • The cycle of nutrients will become accelerated • New species of fish will migrate to our waters from more southern parts of the Baltic Sea • The period of fishing on ice will become shorter	+ Warmwater species will spread towards the north + Growth of fish will increase + The early stages of fish will benefit from warmer waters + Catches will increase + Warming of waters will increase the production of fish farms

3.2.1.4. Reindeer husbandry

Reindeer husbandry in Finland

The severe natural conditions of Lapland limit traditional agriculture in the northern areas of Finland, but livelihood has conventionally been sought from reindeer herding. Reindeer herding is a significant industry in remote northern regions, because it ties people to their surroundings and simultaneously creates the foundations for their livelihood, even though a significant part of their income originates in other natural sources of livelihood as well as business activities based on these. The significance of reindeer herding for the regional economy and society is increased by the industry's connections with other agricultural industries, rural development and the Sami culture.

Reindeer herding in Finland differs from its counterparts in Sweden and Norway in that it is allowed for all citizens of EEA countries resident in the reindeer herding area. With some exceptions, reindeer herding in Sweden and Norway is the exclusive right of the Sami people. However, reindeer husbandry is the most important source of livelihood for the Sami, and the largest number of reindeer per capita can be found within the Sami homeland. In addition to economic values, reindeer herding has a large cultural significance to the Sami, reinforcing their ethnic identity.

The most essential regulations applicable to reindeer husbandry are based on the Reindeer Husbandry Act (848/1990). The Act sets limits on the area where reindeer husbandry is allowed. According to the Act, reindeer may only be owned by permanent residents of the reindeer herding area or reindeer herding cooperatives. The northernmost parts of the reindeer herding area are specifically intended for reindeer herding. State land in this area may not be used in a manner that may significantly hinder reindeer herding. Other important regulations applicable to reindeer herding include the Act on Financing Reindeer Husbandry and Natural Sources of Livelihood (45/2000), the Skolt Sami Act (253/1995), the Nature Conservation Act (1096/1996) and the Act on the Sami Parliament (974/1995).

Reindeer husbandry is supported on the basis of the Skolt Sami Act and the Act on Financing Reindeer Husbandry and Natural Sources of Livelihood. The animal-specific subsidy is based on the Act on National Aid for Agriculture and Horticulture

(1559/2001). The Government and the Ministry of Agriculture and Forestry make annual decisions concerning the aid. Projects aiming to diversify reindeer husbandry are also supported through the Development Fund for Agriculture and Forestry and EU funding channels. Those engaged in reindeer husbandry can receive compensation on the basis of the Government Decree on Compensation for Damages Caused by Predatory Animals (277/2000). Damage to reindeer caused by the golden eagle are compensated from the funds of the Ministry of the Environment.

The land designated as the reindeer herding area is 114,000 km² or 36 per cent of Finland's total land area. Four fifths of the reindeer herding area is in the Province of Lapland. Only the most industrialised and densely populated southwestern part of Lapland falls outside the reindeer herding area. Two fifths of the Province of Oulu, namely the northernmost and easternmost areas of the province, belongs to reindeer herding area. Keeping reindeer outside the reindeer herding area is considered normal animal husbandry with no free right of grazing and no access to the support or compensation systems associated with reindeer husbandry.

Reindeer herding can be practised in the reindeer herding area regardless of the ownership and control of land, which may at times cause conflict with land owners. Many other means of livelihood, such as forestry, agriculture and tourism, can be considered as competing for the same land areas with reindeer herding.

The parts of the reindeer herding area are geographically different from each other. The differences between the regions are reflected in the methods and culture of reindeer herding. The regions also differ in that, depending on vegetation, their exposure to the adverse impacts of climate change varies.

The number of reindeer owners has decreased from 7,500 to some 5,300 in less than ten years, and the decline is expected to continue. Not all reindeer owners are engaged in the trade full-time; the numbers also include other household members who may also seek additional income from agriculture and forestry, fishing and tourism. Reindeer owners have formed regional organisations called reindeer herding cooperatives, which carry out certain tasks imposed on them by the Reindeer Husbandry Act, among other things. A reindeer owner must always be a member of a reindeer herding cooperative, and in order to become a new reindeer owner, one needs the approval of a reindeer herding cooperative, so it is not possible for any random person to become a reindeer owner or take on reindeer herding in practice. The Association of Reindeer Herding Cooperatives serves as a joint body of the cooperatives. There are approximately 35 enterprises engaged in the industrial processing of reindeer meat, while hundreds of reindeer owners market reindeer meat cut and packed at the primary production level. The number of enterprises engaged in reindeer tourism is approximately 200.

The total number of reindeer in all reindeer herding cooperatives has been approximately 300,000 in recent years. Almost 200,000 of these have been "living" reindeer as defined in the Act. The number has decreased considerably since the peak years of the 1980s, when there were approximately 400,000 reindeer and the production of meat exceeded the current level by more than one million kilograms.

Even though the significance of reindeer husbandry to the Finnish national economy is only minor, it is a significant sector of primary production in Lapland. As the activities are related to primary production, tourism and other services, they are mostly carried out in rural and sparsely populated areas. In accordance with the most recent calculations and records of farms included in the profitability bookkeeping scheme, the employment effect of reindeer husbandry is approximately 2,800 man-years. Reindeer meat is economically the most significant product, with annual production of approximately 2 million kilograms per year. The value of reindeer meat at slaughter has been some 11–14 million euros per year. Processing approximately triples the value of reindeer meat to 37 million euros. The value of reindeer tourism is some 15 million euros per year, and the annual consumption of other reindeer products is some 3.4 million euros. These calculations indicate that the annual turnover of reindeer husbandry is 50–60 million euros, making up approximately two per cent of the GDP of the Province of Lapland. Through its multiplicative effects associated with processing, trade, tourism and traffic, the significance of the reindeer industry to the regional economy increases to 2–3 times that of primary production.

During the last decade, reindeer husbandry has been transformed into a modern, specialised occupation, which has lead to an increase in the size of production units. The structural change has been caused, among other things, by the animal-specific support paid to reindeer husbandry, as well as investment aid paid under the Financing Act. No major structural changes are expected in the future. Reindeer husbandry can be a commercially profitable business, but the small volumes cause problems in securing a sufficient livelihood.

The Ministry of Agriculture and Forestry determines the number of “living” reindeer (those left for rearing after others have been slaughtered) a reindeer herding cooperative may keep in its territory and the maximum number of such reindeer a shareholder of a reindeer herding cooperative may own. When determining the maximum number of living reindeer, the Ministry must take into account, among other things, that the number of reindeer grazing in the territory of the reindeer herding cooperative during the winter season does not exceed the estimated sustainable production capacity of the winter pastures.

Impacts of climate change on reindeer husbandry

The mean annual temperature is expected to increase by a few degrees within the next hundred years. This will mean milder winters in Northern Finland, increased growth of forests, and earlier melting of snow. In the short-term, snow may become thicker due to increased precipitation, and the risk of snow becoming hard will increase due to higher temperatures. In the long-term, mosses and shoots may replace lichen and the timberline may rise in the fells. Climate change will have significant ecological impacts, especially on the population dynamics of reindeer. In addition to general warming, one of the risk factors of climate change is that the climate and weather may become more unstable.

The processes affecting the quality and availability of nutrition, as well as the movement of animals, are often linked to winter temperatures and the amount of snow. These factors are regulated by the movements of atmospheric masses in the North Atlantic, the most well-known of which include the North Atlantic Oscillation NAO and the Arctic Oscillation AO.

Changes in the number of reindeer are found to be linked to these weather variations, even though detailed information is for the time being only available from one reindeer herding cooperative. During the last 30 years, the NAO indices have been exceptionally positive, which has been regarded as an indicator of climate change. When the NAO index is positive, westerly winds carry heat and humidity in the winter, and this is manifested as snowfall during the frost season. Abundant rainfall usually means a thick cover of snow, which makes it difficult to move about and find nourishment.

Mutual interdependency has also been observed between climatic variables and the density of reindeer. In other words, the impact of the climate becomes greater as the density of reindeer increases. This is probably due to the fact that with higher densities of animals, pastures weaken and competition for nutrition becomes more intense.

Studies on the impacts of the thickness and hardness of snow cover on the use of nutrition by reindeer started in Finland as many as thirty years ago. According to the studies, the snow conditions in the winter affect the next summer's calf percentage[22] and the autumn weights of calves through the condition of the mother. It is important to monitor the calf percentage and calf weights because the profitability of reindeer husbandry is greatly affected by the success of calving, due to the fact that most of the reindeer taken to slaughter are calves.

The number and condition of natural pastures are of decisive importance to reindeer herding. According to studies, the selection of pastures by reindeer is crucially affected by the depth, hardness and density of snow. Reindeer tend to seek areas where the availability and quality of nutrition is best in relation to the season. In winter, it is most important for the condition of a reindeer that there is enough nutrition available and the amount of energy expended when finding it is lower than the amount of energy gained. If sources of nutrition are abundant beneath the snow, the reindeer will dig them up, but if digging in poor lichen pastures is no longer profitable for the reindeer's energy economy, it will preferably feed on horsehair lichen and beard lichen if they are available. If a reindeer starts to eat horsehair lichen, it often completely stops digging for nutrition beneath the snow. The reason may be that snow conditions in late winter have become too difficult.

Increased instability of the climate and weather is risky for reindeer herding especially early in the winter when a permanent snow cover is formed. For example, if the soil does not freeze properly, snowfall is abundant and warm periods with rain occur frequently after snow has fallen, the probability of the emergence of ice layers, very hard snow layers and moulds will increase.

Winter thunderstorms can also be harmful to reindeer herding, because pools of water and ice may increase the soil temperature, making plant mycoses more common

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[22] The calf percentage refers to the number of calves per 100 females in reindeer counted in round-ups.

and keeping reindeer out of contaminated areas. An example of soil warming was seen in Norway in 1996 when two thunderstorms increased the mean soil temperature from minus seven to zero degrees for most of the winter.

The adverse impact of wintertime rain pouring onto the snow cover can be worse than that of thunderstorms. After the temperature goes below zero, hard layers can be formed in the snow cover or, if the snow cover is fairly thin, water can penetrate it and freeze on the surface of the soil, leaving lichen and other vegetation under the cover of an ice sheet or entirely surrounded by ice. This will prevent reindeer from reaching the nutrition. After freezing, reindeer must resort to lichen growing on trees, also known as horsehair lichen, and if it cannot be found, must use additional nutrition provided by man or find areas that are not frozen. Even if the animals do not actually starve to death, they will consume a significantly larger amount of energy in finding nutrition. This may also force the reindeer to move farther north. This type of so-called ice sheet winters may cause nutrition problems for reindeer and reduce the production of calves. Model calculations carried out in Canada indicate that this type of impact will significantly increase by the end of the century.

On the other hand, an early spring is beneficial to reindeer, because the availability of green nutrition plays a crucial role with regard to the condition and growth of the animals. Warm rains in the spring will quickly melt the snow, facilitating the availability of nutrition and increasing the production of plant biomass (including mushrooms). The nutrition content of plants may also improve as the growing period becomes longer. This will improve the condition of the reindeer and lead to better slaughtering and overwintering conditions.

An increase of 2–4 degrees in summer temperatures may increase the number of blood-sucking and parasitic insects. The number of insects has been found to correlate with summer temperature and windiness. Stress caused by insects affects the weights and mortality of reindeer, because nuisance caused by insects reduces the time spent grazing and increases energy consumption. On the other hand, the potentially increased occurrence of dry summers could result in fewer insects, but the quality or composition of nutrition could be less advantageous for reindeer as, for example, there will be no mushrooms. A wet spring (lots of flooding pools from melted snow) and hot summers with an abundance of rain may also significantly increase the number of insects. Changed weather factors may also affect the occurrence of new and already known parasites and diseases. However, there is little research regarding these issues.

Studies show that forest management will have both positive and negative impacts on reindeer pastures. The negative impacts concern critical winter pastures, areas of lichen and horsehair lichen. Climate change could boost the growth of forests in this century, and the increase is estimated to be focused in Northern Finland. The growth of forests may increase forestry activities, which in turn may complicate the use of pastures. On the other hand, increased forest growth will also provide the opportunity to develop forest management methods causing less harm to reindeer herding.

Climate change may also change the competitive factors with regard to plant species. Shoots, moss and grass will probably benefit from a warm and rainy climate, and they could start to replace reindeer lichen by smothering its growth. The increased growth of forests may also make the growing conditions in the ground layer less advantageous to lichens.

Some species of predators may spread farther north. For example, the lynx could become more abundant in Lapland as the living conditions of its main prey, the hare, improve. This may also cause problems to reindeer herding. If the snow-covered period is further shortened in Lapland, this may affect the compensation received by reindeer owners for predator damage, because reindeer killed by predators can in practice only be found during the snow-covered period.

Milder winters may also affect reindeer herding practices. The arrangement of round-ups in the autumn may become more difficult, as the lack of autumn frost will make it impossible to drive reindeer over rivers and lakes in the normal way.

The scenarios describing climate change predict that the risks of wildfires and forest fires will increase in Finland due to longer summers, more abundant drought periods and increased evaporation. Increased windiness will also increase the impacts of forest fires in lichen pastures, because lichen and shoots are easily ignited by the smallest spark during dry periods. At present, most forest fires are due to the careless handling of fire by people engaged in recreational activities and lightning. The probability of large fires is expected to increase.

The impacts of climate change on reindeer husbandry still involve a great deal of uncertainty, even though there is a lot of information available regarding reindeer husbandry. The uncertainties include, among other things:

- Most research results originate from a short period of time.
- There are no sufficiently long time series of the thickness and hardness of the snow cover available in order to reliably compare variations in snow cover and the calf percentage both with each other and in contrast to the experienced climate changes.
- It is not known with certainty if plants will have enough time to adapt themselves to climate conditions, and how will this be experienced.
- There is no certainty about any connection between the strengthened west-to-east flow in the North Atlantic, illustrated by the NAO index, and anthropogenic climate change.
- The fact that the reindeer herding area is extensive and conditions vary in different parts of the region makes it difficult to make any generalisations.
- Different parts of the territory of even a single herding cooperative may vary in terms of abundance of different pasture types, snow conditions and reindeer herding practices.

Table 3.5. Summary of the anticipated impacts of climate change on reindeer husbandry in Finland. The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant. Some of the impacts are clear advantages or drawbacks but the direction of some impacts is still unclear or the direction of the impact depends on the intensity of climate change.

Disadvantage	Direction of the impact unclear or simultaneous disadvantage and advantage	Advantage
– Snow conditions will become more difficult – Pastures will weaken – The reindeer's competition for nutrition will become more intense – The quality and availability of nutrition will weaken – Weather variations in early winter and rain in the winter will increase the risk of mould formation in vegetation – Increased temperatures will increase the number of insects, which causes stress to reindeer – Climatic warming will increase the occurrence of parasites and pathogens – The risk of forest fires and the probability of large fires will increase	• The growth of forests in Northern Finland will increase	+ Early spring will improve the supply of nutrition, improving the condition and productivity of reindeer + Drought periods in the summer will decrease the number of insects and the stress caused by them to reindeer + The condition of horsehair and lichen pastures will improve, they will regenerate faster and more new pastures will emerge + The longer and warmer growing season will increase the production of plant biomass (including mushrooms), which will lead to better slaughtering and overwintering conditions

3.2.1.5. Game management

Game management in Finland

Finnish game species are plentiful. Among our mammals, there are 34 game animals, some of which are not found wild in Finland. In addition, 26 of the country's bird species are game birds.

The number of hunters who pay an annual game management fee has stayed around 300,000 in the past couple of decades. The decrease in rural populations has also affected game management. At present, a significant number of hunters live in urban areas, which is reflected in longer distances to hunting areas and a decreased number of hunting days. However, hunting opportunities have a positive impact on the settlement and viability of the countryside. Hunting is mostly practised for household consumption; not much of the game caught is sold. In 2002 the value of the game bag was 73 million euros. The value has increased for several consecutive years. Moose meat has the greatest economic significance, and its total amount has increased in recent years. The significance of other game species has remained relatively stable. Most recreational hunters are prepared to invest significantly greater amounts in hunting compared to the possible financial gains.

Hunting rights in Finland are bound to land ownership. A landowner can lease out hunting rights to hunting clubs or private individuals. There are almost 5,000 hunting clubs in the country, with membership covering approximately 80% of the hunters who have paid their game management fee.

The Ministry of Agriculture and Forestry secures the preconditions of game management by regulating the utilisation and management of game stocks, taking responsibility for the preparation of legislation concerning hunting, deciding on the hunting quota for certain game animals, and issuing guidelines and regulations. Metsähallitus is responsible for the use of hunting rights and game management on State land. Statutory organisations associated with hunting and game management include the Hunters' Central Organisation, game management districts and game management associations. The Finnish Game and Fisheries Research Institute, which belongs to the administrative sector of the Ministry of Agriculture and Forestry, produces scientific information on the development and living conditions of game stocks.

Hunting is regulated by the Hunting Act, decrees, Government decisions, Ministry decisions, regulations and guidelines. In addition, statutes such as the Nature Conservation Act, the Prevention of Cruelty to Animals Act, the Criminal Code, and legislation concerning firearms include provisions associated with hunting.

Impacts of climate change on game management

The relationship between the climate and flora and fauna is complex. Each species and habitat has its own level of tolerance to the climate. When the climate changes, each species reacts to the change in a different way. Some species do well, some decline or migrate elsewhere. The entire ecosystem reacts and adapts itself to new conditions.

Impacts of climate change on the populations of small game and small mammals

One of the characteristic features of Fennoscandian fauna is the cyclical nature of the populations of small game and small mammals, referring to regular pronounced variation of populations. Despite vast amounts of research, no single solution to such population dynamics has been found. Population dynamics depend on certain characteristics of the species' population biology, including birth and death rates and age structure.

Studies and models have indicated that, for example, small predators specialising in voles as their prey have a decisive impact on the collapse of vole populations, which may also affect the population dynamics of small game through alternative prey. Predator populations increase in years when voles are abundant, and once vole populations collapse, this may have a reducing impact on other small game populations. However, predator populations cannot survive for extended periods on this alternative prey but will decline until a new peak in voles starts another development cycle. In the north, a characteristic feature of vole population dynamics has been the fact that the collapse has been simultaneous for all vole species and that it has continued during the summer. In the south, the vole populations have traditionally been more stable, which has been explained by the abundance of general predators (red fox, badger, many birds of prey). This has been possible due to the lack of snow, because it is easier for general predators to hunt in snowless terrain, and due to the abundance of alternative prey such as grouse.

Considerable reduction in snow due to climatic warming in the southern and central parts of the country may have several impacts on ecosystems. Reduced snow cover is estimated to favour red fox populations, but a general increase in red fox numbers may also relate to the smaller variation in vole populations in Northern Finland. In addition to red fox, the distribution of hibernating general predators, such as the raccoon dog and badger, will move north due to the extended growth period and shorter winter. The northern limit of the distribution of these species will be roughly determined by the period of hibernation for which they are able to store fat in their bodies. If this physiological property remains unchanged, the species will be able to spread farther north when the climate becomes warmer. The increased abundance of the red fox, raccoon dog and badger will result in significantly higher density of small game mammal predators than at present in large parts of Finland.

The increased abundance of general predators and the stability of their populations may hinder the reproduction of small game species that have previously adapted themselves to only occasional predator pressure. On the other hand, if the occurrence and intensity of population variations essentially depends on the amount of snow, climate change may cause the southern stable type of small game abundance to move north, and the steep variation of the north will be limited to extreme regions or completely disappear. This question concerns the regional migration of entire ecosystems and the types of population dynamics they form. This would make populations more stable, and population dynamics over several years would become more balanced. Cyclicity would be replaced primarily by seasonal variation. This means that the disappearance or levelling of deep crashes in vole population dynamics will reduce the predation pressure on alternative prey such as game birds. On the other hand, the increase in predator populations and the decrease in the amount of snow, which facilitates hunting, will increase predator pressure.

The increased abundance of the red fox may also burden muskrat populations. The increased abundance of the red fox may also have an impact on the populations of the extremely rare Arctic fox due to its inability to compete with the red fox.

The greatest impacts of climate change will concern game birds that winter in Finland. All of our grouse species have declined within the last 40 years. In addition, the cyclic variation of populations that used to be characteristic has disappeared or been disturbed within the last 10–15 years.

Even though the origin of cyclicity is not completely known, it is known that cyclicity is associated with many factors that partly deepen and shape population dynamics. The potential causes of such external interference include weather factors, predators and parasites. The worst possible weather type for the young of many species is cold rain, which soaks both the young animals themselves and the nutrition environment. The heat production of the soaked young accelerates and quickly consumes the scarce energy resources of a young body. A soaked environment prevents nutrition, because studies have indicated that the young avoid wet vegetation soaked by rain. Weather factors can be the reasons for such external interference but do not cause population variations as such. An occasional event of interference impacting on the result of reproduction keeps cyclicity going. The interference factor could be different each time.

It has been estimated that boreal species might decline due to climate change. For example, the distribution of willow grouse will move farther north, and capercaillie, which has recently become more abundant, might suffer. The reduced coverage of bilberry could be a problem, because unbroken stands of bilberry are an important source of nutrition for all grouse, mature as well as young.

Cyclical nature of game stocks

The populations of capercaillie, black grouse and hazel hen used to vary in periods of six to seven years until the mid-1980s. The next cycle was clearly longer, almost nine years. Later on, variations in population became occasional annual variations. The cycles of grouse disappeared almost simultaneously all over the country. This also happened to many other species: for example, long-term monitoring of voles at Pallasjärvi in Lapland started to indicate almost stable densities. Sharply fluctuating vole cycles disappeared in Northern Sweden as well. It is unclear whether climate change has already affected the cycles and turned the traditional 6 to 7-year cycles in Lapland's grouse populations to 3 to 4-year cycles. On the other hand, the disappearance of cycles can be superficial, because local populations may still vary sharply and in cycles.

The decreased amount and increased hardness of snow may hamper the overwintering success of grouse. On the other hand, species that would benefit from a milder climate and lesser snow cover include at least the brown hare, rabbit, pheasant and partridge, because the northern limit of their distribution is mainly dictated by the level of snow. The wild boar may also spread farther north.

Wintering waterfowl would probably belong to a category of species benefiting from climate change, because mild winters with an extended ice-free period would improve their success. According to studies, many species of birds are able to adapt themselves to rapid changes in climate. If mild winters become more common, most migratory birds will come to Finland earlier in the spring. Earlier migration is most probable in the case of species wintering nearest to Finland, because simultaneous warming will occur in their wintering areas. Such birds may also be in better physical condition than after severe winters, and early nesting will produce more progeny compared to species that nest later. Migratory birds that arrive early, such as the goldeneye and mallard, would probably benefit from the earlier thawing of land and water areas from snow and the earlier development of vegetation and insects.

Impacts of climate change on deer populations

If the present climate of Southern Scandinavia and Northern Germany becomes prevalent in Southern and Central Finland, southern species that do not thrive in abundant snow, such as roe deer and the possible newcomer red deer would be successful. Other large herbivorous mammals, such as moose and white-tailed deer, would also benefit from decreased snow cover; edible plants would be available for a longer period and more easily foraged, and it would be easier to move about. The depth of snow cover has been found to have clear impacts on moose behaviour. Damage caused by moose is directly and indirectly linked to their movement. In winter pastures, for example, the risk of forest damage decreases in winters with less snow, because moose will be better able to select their forage and obtain it over a larger area. This could change the proportions of tree species in developing forests. If the number of moose in Southern Finland grows considerably due to more favourable conditions, this may reduce the ability of broad-leaved trees, especially aspen, rowan and goat willow, to grow to mature ages. The thickness of snow cover and severity of the winter are found to be linked to moose movement. In severe winters with thick snow, moose concentrate on smaller areas and cause more damage. A strong decline in the level of snow may thus reduce forest damage if the populations otherwise remain nearly unchanged.

Impacts of climate change on large predators

With regard to predators, distribution is probably dependent on changes in the distribution of their main prey rather than the climate. Thus, for example, lynx can spread farther north as the living conditions of its main prey, the hare, improve in Lapland. Hibernating animals such as the brown bear will also benefit from climatic warming. The northern limit of brown bear distribution is determined by the period of time for which the animal can store energy in its body.

Impacts of climate change on the ability of game species to seek shelter

Snow cover and sleeping in a cavity in the snow protects grouse against small predators and the cold. An intense reduction in protective snow in connection with milder winter temperatures could cause the distribution of some species to move farther north. In these areas, the quality of snow may become harder, compressed by ice layers and difficult to dig, which will cause problems for grouse as well as reindeer.

The early and late appearance of protective white colouring may cause problems for willow grouse, ptarmigan, hare, Arctic fox and ermine when they try to avoid predators in a shortening winter. The transformation into winter colour is primarily regulated by a change in illumination. Even if the duration of the winter becomes shorter due to climate change, illumination will not change. Game animals which are white stand out in a dark forest and are therefore easy prey for predators. Over a longer period, predators will eliminate those individuals that have not adapted themselves to new conditions, and the genetic material they represent, but this is not likely to happen for a very long time – perhaps a hundred years. The risk is that the populations of game species that are exposed to increased predator pressure for long periods of time, as described above, will suffer substantially.

Climatic warming will shorten the duration of the ice cover on the Baltic Sea and reduce its extent. This will cause direct harm to the ringed seal, which descends from the population living in the Arctic Ocean and has adapted to life in fast ice and breeding in snow deposits on ice so well that it requires these to thrive. When the ringed seal has to give birth on bare ice or land, its young are exposed to predatory mammals and birds, as well as severe weather. In addition, the ringed seal may find itself incapable of competing with the larger grey seal that is able to exist on broken and weak ice.

Impacts of climate change on parasites

Reinforcement of the small predator community – red fox, raccoon dog (and, to a lesser extent, badger) – may substantially change the distribution of diseases and parasites transmitted by these species in our country. Many parasites and pathogens transmitted by predators have been nonexistent or rare because the density of the spreading species has not been sufficient to create and propagate epidemics. This issue is even more serious as several of the relevant diseases and parasites can be transmitted to humans and can even cause danger to life. The increased abundance and reduced variations in the populations of fox – and, according to most recent preliminary information, raccoon dog – may allow the most dangerous human parasite, a helminth parasite *Echinococcus multilocularis,* to spread from Central Europe or the region east of the White Sea. This would cause a collapse in the export of forest berries to Central Europe, and the collection and use of natural products, which is important to Finns, would face substantial changes. *Echinococcus granulosus,* or cervid echinococcus, is not harmless either; in addition to wolves and dogs, it is probably spread by other canine species. Prevention of parasites in domestic animals would also have to be reformed due to these trends.

If the density of small predators rises above a threshold value, the risk of rabies spreading to our country will also increase. Even during our most recent epidemic in the late 1980s, the raccoon dog was a much more common vector of rabies than the red fox. The raccoon dog has probably played a central role also with regard to trichinae becoming more common in Finland.

Climatic warming will also promote many diseases that increase mortality in hares, fowls and aquatic birds.

Uncertainties

The impacts of climate change on the populations of game animals and predators are associated with several factors of uncertainty. Natural annual variation in the birth and death rates of mammals is so large that variations caused by climate change can only be reliably observed in long-term studies. Studies on the cycles of Finnish grouse have probably been the most extensive in the world, and the time series are uniquely long, but there is still only currently enough data for preliminary time series analyses. Furthermore, the prediction of population dynamics still includes several theoretical problems regarding the stability of the populations and their sensitivity to interference. Furthermore, the disappearance of regular population variations can be caused by several factors other than weather, some of these partially unknown. For example, mathematical models indicate that cyclicity could also disappear through the fragmentation of habitats.

Table 3.6. Summary of the anticipated impacts of climate change on game management in Finland. The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant. Some of the impacts are clear advantages or drawbacks but the direction of some impacts is still unclear or the direction of the impact depends on the intensity of climate change.

Disadvantage	Direction of the impact unclear or simultaneous disadvantage and advantage	Advantage
– Reduced level of snow in Central and Southern Finland will facilitate hunting by general predators – The populations of small predators will increase, adding to predator pressure and the occurrence of parasites and pathogens – Reduced amount of snow and weaker quality of snow deposits will weaken the overwintering success of grouse – Shorter winter will expose game animals with a protective winter colour to additional pressure from predators – Reduced ice and snow cover will be a threat to the Baltic ringed seal	• Damage caused by moose may increase or decrease, depending on the amount of snow • New game species will spread to our country from the south, and the populations of current species with a southern distribution will become stronger	+ The populations of small game and small mammals and population dynamics will become more stable + Predator pressure on alternative prey such as game birds will decrease + Wintering waterfowl will benefit from mild winters + Migratory birds that arrive early will benefit from the earlier thawing of land and water areas + Deer species will benefit from reduced snow cover + Longer periods of growing and reproduction will promote the development of young and their survival in winter due to their improved condition in the autumn

3.2.1.6. Water resources

Water resources in Finland

Water is a vital renewable natural resource. Precipitation, drainage and evaporation keep water in continuous circulation. By way of international comparison, Finland's water resources are abundant and of a high quality. Sea borders us from two directions. The area of Finland's territorial waters in the Baltic Sea is some 36,000 square kilometres. Finland's water area is vast: 187,888 lakes and ponds of more than five hundred square metres, as well as a total of 25,000 kilometres of rivers. The total area of inland waters is some 10% of the total area of the country. The total volume of water in Finnish lakes is approximately 235 cubic kilometres. Lakes tend to be shallow, but the quantity of water flowing in rivers is large, approximately 300 million cubic metres a day. Groundwater is also abundant. There are some 7,000 classified groundwater areas in Finland, and they are supplemented by about 6 million cubic metres per day, on average. Groundwater is in widespread use in Finland as household water and a source of raw water for water supply plants, because it is often better protected against contamination and of a better quality than surface water. About 60% of all household water distributed by water supply plants is groundwater. Generally, the quality of household water distributed by water supply plants is good.

In addition to water supply, water and water systems are used for hydroelectric power production, fishing, recreation and waterway traffic, as well as for conducting wastewater. Construction work is carried out on water systems and their catchment areas in order to promote the use or protection of bodies of water, prevent floods and drain land for cultivation or forestry. Bodies of water and shores are managed and reconditioned due to landscape management and recreational use. Water regulation is used to adjust water levels and alter runoffs by means of dam structures or hydroelectric power plant structures in order to cater for the needs of flood protection, hydroelectric power production, water traffic and water supply. The objective in water services is to ensure the availability and quality of services in all conditions. To ensure that water and sewerage networks match the needs of households, businesses and recreational activities, efforts are made to extend the networks to all areas where the best way to organise water services is to connect buildings and sites to the networks of water supply plants. The requirements of water services will vary regionally as a consequence of migration and construction activities.

Water quality and water habitats are affected by emissions from different point and non-point sources, as well as natural leaching. Natural leaching refers to the flow of matter that is naturally conveyed to bodies of water from catchment areas without any impact of human activity. Point sources include, among other things, loads caused by industry and communities. Non-point sources include agriculture and forestry, as well as households in sparsely populated areas. In addition to the desired impacts, water system projects may also cause disadvantages to water quality, species, the landscape and recreational use.

The estimated asset value of investments serving the utilisation of our country's water resources, including structures built in, on and around waters to improve communications and reduce flood damage, and structures built for water services purposes, is more than 25 billion euros.

The responsibility for water services in our country lies with municipalities and water supply plants, as well as real estate owners and holders. Municipalities develop water services within their territory to match the development of the community and participate in general regional planning of water services. Municipalities also prepare and maintain regional water services development plans jointly with the water supply plants of the region.

The Ministry of Agriculture and Forestry provides a legislative framework for water services activities, supports water services projects carried out by municipalities, water supply plants and cooperatives, and promotes and supports research and development in the sector. The protection of groundwater and the preparation of protection plans is primarily the joint responsibility of municipalities and water supply plants.

The Ministry of Agriculture and Forestry guides the regional environment centres and the Finnish Environment Institute in dam safety issues, with the exception of rescue operations which are the responsibility of the Ministry of the Interior and administrative bodies under it. The crucial objective is to prevent flood and dam damage in advance. Dam safety issues include the supervision of compliance with the Dam Safety Act (413/1984) and any provisions and regulations issued by virtue of it, as well as attending to the safety of dams controlled by the State. The scope of the Dam Safety Act includes some 450 dams, of which about 380 are waterway dams while the rest are waste dams.

Regulation is usually the responsibility of power companies or regional environment centres. A regional environment centre can be the holder of a regulation permit on behalf of the government when the project has extensive impact. Regulation is subject to a permit from an environmental permit authority in accordance with the Water Act.

Regional environment centres provide expert advice on the rehabilitation of bodies of water and participate in project planning and implementation jointly with municipalities, other authorities and the parties carrying out rehabilitation. The Finnish Environment Institute (SYKE) is involved in education and development within the sector.

Impacts of climate change on water resources

Climate change is expected to cause changes in annual precipitation, drainage, evaporation and temperatures, as well as their distributions. Extreme events such as drought, heavy rain and floods are expected to become more common. The storms in the autumn of 2001 raised extensive debate on the need for society to better prepare for storms.

Potential warming of the climate and increased precipitation will affect the maximum runoffs of water systems and the variation of runoff over time. Estimates indicate that the largest and rarest occasions of rainfall will increase by as much as 50–80 per cent during the next hundred years. Annual variations in the occurrence of floods may also increase.

Floods in Central Europe

Between 1998 and 2002 Europe suffered over 100 major damaging floods, including the catastrophic floods along the Danube and Elbe rivers in 2002. Since 1998, floods have caused some 700 fatalities in Europe, the displacement of about half a million people and at least 25 billion euros in insured economic losses. However, the floods in Central Europe cannot be regarded as caused by climate change, but the probability of flooding is estimated to increase as a result of climate change. Weather conditions indicate phenomena that, in accordance with present understanding, would be caused by climate change.

Source: European Environment Agency, Environmental issue report no. 35, 2003.

Winter floods are expected to become more common in Southern and Central Finland, while spring floods will decline in Southern Finland. The heaviest floods in Southern Finland will be caused by heavy rain in the summer or autumn and may significantly increase in line with the increase in major rainfall. The heaviest floods in Northern Finland will still be caused by melting snow. Their magnitude will remain unchanged or decline slightly, as the decrease in floods caused by melting snow will be replaced by increases in precipitation and rain-induced floods. However, the level of snow and spring floods may temporarily increase in Northern Finland in the initial phase of climate change, but they will decline at a later stage. In principle, the reduction in snow cover and extension of areas that remain open in winter may have positive impacts, because these events will ease spring floods and balance the seasonal variations in water systems. The period of groundwater absorption will be extended and the groundwater resources will increase. Changes in the timing of floods will affect hydroelectric power production and water regulation practices. The reduced need for diversion caused by increased winter runoff and reduced spring floods will increase the amount of energy produced by hydroelectric power. Preliminary results indicate that regional maximum inflows will increase most at dams that have a small upper catchment area or that are located below the large central lakes of the water systems (Saimaa, Päijänne, Näsijärvi). The impact of increased precipitation and melting will be the strongest in these areas. In lake systems, the time of the design flood will move from spring to summer or, in the central lakes of the largest systems, to winter. In order to ensure flood prevention and the resistance of dams, reservoir space must be left in these lakes in order to prepare for autumn floods or even winter floods. If the design floods of dams do increase, this could require expensive investments in dams, for example, in floodgate structures, spillway crests or diversion channels.

In very exceptional circumstances, heavy rain similar to that in Central Europe may also occur in Finland, which would make extreme floods possible here as well. If the rains occur simultaneously with the melting of snow in the spring, river banks and the shores of lake areas may face problems. Winter floods are a threat to the central lakes of large waterway systems. Saimaa, Päijänne and Näsijärvi-Ruovesi will accumulate the increased autumn and winter rains and winter melt waters into a winter flood. Evaporation is no relief for flooding in the winter. However, damage in Finland would be minor in comparison with Central Europe, because swamp and lake areas will balance the peak runoffs. Finland does not have any mountain ranges that would increase the severity and total amount of rain. From mountains, water flows faster to rivers and lakes, causing rapidly rising floods and landslides. The population in shore regions is lower than that in Central Europe, resulting in lower potential for damage.

Sixty-five regions where flooding could cause significant damage have been identified in Finland. The greatest financial losses would be suffered by industry and buildings alongside waterways. For example, paper machines at paper mills would stop once a certain water level was exceeded. The greatest material damage would arise in the Vuoksi water system area, mainly at Imatra and Lappeenranta, where there are major industrial facilities close to water. The town of Pori would also be in trouble in the event of a temporary rise in sea water due to storm and atmospheric pressure variation simultaneously with river flooding, and rising waters from the River Kokemäenjoki to industrial areas. The next most significant damage would be suffered by buildings in the towns of Tornio, Ivalo and Kuopio. Flooding damage to buildings usually causes major financial losses. Even if damage is not permanent, drainage work is often prolonged, tedious and expensive.

Floods in Finland in summer 2004

The current extreme phenomena are not necessarily caused by climate change, but the impacts of climate change can nevertheless be estimated on the basis of the extremes of the current climate. In the turn of July and August 2004, for example, exceptionally high precipitation in Finland caused floods that resulted in intestinal bacteria entering wells and tapwater systems, stormwater and wastewater had to be pumped to bodies of water without treatment, lots of nutrients and decomposing organic substances were conveyed to bodies of water from arable lands and shores, fish populations died in certain sections of rivers, buildings became surrounded by water, basements were filled with water in several towns, many households lost their electrical supply, there were interruptions in rail traffic, roads had to be closed and different parts of the country suffered crop damages.

Floods can cause many disadvantages to water services. Increased water levels may cause the capacity of combined sewers and pumping stations to be exceeded, and untreated wastewater may be released into water systems and water intake plants. This may be a direct consequence of the water level or an indirect consequence of the loss of electrical power, for example. Ice, timber or other material carried by flood water may also cause plants to stop functioning. If flood water enters the household water system, it may cause water quality problems and, at worst, epidemics. In the worst case, the failure of sewage systems may lead to extensive epidemics.

Water services for a scattered settlement are usually more sensitive to floods than the water and sewerage utilities in densely populated areas. Surface water may easily end up in individual wells both in spring as the snow melts and during heavy rain. Overflow may occur in sedimentation basins. On the other hand, temporary water services and sanitation are usually easier to arrange in sparsely populated areas.

Water systems are very sensitive to pollution. Above all, the impacts of climate change on water quality are caused by periods of flood and drought that will become more common as a consequence of more extreme runoffs. The impacts of these on water quality can be assessed on the basis of previous incidents. Flood will very substantially increase the load imposed on bodies of water by nutrients and harmful substances. The load carried by water during a summer flood is a hundred times greater in comparison to normal summer runoff. Some of the load originates naturally, some is caused by human activity. Flood waters originating in industry, filling stations and old landfills are particularly harmful, as they may contain toxic substances or slowly decomposing substances. These substances may end up in a surface water intake plant, and the operation of such plants will also be hampered by an increased concentration of solid matter in the water during floods. Flood may also impair the quality of groundwater at artificial groundwater recharge sites. Nutrients and solid matter will also be washed out to the water from fields and forests. Milder winters will increase non-point source loading at least from catchment areas dominated by agriculture and forestry, even if the mean annual runoff does not increase. The added load is due to the fact that vegetation zones holding the nutrients are lacking, and the proportion of surface runoff increases when the soil is frozen. Climate change may also lead to net mineralisation of organic matter accumulated in forest soil over thousands of years, which may significantly increase nitrogen washout from forests. It is difficult to distinguish the direct impact of climate change from other factors underlying the leaching from forest soil, but the release of an abundant supply of nitrogen in forests is a risk factor.

In addition to floods in water systems, it is obvious that climate change will result in changes in rain intensity. This may make floods caused by heavy rain more common. Exceptionally strong local storms can emerge in Finnish conditions especially close to the coast. Heavy rain occurring in built-up or urban areas may easily cause major financial losses. Storm water systems are not designed for flood runoff, so heavy rain might easily lead to water from streets flooding into basements. Even an urban flood caused by heavy rain in a limited area will wash many impurities from streets, roofs and car parks into the sewerage system. In suburban areas, this storm water is usually drained directly into a body of water, impairing water quality. Storm water from areas with combined sewer systems will end up at sewage treatment plants, which may result in amounts that exceed their capacity, and diversion must be used as a last resort to ensure the functioning of the treatment process. Heavy rain causes damage to the infrastructure and, through erosion, may affect the protection of power and telephone cables.

It has been estimated that climate change will cause a decrease in the groundwater level in dry summers, which would be more frequent and longer. According to some scenarios, the summer season will be longer in the future. Long-term drought will cause problems for water supply, water traffic, energy production and industry. Especially in the summer months, energy production may decline due to reduced runoffs. Low water levels will cause difficulties for summertime water traffic.

Drought will be a disadvantage to agriculture as well. Present irrigation equipment in Finland allows the irrigation of 88,000 hectares of arable and horticultural land. If drought became more common, this would lead to an increase in the need for irrigation of a larger area. The availability of irrigation water might become a problem in some places due to the insufficiency of water resources. Drought can also impair the growth of trees and increase the risk of forest fires.

Drought in 2002–2003

The impacts of drought caused by climate change can be assessed through the extreme conditions of the current climate. For example, prolonged drought in 2002–2003 caused estimated losses of 100 million euros compared to normal water conditions. Thanks to the high price of electricity, hydropower producers did not suffer any losses, but buildings, agriculture and water supply were affected and suffered damage. Water supply problems received the most attention in the media. At least 10,000 households and more than 1,400 farms suffered from drought. Water had to be transported to more than 7,000 households and 1,100 farms. Water transports were expensive for individual households and municipalities and they also imposed a risk on fire-fighting activities, because water transports were mainly carried out using the tanker of fire departments.

In addition to sufficiency problems, the shortage of water will also cause problems for water quality. The supply of sufficient household water of a high standard is vital especially for human consumption, cattle farms and the food industry. Decreased groundwater levels may cause changes in the state of the reserves, and changes in the oxygen situation may lead to increased concentrations of iron and manganese.

The fact that weather events are becoming extreme will also have an impact on water protection of inland waters. Drought will reduce runoffs, causing internal loads in head-waters to impair the quality of water and reduce the oxygen concentration. On the other hand, floods will wash harmful substances into water systems. Increased temperatures will increase eutrophication.

As a consequence of nutrient loads, the basic production of planktonic algae in eutrophicated waters will increase, the water will become cloudy, less light will penetrate the water and oxygen consumption will increase. Eutrophication will increase the amount of organic material sinking to the bottom, and the oxygen conditions at the bottom will be impaired. Vegetation will change, followed by changes in benthic fauna. The biodiversity of species will decrease as eutrophication proceeds. Long periods of drought will cause problems in Finland's shallow lakes in the winter, as a low inflow does not carry enough oxygen-rich water into lakes. For example, the drought in 2002–2003 increased oxygen depletion in lakes, which caused fish mortality in the spring. On the other hand, increased runoff due to precipitation and melting in the winter will carry oxygen-rich water into water systems. The floods during the summer of 2004 caused extensive fish mortality in the River Vantaanjoki due to the abundant entry of oxygen-consuming solid matter and wastewater to the system, as well as the intense oxygen consumption of flooded soil.

The sea level is expected to rise by 0.1–0.9 metres by 2100. The increase in the ocean level, together with increased precipitation and potential increases in windiness and storms, will also raise the level of the Baltic Sea and intensify short-term variation in the water level. Potential increases in the sea level and strong winds may boost the exchange of water into the Baltic Sea. Increased salinity and temperatures may change the composition of species in the Baltic Sea. For example, the reproduction of cod is very sensitive to the impacts of salinity and temperature. The decomposition of wrecks and other objects related to marine archaeology may also be accelerated. However, it is not certain whether the salinity of the Baltic Sea will increase even if the sea level does rise. Increased precipitation may have a salinity-reducing impact, because the runoff of river waters will dilute the salinity of the Baltic Sea, increasing the difference in salinity between the surface and bottom waters, as well as stratification. Increased runoff of fresh water will also impede the inflow of salty water from the straits of Denmark. Because the replacement of water is necessary for the maintenance of the oxygen economy and salinity in deep waters, and for the living conditions of brackish water species, an infrequent inflow of salty water may be harmful to the Baltic Sea. Extended periods of low oxygen will cause chemical reduction reactions at the bottom, releasing nutrients. A strong inflow of salty water will cause the nutrients to move and expose the sea to eutrophication and algal bloom.

Table 3.7. Summary of the anticipated impacts of climate change on water resources. The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant.

Disadvantage	Advantage
– Extreme events will become more common – Winter floods will become more common – The possibility of extreme floods will increase (damage to industry and buildings, disadvantages to water services, epidemics) – Floods will impair water quality – Increased occurrence of drought will impair agriculture and forestry, water supply, hydroelectric power production, water traffic and recreational use of water – Drought will cause oxygen depletion in water systems and impair the living conditions of fish – Milder winters will increase non-point source loading in areas dominated by agriculture and forestry	+ Increased total precipitation and decreased spring floods will increase the amount of energy produced by hydroelectric power + Increased rains will carry oxygen-rich water into water systems

3.2.2. Biodiversity

Biodiversity in Finland

Biodiversity is a central precondition for the continuity and stability of life on Earth. The concept of biodiversity - or biological diversity – refers to the variability among all living organisms (plants, animals and micro-organisms), the genetic variation within species, diversity within and between species, and diversity of natural habitats. In addition to climate change, declining biodiversity is considered as one of the most significant global environmental threats. Human-induced emissions and adverse impacts on the environment cause biodiversity loss. Changes in land use have also changed biodiversity considerably. For example, some of the wild species that benefit from agriculture have not adapted to the changes that have taken place in agriculture during the last few decades. On the other hand, agricultural activities have also a positive impact on biodiversity.The cultivation of agricultural landscapes has created new 'fringe biotopes' for many species and has even created habitats for new species. The structure of forests is influenced by forestry activities.

According to the Evaluation of Threatened species in Finland 2000, about 10% of Finland's animal and plant species are classified as threatened. Of these 28% live in traditional farmland habitats and 37% in forests. The main factors that threaten species or have led to extinctions include the overgrowing of open habitats no longer used for traditional forms of agriculture and changes in forests induced by modern forestry practices. This has occurred even if maintenance and development of biodiversity have been key elements in environmental programmes concerning agriculture and forestry. Comparing the results of the Evaluation of Threatened Species from 1990 and 2000 it is apparent that the most rapid rate of threatening in Finland is among the species that live in traditional farmland habitats. Species that live in shore and mire habitats are becoming increasingly threatened. However, species associated with forest habitats seem to have become less threatened in the 1990s.

Metsähallitus is a State enterprise which administers and manages nearly all State-owned protected areas in Finland. Inventory of biotopes and species, restoration and management are among the methods used to promote the ecological sustainability and biodiversity in protected areas more effectively than before. The number of privately-owned protected areas is quite large, but they are clearly smaller in total area than State-owned areas. The management and usage of privately-owned protected areas are directed by regional environment centres in their respective regions. At the national level, the Finnish Environment Institute is a key operator in protecting species and biotopes.

An overall reform of the Nature Conservation Act came into force in 1997. Statutory protection of areas that belong to protection programmes and the EU's Natura 2000 network will be implemented in the coming years by separate acts and decrees. The decree of protected species, in particular, will be revised on the basis of the most recent Evaluation of Threatened Species in Finland.

Ongoing planning and development projects for safeguarding biodiversity.

- There are several important short-term planning and development projects implemented until 2010. A revision of the Finnish National Action Plan for Biodiversity for 2006-2010 will be carried out in 2005 and it is based on an extensive evaluation of the current Action Plan. The objective of the evaluation is to get a picture of the current state and development trends of biodiversity in Finland, as well as of the impacts of the Action Plan ands its sufficiency in safeguarding biodiversity.The objective of the European Union is to halt the decline of biodiversity by 2010. The evaluation of the impacts of the Finnish National Action Plan for Biodiversity will also review the possibilities and means of achieving this objective.
- The Forest Biodiversity Programme for Southern Finland (METSO) will be implemented and evaluated by 2007, after which a decision will be made on the continuation of the programme.
- The objectives of the METSO Programme include development of new means of protection, as well as some short-term actions, such as collection of basic information on the ecological values of the current protected areas, improving the efficiency of area protection, and increasing habitats important to forest flora and fauna by restoration and management. The need for a specific nature conservation programme to achieve the protection objectives will be assessed after 2007.
- The conservation programmes will be implemented by 2007 in accordance with the funding scheme for nature conservation programmes. The realisation and sufficient level of the funding scheme and the corresponding funding scheme aimed at implementing the EU's Natura 2000 network will be reviewed in 2005.The improved efficiency of the management and use of Natura 2000 areas starting from 2004 will promote the realisation of protection targets and sustainable use of the areas in the next few years.
- An assessment of threatened habitat types will be completed by the Finnish Environment Institute in 2006 and studies on species that are currently categorised as data deficient will be completed by 2007. The latter is funded by the Ministry of the Environment.
- A strategy for restricting the spreading of invasive alien species will be prepared by 2007.
- The Finnish agri-environmental support scheme 2000 – 2006 will reduce the environmental pollution load on the environment, particularly on surface waters, groundwater and atmosphere. Furthermore, the agri-environmental support scheme is used for preserving biodiversity in agricultural areas and managing agricultural landscapes. Special subsidies are used for preserving the valuable traditional farmland biotopes and species living in them.
- Together with basic research, the new Forest Biodiversity and Monitoring Programme in Finland (MOSSE) for the years 2003-2006 aims to produce new research information on the means of protecting the biodiversity of forests, agricultural and aquatic habitats, as well as on their ecological, economic and social impacts.
- The regional target programmes for forestry are due for revision in 2004–2005.

Impacts of climate change on biodiversity

Biodiversity is constantly changing, and it depends on, inter alia, the climatic conditions of the period. According to the results of extensive international studies, recent regional changes in temperature have had noticeable impacts on many physical and biological systems and events on the Earth. There is already evidence of the shrinking of glaciers, melting of permafrost, shortening of annual duration of ice cover on lakes and rivers, and lengthening of growing season. It is predicted that rainfall in winter and the occurrence of extreme rains will increase, especially in northern areas. In addition to other human-induced impacts, climate change adds the stress on nature considerably.

There is a growing risk that some habitats (wetlands, tundra, isolated habitats) may decrease or disappear.In arctic and northern areas, the pollution of the air and soil also weakens nature's resilience and resistance more permanently. On the other hand, the productive capacity of northern ecosystems will increase when the climate warms, which can have both positive and adverse impacts on biodiversity.

Climate change and higher regional temperatures, in particular, will influence the timing of the reproduction of animals and plants, the length of the growing season and/or the migration/movement of animals, the distribution of species and sizes of populations, as well as the appearance of pests and diseases. According to numerous studies, statistically significant changes have been perceived in several hundred species in relation to the expected increase of temperature and the biological characteristics of the species. There is a danger that climate change will have a great impact on many ecological, economic and social benefits that biodiversity brings to humans.

Climate change, together with impacts of human activities and spreading of invasive alien species, will probably restrict the ability of many indigenous species to migrate and survive in fragmented habitats. The most threatened species include those with poor tolerance to climate change, those with restricted possibilities for geographical expansion (such as species in mountain-tops, islands, and capes or species under other restrictive physical factors) or those with small populations. According to the most recent studies, the threat of becoming extinct by 2050 concerns approximately one third of the species, at most, in evaluated areas (20% of the land area of the Earth), and many of these species live in the tropical zone. The cause of this threat is not only climate change but also the destruction of habitats by humans.

In Finland, only preliminary assessments have been made of the impacts of climate change on biodiversity. Of these, the following considerations may be raised:

- Because of the warming climate, the temperature of lakes will rise in the summer, and the prolonged stratification increases the biological productivity of water systems. The fact that extreme weather events (rain, drought) become more common leads to changes in the annual runoff of waters and its timing and, consequently, in the occurrence of floods. These factors also affect the leaching of nutrients into water systems. It is obvious that the annual differences in the occurrence of the aforementioned events will become greater. The ice cover of the Baltic Sea and lakes will weaken and the ice-covered period will shorten.
- Changes in the arctic areas of Europe and in Finland's northern regions will affect the occurrence of permafrost in palsa mires, for example. According to a study carried out in Finland, the distribution of palsa mires has decreased considerably during the last few decades. Melting of palsa hummocks and decrease of water depressions increase the vegetation cover but reduce the populations of the birds and insect groups that benefit from the palsa mire conditions and habitats.
- Climate change is expected to move the climatic zone suitable for boreal vegetation several hundreds of kilometres to the north during this century, so many southern forest species (among others, grove species) will be able to move farther north as well. The distribution of many species living in the boreal forest zone would also change and the timberline might shift 20 – 200m upward, depending, inter alia, on the natural migration speed of trees. Deciduous trees will also become more common and the tree species composition in forests will change. With the lengthening of the growing season, the tree growth will increase and the seed yield will improve, but the frost hardiness of trees might weaken. The risk of pests and diseases, as well as the probability of storm damage, will increase. In the hemiboreal and southern boreal zones, eutrophic vegetation will increase in eutrophic soils, but e.g. species dependent on coniferous trees will decrease. In extreme locations, such as rocks, increased drought will probably cause additional stress for the existing species.

The changes mentioned above would probably affect the distribution and abundance of many species as a whole. The number of species in Finland would apparently increase, but species characteristic of Finland, such as the relic species of cold waters and northern species, would have to give way to more southern species. Furthermore, thinning of ice cover in the sea and lakes as well as thinning of snow cover of forests and the irregularities in its occurrence may have adverse impacts on the viability of many species typical to the boreal zone, particularly in Southern and Central Finland. The living conditions of moose and some other herbivorous mammals will improve because of decreased snow cover and an earlier spring: movement will be easier and changes in the growing season will offer more energy-rich nutrition earlier and for longer. The decreasing snow cover may increase the number of general predators (red fox, badger, many birds of prey) in Central and Northern Finland, because hunting is easier when there is less snow on the ground. The early appearance and late disappearance of the white protective colouring of some mammal and bird species in a shortening winter may also expose them to additional dangers from predators. On the other hand, the conditions of some wintering bird species will improve due to milder winters. Warming may also result in earlier spring migration and nesting of some birds wintering nearby. When living conditions improve, bird populations may move farther north. The number of butterfly species can be expected to increase, but northern butterfly species may decline when certain habitats disappear.

Table 3.8. Summary of the anticipated impacts of climate change on biodiversity in Finland.The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant. Some of the impacts are clear advantages or drawbacks but the direction of some impacts is still unclear or the direction of the impact depends on the intensity of climate change.

Disadvantages	Direction of the impact unclear or a simultaneous disadvantage and advantage	Advantages
– Species characteristic to Southern Finland will have to give way to more southern species. Some of the species adapted to cold conditions may become more threatened. – The present species of Northern Finland will suffer. – Pest insects and weeds arriving from the south may cause harm to agriculture and forests.	• Many southern species living in forests may migrate several hundreds of kilometres further north. • Distribution of many species of the boreal forest zone will change. • (Arctic) timberline may shift upward. • The tree species composition in forests will change and deciduous trees will become more common. • The melting of palsa mires will change the structure of biotic communities. • The biological productivity of water systems will increase and the occurrence and number of algal blooms will change. • The number of species in Finland will increase. • The risk of pests and diseases and the probability of storm damage will increase.	+ The amount of dead wood in forests will increase. + The living conditions of some wintering bird species will improve and some herbivorous mammals will benefit. + Spring migration of birds wintering in the neighbouring areas will occur earlier, which will improve their nesting possibilities.

3.2.3. Industry

Industry in Finland

This chapter presents a concise review of the current state of industry and other sectors of business, as well as their estimated development until 2020. The review is based on a more extensive scenario review which, together with its basic assumptions, has been published as Annex 1 to the National Allocation Plan (NAP) for greenhouse gas emission allowances approved by the Government on 19 August 2004. The review is based on the so-called WM (With Measures) scenario.

Economic starting points for the WM (With Measures) scenario

- The WM scenario assumes that the national economy will grow at an average rate of 2%
- Growth will be faster in the beginning of the period and slow down towards the end.
- The national economy will become increasingly service-oriented.
- The industrial structure will become lighter as the process industry grows more slowly than other industries.

Table 3.9. The development of the volume of gross domestic product by sector 1990–2020, % / year

Sector	1990→2002	2002→2005	2005→2010	2010→2020	2002→2020
Agriculture and forestry	1.2	2.4	1.1	0.9	1.2
Mining	1.6	-3.1	-0.3	0.9	-0.1
Manufacturing industry	4.1	2.7	2.6	2.0	2.3
Forest industry	3.2	3.2	2.3	1.5	2.0
Chemical industry	2.7	2.5	1.6	1.2	1.5
Metal manufacturing	4.4	5.9	1.5	1.0	1.9
Electrotechnical products	16.8	2.9	4.2	3.0	3.5
Other types of industry	1.2	2.1	1.9	1.6	1.8
Supply of electricity, gas and water	2.4	2.3	1.8	1.3	1.6
Construction	-2.2	1.8	1.3	0.8	1.1
Services	1.8	2.2	2.5	2.4	2.4
Gross domestic product	2.0	2.2	2.4	2.1	2.2

Table 3.9. shows the development of the volume of gross domestic product by sector in the period concerned. It is estimated that services will grow slightly more quickly during the whole period than gross domestic product, which will increase the proportion of services in the national economy. Figure 3.1. shows the development of the volume of gross domestic product and its division by industry.

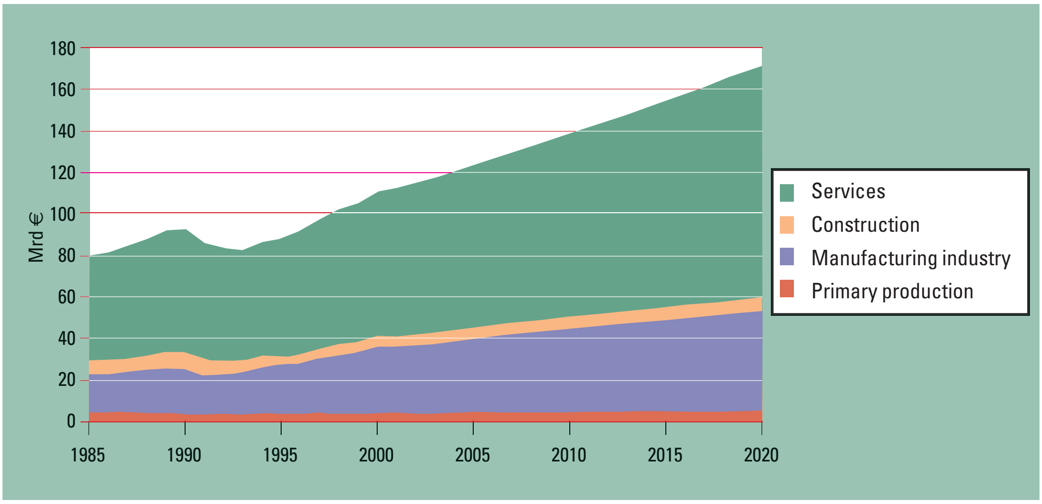

Figure 3.1. *Gross domestic product by industry, € billion at 2000 prices*

The structure of industrial production will become less energy and capital intensive. The fastest growing industry will still be the electrotechnical industry, which is estimated to grow by an average of 3.5 per cent per year until 2020. The average growth of production in energy intensive lines of business, the forest industry, chemical industry and metal manufacturing is estimated to remain clearly below the average industrial growth level, which will reduce their proportion in industrial production. In metal manufacturing, production capacity will, however, grow significantly at the beginning of the period. Figure 3.2. shows the development of industrial production by industry.

Section 2.2 of the Adaptation Strategy examines the development of Finland's economy after 2020 by means of so-called socio-economic scenarios. The three scenarios are specified in more detail in each section, and the development of the different industries and the industrial structure on the basis of the scenarios is illustrated, for example, in Figures 2.14 and 2.15.

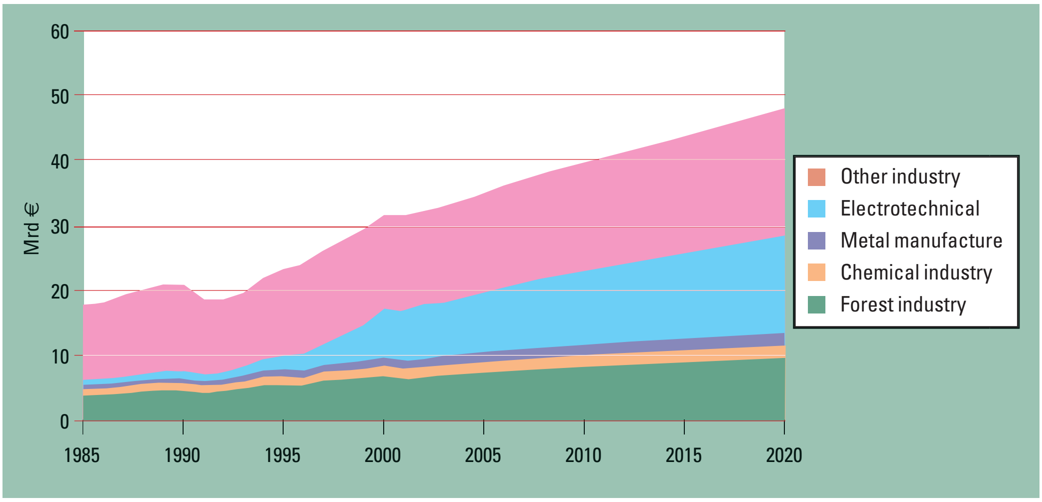

Figure 3.2. *Industrial production by industry, € billion at 2000 prices*

The basic alternative is a scenario that follows the WM scenario specified above until 2025 and provides a continuation of that scenario further into the future. The other scenarios, Alternative Finland and Regressive Finland, have been prepared on the basis of different assumptions on the development of the global economy, Finland's population, employment and productivity. A link to climate change is provided through the development of the global economy (which means exports from the Finnish perspective). The alternatives for global economic development are based on IPCC scenarios. The assessments of the impacts of domestic climate change are based on calculations prepared in the SILMU programme, which only cover some sectors.

The scenarios provide quite different results with regard to Finland's development. It is common to the scenarios that economic growth will slow down after 2030, and that the economy will become more service-oriented at an accelerating pace. Correspondingly, industry's share of added value will decline with the exception of the forest industry, whose share would seem to remain at the current level until 2050 regardless of the scenario. The scenario review indicates that global changes will have a major impact on the development of Finland's economy and industry. The direct impacts of local climate change seem to remain minor in the scenario reviews. The sectors which are affected the most by the climate change are agriculture and forestry.

However, the scenario reviews do not account for any sharp changes in the climate, global economy or technology. The impact assessments of domestic climate change are also associated with significant uncertainties that should be specified in more detail later on.

Direct impacts of climate change on industry

Some industrial and business activities are of such a nature that the impacts of climate change, such as climatic warming, will probably cause changes in the raw material sources in the long-term. These sectors include the forest and food industry. Climate change would not seem to have any direct impact on the raw material sources of some other industries, such as mining.

The impact of climate change will also be reflected in industrial activities so that any interruptions, disturbances and disorders associated with the transportation of raw materials and finished products will have an impact on industrial activities and their profitability. Rail transport will probably be the most reliable mode of transport in unfavourable weather conditions, while air traffic will be the most sensitive. However, due to the large volume, any disturbances in road traffic will have the greatest impact.

Forest industry

The increase in mean temperature due to climate change will increase the growth of forests and amount of wood material available in Finland. On the other hand, wood material and its quality will probably change, while the range of tree species in different regions will change as well. In the long-term, this may affect the locations of mills, their process choices (mechanical/chemical), as well as the paper grades produced. However, the distribution of the increase in stand growth and availability of material between different tree species and quality grades must be estimated in more detail before reaching any further conclusions.

The supply of wood may vary more than currently due to changed harvesting conditions and the weakened condition of the road network due to increased precipitation. If the thawing season becomes longer, transport both in forests and on forest and main roads will become more difficult. Increased storm damage will probably cause sudden peaks in the supply of wood as well.

In international comparison, the increased raw material potential of the boreal forest belt due to climate change, as well as the increased vulnerability of forests in the Mediterranean region and the midland zones of the globe, would further increase Finland's attractiveness as a forest industry location.

Food industry

Climate change will probably result in qualitative changes in the raw materials of the food industry as the cultivation zones of different plants move and the preconditions for primary production change. The changes may also have long-term impacts on the location of industrial facilities.

The transportation of raw materials, such as milk, may become more difficult due to the weakened condition of the road network and sensitivity to disruptions, which would make deliveries less reliable.

Due to global changes, export demand for foodstuffs may also increase in Finland in the long-term as the food production of regions suffering from drought will continue to weaken. In many regions, the demand for foodstuffs may also increase as a consequence of increased prosperity and changing lifestyle and eating habits rather than climate change.

Construction materials and the construction industry

Climate change may have an impact on the design of buildings and choice of materials due to changes in weather conditions over time (ground frost, rain, humidity, storms, snow loads). Increased windiness will probably also affect occupational safety and the endurance of structures.

Other sectors

There would not seem to be any direct impacts of climate change in these sectors. Impacts will mainly originate in the global economy as a consequence of changes in the global market. Climate change may also create new business opportunities in the service sector and industry.

Table 3.10. *Summary of the anticipated impacts of climate change on industry in Finland. The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant. Some of the impacts are clear advantages or drawbacks but the direction of some impacts is still unclear or the direction of the impact depends on the intensity of climate change.*

Disadvantage	Direction of the impact unclear or a simultaneous disadvantage and advantage	Advantage
– Industrial logistics may become difficult due to more complicated traffic conditions – Variation in the availability of wood material may increase	• The impact of climate change on the global economy is a decisive factor for industry • Changes in the proportions of tree species and quality of wood	+ Availability of Finnish raw materials, wood and agricultural products may increase

3.2.4. Energy

The energy sector in Finland

Finnish energy policy focuses on ensuring the availability of energy, maintaining a competitive price for energy and keeping emissions within the limits of commitments entered into. Bringing greenhouse gas emissions to the level of the Kyoto Protocol obligations has been particularly emphasised in energy policy in recent years. Other objectives affecting energy policy include the reduction of environmental impacts and adaptation to the principles of sustainable development. Energy policy is also influenced by the outlook for the price and availability of imported energy and increased international decision-making. During the EU membership, the energy sector has also been influenced by the deregulation of the energy markets.

The energy policy observed has been based on special documents and programmes and international treaties. The key areas of energy policy are recorded in Government Programmes.

Traditional operators in the Finnish energy sector are State-owned power production companies , power distribution and energy companies owned by municipalities, as well as power and heat plants owned by industry. The ownership of different types of companies, as well as their roles in the energy sector, have changed and partially intertwined during the past ten years. Several foreign energy companies have also entered the Finnish energy market.

The energy sector can be divided into at least the following functional blocks: production, import, distribution and transmission of electricity, import, transport and distribution of natural gas, in-house heat and steam production by industry, heat production and district heating in built-up areas, import of coal, oil and motor fuels, oil refining, and the production and transport of peat and wood-based fuels.

Special legislation for the energy sector includes the Electricity Market Act, Natural Gas Market Act, nuclear power plant legislation, energy tax legislation, and legislation associated with energy efficiency. The most recent addition is the emissions trading legislation associated with intra-EU emissions trading, which entered into force this year and concerns the energy sector in particular, but also a number of other sectors. With regard to the security of supply, the energy sector is regulated by acts on ensuring the security of supply and on obligatory reserves of import fuels, as well as international contractual arrangements such as the IEP agreement (International Energy Programme) on oil reserves and actions in times of oil supply emergencies. The operations of the energy sector are also regulated by a large number of other statutes, including environmental legislation (among other things, environmental permits and emissions into the atmosphere, water and soil; the Land Use and Building Act), competition legislation and pressure vessel legislation.

The Energy Market Authority is a crucial operative body with jurisdiction over the energy sector. The Radiation and Nuclear Safety Authority supervises the safety of nuclear power plant operations. Special legislation for the energy sector is generally prepared by the Ministry of Trade and Industry. The domain of the National Emergency Supply Agency includes, among other things, preparation for emergencies and disturbances in energy management.

Development outlook for the energy sector

In Finland energy is mainly consumed in the form of heat, electrical power and motor fuels. The following figures and tables illustrate the structure of energy consumption and production in Finland, and the trends until 2020.The review is based on a more extensive scenario review which, together with its basic assumptions, has been published as Annex 1 to the National Allocation Plan (NAP) for greenhouse gas emission allowances approved by the Government on 19 August 2004. The review is based on the so-called WM (With Measures) scenario. The scenario does not include any assumptions on the impacts of climate change on heating requirements or energy production.

Table 3.11. *Electricity consumption in each sector in the WM Scenario, TWh*

Sector of consumption	1990	2002	2010	2020
Forest industry	19.1	26.1	30.6	34.7
Other types of industry	13.5	18.2	21.1	22.7
Heating	6.3	8.8	9.0	9.6
Households	8.9	12.1	13.4	14.7
Services	9.8	13.7	15.4	16.8
Other sectors[1]	1.9	1.7	1.6	1.6
Total consumption	59.4	80.6	91.2	100.3
Losses	2.9	2.9	3.0	3.0
Total consumption	62.3	83.6	94.2	103.3

[1] Includes electricity consumption in agriculture, house building and transport

Basic assumptions of the WM (With Measures) scenario in terms of energy economy

- The review has been carried out without the potential effects of greenhouse gas emissions trading.
- Current actions to conserve energy and reduce greenhouse gas emissions would be continued with approximately the present intensity. It is also assumed that these actions will be successful.
- The most essential assumptions and starting points with regard to energy supply are the following:
  - hydroelectric power production would not increase
  - the new nuclear power plant would be completed in 2009
  - imports of electricity would decrease from the present
  - the natural gas grid will be extended to the Turku region by the turn of the next decade
  - the competitiveness of wood fuel will gradually increase
  - combined production of power and heat will gradually increase in line with the increased district heating load and industrial heat requirements, as well as the construction of new plants
  - gas is a natural choice of fuel for new combined-production plants within the natural gas distribution grid, and elsewhere wood will be replacing peat
  - new condensing power plants replacing current capacity will use both gas and coal
  - no major changes will occur in the proportions of energy sources chosen for heating
  - the real global market prices for fuels are assumed to increase gradually, with the greatest increase in oil and gas prices, followed by coal.

The total consumption of electricity, including losses due to power transmission and distribution, will grow from 83.6 TWh in 2002 to approximately 94 TWh by 2010, and to approximately 103 TWh by 2020. The average annual growth is approximately 1.2 per cent, i.e. a little more than the growth in the consumption of primary energy.

Between 2002 and 2010, total electricity consumption will grow by 10 TWh, based on the assumptions of the WM Scenario, and in 2010–2020 by a little less than 10 TWh. During the entire period examined, electricity consumption would thus grow by approximately one quarter of the current level.

The proportion of industry in the total electricity consumption growth is a little more than half, which corresponds to the current proportion of industry in total electricity consumption. Electricity consumption in the forest industry will increase by a little more than 4 TWh by 2010, and by approximately 4 TWh in 2010–2020. In the manufacturing of metals, the increase in electricity consumption will be rapid in 2000–2010 due to the growth in the production capacity, but it will clearly slow down during the second half of the period. In industries using little energy, the use of electricity will also clearly increase, because the growth in production will be faster than the average.

Production in service branches will grow relatively strongly, which is also visible in the considerable growth in electricity consumption in the WM Scenario. The amount of electricity used for heating will grow during the entire period by approximately 0.8 TWh.

Figure 3.3 shows the structure of the electricity supply. The new nuclear power unit is assumed to start operating in 2009, which will be reflected as a significant growth in nuclear power production at the turn of the decade. Combined heat and power production will increase both in communities and industry. The production of conventional condensate power will increase and reach approximately 11 TWh by 2020, while in the 1990s the average production was less than 5 TWh. The net imports of electricity will decrease to 7 TWh. The production of hydropower will remain at approximately the current level. The amount of wind power and other new modes of electricity production will increase and exceed 0.5 TWh in 2020.

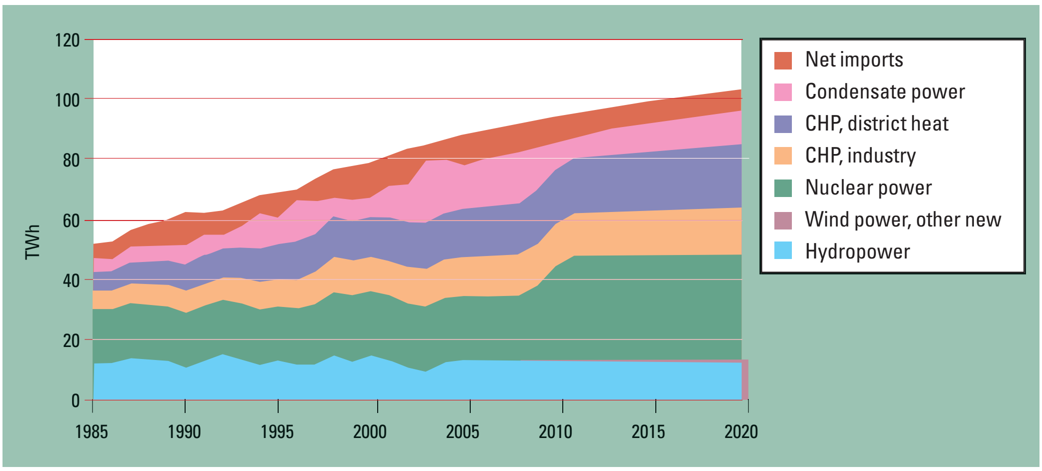

Figure 3.3. *Electricity supply in each production method in the WM Scenario, TWh*

The total consumption of primary energy will grow from approximately 1,400 PJ in 2002 to 1,540 PJ by 2010, and further to 1,630 PJ by 2020. Consumption growth will clearly slow down compared to previous years. The average annual growth in 2002–2020 is one per cent per year, whereas it was a little more than two per cent a year in 1985–2001.

Table 3.12. Electricity supply in each production method in the WM Scenario, TWh

Production method	1990	2002	2010	2020
Hydropower	10.8	10.6	12.8	12.8
Wind power, other new methods	0.00	0.06	0.38	0.69
Nuclear power	18.1	21.4	31.1	34.6
CHP production, industry	7.7	12.3	14.3	15.9
CHP production, district heat	8.5	14.9	18.0	20.9
Condensate power[1]	6.6	12.4	9.1	11.3
Net imports	10.7	11.9	8.5	7.0
Total	62.3	83.6	94.2	103.3

[1] Includes gas turbines

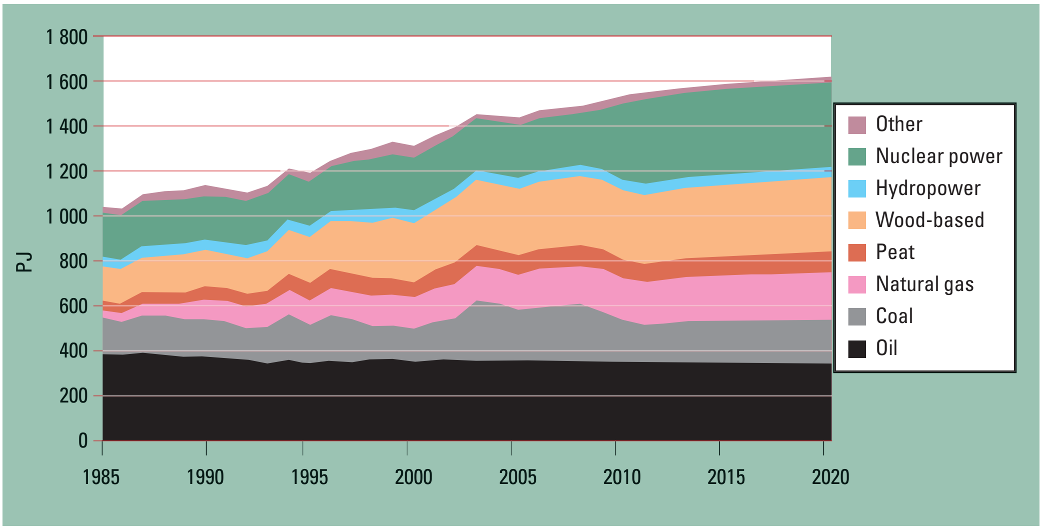

Figure 3.4. Energy consumption for each primary energy source in the WM Scenario.

Figure 3.4 and Table 3.13 show the energy consumption for each primary energy source. The use of oil, hydropower and nuclear power as energy sources will remain close to the current level. The most significant growth in the WM Scenario will take place in the use of natural gas and wood-based fuels. The volume of peat consumption and electricity imports will decrease. The proportional shares of various energy sources in the energy balance sheet are shown in Table 3.14.

Table 3.13. Energy consumption for each primary energy source in the WM Scenario, PJ

Energy source	1990	2002	2010	2020
Oil, total	376	360	354	351
Coal, coke, furnace and cokery gases	167	187	179	191
Natural gas	91	155	194	215
Nuclear power	198	233	339	378
Net imports of electricity	39	43	31	25
Hydropower and wind power	49	38	46	46
Peat	56	88	81	87
Waste liquors from wood processing industry	86	145	155	164
Other types of wood use	81	151	156	169
Total	**1141**	**1401**	**1535**	**1626**

Table 3.14. Proportions of different energy sources for primary energy in the WM Scenario, %

Energy source	2002	2010	2020
Oil	25.7	23.1	21.6
Coal, coke, furnace and cokery gases	13.4	11.7	11.7
Natural gas	11.0	12.6	13.2
Nuclear power	16.7	22.1	23.2
Net imports of electricity	3.1	2.0	1.6
Hydropower	2.7	3.0	2.8
Peat	6.3	5.3	5.4
Wood-based fuels	10.4	10.1	10.1
Others	10.7	10.1	10.4
Total	**100**	**100**	**100**

Of fossil fuels, the proportion of oil in total energy will decrease strongly in the WM Scenario. However, the proportion of natural gas will increase by two percentage points. The proportion of coal and waste gases will remain approximately at the current level. The proportion of nuclear power will increase from the current level of a little less than one fifth to a little more than one fifth. The proportion of wood-based fuels in total energy will be in line with the development of the forest industry. However, the share of forest processed chips will increase.

General outlook of the global energy market

In its publication World Energy Outlook 2004, the International Energy Agency IEA assesses the global outlook for the supply and demand of energy up to 2030. According to the IEA's view, the continuation of the present energy policy in different countries (Reference Scenario) will lead to an increase of almost 60% in energy demand by 2030, most of which will be satisfied by fossil sources. This would cause corresponding increases in carbon dioxide emissions. This growth is not restricted by the energy resources, but the costs of producing the energy involve some uncertainty. According to the IEA's estimate, the global energy economy can only be steered towards a sustainable track through significant technological breakthroughs.

Global energy trade is estimated to grow substantially. For example, exports of energy from non-OECD countries to OECD countries will increase by 80% by 2030. Trade within various groups of countries will also increase, and the IEA sees that increased trade will lead to greater emergency supply risks. The world will be more vulnerable to disturbances in the deliveries, which may be due to different causes.

Impacts of climate change on the energy sector

Climate change will have various impacts on the energy sector, but from the sector's viewpoint, the impacts of actions aimed at mitigating climate change are much more essential. The energy sector is the largest source of greenhouse gas emissions.

General impacts on heating requirements and related issues

As a consequence of climate change, there appears to be some decrease in the seasonal variations in energy demand. In general, the need for heating energy will decrease in winter and the need for cooling energy will probably increase in summer. This means that the production of back-pressure power at combined production plants could slightly decrease in winter. However, winters with extended cold periods will probably occur in the future as well and hot periods are expected in summer, so preparations must be made for peaks in the demand. The increased mean temperature of waters will probably slightly reduce the efficiency of Finnish condensing power plants and the amount of electricity produced at these plants.

Power transmission and distribution

Today's society is very dependent on the electricity distribution system, and this dependency is not likely to decrease in the future. Disturbances in power distribution will cause interruptions also in other technical systems, such as water and heat distribution, wastewater services and telecommunications.

The increased occurrence of extreme events due to climate change is an obvious threat to the functioning of the electricity distribution system. The vulnerability to damage of overhead lines could increase due to storms, maybe also due to ice accumulating on the lines. However, the current trend, particularly with distribution lines, goes from overhead lines towards underground cables at least in built-up areas. In addition, the energy infrastructure may be threatened by accelerated wear and tear or deterioration due to variable weather conditions (such as temperature and precipitation).

Hydropower

Hydroelectric power production is based on the mean runoffs of rivers, heads of rapids, volumes of reservoirs at hydroelectric power plants, as well as licensed regulation limits for the water level.

Finland's theoretical hydropower potential will increase with increased precipitation, but dry periods caused by greater climatic extremes may result in periods of reduced production. Diversion may need to be increased during abundant rain, which will also reduce the yield of electrical power.

Annual runoff totals and distributions will change, and the prediction of floods will become more difficult, which will impose new requirements on flood prevention as well as the optimal operation of hydroelectric power plants. Winter runoff will generally increase due to increased precipitation and melting of snow during the winter, but there will be significant local variation. The need for the diversion of water may also increase, and increased precipitation will not necessarily result in corresponding increases in the amount of energy produced by hydroelectric power plants. Spring runoff will decrease due to decreased amounts of snow, and this will also impact on the production and availability of hydroelectric power. Summer runoff may decrease or increase due to the ratio of evaporation to precipitation.

Generally speaking, the predictability of hydroelectric power production would seem to decrease.

Due to the common Nordic energy market and the Nordpool electricity exchange, any changes in the conditions of other Nordic countries, particularly the hydropower-intensive Norway and Sweden, may have significant impacts on the Finnish energy market.

Peat

In Finland, peat for energy, either milled peat or sod peat, is produced on rainless summer days using tractors in bogs where the thickness of the peat layer has typically been some 2–4 metres before the bog was drained. In peat production methods, the thin layer of peat detached from the surface of the production field in one go is dried to a suitable degree of dampness by solar heat during 2–3 rainless days and then moved to a storage pile beside the bog. Finnish peat production methods are quite sensitive to weather, which means that peat production decreases during rainy summers and increases during dry summers. Because the estimates on the impacts of climate change concerning increased precipitation in summer and the duration of dry periods are very uncertain, the overall impacts on peat production cannot be clearly deduced. The potential extension of the peat production season due to warming will contribute favourably to peat production. The total amount of peat to be produced could also be regulated through the number of bog hectares put into production-ready condition the previous autumn, but this is a cost issue for peat producers.

Bioenergy

The growth of forests and arable biomass will increase due to increases in carbon dioxide, precipitation and temperature, and thus the amount of biofuel that may be used for energy production will also increase. However, transport conditions may weaken, for example, and have a negative impact on the availability of biomass.

Wind power

The impacts of climate change on Finland's wind conditions are quite uncertain, and the estimates are partially conflicting so it is difficult to assess the overall impacts on wind power production. Increased occurrences of stormy winds and periods with weak winds may even weaken the preconditions for production. Wind power plants are usually built on the sea shore, in the archipelago or on fells. However, the construction of offshore wind power farms in shallow sea water will probably be favoured in the future.

Solar power

There is no absolute certainty about the impacts of climate change on the direct utilisation of solar power yet. For the time being, the high unit cost of solar technologies (cents/kWh of power produced) in comparison with other energy production methods is a crucial barrier for the increased utilisation of solar electricity and heating. Utilisation of passive solar energy could be increased even today by paying attention to the placement of buildings in relation to compass directions and terrain.

Coal, nuclear power and natural gas

Climate change would not seem to have any direct impacts on the coal, nuclear power and natural gas sectors, with the exception of the slight decrease in the efficiency of the condensing power plants mentioned above. However, climate change has been the very reason for considering how electricity production by coal power could be restricted or the emissions substantially lowered. Nuclear power is not burdened by greenhouse gas emissions, and the emissions from natural gas are substantially lower in comparison with coal.

Table 3.15. Summary of the anticipated impacts of climate change on the energy sector in Finland. The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant. Some of the impacts are clear advantages or drawbacks but the direction of some impacts is still unclear or the direction of the impact depends on the intensity of climate change.

Disadvantage	Direction of the impact unclear or a simultaneous disadvantage and advantage	Advantage
– The predictability of hydroelectric power production will decrease to some extent. – Peat production will become more difficult in rainy summers. The predictability of peat production may decrease further. The condition of the road network may deteriorate. – The deteriorating condition of roads may also hamper the use of wood and arable biomass for energy. – The share of back-pressure power may slightly decrease. The use of energy for cooling and air conditioning in summer may increase.	• Increased mean temperature and reduced need for heating	+ Amount of energy produced by hydropower will increase. + Peat production may increase in dry summers and due to the longer production season. + The growth of wood and arable biomass for energy use will probably increase. + Energy consumption for heating will decrease. Seasonal variations in demand may become somewhat more stable. + The increased need for cooling can probably be partially utilised in back-pressure power production.

3.2.5. Transport and communications

Transport and communications in Finland

The transportation system consists of traffic routes, terminals, traffic control systems and traffic services. The planning, construction and maintenance of these aims to guarantee the level of service, condition, safety and lack of disturbances, as well as the quality of services and observation of environmental aspects, so that the system fulfils the needs of society. The objectives of transport policy include the continuous maintenance and development of traffic routes, improving the operational preconditions and services of public transport, promoting traffic safety, securing the level of service in merchant shipping and aiming to ensure the competitiveness of our vessel tonnage in relation to the most important competing countries.

The value of all traffic routes and terminals in Finland is some 30 billion euros, and the State's share is some 19 billion euros. The total length of traffic routes is 470,000 km. Traffic routes include public roads, streets, planned roads, private roads, railways, waterways, the underground and tram-lines. There are 27 airports in Finland (*Table 3.16*)

Table 3.16. *Lengths of traffic networks in Finland. Sources: [1]Public Roads of Finland 1.1.2004. Finnra Statistics 2/2004. [2]Publications of the Ministry of Transport and Communications 8/2004 (in Finnish): Strategy for the development and maintenance of Finland's transport infrastructure in 2004–2013. Background study. [3]Finland's third report under the framework convention on climate change. 2001.*

Traffic routes	Length (or number)
Public roads[1]	78,137
Highways	8,574
Principal roads	4,686
Other main roads	28,437
Local roads	36,441
Bridges	13,979 (number)
Private roads[2]	350,000
Bicycle routes[3]	11,000 (in connection with public roads 4,508)
Streets	26,000
Railways[3]	5,836
Waterways[3]	16,000 (fairways maintained by the Finnish Maritime Administration)
Number of airports[3]	27

There are 78,137 km of **public roads** and 350,000 km of **private roads** in Finland. In 1989, 73% of private roads were estimated to be in good condition, but in 1999 the figure had dropped to 27%. Of the bridges serving the road network, 50% will need to be modernised in the next few years. State subsidies for private roads decreased significantly in 1994, and the condition of roads has since declined. Work that would be important for the structural condition of roads, such as the conditioning of trenches and culverts, has been carried out less often.

Traffic on Finland's public roads is estimated to increase by 24% in 2002–2030. According to Statistics Finland, the population will continue to increase after this, and the growth in traffic volume is also expected to continue until 2050. The concentration of settlement in population centres will increase traffic on main roads at the expense of other roads. However, local and private roads will remain crucial traffic routes in sparsely populated areas. There is great regional variation in the development of traffic volumes. Passenger cars are by far the most popular means of transport in Finland. About 54 per cent of all trips (74 per cent of person-kilometres) are driven in private cars. The share of public transport is nine per cent of trips and approximately 16 per cent of person-kilometres. The total haulage of road transport has outperformed all other means of transport since 1958. The total haulage of domestic goods transport in 2002 was 41.9 billion tonne-kilometres, of which road transport accounted for 29.0 billion t-km (69%), rail transport 9.7 billion t-km (23%), shipping 2.9 billion t-km (7%) and log floating 0.3 billion t-km (1%). Timber transport accounts for a significant part of all road transports.

Per capita, the Finnish **rail network** is the most extensive in Europe. It is the responsibility of the Finnish Rail Administration to ensure that passenger traffic connections of the best possible standard exist between provincial centres, and that the condition of the rail network allows cost-effective and timely goods transports. The rail network of the future will support the development of the different parts of the country, serving both passenger and goods traffic. Efforts are made to develop the rail network so that it allows increased rail traffic, shortened travel times and efficient heavy transport required by industry.

The outlook of the development of goods traffic on the Finnish rail network is optimistic, and this is also the case with passenger traffic particularly in the Greater Helsinki area. Growth potential in domestic long-distance traffic lies with faster train connections, which will increase the share of rail traffic as a mode of travel. The implementation of new pricing schemes or other actions related to passenger car traffic or air traffic due to environmental issues will significantly increase the demand for rail traffic. The creation of travel centres in different parts of Finland will create hubs in the transportation system promoting interconnection between different forms of traffic.

Foreseeable changes in goods transport include the transfer of port operations in Helsinki to the new harbour at Vuosaari, as well as the development of logistics centres. These changes are expected to increase international rail transports in particular. The significance of international connections will be particularly emphasised in connection with Estonia's EU membership and economic development in the St. Petersburg region. The number of train passengers between Helsinki and St. Petersburg is estimated to increase many times over.

Maritime transport is the most important form of transport for Finland's foreign trade. Approximately 90 per cent of Finland's exports and 70 per cent of imports are transported by sea. The harbour network is dense, but the harbours are small and the flows of goods are distributed between a large number of harbours. Twenty-three harbours are kept open year-round. Harbours on the Gulf of Bothnia need icebreakers for six months and harbours on the Gulf of Finland need them for three months each year. Due to longer transport distances compared to competing countries, among other reasons, it is important to develop Finnish maritime transport and ensure competitiveness. At present, approximately 800 km of fairways used by merchant shipping are in poor condition. The Finnish Maritime Administration is responsible for the operational preconditions of merchant shipping and other water traffic.

Due to the remote location of our country, **air traffic** is important for international connections. The number of air passengers passing through Finnish airports was more than 13 million in 2003. The numbers of passengers on domestic and international flights are in the same order of magnitude. About 14 per cent of the total value of exports is transported by air. Ninety-five per cent of international air traffic uses Helsinki-Vantaa Airport. The demand for air traffic will increase due to increased levels of income and leisure time. Further into the future, the number of passengers is anticipated to increase to as many as 20 million passengers per year. Demand strongly follows fluctuations in the growth of the national economy. The number of flights in Finland is estimated to double in a couple of decades.

Telecommunications networks can be divided into broadband, mobile phone and television networks, as well as the public authority network (VIRVE) and telecommunications operations. Fast and secure networks with high throughput are an absolute prerequisite for a profitable, competitive and socially and regionally equal information society. There were 4.1 million mobile phones and 2.4 million Internet users in Finland in 2002. Transport telematics refer to the application of information and communications technology in passenger and goods traffic. The crucial objective is to fulfil the travel and transport needs of citizens and business life in a smooth, safe and efficient manner. The aim is to develop the network so that by 2010 electronic information is available to help avoid traffic jams, find the best public transport connections and promote goods transports.

Impacts of climate change on transport

Changes in traffic behaviour

The impacts of climate change concern the entire transportation system, but their significance varies according to the form of traffic. Climate change will affect the operational preconditions and attractiveness of different forms of traffic. In addition to this, impacts on other sectors will be reflected in the demand for traffic services. The conditions of bicycle and pedestrian traffic can be estimated to improve as the temperature increases, but could occasionally turn very difficult due to windiness, heavy rain and skidding. Shortening of the ice-covered period will increase the severity of waves in all sea areas, particularly in the northern part of the Gulf of Bothnia, because the sea will be more open during the windiest season. The feeling of safety experienced by passengers is the most significant factor that could be affected by the increased frequency of extreme climatic events (windiness, increase in storms, whirlwinds).

Infrastructure

The decisions on and design of traffic infrastructure are based on certain limits and loads, whose magnitude and frequency have been determined or the endurance has been otherwise verified. Design standards for the road and rail networks may not be valid in the future. As a consequence of more abundant rainfall, the groundwater level will increase. In addition, rains will cause increased erosion in road ramps and bridge stems. The functionality of graded interchanges and drainage arrangements will be endangered as the groundwater level increases. The trenches and bridge and culvert structures of smaller roads have not been designed for high precipitation. The risk of collapse of railway beds and roads will increase due to erosion caused by rainfall and floods. Potential increases in storms may also impose new requirements on harbour and airport structures, as well as telecommunications networks based on overhead cables. The same could be true for navigation safety equipment (strong winds, increased pack-ice). Extreme climatic conditions will increase the need for network maintenance and repairs in any case.

Water systems close to traffic routes or surrounding them are sensitive to pollution from traffic emissions. Floods may worsen the loads of nutrients and harmful substances in water systems. Flood waters will carry nutrients and other substances to new areas where they may end up in water supplies. Flood waters flowing on abandoned military base areas, salt repositories or otherwise contaminated soil may cause further problems.

Maintenance and level of service

In Southern and Southwestern Finland, changes in the duration and thickness of snow cover will affect the maintenance of road and rail transport and airports in winter. If the snow-covered period is approximately two months shorter and the depth of snow is approximately one-third of that at present also in midwinter, there would appear to be cost savings in the winter maintenance of traffic routes and airports. On the other hand, the fact that most of the wintertime precipitation is in the form of rain that will freeze in subzero temperatures will cause more difficult conditions on roads and for airports, as well as potential sensitivity to interference in rail traffic control equipment. Elsewhere in Finland, the snow-covered period, and simultaneously the winter maintenance period, will become shorter than present due to warmer autumns and springs.

The expected increases in mean temperature, precipitation and extreme weather conditions may cause difficulties in road transport and impair the daily level of service on traffic routes. In addition to average change, temporal and local climatic variation and extreme events will affect traffic. These could cause delays for the schedules of both passenger and cargo transports in road traffic, rail traffic, maritime traffic and air traffic. The potential intensification of storms and increased windiness will cause various safety risks and functional disturbances. Fallen trees and damaged power lines, as well as snow drifts, will significantly hinder traffic connections, which may have disastrous consequences when trying, for example, to get help through.

Warm winters have been found to increase the need for antiskid treatment on the road network and at airports particularly close to the coast. As climate change increases the temperature and causes variations in weather, the need will move inland and towards the north, which means that the need for chemical antiskid treatment would seem to increase all over the country.

Warming is estimated to increase the costs of road and airport maintenance in January and February due to increased costs of snow removal and antiskid treatment. However, in November, December and March, the costs will decrease due to milder temperatures, because particularly in November precipitation will be in the form of water, and snow removal costs will be eliminated. The change in costs over the entire winter season will be minor, because the lower costs in early and late winter will compensate for the increased costs in midwinter. Changes in ground frost vary in different parts of the country, and ground frost will not necessarily decrease everywhere. The facilitating impact of ground frost for timber transport in winter may decrease to some extent. Heavy rain may cause floods and damage road structures. Particular difficulties will be seen in the maintenance of gravel roads.

Impacts of the heavy rains in July 2004 on the road network

According to the Finnish Meteorological Institute, rainfall was particularly abundant on 27 and 28 July 2004 in Uusimaa, Häme, Central Finland, the province of Savo and the province of Oulu, where 48-hour aggregate precipitation exceeded 100 millimetres at many locations. Such accumulated rainfall is as much as double compared to the average monthly precipitation in July. Heavy rains caused severe damage on dozens of roads in Central Finland and North Savo. Parts of almost all gravel roads in Central Finland collapsed and 3–4 roads were cut off. The level of the River Vantaanjoki rose by 177 cm due to rain, and several roads had to be closed down for traffic.

According to Finnish Road Administration's estimates, the repair of road damage may rise up to two million euros.

There should be no immediate problems resulting from climate change on new and modernised main railway lines. However, problems may surface on branch lines, where the increased temperature may add to the risk of accidents during heat waves. Increased heavy rainfall may cause rail beds to collapse in some places. The stability of railway lines on and near soft ground will suffer as dampness increases. There is annual variation in the thickness of ground frost even today, and the need for ground frost protection will continue, because periods of ground frost will occur also in the future.

Traffic accidents due to deer depend on the movement of moose and other deer. The moose, roe and white-tailed deer will benefit from the thinning snow cover, because feed will be available for a longer period and more easily, and it will be easier to move about. More favourable conditions might lead to generous growth in deer populations, which would result in an increased number of deer-related road traffic accidents.

The severity of ice-winters will significantly decrease towards the end of the 21st century. The extent of ice cover and the shortening of the ice-winter may have substantial impacts on navigation and maritime fairways. Ice conditions may vary substantially between years, which will affect the duration of the icebreaker operating season, port operations, and indirectly the flows of goods traffic transported by sea. Estimates indicate that the ice coverage on the Baltic Sea will decrease, the ice-winter will become shorter and the ice cover will become thinner. The decreased ice cover on the Baltic Sea may increase windiness and sea swells, which would impair marine traffic. At the end of the century, the duration of the ice winter is estimated to have shortened to half of that at present on the southern and southwestern coasts of Finland, and to 70–80% of the present in the Gulf of Bothnia. On the southwestern coast, freezing will be delayed by almost one and a half months, and melting will occur almost a month earlier. In the northern part of the Gulf of Bothnia and the eastern part of the Gulf of Finland, the ice-winter will shorten less than in the southwest, and the delay in freezing will be approximately equal to the difference in the time of melting compared to that of the present. In a comparison between present ice-winters and those at the end of the century, the mean thickness of ice at Kotka, Oulu and Turku harbours will decrease by 10–20 cm, and annual maximum thickness will decrease by some 30 cm. Strong westerly and southwesterly winds will increase the packing of ice and formation of thick sludge belts in the waters around winter harbours in the Gulf of Finland and the eastern parts of the Gulf of Bothnia. If such wind conditions prevail in the warmer climate, winter navigation will face difficult conditions from time to time even if the ice cover is not as thick.

Potentially intensifying winds and storms will cause disturbances to overhead cable networks. During winter storms that have occurred in recent years, the batteries of mobile phone base stations have been drained during prolonged power failures. Heavy rain may also cause breaks in underground cables. The Finnish Communications Regulatory Authority, as the maintainer of telecommunications networks, issues regulations on fault repair times. The task of the Authority is to guarantee undisturbed and secure communications connections for the population. The increasing occurrence of extreme climatic conditions will increase the need for repairs, which will add to the maintenance costs of telecommunications connections.

***Table 3.17** Summary of the anticipated impacts of climate change on transport and communications in Finland. The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant. Some of the impacts are clear advantages or drawbacks but the direction of some impacts is still unclear or the direction of the impact depends on the intensity of climate change.*

Disadvantage	Direction of the impact unclear or a simultaneous disadvantage and advantage	Advantage
– The risk of collapse of railway beds and roads will increase – Floods and heavy rains will damage the structures of road and rail networks, maintenance problems could be expected particularly on gravel roads – The functionality of drainage arrangements based on today's design will be endangered – Bridge and culvert structures are designed to convey present waterflows – Problems may be caused to railway and navigation safety equipment – Difficult weather conditions will increase in all forms of traffic (road, rail, sea, air) – The sensitivity of traffic to disturbances will increase – The rectification of and preparation for functional disturbances will impose additional costs – Increased need for antiskid treatment all over the country; for example, the need to apply de-icing salt to roads will extend to the north – Potentially increasing formation of pack-ice and thick sludge belts will impair marine traffic – Windiness, storms and heavy rain will cause damage to overhead cable networks and breaks in underground cables	• The impacts may change the attractiveness of different forms of traffic • The need for de-icing salt will increase in some places and decrease in others, so the total cost is unclear • Ice and snow conditions may vary significantly between years	+ Shortening of the ice-covered period will bring savings in navigation and harbour maintenance costs + Thinning of the snow cover and shortening of the snow period will bring savings in winter maintenance to the road and rail network and at airports

3.2.6. Land use and communities

Land use and communities in Finland

Present situation

Due to its extensive area, small population and livelihoods based on agriculture and forestry, Finland has always been a sparsely populated country. Distances have been long, and localities, villages and towns have been large in area but, in international comparison, small in population. The process of urbanisation in Finland in the last few decades has been the most rapid in all of Europe, and the urban population presently accounts for 80% of the total. Depopulation of the countryside and concentration in larger centres continue.

Natural conditions have regulated the locations of Finnish communities for a long time. Villages and towns mostly emerged alongside waterways, at trading posts and along routes leading to these. Natural conditions, cold climate and scarce construction materials have guided Finns towards a rational and sustainable method of construction. The issues taken into account when selecting a building site included the terrain, vegetation, soil quality, availability of water and energy, landscape, means of communication, prevailing directions of wind and the solar cycle. Preparations were made for seasonal variation, changes in weather conditions, spring floods, heavy rain and drought.

Development of the society has made construction independent of nature. Buildings have also been constructed on sites that have not always fulfilled the earlier criteria. Advanced technology has allowed construction on low-lying land and areas becoming swampy, the utilisation of pilework to make poorly bearing soil suitable for construction, as well as the decontamination of former industrial sites to serve as residential areas. Road routes have provided new communication opportunities, and motorisation has shortened distances and increased mobility. Sea and lake shores and river banks located close to urban centres have been made available for more efficient construction than ever before. However, strict regulation of planning and construction has ensured that functions planned for and buildings constructed on sites with difficult natural conditions fulfil the planning regulations as well as the minimum requirements for construction.

The structure of regions and communities is changing continuously. During the last few decades, Finland has undergone the most significant change of social and regional structure in its recent history. The most visible manifestations include intense migration from the north to the south and from the countryside to centres of growth, as well as the transformation of the economic and industrial structure from primary production through an industrialisation phase to service industries and further to competence and information-intensive professions.

Future trends

The strong flow of migration to the largest cities, which has continued for a long time, is dying down. Migration is directed towards municipalities located around major cities. Particularly young families with children are finding their way to rural areas close to centres of growth. The reasons include lower costs of living compared to cities, as well as the idea of the countryside as a safe and healthy environment to bring up children. Improved traffic connections have contributed to this development.

A major change in Finland by 2020 will be the retirement of the post-war baby boomers. Lifestyle choices, such as the share of retirees of the total of almost 400,000 who will change their place of residence, will have an impact on land use, housing production, demand for services, other sectors of the economy, and the environment.

Even though migration during the past decades has lead to great concentrations of the population, the long-term intensity of the change is uncertain. Long-term scenarios in terms of land use and communities in the post-2020 era have been studied very little until now. The assessment of land use and communities has usually extended to 2020. The 2001 population forecast of Statistics Finland indicates that Finland's population will turn towards a permanent downward trend after growing to 5.32 million by the year 2023, but the trend in the decades after 2020 is uncertain. Changes in the age structure of the population, including decrease in the number of young people and the working population, increase in old age groups, as well as migration, will substantially affect the use of land areas for residences, production and services.

When the regional distribution of population changes, in some regions a substantial amount of national wealth in the form of empty dwellings, schools, other buildings and infrastructure will be abandoned. New construction will simultaneously take place in growing regions.

The form of communities, individual towns and urban regions will be influenced by two kinds of simultaneous forces: on the one hand, forces promoting the dispersion of communities, and on the other hand, forces promoting the centralisation of urban functions and a condensing urban structure. New telecommunications systems, flexible logistic systems, the "suburbanisation" of certain urban functions, the low-density operating environments favoured by the national urban culture, as well as the problems associated with the mobility infrastructure and partial deterioration of the built-up environment that one may experience in the inner parts of cities are considered to promote dispersion. Forces promoting condensation include the need for personal contacts, increased energy costs, costs associated with urban planning, stricter environmental legislation and the fact that certain functions find their way to urban centres, as well as reform projects directed at improving urban centres.

Communities take on new forms under the influence of economic, technological and social factors. For example, band-like conurbations that have emerged along traffic routes may correspond to the future ideal of an urban unit with mixed functions and land use. City centres will retain their unique role as attractive residential and operational environments. A common understanding is that future communities will be more fragmented in form, chaotic in structure and diverse in history of emergence than previously.

In terms of community development, debates on social, economic and environmental policy mostly take their own routes. However, the pressure to replace sector-oriented thinking based on economic growth with the idea of sustainable development has increased all the time. If realised, an ecological tax reform that would impose higher taxes on the consumption of natural resources, waste and emissions could interlink the social, ecological and economic aspects and have a great impact on community planning.

The increased possibility of technological risks will also affect the formation of communities, because communities are more and more dependent on technology. The risks may be associated with climate change as well as the threat of large-scale risks and accidents related to modern technology. Even if we are not concerned with any national crisis, perceptions may indirectly affect land use and living preferences through the opinions and feelings of the population. Remote regions are currently losing their populations, but it is not impossible that their significance as a kind of reserve area would increase.

The currently prevailing lifestyle and corresponding urban structure are more and more based on passenger car traffic. If travel by passenger car becomes significantly more expensive, the pressure to increase the density and efficiency of urban construction will increase. On the other hand, a low-density settlement structure, space and nature may also become attractive factors and even more worthy of pursuing.

One of the most essential challenges in terms of land use and community development is that within the next few decades means should be found to control the centralisation of the population in a manner that would minimise the financial and social costs associated with this trend. At the same time, taking long-term population forecasts into account, it should be possible to anticipate the downtrend of population that will start in less than two decades.

Impacts of climate change on land use, communities and waste management

Land use and communities

Climate change will introduce a new aspect to land use besides the economic and social viewpoints, but its detailed nature is not yet known. More detailed investigation of natural conditions and more intense observations of the results will require further study. Detailed information on the regional and local impacts of climate change and the means of adaptation will be necessary.

Communities are even more dependent on technical systems and more vulnerable to disturbances in the systems or external factors. In the long-term, land use planning could contribute to ensuring the functionality of communities. More attention should be paid to technical systems such as water services, as well as preparation for the associated risks.

Extreme variation in weather is expected to become more common due to climate change. Events including storms, floods, humid winters, dry summers and an increased sea level will impact on extensive areas as well as individual buildings and people. According to the VTT report “Impacts of climate change on the built-up environment” (in Finnish), intense storm winds blowing from the sea, the associated depression and flow of water to the coast may substantially raise the water level and cause floods in low-lying regions. Increased precipitation will also cause increase in water levels, which will be reflected in an increased groundwater level. Increased soil dampness will result in added load and increased pore water pressure, which will reduce the firmness of soil. Increased precipitation will also increase the runoff of waters, adding to the risk of erosion.

Waste management

Waste management is a part of the technical management of communities and production operations. The activities are increasingly based on versatile industrial preprocessing and utilisation of waste. Climate change will probably not affect this. Prevention of the emergence of waste is a crucial line of action in waste policy.

Waste originating in production operations and energy production is partially utilised for construction. The requirements imposed on waste include, among other things, that earth construction does not cause any emissions or impacts that are harmful to health or the environment. Some of the waste will end up in landfills, and in this case, it must also be ensured that once the operations have ceased, the accumulated harmful materials will not be released from the landfill into the environment in a manner that would endanger health or the environment. The risk assessments underlying waste management and the planning of landfills also include risks associated with weather, and the variation of the present environment, such as rain and runoff conditions, are being assessed.

The placement of biodegradable waste in landfills will be minor after 2016, which will decrease the emission of nutrients and other substances carried by water.

Table 3.18 *Summary of the anticipated impacts of climate change on land use, community planning and waste management in Finland. The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant.*

Disadvantages	Advantages
– Storms, floods, humid winters and dry summers will become more common – The sea level will rise – Increased water concentration in soil will decrease firmness and increase the risk of erosion – Absorption of rain water will be retarded – Variations in the groundwater level will cause problems for water availability in sparsely populated areas and cause a risk that wood pole footings in old buildings may dry up in urban areas	+ The distribution of plant species in parks and recreational areas will become more diverse and growth will be accelerated

3.2.7. Construction and buildings

Construction in Finland

The building stock and its properties will be changed by new construction and extensions, removal of old buildings, repairs on buildings, as well as alterations of use. The volume of new construction is derived from the sum of removal and additional space requirements. The building stock is divided into quite an extensive range of combinations in terms of age, type of building, construction technique and heating method, among other things. Buildings are currently designed for a service life of 50–100 years. The estimates presented do not include factors associated with construction products or their manufacture, or the actual construction work. The reviews presented are associated with buildings, their structures and the phase of usage, or the foundations of design.

Finland is estimated to have a population of slightly less than 5.2 million in 2050. The population will have started to slowly decline from the peak in 2020–2030. The estimated number of dwellings in Finland in 2050 is 2.9 million, and the average size of a household remains at the level of 1.8–1.9 people. The average size of dwellings will have increased somewhat since the beginning of the 21st century, but we will still be behind the other Nordic countries. The rate of new construction in 2050 will be 15,000–20,000 dwellings per year, while the corresponding figure in 2004 was approximately 30,000 dwellings. Finland's housing reserve will have exceeded 300,000 dwellings in 2050 and be in the order of 11% of the housing stock. Living space will have increased by some 10 square metres from the present to about 45 square metres per person.

The review of construction and the building stock until 2025 is concerned with residential and service buildings, and in this context, the review of the year 2050 focuses on residential buildings only. The rate of new construction is expected to fall short of the late 20th century (the 1970s and 1980s) until 2025. No growth is expected even over a longer time span, because the growth of the population is anticipated to stop in the 2020s. The volume of new construction in relation to repairs has decreased, and the trend seems to continue. The volume of repairs in the stock of housing blocks will significantly increase when the stock built in the 1960s and 1970s reaches modernisation age (in 35–45 years from completion) and opportunities for energy conservation in repair operations will increase. According to the estimate, the energy consumption of the building stock will increase, because the increasing impact of the growth of building stock will be greater than the reducing impact of new construction that replaces the reduction and consumes less energy than the average.

Impacts of climate change

The climate change factors associated with buildings and construction are very much the same as those associated with the structure of regions and communities, and these sectors should be examined relative to each other. The crucial impacts of climate change associated with construction and community planning include the greatly increased risk of floods in many inhabited areas due to increased heavy rain. Another factor will be the increase of energy spent on air conditioning (increased need for cooling) due to increased summer temperatures. Correspondingly, positive impacts on construction include reduced energy requirements during the use of buildings.

According to forecasts, the amount of precipitation will increase particularly in winter. Due to the impact of increased temperatures, precipitation will more often be in the form of water rather than snow. Increased water concentration in soil will reduce firmness and impair its bearing capacity. Increased precipitation may raise the groundwater level, which will also reduce the firmness of soil. The risk of erosion may also increase through precipitation if the volumes of water runoff in the environment increase. This may impact on the stability of ramps, for example. Increased floods may lead to the flooding of basements and underpasses, as well as damage to road and underpass structures. In some cases, an increased groundwater level may affect the functionality of foundation draining structures and cause structural damage, including mildewing of wooden structures. The groundwater level may also be significantly lower during dry and hot summers. In this case, the sinking of clay beds may cause damage to the foundations and walls of buildings with a natural foundation bed.

Estimates regarding the changes of windiness are very uncertain and dependent on the climate models used. Due to the reduction of ice cover on the Baltic Sea, the sea level may rise more than at present in some cases.

Increased precipitation will add to the moisture load of exterior surfaces. Corrosion of building components may also increase. Materials will be put to severe test particularly if the freezing-melting cycle quickens, meaning that the temperature constantly varies above and below 0 °C. This will particularly increase the number of stress cycles on the surface structures of facades and roofs and be harmful for porous materials, such as bricks and plastered surfaces. The need for care and maintenance can be expected to increase. However, the structures will remain drier with climatic warming as the temperature will more often stay above 0 °C.

The impacts on overall construction may also extend to the development of individual building engineering devices and systems, which means that some structural solutions should also be developed (including ducts and flues).

As a consequence of climatic warming, the need for ground frost protection of structures might decrease in some regions. However, despite the climate change prolonged occurrence of low temperatures is still probable, and the need for ground frost protection similar to the present will continue to be justified.

Climate change will probably also have a significant impact on the energy management of buildings. The need for heating energy in buildings could decrease by some 10%, but the need for cooling may increase. Hot summers in recent years have increased the temperatures in housing blocks as well as in other buildings. For example, cooling equipment has been retrofitted at business buildings. A potential increase in windiness may impact on the energy consumption of individual buildings.

Table 3.19. *Summary of the anticipated impacts of climate change on buildings and construction in Finland. The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant. Some of the impacts are clear advantages or drawbacks but the direction of some impacts is still unclear or the direction of the impact depends on the intensity of climate change.*

Disadvantages	Direction of the impact unclear or a simultaneous disadvantage and advantage	Advantages
– Precipitation will increase, which will in turn increase the groundwater level, reduce the firmness of soil, increase the risk of erosion and the moisture load on exterior surfaces, and lead to the flooding of basements – Moisture damage and need for maintenance will increase – Corrosion will increase – Increased groundwater level may prevent the operation of foundation draining structures and cause structural damage – Impacts of extreme events, such as potential increases in windiness and wind strength – Diagonal rain will be an extra burden on exterior cladding	• The need to protect structures against ground frost will decrease; • The occurrence of prolonged low temperatures will still be possible, which means that ground frost protection similar to that at the present will continue to be justified. • The risk of flooding in coastal areas will grow due to the estimated increase in sea level combined with increased windiness; however, uplift will partially compensate for the expected disadvantages.	+ The need for heating energy in buildings may decrease + With the exception of external cladding and roofs, structures will remain drier

3.2.8. Health

Social services and health care in Finland

The population of Finland is 5.2 million, and there are almost 200,000 health professional responsible for their health care, while social services employ almost 120,000 professionals. Health and social services in Finland are mostly produced in the public sector on the basis of obligations imposed on municipalities, but particularly in the social sector and care for the elderly, the volume of private services is increasing. The basic unit of health care services in Finland is the health centre. There are 275 health centres and 444 municipalities in Finland (in 2004), which means that many municipalities join their forces when arranging health care services.

Potential increases in extreme climatic events, particularly in periods of extreme heat and coldness, may impose a challenge on the health sector, because the population is ageing rapidly. According to forecasts, 20% of the population will be over 65 years of age in 2020, compared to 15% at present, and the number of people over 80 years will increase by 50%. A crucial objective of social services and health care with regard to geriatric policy is the development of outpatient care and various forms of support for old people living at home.

The prevention of sudden health hazards caused by climatic extreme events falls primarily within the scope of the Health Protection Act – that is, environmental health care. Section 8 of the Health Protection Act requires municipal health protection authorities, in cooperation with other authorities and institutions, to undertake emergency preparations and precautionary measures required to prevent, investigate and eliminate any health hazards caused by accidents or similar situations (exceptional situations) in advance. In most cases, the organisation of environmental health care is subordinate to the municipal board of health or the environment, but in some smaller municipalities it may belong to the technical board.

Impacts of climate change on the health sector

Direct health impacts of climate change

The potential increase in mean temperature will not cause any direct health hazards as such. In countries like Finland, mortality will probably decrease as the mean temperature increases. The reason for this is that the mortality minimum in Finland is reached at approximately 14 degrees Celsius, excess mortality is significantly higher in extremely cold temperatures than during periods of intense heat, and extremely cold temperatures are estimated to become less common. Time series analyses indicate that excess mortality caused by cardiovascular diseases will begin with a two-day delay after the start of a cold period, and the corresponding delay for respiratory diseases is 12 days.

In principle, changes in the frequency, duration and intensity of other extreme climatic events that are hard to predict (storms and floods) may cause direct health impacts in Finland.

The warm summers in the beginning of the new millennium have raised concerns on the impacts of heat-stress on public health in Europe, among other places. Events associated with the August 2003 heat wave in France and Italy have particularly contributed to increasing health authorities' knowledge of how heat waves affect health and how the authorities should design their actions under such circumstances. The information may be utilised in the examination of Finnish conditions as well, with the reservation that health impacts due to hot weather can be expected at lower temperatures in Finland compared to Central Europe. This view is supported by the fact that the excess mortality due to the 1972 heat wave was greater in Northern Finland than in Southern Finland. The more the mean temperature increases, the more climatic adaptation is expected, which means that the north-south differences in excess mortality will be smaller.

Changes in windiness – for example, increased occurrence of intense whirlwinds found in Eastern Finland – may cause limited health impacts.

The anticipated increase in precipitation in Finland may also cause health impacts in regions sensitive to flooding (Ostrobothnia). Contamination of drinking water by faeces can also cause health hazards originating in floods. However, maybe somewhat surprisingly, recent floods caused by heavy rain in the American Midwest resulted in fairly minor health impacts. In practice, the floods caused increased diarrhoea only in people who were in direct contact with flood waters. Water-originated diarrhoea was also successfully controlled during the floods of the 2004 summer, for example, at Riihimäki, thanks to rapid official action and distribution of information. Experience indicates that the health protection network of developed countries like Finland, combined with official action and efficient distribution of information, is able to protect the population against immediate health hazards caused by floods quite well.

The urban heat island phenomenon

The increased mortality associated with the heat wave in summer 2003 in France, Italy and Portugal affected in practice only large cities. In Paris, the industrial cities of Northern Italy and Lisbon, almost 20,000 elderly people (particularly those older than 75) died when the temperature exceeded 25 degrees Centigrade in several consecutive nights. The 2003 heat wave was not essentially different from the one in 1948, when no increased mortality was discovered. The investigation had to be extended to the local climate – that is, the urban heat island phenomenon, which may be of practical significance also in Finland, mostly in the Greater Helsinki area. The urban heat island phenomenon occurs in winter as well as in summer. These have different physical backgrounds. In winter, waste heat produced in various ways warms the urban atmosphere. The warming effect is particularly clear at night, when waste heat compensates for the effect of low night-time temperatures. In summer, the built urban environment (stone, concrete, asphalt) absorbs solar radiation, warms up and releases heat back to the atmosphere at night. Urban areas mostly lack vegetation that would consume the Sun's radiation energy on evaporation. The rapid increase in the number of automobiles should not be forgotten, either. Both daytime temperatures and particularly night temperatures will be higher in densely built-up areas.

Indirect health impacts of climate change

The climate – and seasonal variations in particular – plays an essential role in the prevalence of several infectious diseases. Before the emergence of the cold chain that was made possible by modern electricity production, which improved the preservability of foodstuffs, as well as the centralised industrial infrastructure that otherwise emphasises food hygiene, various types of food poisoning were dependent on climatic conditions. During the Little Ice Age, for example, a particular problem in Finland was the contamination of grain crop by ergotic alkaloids due to rainy and cold summers. On the other hand, heat waves before industrialisation used to be associated with local bacterial toxication due to the lack of a cold chain. Later, approximately from the 1920s to the 1950s, while the centralised production of food was still developing, heat waves could contribute to the emergence of regionally and quantitatively significant epidemics transmitted through food. The risks of infection caused by industrial food production have since been brought into control as experience has accumulated and technology has advanced.

Even though the most essential epidemic diseases that used to regulate mortality and are communicable between humans, such as measles, influenza and tuberculosis, are most often spread in the northern parts of the globe in winter, the climate has not been decisive for the occurrence of these communicable diseases or the emergence of a pathogen cycle, even though they were often associated with years of crop failure and increased mortality in Finland. Before mass vaccinations, measles used to kill some 7–8 million children each year, and it has probably been one of the most decisive individual diseases reducing the human population due to relatively high mortality and an extremely high rate of transmission. The emergence of developed civilisations and critical concentrations of people was decisive for the emergence of a pathogen cycle.

At present, the occurrence of diseases communicable between humans, particularly in poor countries, is mainly regulated by the degree of urbanisation, which directly reflects the frequency of daily human contacts – that is, infection pressure. Particularly in large concentrations of the population in developing countries, high infection pressure requires that vaccinations against measles must be started at an immunologically too early age in order to reduce mortality. However, these generalisations of infection pressure only tell the partial truth, because in the case of measles, for example – especially due to partially functional mass vaccination operations – specific problems arise in the countryside as the interval between measles epidemics becomes longer in these regions. When the disease arrives after a long interval, the number of secondary infections caught within one's family will increase, which leads to an increase in infant mortality associated with measles. This example – in principle concerning the epidemiologically "simplest" communicable disease – provides concrete proof of the complexity of the interconnections between the various factors affecting the occurrence of communicable diseases, particularly when human activities change the epidemiology of diseases.

In northern countries such as Finland, human contacts become more common when the climate cools down in the autumn and people spend more time indoors at their workplaces and schools and on board public transport. This increases infection pressure. The most distinct global change that will probably increase the risk of diseases transmittable between humans and may accelerate the emergence of epidemics is increased air traffic. However, this is probably a simplification, because the progress of the influenza epidemic season seems to follow the "same old routine" despite air traffic, and it is often possible to start the production of a new annual vaccine before the influenza arrives from Asia to Europe.

The occurrence of many such diseases is currently being prevented globally by vaccinations alone (measles) or combined with screening, treatment and medication for those that have been in contact with disease carriers (tuberculosis). All of this will further decrease the impact of climatic changes on the occurrence and circulation of epidemic diseases transmittable between humans.

The Little Ice Age

The Little Ice Age (approximately 1300–1900) had a significant impact on the availability of food. Mortality was repeatedly increased by, for example, famine and infectious diseases. Famine was often associated with increased mortality from epidemics. In bad years, mortality in the very young population could increase up to 4–5%, which is 4–5 times higher than today's aggregate mortality. Increased mortality affected all age groups and both genders, but particularly children. At worst, bad weather destroyed the crops in the consecutive years 1695–1698, during which as many as 200,000 people died of hunger and diseases in Finland, representing almost half of the population at that time. Cold and humid summers often resulted in contamination of grain crop by ergotic alkaloids. As recently as in the 1860s, more than a thousand people (1863) may have died of this nervous toxin produced by the fungus *Claviceps purpurea* (ergotism). This is almost nine times the fatalities of road traffic in 2003.

The occurrence of many vector-borne or zoonotic diseases is even more complex, in terms of different interconnections, than the simple examples of food poisoning and epidemic diseases transmittable between humans described above.

Many vector-borne forms of spotted fever occur either in winter (classical spotted fever associated with war and captivity, for example) or in summer (the more moderate Brill's disease in North America) depending on the ecology of the vector participating in the disease cycle (such as ticks or fleas) and so-called reservoir animals (such as rat, mouse or moose). Reservoir animal refers to the animal in which the disease actually circulates, while man is mostly an occasional terminus of the pathogen.

On the other hand, favourable reproduction conditions for bank voles will increase the occurrence of zoonotic infectious diseases transmittable through vole urine, also known as epidemic nephropathy caused by the *Puumala virus,* late in the autumn when voles arrive in indoor spaces where people work, such as woodsheds. There is no direct proof that the climate will play any decisive role in the endogenous quadrennial variation of bank vole populations, which is determined by factors including predator stocks – contrary to what is found in Central Europe. However, it is possible that the climate will have an impact on the vole population in the peak year, and this is being studied in Finland with funding from the Sixth Framework Programme of EU research.

Studies have been conducted in Sweden in the last decade to find out whether the geographical distribution of diseases spread by ticks (*Ixodes ricinus*) has moved north as a consequence of milder winters, earlier spring and later emergence of winter. The highest occurrence of Kumlinge disease was reported in Sweden in 1994. Kumlinge disease is caused by the *TBE virus,* which is a flavivirus. The disease has been recognised and registered since 1960. The year 1994 was preceded by five mild winters, and in seven consecutive years, spring had come early; these factors promoted the overwintering of tick larvae and the development of nymphs. A Swedish study also indicated that the late emergence of winter, which prolongs the berry and mushroom season, is associated with the increased occurrence of Kumlinge disease. It has also been estimated that Lyme disease (*Borrelia Burgdorferii,* brain fever) and erlichiosis (member of the genus *Ricketsiae*) have become more common in Sweden due to warming.

The results of the most recent Swedish study (2001) remain disputed. The impacts of climate change on the frequency of diseases spread by different vectors are tightly linked to economic (forestry) factors and health care interventions. Furthermore, variation in the frequency of the Kumlinge disease in Europe does not follow climatic variation, which suggests that the disease risk factor is independent of climate. An alternative explanation discussed in Sweden is that the distribution of ticks is attributable to socio-political factors related to agriculture. On the other hand, changes associated with forestry (reforestation of arable land) have increased the occurrence of wild reindeer and, jointly with the planning of forested areas for residential use, have mostly explained the fact that Lyme disease has become more common in the US. The factors described above have increased the probability of tick bites in the US and therefore the occurrence of the Lyme disease. An efficient vaccine is available against Kumlinge disease. Thus there is no certainty with regard to increased occurrence of Lyme and Kumlinge diseases in Finland as a consequence of climate change for the time being.

In 2003 the National Public Health Institute received reports of 753 cases of Lyme disease and 16 cases of tick-borne encephalitis (all types combined).

It is necessary for the emergence of an endemic cycle of malaria that the *Anopheles* mosquito, acting as an intermediate host, is able to reproduce in the region. The Anopheles species (*messae, beklemischevi* and *claviger*) that have acted as malaria vectors are still found in Finland. A warm climate is assumed to promote sexual reproduction (sporogony) of the malarial parasite in the mosquito. However, this is improbable in the case of Finland, because mature *Anopheles* mosquitoes are not found at all in midsummer when, at least in some summers, the outdoor temperature would be high enough for sexual reproduction of the malarial parasite in the mosquito.

It is very improbable that climate change would result in the distribution of the malarial parasite extending to Finland or the entire Western Europe. Malaria is incorrectly perceived as a tropical disease, even though it was very common in England particularly during the Little Ice Age. Malaria or ague was also abundant in Finland during the years of famine in the 19th century, and its occurrence was also apparently high throughout the Little Ice Age in Finland. The temperature required for the sexual reproduction of the malarial parasite in the *Anopheles* mosquito was guaranteed indoors in Finland, and it is obvious that the occurrence of the malarial parasite has not been dependent on outdoor temperature.

A mild form of malaria (*Plasmodium vivax*) was last found in Finland during the Second World War. Its temporary re-endemicity was not a consequence of climate change but it was rather caused by troop transports from the Caucasus close to Leningrad and the Karelian Isthmus. As far as is known, malaria did not cause any deaths at that time. The importance of social structures related to health protection for the prevention of an endemic cycle of malaria has been concretised by the fact that after the collapse of the Soviet Union, malaria has become endemic again in southern parts of the former Soviet Union.

Cricetid echinococcus (*Echinococcus multilocularis* tapeworm) infection in humans can cause a severe cystic disease spreading mainly to the liver, less commonly to the central nervous system. In recent years, cricetid echinococcosis disease has become more common elsewhere in Europe. The most typical definitive host of cricetid echinococcus is the red fox, while the intermediate host is any cricetid rodent. Finland may have avoided cricetid echinococcus because the red fox density is not great enough to cause an epidemic. The degree to which the Finnish red fox population is controlled by climate is unknown. The occurrence of cricetid echinococcus in potential intermediate and definitive hosts in Finland is monitored closely, because in accordance with the new Zoonosis Directive, the disease must be included in zoonosis monitoring. The primary measure of risk management against echinococcosis is obligatory medication of imported dogs with a drug effective against tapeworms before import. If cricetid echinococcus entered the country, it would have significant consequences, because the infection is dangerous to people and could spread from forest berries eaten raw. Cricetid echinococcus has not been found in Finland, not even as an imported case. However, 1–2 cases of cervid echinococcosis are reported to the register of infectious diseases in Finland each year.

It has been suggested that if there are changes in the distribution of allergenic plants (such as mugwort) or the time of flowering, this will be reflected as temporal changes in allergy symptoms in the population.

Exposure to the hepatic and nerve toxins of cyanobacteria (algal bloom) may become more common as the temperature rises in the Baltic Sea and inland waters. These toxins have not caused any severe health hazards in Finland until now. At worst, they have caused flu-like symptoms in the respiratory tract, gastrointestinal inflammation manifested as diarrhoea, erythrema in the eyes, as well as itching and irritation of the skin. The health hazards of cyanobacteria can be efficiently prevented by official action and by preventing their entry into drinking water in particular.

3.2.9. Tourism and the recreational use of nature

The tourism industry and the recreational use of nature in Finland

The tourism industry is a labour-intensive sector characterised by a high degree of domestic added value, as well as small and medium-size enterprises. The industry employed 114,800 people in 1999. The economic significance of tourism is best characterised by its contribution to the gross domestic product, amounting to 2.4% in 1999. The starting point for tourism development is the activities of entrepreneurs. The government supports the development of the industry's operational preconditions and environment. Tourism development is guided by the Government's decision in principle on Finland's tourism policy. The Finnish Tourist Board is responsible for promoting tourism to Finland and supporting the development of tourist services. Public subsidies to tourism are channelled through regional authorities such as the Employment and Economic Development Centres (T&E Centres). The enlargement of the EU is believed to intensify competition in the tourism sector.

In 2003 4.6 million foreign tourists visited Finland, more than 90% of whom came from Europe. Tourism in Finland can be divided into summer and winter tourism. The challenge for summer tourism in our country is that the tourism season ends earlier than in other European countries. Many summer tourism services end their season in mid-August when schools start, even though the weather would allow an extension to the summer season. Services are not kept open solely for foreigners, and potential tourists are lost while the holiday season elsewhere in Europe is at its best. With regard to winter tourism, Finland's largest ski resorts are located in the provinces of Lapland and Oulu. The coverage of artificial snow equipment at Finnish ski resorts is one of the most extensive in the world; an estimated 80% of the total slope area is covered with artificial snow.

The recreational use of nature can be divided into everyday recreation and tourism utilising natural recreation services. Recreational use is based on the right of public access, also known as 'everyman's right', which guarantees a relatively free right of access to nature. Everyone may walk, ski, cycle or ride horseback in the countryside and set up camp temporarily, except in the immediate vicinity of another person's home, fields during the unfrozen season, plantations and restricted areas within nature reserves. Picking wild mushrooms and berries is generally allowed wherever access is free. There are certain restrictions on the right of public access; among other things, living trees may not be damaged and lichen may not be collected without the landowner's permission. Fishing with a rod and line, as well as ice-fishing, is allowed except in rapids and the currents of water systems rich of salmon and powan and in areas where fishing is prohibited. The right of public access in Finland is exceptionally extensive. Similar rights exist mainly in the other Nordic countries. Everyday recreational use of nature in Finland is not concentrated in any specific recreational areas. More than half of the working-age population picks berries, while 38% pick mushrooms. Almost 70% of the population engage in walking and swimming.

Impacts of climate change on tourism and recreational use of nature

The uncertainties associated with the assessment of climate change impacts in the sectors of tourism and recreational use of nature are caused by uncertainties in the prediction of climate change impacts on the one hand, and the difficulty of forecasting the development of tourism on the other. The tourism industry and recreational use of nature are very dependent on the climate and natural conditions. Other important factors include customs, habits, spirit of the time, fashion, and global threats. Increased leisure time and standard of living, as well as changes in lifestyle, may boost tourism and the recreational use of nature. People spend an increasing share of their leisure time indoors, which means that outdoor activities may diminish in the future. Estimates suggest that mass tourist destinations will lose popularity, and more remote destinations and adventure tourism may become more popular. The impact of climate change on tourism and the recreational use of nature, as well as the sector's ability to adapt to climate change, has been studied very little in Finland.

Summer tourism

The boating, swimming and summer cottage seasons will become longer due to climate change. However, algal blooms may become more common when water bodies warm, and precipitation will increase. Preliminary estimates indicate that swimming will become more common as the temperature increases, but diminish with increased precipitation. However, precipitation will probably have a lesser impact on swimming behaviour than temperature, meaning that in the light of these estimates, outdoor swimming will probably increase unless the quality of waters becomes substantially deteriorated.

In the medium and long term, the Southern European climate will probably become less advantageous for tourism, while the climate in the present origins of major tourist flows in Central and Northern Europe will become more advantageous. It is difficult to predict international tourist flows, but if climate is considered a substantial pulling factor, Finland's attractiveness as a country for summer tourism will probably increase at least in the eyes of domestic tourists.

Winter tourism

Finnish winter tourism, particularly in Northern Finland (the provinces of Oulu and Lapland) is very snow-oriented and therefore vulnerable to climate change. The certainty of snow is not expected to diminish quickly, but periodic variation in snow conditions may appear in the short term particularly in Southern Finland. Northern Finland has already suffered from the delayed appearance of snow. For example, it is no longer guaranteed that Christmas schedules for foreign groups can be successfully planned, as snow falls later and later at the latitude of Rovaniemi. Snow cover is estimated to diminish, but local increases are possible in regions where low temperatures dictate that increased precipitation will be in the form of snow. As a domestic winter travel destination, Northern Finland is expected to benefit from the unstable winters of Southern Finland. However, it is of primary importance to domestic tourism in the long run that new generations of downhill and cross-country skiers are able to introduce themselves to the hobby close to important population centres. Cross-country skiing is more dependent on temperature and snow conditions than downhill skiing, because artificial snow has traditionally not been used. The skiing hobby is concentrated in Eastern and Northern Finland, and due to climate change, the popularity of skiing will continue to decrease in the south and on the coasts in the long run. Northern Finland has the opportunity to benefit as a winter travel destination if the certainty of snow in traditional Central European alpine resorts diminishes as expected.

Table 3.20. *Summary of the anticipated impacts of climate change on tourism and recreational use of nature in Finland. The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant.*

Disadvantage	Advantage
– Increased occurrence of algal blooms due to warmer waters – The certainty of snow will decrease particularly in Southern Finland	+ The summer tourism season and recreation season will be longer + The temperature of waters will increase + The attractiveness of winter travel to Northern Finland may increase if the volume of snow in the Alps diminishes as predicted

3.2.10. Insurance operations

Insurance operations in Finland

The direct significance of insurance operations within the actual national economy is quite minor, approximately 1% of GDP. However, the indirect significance of the insurance sector is far greater. The role of the insurance sector is significant, for example, when observing its share as an allocator of capital and creator of savings. The role of the insurance sector, especially non-life insurance, in redistributing various risks is substantial.

Reinsurance is a widely used method for redistributing the exposure taken by direct insurers between several insurance companies. Reinsurance makes it possible to insure against major risks. International cooperation is a tradition in Finnish reinsurance.

Impacts of climate change on insurance operations

The global population is twice that of the 1950s. Settlement is more and more concentrated in large cities located on the coasts and thus vulnerable to the risk of natural catastrophes. However, the change in population and urbanisation is not enough to explain why the amount of insurance compensation paid for natural catastrophes has increased 15-fold in four decades. At the same time, insurance compensation amounts for accidents caused by human activity have increased moderately, except for the peak in 2001. Asset values have increased, but it is also probable that the climate is actually changing, storms are more intense and damage is greater than before.

Losses incurred by the insurance sector due to the harmful impacts of climate change are a global problem through reinsurance. According to an estimate by the Reinsurance Association of America (RAA), 50% of insured losses in the world within the last 40 years have been the consequence of natural catastrophes in the 1990s. Insurance experts have warned that large regions of the world may be recategorised as ineligible for insurance, because changes in weather caused by climate change (such as heat waves and hurricanes) continue at an accelerating pace. Climate change is expected to lead to an increase in compensable damage, which will contribute to increased insurance premiums. This means that extreme events will result in an increased level of risk in the insurance sector. Climate change may lead to increased costs and maybe even the bankruptcy of insurance companies.

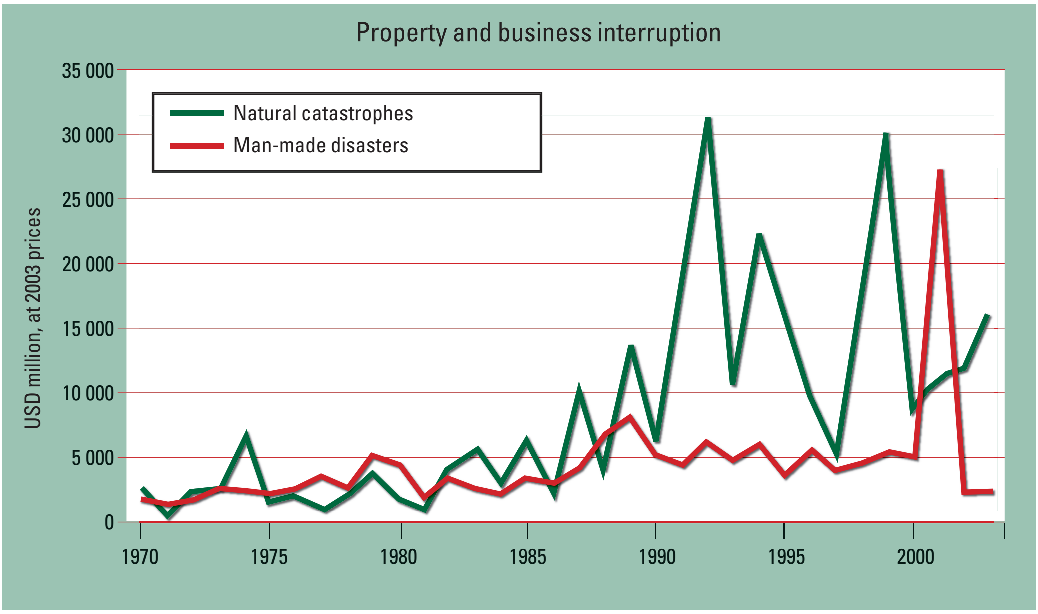

__Figure 3.5.__ Diagram of insured losses (property and interruption of business) as a consequence of natural catastrophes and man-made disasters globally from 1970 to 2003. The development of insured losses since the 1970s indicates a clear upward trend towards greater losses. Source: Swiss Re, sigma No. 1/ 2004: Natural catastrophes and man-made disasters in 2003.

The threat of insurance company bankruptcy in Finland can be considered extremely improbable, because the pricing schemes, terms and conditions employed by insurance companies usually keep their financial base solid also in exceptional circumstances. Furthermore, our geographical location has saved Finland from the kinds of damage seen in the other Nordic countries.

For example, the storm Anatol in Denmark in 1991 had a wind velocity of 160 kilometres per hour and resulted in insurance compensation amounting to almost 2 billion euro. Damage of such magnitude was not generally considered possible in Denmark. Revised estimates assume that the maximum weather damage event in Denmark over a period of 100 years would be in the order of 2.5 billion euro, and the 10-year maximum would be 500 million euro. However, the degree of uncertainty is substantial.

Events depending on weather affect almost all types of insurance providers. It is probable that climate change and anticipated changes in weather-dependent events perceived as depending on climate change will increase mathematical uncertainty in risk assessment and bring added uncertainty to the functionality of the insurance market (for example, the availability and pricing of insurance services). This may cause pressure to recategorise some operations as ineligible for insurance, increase deductibles or reduce the limit of indemnity. This may also result in changes in the roles of private and public insurance and increase the need for the government to engage in insurance operations.

High maximum and minimum temperatures, level of snow, rainfall, floods, heat waves, frost, etc. will cause problems for health, property, agricultural products, transports, and water structures – that is, almost all of the sectors where the insurance industry is involved.

The sectors most sensitive to impacts are estimated to be property and personal insurance, as well as reinsurance. Weather is a contributing factor in many hazardous situations, and insurance companies compensate for thousands of losses caused by weather events every year. Insurance companies offer policies against forest fires and damage caused by storms, snow, rodents, mycoses and floods. Seventy per cent of all forest damage compensated for by insurance companies is caused by storm.

However, information regarding the potential impacts of climate change is insufficient in the insurance sector. The insurance industry is interested in developing materials, insurance products and systems associated with floods, for example. In some countries, so-called pool schemes have been developed to cover flood damage. Pool schemes are used e.g. in Norway, France and Switzerland, among other countries. In Norway, the insurance policies in the pool scheme include storm damage in addition to flood insurance, because these are generally regarded as being similar "natural catastrophes". According to an OECD survey, such an insurance package against damage by natural forces is better than policies developed for individual catastrophes. Reinsurance amounts are high in Norway. On the other hand, Swedish flood insurance is closer to market terms and is included in home insurance, but the policies have high deductibles (can be as high as 2,000 euros). Insurance policies solely against flood damage are practically unavailable in any EU Member State. This means that there are no insurance products just for flood damage but coverage is attached to some other type of policy, such as storm insurance or comprehensive home insurance. The United States has a national flood insurance scheme, and the government may prescribe that a flood insurance policy is a prerequisite for receiving funding for the repair or purchase of buildings in high-risk areas. Otherwise the insurance policies are voluntary.

In Finland, the general rule is that real estate or home insurance does not cover damage by rain or flood. The reason is that if a house is correctly built in compliance with construction regulations, water should not be able to enter the structure. However, an insurance company may pay compensation in exceptional cases. The contract terms for home insurance from many companies allow compensation if some other type of damage causes water to flow into the residence. It is not clear whether heavy rain, and the associated damage, fulfil the definitions of unexpectedness and suddenness generally mentioned in the terms and conditions for real estate and home insurance. Contrary to the case of wind velocities, the insurance industry does not have any common rules regarding the amount of rainfall that could be applied to claims settlement decisions.

However, the Finnish Government has created some procedures for compensating damage caused by extraordinary weather either in part or within the framework of available appropriations. Damage to crops due to extraordinary weather conditions will be compensated for using State funds, as well as damage to horticultural plants and field crops due to extraordinary flood. Compensation for crop damage is paid when the damage exceeds 30 per cent of the value of the farm's standard harvest. After the 30% deductible, the rest is compensated for to the extent prescribed by the Government; in recent years, this has been 90 per cent of the remaining amount. Compensation for flood damage to tree stock can be claimed from the State once the damage is discovered. Flood damage compensation can only be paid for damage caused by extraordinary flooding of water systems and for costs arising from the prevention of damage. In 2004, for example, 841,000 euros were allocated in the State budget to damage caused by extraordinary flooding of water systems and the prevention of such damage. However, the Government's supplementary budget proposed an increase of 4 million euros to compensate for damage caused by extraordinary flooding in the summer of 2004. A flood can be considered extraordinary if, for example, floods of equivalent magnitude occur less frequently than once in 20 years.

Table 3.21. Summary of the anticipated impacts of climate change on insurance operations in Finland. The impacts are not commensurable – in other words, the number of the listed advantages and disadvantages cannot be used to conclude which ones are quantitatively more significant. Some of the impacts are clear advantages or drawbacks but the direction of some impacts is still unclear or the direction of the impact depends on the intensity of climate change.

Disadvantage	Direction of the impact unclear or a simultaneous disadvantage and advantage	Advantage
– High maximum and minimum temperatures, snowiness, rainfall, floods, heat waves, frost, etc. will cause problems for health, property, agricultural products, transport and water structures, and higher compensation will have to be paid – Mathematical uncertainty in risk assessment will increase – Uncertainty will increase in insurance market functionality – Increased pressure to recategorise some operations as ineligible for insurance, increase deductibles or reduce the limit of indemnity	• Changes in the roles of private and public insurance	+ New insurance products and schemes will be introduced to the market + The policy on claims provision will become clearer

4. Adaptation to climate change

4.1. Sector-specific adaptation

4.1.1. Use of natural resources

4.1.1.1. Agriculture and food production

Adaptive capacity of actors

The common agricultural policy of the EU will continue to steer agriculture and its regional orientation in Finland in the near future. Compared to other livelihoods based on natural resources, agriculture generally has good opportunities to react quickly to climate change, because the cycle of cultivation is short. Furthermore, the general adaptive capacity of cultivated crops is good.

Possible measures

Changing climatic conditions must be taken into account in future agricultural policy. Incentives could be used to improve more flexible land use and the regional distribution of cultivation so that any potential benefits of climate change can be utilised. Furthermore, it is necessary to support the adoption of new technologies and cultivation methods and the diversification of agriculture. Minor changes may be required in the monitoring systems for animal diseases. In order to control the load from agriculture to waters under changing circumstances, the means for water protection must be assessed due to increased leaching of nutrients. In addition, the need to develop risk management measures, as well as the compensation systems for crop damage and storm damage, may need to be assessed.

Improvement

The varieties of arable crops used in the future will not be the ones cultivated today. With current breeding methods, the time required for developing a new variety of arable crops varies from approximately seven years (self-pollinating grain, oil plants) to 12–15 years (fall grain, grass). This means that the improvement process for arable crop varieties will be able to react to relatively rapid changes in climatic conditions.

Even if the climate becomes warmer, it is not probable that varieties developed for more southern conditions would be usable in Finland. This is due to the quite extraordinary length of our day during the growing season and the special rhythm of the growth required for the varieties used, as well as the types of soil in our fields, which vary substantially within Finland and in comparison to those found in more southern growing conditions. In addition, the extraordinary nature of our growing conditions is emphasised by multidimensional interaction between the factors mentioned above. Therefore, it is clear that our arable crop production can only be based on the improvement of varieties intended particularly for our local conditions.

In places, spring turnip rape could be replaced by spring rape, which gives better yield in places, and winter rape may be introduced for cultivation later. New species such as corn and sunflower will probably remain marginal. If the cultivated species was changed, this would require changes in production methods and maybe new machines.

Pests, plant diseases and weeds

The spreading of pests and plant diseases must be prevented in advance. However, due to the emergence of new risks of weeds, plant diseases and pests, climatic warming will probably result in the need to increase the use of pesticides and introduce more powerful pesticides. An extension of two weeks to the growing season means one or two more rounds of pesticide spraying. Disadvantages caused by increased use of pesticides should be mitigated.

At present Finland has a protected zone status recognised by the EU for six quarantine pests (fire blight, sweetpotato whitefly, tomato spotted wilt tospovirus, white potato cyst nematode, beet necrotic yellow vein virus, Colorado beetle). The protected zone status has to be separately applied for on the grounds that the pests in question are not permanently found in the country. The protected zones may change in the future.

Changes in agricultural production

As the climate is changing, it is very important to maintain the general fertility of fields. The negative impacts of climate change on the soil can be reduced by developing cultivation methods. The leaching of nutrients from the soil can be prevented by cultivating perennial plants or using wintertime vegetation cover on fields, cover and undersown crops, as well as buffer zones. The soil structure can be improved by ploughing straw into the soil, as well as reduced tillage and direct sowing. Direct sowing preserves the dampness of soil and snow cover better in the winter.

In addition to improvement and plant protection activities, the efficiency of agricultural production can be improved while utilising the opportunities of climate change by changing sowing times and fertilisation. According to estimates, in 2050 spring sowing around Jokioinen in south-central Finland can be started more than ten days earlier than at present – that is, in late April. However, increased occurrence of spring frost may limit the early cultivation. Cultivation of winter crops is currently limited to Southern and Southwestern Finland, but the area could be expanded in a changed climate. The harvest potential of winter crops is better than that of spring crops. They also protect the soil from erosion and leaching and are not as sensitive to dry weather.

The benefits of climate change can be utilised in horticulture by expanding production. In animal husbandry, a longer grazing period will increase the well-being of the animals. More attention must be paid to advance prevention of animal diseases. More cooling may be needed in barns housing cattle in summer.

Research on adaptation

The impacts of climate change on agriculture have not been extensively studied since the SILMU research programme of the Academy of Finland. However, the standard of impact research in agriculture can be considered good. A need for additional research has been identified in the following subjects of impact and adaptation research:

- Preparation of alternative scenarios for the impacts of climate change on Finnish agriculture – that is, what is agriculture going to be like in different parts of Finland with a changed climate, how can agriculture adapt to change and what are the risks?
- Needs for change in production techniques in plant and farm animal production
- Feedback on climate change adaptation measures to climate change and environmental loads, including water system loads and gaseous emissions

- Efficient utilisation of water to minimise the impacts of climate change, such as occasional drought
- Identification of new plant stress factors and minimisation of stress effects
- Cost-efficient control of diseases and pests in a changed climate
- Utilisation of the diversity of gene pools for adaptation to climate change
- Opportunities for horticultural production in a changed climate
- Means of steering that promote adaptation to climate change
- Impacts of climate change on the global and EU food markets, and the impact of these on the Finnish food economy
- Coordination of climate change adaptation measures and mitigation measures in agriculture
- Adaptation of the overall food chain to climate change and observation of the quality aspects
- Impacts of climate change and adaptation measures on the diversity of the agricultural environment

Table 4.1. *Summary of indicative adaptation measures to climate change in agriculture and preliminary timing: *Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080.*

		Anticipatory	Reactive
Public	Administration and planning	• Attention to production methods adaptable to climate change, production structure and locations in support policy*** • Development of animal disease monitoring systems** • Development of plant disease and pest monitoring systems*	
	Research and information	• Development of new technologies and cultivation methods and providing information on them** • Conceptualisation of climate change and its risks*	
	Economic-technical measures	• Integration of changed climatic conditions and plant protection requirements into plant improvement programmes*	• Minimising the disadvantages of the potentially increasing use of pesticides**
	Normative framework	• Assessment of the revisions to water protection guidelines**	
Private		• Introduction of new cultivation methods, cultivated crops and technology**	• Extending the farm animal grazing period*** • Increasing the control of pests and diseases**

4.1.1.2. Forestry

Adaptive capacity of actors

The knowledge base of climate change in forestry is good. Thanks to several research programmes (SILMU, Fibre, Figare), research information on the impacts of climate change on the forest ecosystem exists in Finland, and most forests are included in the scope of regular management. However, not much adaptation research has been conducted as yet. In addition, the time span for the impacts of forestry activities is very long (approximately 50–100 years), so the preparation of adaptation measures must be initiated quite soon.

Instruments for planning adaptation to climate change include, for example, the National Forest Programme at the national level, and regional target programmes for forestry at the regional level. Climate change aspects can be included in these. Practical forest management operates with a 5–10 year time span in accordance with forest plans, but the decisions have long-term impacts on forest life, the profitability of forestry, and forestry products.

It is particularly important to be able to identify and anticipate the means, intensity and timing of essential changes in the operation of the forest ecosystem imposed by climate change. Identification of risks is also an important part of adaptation to climate change. Work on these will make it possible to prepare well in advance for any disturbances caused by climate change, identify threats in the operation of the forest ecosystem, and mitigate the impacts of disturbances. In addition, the ability of forestry, its organisations and structures to adapt to changes must be assessed so that operations will be suited to the changed circumstances and remain profitable. Measures must be taken early enough and focused on areas where the risks are the greatest.

The base for genetic diversity in our most common tree species is probably extensive enough to make adaptation possible. Forest management methods can be used to shorten the lead time of nature's own adaptation measures.

Possible measures

Gene pools of forest trees, forest tree improvement and seed management

The objective of storing the gene pools of forest trees is to preserve the genetic variation of the species and their local populations far into the future in order to ensure sufficient viability and adaptive capacity in changing circumstances. A network of gene reserve forests has been established for the purpose of protecting the gene pools of our main tree species. The areas chosen to be gene reserve forests have tree stocks of local origin. The areas are otherwise managed like normal production forests but regenerated either naturally or by planting seedlings that have been cultivated from the seeds of trees growing on-site. The gene pools of valuable broad-leaved trees are protected by maintaining collections of material taken from original forests. Nature reserves, seed banks and breeding populations supplement the protection of forest tree gene pools.

A crucial method of adaptation is forest regeneration using suitable species of suitable origin that can adapt to the climate and soil conditions. Preference in artificial regeneration should be given to origins somewhat south of the place of cultivation. However, care must be taken when moving trees from their origins, with proper attention to the tree's survival in the seedling stage when the climate might not have warmed as much as in the subsequent stages of growth. Central European pines cannot be successfully moved to Finland, because they have adapted to light conditions different from ours. Trees of southern origin will be vulnerable to damage from scleroderris canker, because they are in the incorrect phenologic state when they become exposed. The testing of species' origins must be carried out across the boundaries of the current breeding zones, and different targets for improvement can be established within the breeding zones. Improvement should be directed at several partial populations in order to preserve an extensive genotype. Properties to be improved in the future include, among others, adaptation to increased mean temperature and an extended growing season, as well as resistance to pests.

The most significant method of utilising the results of forest improvement in practical forestry is to establish seed orchards and promote the use of seeds from these. In order to prepare for climate change, it is important to know the genetic origin of the artificial regeneration material as precisely as possible. This will make it possible to determine the applicable domain of usage for a certain batch of seeds and the seedlings grown from it – also upon climate change. In this respect, seeds from seed orchards are much better and safer than seeds collected from forests; in the latter case, the only thing that is known of the origin might be the municipality where the cones were collected from.

Forest management

A well-managed forest creates preconditions for adaptation to climate change. Natural and artificial regeneration both have their advantages in terms of adaptation to climate change. Natural regeneration creates opportunities for utilising the natural genetic potential of the tree species for adaptation to climate change. On the other hand, selection of the origin of artificial regeneration material and the use of improved material will allow a more efficient response to climate change. If the intention is to favour coniferous trees over others, artificial regeneration must be increased.

A shorter rotation of forest and regular forest management will improve adaptation by accelerating the spreading of new, genetically better adapted populations and reducing the risk of pest damage. Tending of seedling stands must also be improved in order to secure the growth of coniferous trees, because the natural preconditions of broadleaf regeneration will improve. Forest management practices should be reassessed in the future, with the objective of developing adaptive forest management in which production targets and forest management are proportional to expected climate change and its impacts on the forest ecosystem. Issues to be observed include the preconditions for artificial and natural regeneration, the intervals and strengths of thinning, the rotation time and the need for forest drainage.

Efforts to prevent the spreading of annosus root rot will minimise its risk and, over time, this will be reflected in the retarded spreading of butt rot and root rot. Hopefully, these will diminish in our forests. Damage monitoring systems must be developed, and cooperation with European expert parties must be intensified. Restrictions on the importation of wood from regions most badly contaminated by pests may have to be considered in the future. Resistance breeding of trees is a potential means of mitigating damage, even though it remains a slow and difficult method in practice. Preparations for potential causes of large-scale damage, such as pine wood nematode, can be made by assessing the impact of climate change in the crisis preparedness plan. Increased populations of pest insects may require a reassessment of plant protection regulations and regulations on the prevention of damage to forests by insects and fungi.

The most important method for reducing damage caused by deer is the regulation of populations by systematic hunting. Damage caused by moose can be reduced to some extent by means of game management methods, such as the correct placement of mineral stones, game fences, repellents and mechanical treetop protectors.

Table 4.2 presents forest management actions aimed at adaptation to climate change on the basis of current knowledge. Practical forest management must take into account several ways of using forests, which may sometimes be in mutual conflict: wood production, protection of diversity, mitigation of climate change either by increasing and protecting carbon reserves or by replacing more harmful raw materials and forms of energy with wood, and adaptation to climate change.

Table 4.2. *Adaptation of forest management actions to climate change on the basis of current knowledge.*

Forest management action	Adaptation to climate change
Improvement	• Adaptation of artificial regeneration materials to a changing climate by means of forest tree improvement aimed at increased reliability of cultivation • Origins resistant to damage
Natural regeneration	• The natural adaptation potential of trees is available
Artificial regeneration	• Use of artificial regeneration if the aim is to favour conifers • Enables the use of seed orchard seeds and clones bred for better adaptation
Seedling stand management	• Tending of seedling stands may have to be carried out earlier
Thinning	• Suitable intervals and strengths of thinning • Regular forest management prevents damage by insects, fungal diseases, storms and snow
Turnover time	• Increased growth allows for a shorter turnover time
Forest drainage	• Reassessment of the need for ditch cleaning and supplementary ditching

Forest use

The increased difficulty of transportation from forests during the thawing season will increase the need for investments in road network maintenance and development. Thinning and harvesting technology and methods must be developed to suit the changing circumstances. The production processes of the forest industry can probably be adapted to a change in the composition of stand in Finland, but it is still necessary to survey and develop the facilities of the forest industry. The distribution of the increases in tree stock growth and availability of material between different tree species and quality grades must be surveyed before making any further conclusions on the adaptive capacity of Finnish forestry to climate change.

Research on adaptation

In the field of forestry, additional research on ecosystem functions is needed in order to develop methods for forest management that are more adaptive to climate change. The impacts of climate change on the nutrition networks of the forest ecosystem must be studied, which will create facilities for understanding the impacts of climate change on the dynamics of the biological control factors maintaining the balance of the forest ecosystem. The mitigation of the harmful impacts of climate change will also require proactive and adaptive forest management, and information on the succession dynamics of the forest ecosystem is required for developing this. Adaptation to climate change must be linked to forest planning, because the use and management of forests are always bound to a certain location and time. For example, reasonable scheduling of felling can reduce the risk of wind damage. The risks of silviculture should generally be studied as part of forest management and forest planning in order to be able to develop forestry risk management and respond to threats associated with climate change.

Adaptation research in the forest sector should be directed at developing advance warning and monitoring systems for climate change. Linking the monitoring system to climate observations will require close cooperation between both climate and forestry researchers. Changes in the extent and duration of snow cover, as well as changes in ground frost, are particularly important. The impacts vary between the different regions of Finland. In addition, research on the threats and risks associated with forest damage in relation to climate change is required, and it must be studied how these risks can be reduced in forest management by altering the structure of forests, for example. Pan-European cooperation is particularly important for the development of pest anticipation and monitoring.

Research should also be directed at empirical transfer experiments with different species and origins, anticipating various alternatives of change, as well as the study of possibilities to improve genetic flexibility and resistance to environmental stress at the level of individual trees.

Table 4.3. *Summary of indicative adaptation measures to climate change in forestry and preliminary timing: *Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080.*

		Anticipatory	Reactive
Public	Administration and planning	• Inclusion of climate change aspects in the National Forest Programme* • Revision of forest management recommendations to correspond to climate change** • Protection of gene pools of forest trees*	
	Research and information	• Development of forest management adapting to climate change and mitigating it* • Development of a system for anticipating and monitoring damage*	
	Economic-technical measures	• Development of harvesting* • Tree improvement* • Control of pests and diseases*** • Maintenance of forest roads*	• Rapid harvesting of wind damage in order to prevent consequential damage** • Selection of the origin of artificial regeneration material**
	Normative framework	• Assessment of the needs for change in forest legislation in changing climatic conditions**/*** • Potential bans on wood imports from areas most badly contaminated by pests***	
Private		• Preparation of forest plans on the basis of new management recommendations**/***	• Rapid harvesting of wind damage in order to prevent consequential damage**

4.1.1.3. Fisheries

Adaptation of fish stocks to climate change

The marine ecosystem is relatively flexible in terms of environmental changes, and fish in inland waters can adapt to changes in temperature by changing their habitat or distribution. It may be a problem if climate change is rapid and has impacts that make adaptation difficult for the populations of some species. The anticipated change would seem to be so rapid that all species of fish will not have enough time to adapt through their genotype. Fish have four alternatives for adaptation: (1) their distribution moves north, (2) the species disappears from the current distribution area but is unable to settle in new waters, (3) the species adapts to the new conditions, or (4) the species perceived as valuable will be transferred to new waters suitable for them. It is probable that all four of the alternatives will be realised. Most Finnish fish species are quite tolerant to their environment, meaning that they adapt to changes relatively well.

The ability of fish to adapt to new conditions or a new habitat varies by species. Fish have the opportunity to rapidly move to a more suitable habitat, unlike shellfish, for example. Fish species with a long life span can also endure better in conditions that are not particularly favourable for spawning. Species with a high productivity and faster growth to maturity will probably also survive the decline and adapt to the changing conditions.

Species that already live in a variable environment and are capable of competing with other species will be the best at adaptation. The living conditions of coldwater species will be preserved best in deep lakes where the stratification of temperature ensures the existence of cool water also in summer.

The habitat of several fish populations will change, and depending on the species, they may completely disappear or become more abundant at the cost of other species. Adaptive species include our most common fish: perch, pike and roach. Their present distribution areas are extensive and they are found in all types of waters. On the other hand, Arctic charr is an example of a fish species with a poor ability to adapt to changes.

Adaptive capacity of actors

Ensuring the sustainable use and management of fisheries resources will require precise scientific information about the changes in the environment that affect fish populations. In addition, administrative flexibility to act on the basis of the information received will be required. The fisheries sector already has several alternatives for adaptation measures, because many of these have been created in order to respond to non-climatic changes in past decades. The greatest challenge will be the coordination of changes in the state of fish stocks and changes in fishing due to climate change. In connection with the regulation of fishing, for example, fishing restrictions will not be changed on the basis of a single environmental factor; instead, the overall picture will always be considered. Fishing faces many pressures (profitability problems, regulation of fishing, dioxin problems), so its consideration must be comprehensive, observing economic, social and regional issues in addition to ecological ones.

Changes in the proportions of species due to climate change will probably be negative for most Finnish fishermen, because valued species such as salmonoids will decline, and species of a lesser value such as cyprinids will become more abundant. As the catch proportions of pike, pike-perch and perch increase, the significance of salmonoids may decrease in the domain of fishing water services. On the other hand, the value of pike-perch may increase within occupational fishing, for example, because it will benefit from climate change, and fishermen will receive the best price per weight for it. The demand for pike-perch is already high, and annual imports from Estonia to Finland are approximately equal to the catch of Finnish professional fishing. An increase in temperature may be beneficial to pike-perch in rich coastal waters, for example, but in order to gain any potential benefit, fishing must be carried out under reasonable regulations.

Shortening of the ice-winter and thinning of ice will be favourable for trawling, which is the most important mode of catching fish in Finland, but in connection with wintertime seine fishing of vendace, the changes would probably be regarded disadvantageous.

As the species and their spawning times change, the modes, locations and times of fishing will also change. The significance of old fishing knowledge will also diminish. Good fishing grounds and old catching methods will also lose their significance, so the need to develop new methods will constantly increase. With regard to recreational fishing, the possibilities of lure fishing will improve, and ice-fishing will decline. Adaptation to this will not necessarily be too difficult, because the nature of recreational fishing is also changing. This is reflected, among other things, in the decline of net fishing and the increased use of rod fishing equipment. It is probable that the impacts of changes in fish populations will have fairly minor impacts on recreational fishing. Expectations can be quite flexible when taking into account that the changes will be slow and that in this case fishing is a leisure-time activity. Adaptation will be easier because recreational fishing is quite rapidly developing and changing. New modes of catching come into fashion all the time (today's trolling trend, for example). On the other hand, the commercialisation of the hobby and aspects related to the protection of animals may significantly affect the nature of recreational fishing in the future.

Increased winter temperatures can be a particular benefit for fish farming facilities. Increased precipitation may also benefit fish farming, as the water will be sufficient to cultivate a larger number of fish. This requires that increased evaporation will not significantly reduce runoff. The impacts of increased summer temperatures will essentially depend on the availability of cold groundwater at the facility. The increased risk of diseases may worsen the situation at fish farming facilities. Good adaptive capacity will require the development of cultivation techniques and equipment with climate change in mind. Adaptation may be easier at facilities using new cultivation techniques, such as closed-circulation facilities, because almost all of the cultivation conditions, including water temperature, can be regulated.

Possible measures

In order to improve the adaptive capacity of fish stocks and the fisheries sector, the impacts of other human activity that burden fish populations should be mitigated. This includes eutrophication and pollution of waters, fishing pressure on threatened stocks, as well as other deterioration of habitats. Harmful impacts can be mitigated by fishing. Utilisation of the increased fish-producing capacity of fishing waters and diversification of recovery will require the development of new ways to use fish species and the reintroduction of old methods. It is also important to preserve genetic diversity. These actions will benefit fishery resources regardless of climate change.

It is also very important to find out where changes are taking place, so that these issues can be taken into account when actions to regulate fishing are being planned and implemented. For example, in addition to planting activities that seek financial benefit, it may be necessary, following climate changes, to let existing populations change in different lakes without altering the state of the water systems and fish populations by planting. Research information will be required in order to find out which species will need increased protection and how the change will influence the fishing culture. Existing law provides the opportunity to respond to the necessary actions by legislative means.

The lack of natural dispersion opportunities in inland waters is a problem in places. With regard to common economically valuable species such as pike-perch, planting that is constantly underway will ensure that populations spread to the north as conditions improve. It could also be possible to transfer pike-perch farther north.

The regulation of waters could be used to maintain a certain water level to ensure the success of salmonoid spawning and, on the other hand, diversion at power plants could be increased in order to increase runoff. Buffer zones around arable lands reduce the leaching of solid matter and nutrients, provide protection and nutriment for aquatic animals and prevent excessive aquatic vegetation and increases in temperature.

Fish farming is a quite highly regulated activity, so there are no significant possibilities to change the location of a facility. When new fish farming facilities are established, the location can of course be considered also from the viewpoint of climate change. In order to make Finnish fish farming able to adapt to the impacts of climate change, carefully planned adaptation measures will be required. These could include improved oxygenation of water and securing the supply of sufficiently cool water. One of the adaptation measures to be carried out at fish farming facilities would be the coordination of temperature rhythms important to the life cycle of fish to correspond to natural rhythms. In net bags, for example, the temperature conditions for fish can be influenced to some extent by means such as bag depth and flow generators. If the facility takes its water from the hypolimnion, problems may arise with regard to oxygen concentration in the water, because warm water or water taken from near the bottom will not necessarily have enough oxygen. However, almost all fish farming facilities that use the hypolimnion oxygenate their water. It may also be necessary to increase purification of the discharge water from fish farming facilities, because during the warm season an increased amount of feed and excrement will accumulate in the water. The connections between sediment composition, fish mortality and temperature have not been studied, but several means of removing the sediment accumulating at the bottom of net pools have been developed.

Research on adaptation

Water ecosystems are very complex. More research is needed on the processes that regulate our fish stocks, their use and abundance, as well as their reactions to climate change both in nature and in fish farming. The efficiency of monitoring the state of fish stocks could be improved through cooperation between different parties. For example, research information is required on the relationships between aquatic habitats and fish populations, as well as the relationships between climatic variables and aquatic habitats. Even though the functionality of inland water ecosystems is better known than that of sea ecosystems, uncertainties still exist in research information. Methods of improving the fishing industry's adaptive capacity and providing opportunities to respond to climate change should also be studied. The adaptation of aquaculture to climate change should be studied as well. Monitoring the social and economic development of the production sector should be continued. The impact of catchment areas on water systems is increasing, and in order to improve the efficiency of measures preventing scattered loads, research on the means to prevent water eutrophication due to additional nutrients used in agriculture and horticulture should be increased.

*Table 4.4. Summary of indicative adaptation measures to climate change in fisheries and preliminary timing: *Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080.*

		Anticipatory	Reactive
Public	Administration and planning	• Improvement of monitoring in order to assess the state of fish stocks, and development of cooperation between different parties* • Prevention of water pollution, fishing pressure and the deterioration of fish habitats*	
	Research and information	• Assessment of the ability of different species and age groups to adapt to the impacts of climate change* • Investigation of interdependencies between species and ecosystems* • Monitoring the development of the sector*	
	Normative framework	• Consideration of the locations of new fish farming facilities with regard to climate change*	
Private		• Regulation of waters and diversion at power plants* • Increasing buffer zones around small waters* • Coordination of the temperature cycles important to the life cycle of fish at fish farming facilities to match natural cycles* • Investments in aeration and oxygenation equipment at fish farming facilities*	• Change in fishing practices (for example, partial replacement of ice-fishing with open water fishing)*** • Increased purification of discharge water from fish farming facilities in order to reduce feed and excrement*

4.1.1.4. Reindeer husbandry

The impacts of climate change on reindeer husbandry seem to be mostly negative, but other factors, such as those related to production and economy, play a significantly larger role than climate change with regard to the sector's ability to adapt to various changes. Despite this, the introduction of climate change adaptation measures will benefit the sector as a whole. In the adaptation of reindeer husbandry, the combined impacts of all factors relating to pastures and their usability are very significant. These factors include climate change with weather variations and changes caused by other land use, as well as changes caused by reindeer husbandry itself, such as the deterioration of pastures. Another aspect is the adaptation of reindeer herding to changes; this can be affected by reindeer husbandry itself, its administration and steering, as well as the strategies of practising different forms of land use.

Adaptive capacity of actors

The greatest challenges for adaptation in Arctic ecosystems are associated with culturally important natural resources such as reindeer. Controlled reindeer herding and utilisation may reduce the impacts of climate change on the local population. The vulnerability of reindeer husbandry is associated with the fact that those engaged in reindeer herding are often heavily dependent on a single natural resource or a small number of them. This means that a sudden extreme phenomenon may cause substantial losses to the private and regional economy. The adverse changes caused by climate change – and other land use – on pastures will probably increase the costs of reindeer herding if there is a need to improve the efficiency of feeding or other actions associated with reindeer herding.

The most significant adaptation measures are associated with increasing economic diversity, mitigating the adverse impacts of changes in land use, and continuous development of reindeer herding methods. Anticipation of the impacts of climate change will facilitate the planning of adaptation measures. Due to changed reindeer herding methods, the present reindeer population has been relatively well-protected against difficult snow and weather conditions since the 1990s. Calf slaughtering, additional feeding and medication against parasites have made it possible to maintain relatively high numbers of living reindeer despite the fact that winter pasture resources have been insufficient.

Possible measures

It would be easier to prepare advance adaptation measures regarding the movement of reindeer and their acquisition of food in adverse weather conditions if there were more information available on the regional impacts of weather conditions.

If the snow conditions are difficult or lichen deposits are in poor condition, additional feeding can replace the amount of nutrition that the reindeer need but cannot get from nature. Feeding can be implemented by taking additional nutrition to the herds or by keeping the reindeer in pens during the winter. Additional feeding may encourage reindeer to move to areas where they can live with the support of additional feeding. The advantages of feeding include the fact that it reduces the dependence on winter pastures and natural conditions, improves productivity and stabilises operations. Even though winter feeding generally promotes the health of reindeer stock, poor feeding may also impair health. The risk of communicable diseases must be taken into account when arranging additional feeding. In this respect, distributed feeding in the wild is probably a better alternative compared to farmyard feeding, but it is more expensive and difficult to implement due to the need for all-terrain vehicles.

Maintaining the production capacity of pastures is a basic requirement for sustainable reindeer herding. Pasture deterioration can be reduced by pasture rotation arrangements, and reductions in maximum numbers of reindeer for each herding cooperative allow the populations to be adjusted so that winter pastures can sustain them. However, it has become quite difficult to prescribe maximum numbers of reindeer that would be sustainable in terms of winter pastures because, in addition to reindeer herding, many other forms of land use change the state of the pastures. Changes in forests may have a decisive impact on the pasture situation. Forestry planning systems can be developed further so that reindeer herding aspects will be taken into account more than at present. For example, if it is impossible to leave important horsehair lichen pastures outside the scope of felling, means for making the lichen move early from older tree stock to trees in the seedling phase could be considered. Such means could include, for example, altering the methods of managing horsehair lichen pastures, or regulating the size and shape of felling areas. In terms of forest management, thinning of seedling stands and young forests, as well as the development of the recovery of felling and thinning waste would improve the state and usability of reindeer pastures. Reindeer herding methods (winter tending, feeding in the wilderness) may also be used to adapt to changes in pastures caused by forest management.

A balanced relationship between reindeer pastures and reindeer numbers is an essential factor for the trade. The impacts of the actions taken to revive reindeer pastures can be monitored by regular assessment, and if lichen pastures are found to be deteriorated, the number of reindeer will be reduced, taking into account the economic and social issues caused by this. A sharp drop in the numbers of reindeer could mean that many reindeer owners would have to give up the trade as unprofitable.

Climate change is expected to increase the dryness of lichen pastures, which will result in a higher risk of large fires. In order to improve the early detection and extinguishing of forest fires and wildfires, the present air supervision scheme and forest fire warning systems should be developed further.

Research on adaptation

The greatest questions of reindeer husbandry related to climate change are: will reindeer pastures recover sufficiently, will feeding costs continue to increase, and will reindeer husbandry be able to provide a sufficient level of income for reindeer herders in changing circumstances? An extensive and important issue is to find out how the different factors – climate change, different forms of land use and reindeer husbandry itself – have changed and are changing the state and availability of pastures, and what is the role of each factor in the total change.

A longer time series of the thickness and hardness of snow cover will also be required in order to reliably compare the variations in snowiness and calf percentage. The impacts of the cyclic changes in the west-east flow caused by North Atlantic Oscillation (NAO) on reindeer herding have so far only been studied in the one reindeer herding cooperative, so research results have not yet reached a level that would allow any further conclusions. However, the NAO phenomenon is a subject of active research, so more information will probably be available in the future. Studies investigating long-term changes experienced in the state of pastures must continue. This would naturally be associated with a study of the adaptation of warm-blooded animals such as reindeer to a warmer and more humid winter, as well as a study on the ecophysiological impacts of environmental changes on plants and soil, particularly on horsehair lichen, mosses and lichen in northern regions. The impacts of the actions taken to revive reindeer pastures should be monitored by regular assessment. Among other things, the Reindeer Husbandry in a Changing Environment project of the Finnish Forest Research Institute (2002–2006) studies long-term changes experienced in the state of pastures, as well as the impact of climatic factors on reindeer herding, the concept of sustainability and the adaptive capacity of reindeer herding. Furthermore, it must be investigated how felling practices should be chosen to preserve the sources of winter food for reindeer, such as horsehair lichen, in forests from one generation of trees to the next.

***Table 4.5**. Summary of indicative adaptation measures to climate change in reindeer husbandry and preliminary timing: *Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080.*

		Anticipatory	Reactive
Public	Administration and planning	• Coordinating the interests of reindeer husbandry and forestry* • Development of aerial supervision in order to reduce the risk of large fires* • Comprehensive planning of different forms of land use through the development of planning systems*	
	Research and information	• Studying the long-term changes experienced in the state of pastures and the impacts of climatic factors** • Providing information on the most critical pasture areas* • Study on the adaptation of reindeer to climate change** • Study on the ecophysiological impacts of environmental changes on plants and soil, particularly on horsehair lichen, mosses and lichen in northern regions** • Development of planning systems for different forms of land use**	
	Economic-technical measures	• Separation of winter and summer pastures by fences*	
	Normative measures	• Prescription on the maximum number of reindeer**	
Private		• Development of pasture rotation systems (including rotation fences)*	• Arrangement of additional feeding**

4.1.1.5. Game management

Adaptive capacity of actors

Climate change is expected to cause variations in the abundance of species. For example, because of the smaller variation in the vole populations, predators will not need to resort to alternative prey as often as previously. This might lead to increases in grouse populations due to decreased predator pressure. The spread of species that are currently only found in certain parts of the country would probably be considered positive. An example of this would be the spread of roe deer from Southern and Western Finland into other parts of the country. Hunters would probably be satisfied with the stabilising of small game stocks, but it is difficult to predict the level at which game stocks would settle. On the other hand, it is easy to adapt to the change by adjusting closed seasons, protection decisions and regulating hunting. The age structure of hunters may also influence the willingness to adapt. The ageing of the members of hunting clubs seems to continue also into the future and it may affect the success of moose hunting, because the number of active members in moose-hunting parties has diminished and moose hunting has been experienced as physically too demanding. Difficulty in regulating the growth of moose stocks may indeed become a problem when the climate changes if the targeted numbers of kills are no longer achieved. Forest owners, in turn, might be compelled to compromise over the most advantageous alternatives both in the proportions of tree species and in the growing of high-quality wood because of moose. This might lead to considerable losses for wood production.

Ability of game to adapt to climate change

The adaptive capacity of animals has clear genetic limits. If a change takes place too fast, not all animals will be able to adapt themselves. Adaptation will probably become more difficult for animals as extreme climatic events become more common and unpredictable. For these animals there will be three alternatives: (1) their distributions change, (2) they disappear from Finland, or (3) they develop within the limits allowed by their genes. The first and last alternatives can of course take place simultaneously. It is difficult to predict, for example, how rapidly grouse will change their genetically-based behaviour patterns once snow and snow burrows no longer offer protection. In the previous decades, the capercaillie of Northern Finland has adapted itself to spending nights in a snow burrow. The capercaillie of Southern Finland does not always have this possibility, so it spends winter nights under the branches of spruce trees. The capercaillie can be expected to adapt itself to the changing snow and weather conditions in accordance with these behavioural characteristics. The species which will suffer from a shortened snow season include at least the willow grouse, because its white protective colouring will become a drawback during the transitional season.

Possible measures

Increases in precipitation and snow masses in Northern Finland may result in difficult snow conditions for game animals and, for example, moose may cause more forest damage in winter pasture areas. Systematic hunting remains a central control method in order to contain the damage caused by the populations to agriculture, forestry and traffic. Damage caused by moose can also be reduced by means of game management methods, such as the correct placement of mineral stones and the use of game fences, repellents and mechanical treetop protectors. Moose can be directed away from pine and birch seedling stands by preserving willow thickets and establishing game fields. If the risk of moose damage is considerable, one alternative could also be to leave somewhat denser seedling stands. By surveying the winter habitats of moose and combining different levels of geographical information, areas susceptible to moose damage could be predicted, and potential regional damage could be prevented in advance by forest planning and game management methods. The increase of roe deer should also be kept in control by means of population management, in practice by hunting and preventive measures (fenced areas, deterrents, support feeding) so that the damage caused by roe deer to plantations and forestry would remain moderate.

Regardless of whether the changes in the populations are caused by natural variation or climate change, hunting policy has several means for regulating game stocks on quite a rapid schedule. Methods of hunting legislation, such as the regulation of hunting seasons, hunting practices and protection decisions provide the opportunity to keep game stocks at a sustainable level. For example, if a game species is threatened by extinction, the extreme method is to protect the species by law. This was done in the 1940s to prevent the extinction of the Arctic fox. It would also be possible to accommodate the impacts of climate change and adaptation measures with the stock management plans.

Species of foreign origin, such as the raccoon dog and mink, can have a substantial impact on bird stocks. The intensified hunting of small predators may have positive impacts on the development of bird stocks. To prevent the growth of small predator populations, a national small predator campaign similar to that coordinated by the Hunters' Central Organisation in 2001–2002 could be organised.

Even if grouse adapted themselves to climate change and present kind of forest management, efforts could still be made to manage grouse stocks so that forests would be managed in favour of the birds' living conditions.

Research on adaptation

Game inventory surveys and research play an important role in ensuring the correct method of adaptation to changes in game stocks. The diversity of game species can be monitored by triangular surveys, for example, and measured by the game richness index. Annual survey results can be used to determine hunting and protection decisions concerning grouse, among other things. Hunting clubs can also regulate their hunting on the basis of information obtained from game triangles and other game assessments. The game richness index can be used to estimate if game stocks and hunting are based on sustainable foundations. Perhaps the most important use of the game richness index in the future will be its function as a kind of alarm bell. If there is a sudden substantial drop in the index in some region, the matter must be investigated and corrective actions must be considered. The survey could also take the impact of climate change on the region's index into consideration.

Figure 4.6 *Summary of indicative adaptation measures to climate change in game management and preliminary timing: *Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080.*

		Anticipatory	Reactive
Public	Administration and planning	• Preparation of management plans for game stocks* • Guidelines for forest management and care should recommend that the living conditions of grouse be taken into account*	
	Research and information	• Development of game management methods – that is, measures directed at the habitats of game* • Continuing development of the game richness index, triangular game surveys and other methods of stock assessment* • Information about hunting and protection decisions* • Study of the response and adaptation of game species to climate change*	
	Economic-technical measures	• Development of game management methods, as well as methods and equipment intended to prevent damage, and support for their use* • Prevention of forest damage, agricultural damage and road accidents using suitable means (such as fences, mineral stones, repellents)*	
	Normative framework	• Legislative regulation of game stocks (hunting and protection decisions)***	
Private		• Construction of game fences, use of repellents, restriction of stock by hunting or expansion of stock by restricting hunting* • The living conditions of game should be favoured in forest management* • The growth of small predator populations should be controlled by hunting*	• Regulation of hunting in accordance with game stocks (hunting clubs, hunters)*

4.1.1.6. Water resources

Adaptive capacity of actors

Annual variations in water resources and regular flood and drought seasons of varying magnitudes have offered those dealing with water resources the opportunity to learn to prepare for different kinds of weather variations and, thus, for problems created by climate change. The most important parties engaged in water resource tasks are the regional environment centres that are responsible for the use and care of water resources in their own territories. Particularly the environment centres located in Western and Northern Finland, in whose area floods occur regularly every year, possess the know-how and professional skill associated with preparing for floods, flood protection and operational flood prevention. Good cooperation with rescue services is important for flood prevention.

Finland is relatively well prepared for floods. For example, the most significant agricultural regions, such as the region of the River Kyrönjoki, are protected against flooding up to certain limits. However, climate change may cause unpredictability. In the flood areas of Ostrobothnia, for example, people have known for decades how to prepare for spring floods because the annual rhythm of floods is fairly regular. Preparation for major floods at other times, for example in the winter, is still challenging because it is difficult to predict situations of this kind. Prediction is easier in lake districts, for example in Saimaa and Päijänne, where flood waters move more slowly down the lake routes and where there is enough time to make room for floods caused by the melting of snow in particular. The prediction of floods caused by the melting of snow and their consequences is also usually possible in Lapland. Preparing for floods caused by heavy rains is the most difficult task.

The task force on extreme floods that submitted its work to the Ministry of Agriculture and Forestry in 2003 has also considered flood problems caused by climate change. Carrying out the 12-year action programme proposed by the team will significantly reduce flood risks and improve flood prevention. The direct costs of the action programme will be about six million euros during the next 12 years. The implementation of proposals for action and tasks will require the contribution of approximately one hundred man-years of work by permanent staff in environmental administration alone. The implementation of the action programme is in progress.

The task force has identified 65 of the most significant targets of flood damage where the possibilities to reduce flood damage have to be surveyed. According to the task force's proposal, general plans will be drawn up for the regions to limit damage. Flood maps will also be required for flood damage targets in order to improve the planning of land use, operational flood prevention and rescue operations. They will also serve as an important means of information. The impacts of climate change are being directly studied by, among others, the Finnish Environment Institute by modelling changes in the design inflows of dams.

The quality of household water is usually high in Finland and the purification of wastewater is efficient. The organisation of water services is directed by water services development plans drawn up by municipalities in cooperation with the region's water supply plants. The utility companies are responsible for organising water services, and there are a lot of differences in their preparedness for various exceptional situations. Generally speaking, larger utility companies have more know-how and financial resources to prepare for exceptional situations. Exceptional situations like floods and drought cause the greatest problems for small waterworks that usually use ground water and do not necessarily have disinfection facilities, for example. On the other hand, it is easier to arrange an alternative water supply and sanitation in limited areas than in large population centres. Regional cooperation and reserve water systems have been promoted through Government support. This is important for avoiding problems in water services caused by drought and floods. The Ministry of Agriculture and Forestry has appointed a task force on preparedness to exceptional situations in water services, whose work is currently in progress. The group will issue proposals for action in 2005 in order to improve preparation for special water services situations.

One of the challenges brought about by the ageing staff is how to maintain the competence of those working with water resources in the future, both in public administration and at water supply plants. Problems can be avoided by sufficient basic and advanced training in the sector, by the transfer of know-how through mentoring, and by procedural development.

Private citizens can try to prevent flood damage by monitoring flood warnings and following the instructions from the authorities given in connection with them, such as protecting properties with sand bags, sealing doors, blocking sewers and underdrains, moving valuable items to a safe location, etc. A traditional way of preparing for unexpected catastrophes has been to take out insurance. However, real estate insurance or home insurance policies do not generally cover damage caused by the flooding of water systems; only damage caused by heavy rain is covered in some cases. There are some insurance products on the market that will compensate for damage comparable to that caused by climate change in certain situations specified in their terms and conditions. In addition to this, the Government has created various schemes to compensate for damage caused by exceptional weather either in part or within the framework of available appropriations. Flood compensation can be paid for damage caused by extraordinary flooding of water systems and for costs arising from the prevention of damage using an annual appropriation in the State budget. Damage caused by flood to growing crops can be compensated for on the basis of the Crop Damage Act.

Drought causes more problems for households which depend on their own wells than those within the scope of water supply and sewage networks. Therefore, the best method to avoid running out of water is to join a network, if possible. It is particularly important for major consumers of water, such as cattle farms, to secure sufficient water supplies of a high standard. If a site depends on its own well, the location of the well must be chosen with great care. This is important in order to prevent running out of water due to drought as well as to preventing pollution caused by flood waters. Many well problems can be avoided with sufficient maintenance and renovations of wells when necessary. If, however, water diminishes substantially or runs out or becomes contaminated due to flood, the only options are to resort to water transportation and saving water. Floods can also cause problems for site-specific wastewater purification.

Possible measures

Problems caused by flood and drought seasons to water services can be reduced by using reserve water intake plants and interconnection lines between water supply plants. The Ministry of Agriculture and Forestry and the regional environment centres aim to direct State subsidies towards investments that improve preparation for special water services situations and boost regional cooperation. Municipal and regional planning is an important method of developing water services, including preparedness for exceptional situations. Furthermore, water services should be taken into consideration in the emergency preparedness plans of municipalities. The networks of water supply plants usually suffer less from drought compared to site-specific water services, so problems affecting the population can be reduced by extending the water supply and sewerage networks.

Drought can cause a need for increased irrigation on the one hand and saving water on the other. It is important to develop irrigation systems that save water, for example drip irrigation. Construction of irrigation systems will cause costs to farmers, even though it is possible to receive investment subsidies for the acquisition of fixed irrigators for horticultural production (such as drip irrigators). As a consequence of the development of water fittings, among other things, water use in Finnish households is fairly efficient today, so any major measures to improve the efficiency will hardly be needed. In an extreme situation of water shortage, it would be necessary to recycle water and use lower-standard water for washing, flushing toilets and as drinking water for cattle and domestic animals. However, problems would be local because on average in Finland only 2.2 per cent of the total runoff of water is used each year. The quality requirements for water at cattle farms and dairy farms should be surveyed. It is also important to develop dry toilet systems.

The consideration of floods caused by heavy rain is a great challenge in zoning and urban planning. From the point of view of municipal building regulations, it is important to know the flood risks. The means include surveying the routes of flood waters, proper design of stormwater drains, giving preference to permeable surfaces in construction, and the planning of basement rooms. More research on the impacts of rain-induced floods and changes in the intensity of rain will also be needed. Regional planning should examine the water services of densely populated areas as a whole from town planning all the way to detailed methods of rain water treatment. Unbuilt flood areas, delay basins, impregnation areas and wetlands for the treatment of stormwater should be planned and utilised in the prevention of floods caused by heavy rains.

The reduction of flood risks, and the avoidance of construction in flood risk areas in particular, can be influenced by land use planning. Land use planning and concentrating construction outside flood risk areas are the cheapest ways to avoid flood damage. In areas with existing building stock, flood prevention will be more challenging and it will be more difficult to find suitable methods. In locations where construction or other land use in flood areas cannot be avoided, structures have to be protected. Flood risks and risks imposed on water services by drought, for example, must be taken into consideration in town planning and when granting individual building permits. Municipalities are in the key position in this respect. More attention than before should be paid to the technical systems of communities and to the preparation for risks. It is important to plan and agree beforehand how authorities and other parties will operate, how the population will be informed and how property damage can be restricted as effectively as possible. It is difficult to prepare for town floods caused by heavy rains, but the means for the prevention of associated damage do exist. In the future, there might be a need to provide a guide for building owners and maintenance companies regarding the actions that should be taken in preparation. Advance planning of functional cooperation between rescue and water services authorities and the restriction of damage is essential. To develop methods of action, it is important to conduct a post-event assessment similar to that carried out after the town flood caused by heavy rain that occurred in the summer of 2003 in Vaasa. Such a study can provide useful information both at the national and local levels when preparing for future floods. It is also important to prepare safety plans and, if necessary, risk assessments of dams taking the occurrence of extreme floods into consideration. Plans and regular drills are needed to secure flood prevention and rescue operations.

The surveying of risk sites suffering from floods, as well as general plans for risk sites proposed by the task force on extreme floods, are important planning methods for reducing the flood risks of the existing functions. Alternatives for suitable flood protection structures, temporary flood control structures, changes in regulation practices, etc. should be separately considered for each risk site. The impacts of climate change should be taken into consideration in the general plans. The fact that climate change may result in increased flooding and increase the risk of extreme floods can lead to the further requirements for flood protection for settlements and risk sites, and it may also be necessary to change the design of existing flood protection structures and, for example, construct higher banks. Ice jam flooding can be prevented in advance by sawing the ice in quiet waters in the spring. This work will, however, lead to costs to municipalities, operators and the Government. If alterations are required in the structures of dams, as a consequence of changes in design runoffs, this will mean costs to the dam owners, hydropower companies and the Government. Changes in the timing of floods and runoffs in general could require changes in regulation permits. Research work is required in order to survey the need for temporary flood protection structures, such as various types of flood walls that can be erected quickly, acquire them and determine the responsibilities related to their use. In order to predict the magnitude and timing of the flood peak as correctly as possible, precise weather forecasts, sufficient real-time observation of rain (weather radar), temperature, water levels, snow and soil dampness (satellites), as well as rapid data connections from observation points and water system models correctly calibrated for the flood situation are needed.

*Table 4.7. Summary of indicative adaptation measures to climate change in the use and management of water resources and preliminary timing: *Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080.*

		Anticipatory	Reactive
Public	Administration and planning	• Planning of water services* • Surveying of risk sites and preparation of general plans for risk sites* • Acquisition of temporary flood control structures* • Emergency preparedness planning* • Land use planning to reduce flood risks and especially to avoid construction in flood areas* • Taking rain-induced floods into account in zoning and urban planning* • Flood forecasts • Planning of trenching and stormwater services	• Operational flood prevention • Cooperation between authorities
	Research and information	• Surveying the quality requirements for water at cattle farms and dairy farms* • Improvement in the predictability of floods (heavy rains): weather forecasts, weather radar, follow-up of soil dampness and snow/ satellites and observation • Studying the impacts of rain-induced floods* • Surveying the need for temporary flood protection structures, their acquisition and the responsibilities associated with their use* • Information about flood hazards	• Information in flood and drought situations • Instructions from the authorities to reduce flood damage • Restrictions on water use
	Economic-technical measures	• Raising of flood banks • Construction of reserve water intake plants* • Interconnection of the networks of water supply plants* • Investments in projects that improve preparation for exceptional situations and regional cooperation* • Expansion of water supply and sewerage networks* • Supporting the construction of irrigation systems for agriculture*	• Compensation for damage caused by exceptional flooding of water systems • Use of temporary flood protection structures • Use of reserve systems at water supply plants, disinfection • Transportation of water, water pickup points, bottling of water • Purchasing water from another water services company • Distribution of lower-quality water
	Normative framework	• Changes to regulation permits	• Implementation of building regulations • Changes to regulation permits
Private		• Taking out insurance* • Construction of properties farther away from flood areas* • Construction of irrigation systems* • Joining the network of a water services company / choosing the location for a well and maintaining its condition	• Protection of properties against flood • Saving and recycling water, use of lower-quality water • Increasing the discharge capacity of dams

4.1.2. Biodiversity

The biodiversity and functioning of ecosystems and the abundance of species have great economic and social significance and value for humans. Every species has its own value, which means that the extinction of a species with specific evolutionary history due to human activity is an irreplaceable loss. Therefore, it is important to try and mitigate the adverse impacts of climate change by all available means and increase the adaptive capacity.

The capacity of species and habitat types to adapt to climate change

Northern ecosystems are less rich in terms of their biodiversity and number of species compared to many more southern areas. Their adaptive capacity is poorer and their structure and biodiversity is simpler, so their buffer capacity is lower than that of southern ecosystems with a multitude of species. The severe climate also affects their adaptive capacity and they are vulnerable to the irregular variations of natural events and to changes in species. Climate change can cause irreversible damage to some ecosystems and habitats (for example, arctic habitats and mountain habitats, partly also boreal mires and forests).

Some species can move spontaneously, but some species have a poor migratory ability. The time span varies from years to at the least decades for such species, and even then it can be difficult for them to find a suitable habitat. Birds, however, are an example of a group of species that is able to rapidly migrate to more favourable areas.

Possible measures

The adaptive capacity to climate change in Finland can be estimated, for example, on the basis of biogeographical zones, because the impacts of climate change vary in different parts of the country. It is, however, probably impossible to influence some of the changes. It is predicted that considerable pressure for change will be caused to certain biogeographical zones, such as the alpine zone (which approximately corresponds to the northern boreal forest vegetation zone). In Finland, a large part of this zone is included in different protected areas, where it should be possible to control land use efficiently to reduce the human-induced stress and thus promote the conservation of alpine habitat types and the habitats of species. In some cases, climate change can lead to the loss of the natural values for which the protected areas of the zone in question had originally been established. Most of the "spatial resources" offered by the protected areas in the boreal zone are in the eastern parts of the Finland, so the possibilities for species to adapt/move exist. In southern parts of the country, the possibilities for the protected areas to provide species with opportunities for adaptation/transition are restricted. If climate change proceeds rapidly and intensely, the possibilities for adaptation within the Finnish borders, especially in the alpine zone, will probably weaken, which would call for a more extensive international evaluation and development of the network of protected areas, for example, within the Barents cooperation, as well as monitoring of the impacts of climate change on biodiversity.

The capacity of ecosystems and biotic communities to adapt to climate change can be promoted by maintaining and restoring traditional farmland habitats and by promoting the ability of ecosystems to function sustainably in accordance with their own regularities. The reduction of other adverse factors caused by human activity in the short term is also necessary for improving adaptation to climate change.

Sufficient networks of protected areas that are representative in terms of conservation biology, with ecological interconnections and protection zones, will support the maintenance of biodiversity and provide plants and animals with channels for spreading and migration. They also increase the probability that genetic biodiversity will be maintained and spread to habitats that have become more viable for some species owing to actions intended to restore the natural state. In parts of the country, the network of protected areas will secure possibilities for movement or migration at least for some species. If necessary, it is possible to change the measures regarding the management and use of protected areas in order to adapt to the impacts of climate change. Commercial forests also maintain biodiversity and serve as migration channels. However, more research on the mutual relations of species, changes in these, and the tolerance of different species against global warming is still needed.

Even though protected areas lay the foundation for the protection of the forest biodiversity, biodiversity must also be protected in managed commercial forests. This can be done by taking account of the habitats of special importance as referred to in the Forest Act as well as other valuable habitats of commercial forests, such as biotopes protected by the Nature Conservation Act, and other valuable habitats that should be conserved in the management and use of forests.

With regard to water habitats, special attention must be paid to the species of cold and clean waters. The Natura 2000 network and the Water Framework Directive will probably secure the survival of at least some of the species in these waters if warming is not very strong.

Planning of the management and use of protected areas as well as the protection of threatened species and the management of habitats will require a great deal of cooperation between administration and other stakeholders, as well as the provision of guidance and information during the next few years. In a similar manner, securing the diversity of commercial forests, for example, with regard to habitats of special importance as referred to in the Forest Act will require information and advice for forest owners and training for forest professionals. The agri-environmental support scheme can be used to reduce the environmental pollution load on the environment and atmosphere and to manage the biodiversity of agricultural areas. It is possible to retain valuable traditional farmland biotopes, their habitat types and species with the help of special subsidies.

Nature conservation actions already completed or planned for the next few years in Finland create a solid basis for the adaptation to the pressures for change imposed on nature by climate change. However, no significant changes to legislation required due to the effects of climate change are visible at the moment. Several planning and development projects for promoting diversity are underway. These should include the evaluation of the impacts of climate change, and consideration of the adaptation needs and potential methods should be initiated.

Adaptation is also promoted by preventing and controlling the spread of invasive alien species. A more extensive evaluation is also needed with regard to the extent that the protection of biodiversity can be promoted outside their natural habitat (*ex situ* protection). Reproduction in a zoo or similar facility and the planting of individuals in a restored habitat might be necessary for preventing the extinction of some species.

The maintenance of the ability of ecosystems to function and recover and the management and restoration of habitats valuable to biodiversity, in addition to a sufficient network of protected areas, lay the foundation for the conservation of Finland's natural species and for the adaptation to climate change. The establishment of new nature reserves and supplementing the network of protected areas where it is clearly insufficient in the light of the impacts of climate change may require further evaluation and sufficient anticipation.

Research on adaptation

At present there is not yet enough information on the adaptive capacity of ecosystems, flora and fauna expressing biodiversity with regard to climate change. In the light of present knowledge, the following points call for attention:

- Evaluation of the integrity and connections of Finland's network of protected areas in the core areas of boreal species near the Finnish-Russian border, as well as in the watershed Suomenselkä and a number of places elsewhere in Southern and Central Finland. Discovering the possibilities to reduce the pressures for change in the ecosystems of mountain areas.
- Studying the preconditions for the protection and management of water systems and their catchment areas so that deterioration in the quality of water can be prevented and the living conditions and opportunities for certain cold water species can be improved.
- Reconstructing and restoring wetlands and mires to reduce the pressures for change in the water economy of catchment areas and to ensure that they function as naturally as possible, while studying the potential drawbacks caused by such measures.
- Matters related to the conservation of semi-cultural biotopes and traditional farmland biotopes of the agricultural environment.
- Further studies on the threatening factors imposed by climate change on Finland's nature at the general level of ecosystems and species for making decision on further development projects to most efficiently promote the adaptation to climate change and to support the sustainability of the original ecosystems of Finland's nature, as well as the conservation of species and their transition to suitable new areas.
- The improvement of monitoring, planning and information systems regarding biodiversity for studying the overall impacts of climate change and the means of adaptation is a crucial development task for the next few years, which will provide answers to the question of what kind of additional measures will be needed in besides the above.

The framework of the national monitoring of biodiversity will be built on the general follow-ups already carried out mostly at the habitat level, as well as supplementary special follow-ups at the species level.

The implementation of the EU Natura 2000 network, particularly the Council Directive on the conservation of natural habitats and of wild fauna and flora (the so-called Habitats Directive and its Article II) requires that Member States must, among other things, monitor the protection level of the habitats listed in Annex I and the species listed in Annexes II, IV and V, which the Community regards important, with particular attention paid to protected habitats and species. Furthermore, the directive on the conservation of wild birds imposes certain obligations on monitoring and reporting. The planning and implementation of the classification of surface waters, evaluation of their ecological state and monitoring in accordance with the EU Water Policy Framework Directive must also pay attention to the monitoring obligations regarding habitats and species in inland waters and coastal waters imposed by the Habitats Directive.

The parties mainly responsible for the implementation of biodiversity monitoring and recording of data are the Finnish Environment Institute, Metsähallitus (a State enterprise administrating State forests) and the regional environment centres. In order to implement the monitoring, recording and processing of data, a comprehensive and efficient nature conservation information system is being developed. The part concerning species is already in use, and the aim is to introduce an information system related to conservation areas by 2006.

***Table 4.8.** Summary of the measures aimed at the protection of biodiversity associated with the impacts of climate change and adaptation and preliminary timing: *Immediate: 2005–2010, **short-term: 2010 –2030, ***long-term: 2030–2080.*

		Anticipatory
Public	Administration and planning	• Reducing human-induced stress on nature by controlling land use* • Evaluation, development and monitoring of the extent of the network of protected areas * • Maintaining original habitats* • Changes in policy regarding the management and use of protected areas, when necessary* • Taking valuable habitats into consideration in the management and use of forests* • Conservation of valuable traditional farmland biotopes with the help of the agri-environmental support scheme* • Including an evaluation of the impacts of climate change in the ongoing planning and development projects for the promotion of biodiversity* • Introduction of an information system for protected areas*
	Research and information	• Increasing cooperation, information and consultation between the different administrative sectors* • Information for forest owners and training for forest professionals* • Improving the monitoring, planning and information systems for biodiversity* • Evaluation of the possibilities for ex situ protection with regard to climate change* • Studies of threatening factors caused by climate change at the ecosystem and species level • Carrying out general habitat-level follow-ups and supplementary species-level follow-ups
	Economic-technical measures	• Control and prevention of the spread of invasive alien species* • Restoration and management of valuable habitats* • Prevention of the extinction of species with the help of zoos and planting* • Reconstructing and restoring wetlands and mires*
Private		• Reducing the environmental pollution load on the environment and the atmosphere • Conservation of valuable traditional farmland biotopes* • Taking valuable habitats into consideration in the management and use of forests*

4.1.3. Industry

Adaptive capacity of actors

Industry operators and the business sector possess a good adaptive capacity and the necessary flexibility and preparedness to adapt themselves to changes caused by climate change. In the course of their normal operations, enterprises have to adapt themselves to different kinds of changes all the time – such as changes in demand, prices and the raw material sector. Industry and business operations rarely use the design time span of 50–70 years typical of climate change adaptation reviews, because it is usually regarded as far too long with regard to changes. The long-term plans of businesses usually cover 20–30 years at most, which is a typical repayment period for heavy infrastructure investments. Today's rapidly changing business environment seldom provides opportunities for any extensive study of the factors affecting it after 50–70 years. So, in the initial phase, it would be good for industrial and branch organisations to introduce long-term climate change adaptation reviews into their own programmes and conduct more detailed studies on the change situations in their respective fields and the preparations for these. In the long run, this could become part of the social and environmental reporting of businesses. Within certain limits, the National Emergency Supply Agency could probably also participate in preparatory actions arising from adaptation to climate change.

Possible measures

Forest industry

The forest industry can increase the use of domestic wood material to some extent. Changes would need to be introduced to the production structure on the basis of changes in wood material. However, imported wood already serves as a substantial buffer for flexibility (17 Mm^3 per year). The maintenance of the road network will also be a crucial challenge in order to make wood transportation smooth and preserve the reliability of raw material deliveries. Preparations for various international changes will also have to be made, even though this is nothing new for the Finnish wood processing industry, which has operated in the global market for a long time.

Food industry

The food industry will probably have to prepare to a growing extent for disturbances in the supply of raw material, and the maintenance of the road network for the transport of agricultural products will probably become a bigger challenge. On the other hand, the supply of some agricultural products could even increase due to climate change. There may be growing markets for food exports abroad, partly due to climate change.

Construction industry

Covered scaffoldings will probably be used more than before to improve occupational safety. This is mainly an extra cost from the point of view of the industry. More attention than before will be paid to materials, fastenings, service life and durability. Also, the protection of building materials and the development of working methods will receive more attention. Year-round construction may increase further.

Research on adaptation

In addition to market factors and the other socio-economic developments presented in Section 2.2, various types of technology leaps (biotechnology and the like) will probably have a significant impact on the structure of industry after 40–60 years and the types of industrial processes used at that time. Thus, there are no clear needs for adaptation research to be presented here. However, at least the costs and economic impacts of adaptation measures should be investigated further.

Now in the initial phase, the industrial and branch organisations especially, as well as possibly some big industry conglomerates, could invest in the specification of adaptation research needs in their sector. They could also make the adaptation considerations and associated functions a natural part of the normal monitoring and other methods used by the industry and the businesses in some time frame.

Table 4.9. Summary of indicative adaptation measures to climate change in industry.

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

4.1.4. Energy

Adaptive capacity of actors

Actors in the energy sector have traditionally shown good adaptive capacity to changes, especially in the long-term. In the energy sector, investments are often fairly large and economically burdensome. The repayment periods and service lives of basic investments in the sector may be fairly long. For example, the service life of hydroelectric power plants may well be 50 years, followed by 25–30 years for thermal power plants. Even small boiler plants typically last for 10–15 years. Power transmission grids are usually very long-lasting as well. This means that long-term planning as such belongs to the basic characteristics of the sector. The fairly heavy investment structure of the sector causes certain rigidity to the activities. The readiness of the actors in the sector to flexibly adapt themselves to market changes has increased during the last few years since the energy market has been gradually deregulated. On the other hand, market challenges have also increased, for example, in the form of price fluctuations, and issues such as greenhouse gas emissions trading will have a significant impact on the energy market in the coming years.

When responding to climate change challenges, the adaptive capacity and readiness of all actors in the energy sector are important, but particularly hydropower, peat production, and the transmission and distribution of electricity may be sectors where the need for readiness and adaptive capacity is emphasised.

Similar to the manufacturing industry, businesses in the energy sector operate in so tight a market situation that in the initial phase, the branch organisations of the energy sector could perhaps introduce long-term climate change adaptation reviews into their own plans and conduct a more detailed survey of the change situations of their sector and the associated preparations. In the energy sector, too, these operations could become part of the social and environmental reporting of businesses in the long run. In addition to the branch organisations, adaptation to climate change and the associated preparatory measures might be suitable for integration into the operations of the National Emergency Supply Agency at some period of time in the energy sector as well as in industry.

Possible measures in the energy sector

Some considerations

The reliability of energy supply is important. Finland's energy supply, which is based on multiple sources of energy, provides excellent opportunities to face the challenges of adaptation. The joint Nordic electricity market area creates certain flexibility. The sources of energy must be kept versatile, and as electricity consumption may still increase, the reliability aspect of the supply must be maintained as a central starting point.

It is important to secure the transmission and distribution of electricity in extreme conditions as well. Among others, issues to be taken into consideration include the maintenance of sufficient production capacity in case of consumption peaks, functionality of the remaining overhead lines and design of the width of line routes to prepare for extreme situations (storms), as well as preparations to raise the level of maintenance of the energy infrastructure and face the associated costs.

The development of production opportunities for district cooling, at least for selected targets in densely populated areas, will probably also become topical when intense hot periods increase in the future.

Hydropower

It should be possible to increase the amount of energy produced by hydroelectric power. The flood charting of water systems and the optimisation of regulation practices will be important. Increased winter runoff could perhaps make it possible to increase the capacity of turbines and water reservoirs if this is considered feasible, for example, with regard to environmental reasons.

Due to the Nordic electricity market, among other things, it is also necessary to carefully follow any potential changes in the hydropower situation and operational preconditions of the other Nordic countries in the long run.

Peat

Peat production should prepare for even larger annual variations in production levels by means of technology development and other measures. Road condition issues may also become increasingly topical.

Bioenergy

The use of bioenergy can probably be increased further, taking regional differences and changes into account, provided that production technology can also be made more efficient. The condition of the road network will also be an important factor, particularly for the use of wood biomass such as forest chips. In the case of arable biomass, it will probably be necessary to develop new "harvesting techniques" that can also operate cost-efficiently in very wet conditions.

Wind power

In the wind power sector, solutions have to be considered for issues such as how to minimise power production losses caused by increased storms on the one hand and calm periods on the other, for example, by utilising technologies. Likewise, it will probably be necessary to increase efforts to minimise power production losses caused by the icing of propeller blades.

Research on adaptation

The energy sector is the biggest individual producer of greenhouse gases, so it is natural that present research and development related to climate change in the sector is focused on mitigation measures and technologies. Once information is accumulated, it will be necessary to gradually increase research and development efforts related to adaptation also in the energy sector, partly because the undisturbed supply of electricity and heat will be very important in various exceptional situations as well.

At this stage, there are no clear needs for research on the long-term adaptation of the energy sector to climate change that could be presented here. The needs are being investigated in the energy part of the FINADAPT research project to be completed in late 2005, among others. Also in the energy sector, in addition to market factors, various technology leaps will probably have a significant impact on the methods and amounts of energy consumption in traffic, dwellings and industrial processes during the next 40–60 years. Such new technologies could include, for example, hydrogen and solar energy technology, biotechnology to some extent, intelligent and energy-saving construction technology, and intelligent process technologies. Recovery technologies for carbon dioxide contained in the combustion gases of power plants are an interesting alternative in technological development, and investments in these are being made around the world. If their development succeeds in terms of technology and the economy, this will have a great impact on climate change mitigation and very likely adaptation as well.

It will probably be possible to use technological methods, among others, to develop the structure of energy production towards significantly lower emissions and reduced energy consumption over the long-term period of 50 years. Of course, part of the energy-consuming sector, for example, the building stock as a whole, changes and renews itself quite slowly, and the same is true of part of the production capacity, such as existing hydroelectric power plants.

It would be desirable that in the initial phase energy industry organisations and possibly also some big energy-producing conglomerates could invest in the specification of adaptation research needs in their sector as well as in incorporating the adaptation considerations and associated functions to the normal monitoring and other methods used by the energy sector and the businesses in some time frame. Once the needs and possibilities of adaptation research are known better, it will be easier for public financiers of research, such as Tekes, to invest in the theme.

Table 4.10. *Summary of indicative adaptation measures to climate change in the energy sector.*

		Anticipatory
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
	Research and information	• Research and development targeted at adaptation will be added to continue and supplement the research on climate change mitigation
	Economic-technical measures	• More detailed examination of the need, quality, design and possible realisation times for concrete adaptation measures • Using suitable means of preparation for an increased need for repairs in some sectors
	Normative framework	• Surveying the potential need to change standards, etc. as necessary
Private		• Adaptation surveys specific to each branch of energy • Systematically introducing adaptation to climate change as part of long-term planning and strategies in branch organisations and large enterprises of different energy branches

4.1.5. Transport and communications

Adaptive capacity of actors

Measures in the transport sector can promote adaptation to climate change in advance, but this will require administrative decision-making based on research information and anticipatory measures to achieve the desired trend. Adaptation will require that the impacts of climate change be included in long-term investments, such as the construction of traffic routes or acquisition of vehicles. In these, the lifetime of the investment varies from a couple of decades to several decades, even up to a hundred years. Adaptation may also be possible in these cases but will become expensive. The time span is even longer when pursuing more economical vehicles and compact communities.

The Transport Infrastructure 2030 report by the Ministry of Transport and Communications does not mention the impacts of climate change. The most important factors of change on transport infrastructure are considered to be migration and changes in the production structure and business practices. Up until now, the strategies of the transport sector have not paid attention to the impacts of climate change or the need for adaptation. However, the Finnish Maritime Administration's Research and Development Strategy and Preliminary Programme 2003 states that climatic changes are probable in the long-term. According to the report, their impacts must be anticipated to the extent possible in connection with further development of the Saimaa Canal and the planning of multipurpose vessels for ice breaking, for example. It is essential to include climate change in the visions and long-term planning of all of the actors in the transport sector and to make it a theme for research and development programmes. Further improvement of energy efficiency must be observed as a measure worthy of attention also in the branches of the transport sector.

Possible measures

Infrastructure

Adaptation to the measures required by climate change should be initiated at an early stage. The measures concern the durability of the infrastructure, control of fault situations and information on disturbances. The fact that climate change may result in more frequent flooding and increase the risk of extreme flooding will lead to adjustments in the design of existing drainage arrangements on traffic routes and potential changes to the instructions concerning bridge openings and culverts, edge heights and other such issues. Water drained from vehicle routes could be conducted into filtration basins so that emissions produced by traffic do not end up in water systems or groundwater. The report on flood sensitive areas produced by the task force on extreme floods will be used as background information for the design of structures in risk areas.

Climate change will require an assessment and the revision of the design standards and instructions for transport infrastructure. The general planning principle for the route network is to avoid flood sensitive areas as far as possible. Changes in temperature conditions will affect the materials used and the technical solutions. Indirect impacts must also be taken into consideration in construction. These include, for example, changes in the habitats of flora and fauna (distribution zone boundaries, distributions and the relative abundance of populations will change), and must be observed both in the prevention of harmful impacts and in the foundation of plantings and structures. Preparedness for route maintenance and sudden repairs has to be intensified.

The road traffic network has to be protected in different ways to endure extreme weather conditions. In road construction, sufficient bridge openings, ditches and culvert structures must be taken into consideration with regard to heavy rains and floods. The design must be based on new research information on the impacts of climate change. Material potentially carried by floods must be taken into consideration when renewing bridge structures. The possibility of increased flooding must be taken into consideration in the design of underpasses in road structures, and, for example, new pumping stations must be added to underpasses to prevent overflows.

Railway beds have to be protected from floods and erosion. Due to increased waves, mostly attributable to the shortening of the ice-covered period, harbour structures may need to be reinforced by using breakwaters, for example. Securing the functionality of telecommunications in changing conditions must be taken into consideration in the design of structures. The replacement of overhead lines with underground cables will be considered increasingly.

Maintenance and quality of service

The impacts of extreme events on different forms of traffic may very and the impacts may be both direct and indirect impacts. Any change in traffic behaviour in one form of traffic is reflected as a change somewhere else in the traffic/transport system. A growing need to make the transport system more flexible, in other words to increase the intermodality of the transport chain, can be expected particularly in goods traffic. If a form of transport is not available due to an extreme phenomenon, it must be possible to smoothly create alternative forms and routes of transportation.

Research and investigations should be used as background tools in considering how the vulnerability of road traffic can be reduced in changed weather conditions. If necessary, a programme for improving the condition of the road network must be started. The transfer of some freight traffic from roads to railways might reduce the vulnerability of transportation.

More effort will be needed in the antiskid treatment of roads and airports by increasing the use of antiskid agents. The environmental hazards to water systems and groundwater due to increased antiskid treatment must be taken into account and minimised to the greatest extent possible. The drawbacks of salting can be reduced by building protection on road sections that are important for groundwater intake. According to research results, decomposing formiates that are an alternative to de-icing salt can also be used in groundwater areas, but due to cost reasons, they can only be used on limited road sections. They are already in regular use at airports.

More favourable conditions might lead to generous growth in deer populations, which would result in an increased number of road traffic accidents involving deer. Adaptation to these impacts will require the additional construction of animal access arrangements (green bridges, underpasses) in the road and rail network and control of populations by hunting.

Precipitation in 2004 indicated a similar development in Finland as observed in Denmark and southern Sweden; abundant rainfall at one time causes additional disturbances in maintenance, which will require preparations and standby arrangements in maintenance during the rainy season.

Delays caused by extreme events and affecting travel chains during periods of difficult weather must be taken into account in connection with passenger traffic information and freight transportation. Maximum wind velocities may impose the need to adjust the design speeds of double-decker trains. Intense hot periods and the potentially increased frequency of thunder will cause susceptibility to interference in rail traffic control equipment.

Climate change will cause the ice coat of the Baltic Sea to decrease, but the packing of ice and sludge belts could become as difficult or even more difficult for navigation than at present. This suggests that an icebreaker fleet of today's size needs to be maintained.

Safety risks in air traffic and navigation caused by extreme events have to be taken into serious consideration in safety arrangements. Fairly precise and frequently updated weather radar information and forecasts have been acquired for air traffic control purposes. An observation system to detect extreme events related to wind and turbulence, for example, is being planned for Helsinki-Vantaa Airport. When sea traffic in the Baltic Sea increases, sufficient harbour capacity must be secured. Increased sea traffic in the Baltic Sea could increase environmental risks further.

Telecommunications mainly rely on satellites, and therefore are not very susceptible to weather conditions. The significance of telecommunications networks will increase further in exceptional circumstances, because real-time information about weather conditions and the disturbances caused by them can be transmitted through different channels. Information about exceptional arrangements must be intensified. This will be facilitated by data communications links and methods of transport telematics, whose significance, as a part of the transport system, will receive even more emphasis. Preparations must be made with regard to the avoidance of disturbances in IT networks and risks caused by extreme weather conditions. The operation of information channels important to the functions of society has to be secured also in exceptional situations.

Research on adaptation

The changes in Finland's climate will be significant and the size and variation of the changes will be determined more precisely as climate research is developed further. Progress in the transport sector should be systematic and staggered. Research concerning adaptation measures should pay particular attention to the special characteristics of Finland, such as sparse population, a declining community structure, seasonal variations and special natural conditions (geology, hydrology), proportion the examination to global changes, and consider the significance of these factors to adaptation planning. With regard to goods traffic, the transport system should be examined as a whole in which alternative transport chains can be identified and assessed on the basis of usability.

The impacts of extreme events on different forms of traffic depend on each other through indirect impacts. It should be possible to take the uncertainties related to the direction and magnitude of impacts into consideration in a model-based examination, and it should be possible to identify the most important areas of dependence. A strategy should be prepared for all forms of traffic (roads, sea traffic, railways, air traffic, telecommunications networks), discussing how to begin the preparations for climate change and assessing the risks and disturbances to each sector and the associated structural impacts. Important factors include, heavy rains, floods, storms, winter climate, extreme weather events, and the like. Future research needs include the following:

- Sensitivity of different forms of traffic to the impacts of climate change and their susceptibility to interference
- Development of ice conditions in Finland's sea areas
- Changes in snow conditions in different parts of the country
- Consideration of extreme climatic events in the design of routes and related structures
- Needs and grounds for change in the design of structures (roads, railways, bridges, etc.)
- Observation and anticipation of extreme weather events and preparation for them in air traffic.

Summary

From the perspective of the impacts of climate change and adaptation, the vulnerability of the different parts of the transport system varies. It is estimated that road traffic in particular will be sensitive to climate change. This will impose great challenges on comprehensive transport chain management for goods traffic, in which alternative transportation routes and forms of transport must be available in different disturbance cases. Some preparation for anticipated impacts can be achieved in the short run, but some impacts have to be anticipated early enough so that the needs for change can be observed without endangering the social objectives set for the transport system. The impacts of climate change must be examined as potential future encumbrances, and preparations must be made for their existence both in the planning of functions and particularly in the planning of structures that are intended to have a maximum life span.

Table 4.11. *Summary of indicative adaptation measures to climate change in transport and communications and preliminary timing: *Immediate: 2005–2010, **short-term: 2010 –2030, ***long-term: 2030–2080.*

		Anticipatory	Reactive
Public	Administration and planning	• Inclusion of climate change in the transport sector's long-term planning* • Securing the functionality of telecommunications networks (wired networks) **	
	Research and information	• Surveying of flood sensitive areas* • Anticipatory systems and warning systems for extreme events** • Assessment of the ice situation in the Baltic Sea*	
	Economic-technical measures	• Maintenance of the structures (road body, ditches, bridges and culverts) and condition of road network, particularly on smaller roads and gravel roads as floods and rains increase and ground frost diminishes** • Maintenance of the structures (railway beds) and condition of railways while floods and rains increase and ground frost diminishes** • Minimising the environmental hazards caused by antiskid treatments (alternatives to salt, planning of groundwater protection)**	• Taking more difficult traffic conditions into account in planning and schedules • Repair of storm damage to overhead cables • Increase of winter traffic in the Baltic Sea • Antiskid treatment of roads and airports • Repair of storm damage to the road and rail networks
	Normative framework	• New planning norms and guidelines for road and railway construction**/***	• Guidelines and definition of tolerances for the duration of disturbances
Private		• Maintenance of the structures and condition of the private road network as floods and rains increase and ground frost diminishes**	• Taking more difficult traffic conditions into account in planning the schedules and timing • Salting and antiskid treatment of roads

4.1.6. Land use and communities

Adaptive capacity of actors

Present legislation emphasises the promotion of sustainable community development, the creation of preconditions for a good environment, and the promotion of construction based on a life cycle model that is of high quality and emphasises environmental issues. The development of communities, placement of functions and use of the environment are directed towards the promotion of sustainable development, the reduction of environmental impacts and the saving of natural resources, taking the prevention of climate change into consideration.

Present regulations already make it possible to take climate change into account. A crucial point in community planning is the consideration of environmental and other impacts. Acts and decrees on land use and construction, as well as municipal building codes, can be supplemented, and town planning processes can be associated with a requirement to carry out additional investigations on adaptation to climate change in particularly vulnerable areas. Recommendations can be issued at different levels of planning.

Changes in communities are traditionally slow, but their impacts are long-standing, often permanent in practice. Even though it has been estimated that climate change will be slow, communities cannot adapt to change automatically. The consequences of the introduction of new planning principles are seen in the development of communities with a delay of a few decades. However, land use planning can employ research information and new methods that allow advance planning of adaptation and make it possible to mitigate the impacts of climate change.

Possible measures

Better consideration of the impacts of climate change and natural conditions in general may require some adjustment to the planning principles applied to the use of areas and land. For example, investigating the routes of floodwaters caused by heavy rains, design of stormwater drains and sufficient allocation of areas with a soil surface permeable by water masses will require attention when developing the use of land in communities. Despite the conflict between the objective to preserve the integrity of communities and the aim to direct construction outside flood areas – or due to the conflict – a new perspective may be introduced for the local use of areas.

Some of the points that should be taken into consideration are the definition of flood risk areas, construction restrictions for risk areas, attention to the microclimate, terrain and soil, the conduction of rainwater and surface waters, and construction in shore areas. A potential increase in windiness can also be taken into account through the placement, form and direction of buildings.

The vulnerability of municipal utility systems – energy production, water supply and purification, and waste management plants – in extreme weather conditions may have to be taken into account in more detail when planning the use of areas.

The systematic investigation of landfills removed from use before the present regulations, landfills with insufficient environmental protection facilities, and areas with contaminated soil began in the late 1990s and is expected to continue for the next few decades. It is foreseeable that the sites could be decontaminated on such a schedule that once the climatic conditions have changed, there will be no significant danger or harm caused by old landfills or contaminated soil.

The after-treatment of landfills will continue for several decades, and in the course of this work, more detailed climatic information could be taken into consideration, if necessary, when estimating risks and planning actions.

Communities are increasingly dependent on the functionality of technical systems. Severe accidents affecting the safety of people and property may result from some sort of chain reaction, which could be initiated by a disturbance in a single system due to the weather. Consequently, attention has to be paid to the reliability of systems.

However, because the functionality of technical systems of communities can seldom be reinforced to totally endure extreme weather conditions, the possibility of catastrophes exists in the preparation for unusual conditions. Land use planning has to cooperate with rescue services, civil defence and preparation for unusual conditions, and the organisation of these.

The most immediate consequence of the adaptation to climate change is the need to strengthen cooperation between different sectors and strategic planning. In the new situation, the development of traffic routes and networks, as well as infrastructure systems related to energy, water and waste, should be more closely coordinated with the development of land use in communities.

If the impacts and risks increase significantly, the use of areas and the control systems have to be considered and developed according to the new situation.

Research on adaptation

The impacts of climate change on the functionality of communities from the perspective of land use planning and control have not been studied much in Finland yet. It is particularly important to study the regional and local impacts of climate change.

In order to amend regulations or issue more specific guidelines, climate change and its consequences affecting the functioning of communities and the planning of land use must be studied in much greater detail. Preparation for adaptation to climate change also requires that the regional impacts of climate change must be understood far more thoroughly than at present.

Table 4.12. Summary of indicative adaptation measures to climate change in land use and community planning.

		Anticipatory	Reactive
Public	Administration and planning	• The evaluation of the impact of climate change will be included in the long-term planning of regional and urban structures • 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)	
	Research and information	• Flood-sensitive areas and structures will be surveyed • Anticipatory systems and warning systems for extreme events will be developed • Regional and local impacts and means of adaptation will be investigated	
	Economic-technical measures	•	• The conduction of rain and surface waters will be improved
	Normative framework	• The need to amend the Land Use and Building Act and Decree and municipal building codes will be investigated • Recommendations will be issued at different levels of planning as necessary	
Private		•	• The conduction of rain and surface waters will be improved

4.1.7. Buildings and construction

Adaptive capacity of actors

Adaptation can be taken into consideration at the construction planning phase for new buildings so that expensive renovations can be avoided. Designs based on ecological factors take local natural conditions into consideration. It is then possible to create solutions suitable for the building site and region in question.

Possible measures

Adaptation measures in the construction sector are mostly associated with the same issues as the adaptation measures applicable to the community structure (including potential increases in windiness and storm winds, the risk of floods in built-up areas, conduction of waters and design of drainage systems). Changing stress circumstances should be taken into consideration in the planning of new buildings. The existing building stock constitutes an entity of its own in relation to the measures that may be called for by climate change.

The damage risk posed by rains can be lowered by securing the capacity of drainage systems so that it corresponds to the heavy rains expected in the future. The need to rebuild rainwater drains in built-up areas and the possibilities to impregnate soil with water or direct it to basins should be surveyed. Furthermore, instructions for the treatment of stormwater should be prepared to prevent flooding and erosion. It will be possible to set restrictions and regulations for areas where flooding and a rising ground water level are expected in the future. The capillary rise of water above the flood limit should be prevented. The need to tend to the ventilation of base floors will be emphasised. The methods used to calculate stability, carrying capacity and settlement should be checked when the dampness of soil varies during extended dry and damp seasons.

The significance of the locality of measures is emphasised when instructions are being issued. They must be drawn up to suit the local conditions. When locality is emphasised, control methods must also be focused on the area in question. This means that instructions will be prepared and issued specifically to each municipality or region. Regional and local impacts have to be investigated particularly with regard to the existing building stock.

So-called excess heat caused by increased temperatures can be prevented in new construction, among other things, by structural and architectural methods, employing target-specific designs that take the characteristics of the construction project and location into account. Recovery or reduction of excess heat in the existing building stock will require case-specific planning. Current building engineering systems allow excess heat to be recovered, providing a benefit.

Due to the potential increase in windiness, sufficient sealing of a building's outer shell can be arranged in new construction by taking the local climatic conditions and the properties of the building site into consideration at the construction design phase. In existing buildings, the sealing of the outer shell and heat losses can be examined in connection with planned repairs and maintenance.

The number of stress cycles on the surface structures of facades and roofs will increase due to increased rainfall. This is significant, for example, in porous materials. Due to this, the need for service and maintenance receives more emphasis.

The existing building stock will transform to some extent as the consequence of more efficient use of real estate stock and buildings, new operational requirements and purposes, as well as reconstruction. Structural checks related to a new purpose of use are often performed in this context. As far as building stock is concerned, local surveys must be conducted on the potential damage imposed by climate change on buildings and structures, as well as on structural reinforcements that should be made to structures and buildings.

The observation of climate change adaptation in building stock can be approached through the probabilities of different natural events that shape the built-up community. With regard to building stock and construction, it is important that preparations for climate change and potential needs for modifications due to climate change be taken into account now, due to the slow rate of the replacement of buildings. The results of research activities related to climate change and extreme events provide the opportunity to take climate change into account and apply more detailed design methods in new construction and the existing building stock, for example, to assist in community planning and the planning of standards. An understanding of the occurrence of extreme events in the changing climate is an essential part of choosing the measures related to adaptation.

Research on adaptation

Studies and reports presented earlier provide good starting points for studying the impacts of climate change on construction and the existing building stock. The investigation of impacts will certainly require more detailed study of the identified problem areas. Focused research activities and their results provide better opportunities to plan activities concerning construction and the existing building stock due to climate change. On the basis of research results, one can estimate whether the changes will require adjustments to design principles and standardisation. Once basic research concerning the changes has been completed, preparation for climate change can be combined with other research associated with construction and structures. The research must be multidisciplinary.

According to one survey, the level of research activity related to the impacts of climate change and adaptation has previously been very low in the fields of construction and community planning. The study “Impacts of Climate Change on the Built-up Environment” conducted by VTT Building and Transport and associated with buildings, construction and community development, raised subject matter related to climate change. The results present topics for further research as such, but they must be combined to gain a comprehensive general view, congruent impact results and suggestions for adaptation measures that can be generalised. The ongoing environment cluster research project “Extraordinary Natural Events and the Built Environment in a Changing Climate” develops a method for the reliable analysis of rare natural phenomena and is thus focused on buildings and construction.

The need to rebuild rainwater drains in built-up areas and the possibilities to impregnate soil with water or direct it to basins should be surveyed. Rain intensity observations conducted by the Finnish Meteorological Institute should be extended from the current four–five population centres to some 50. Likewise, the observation of ground water should be extended.

Research activities related to climate change and their results serve as a foundation for estimating the predictable impacts of climate change and considering adaptive measures. In addition to new construction, the surveys must be extended to the existing building stock.

Table 4.13. Summary of indicative adaptation measures to climate change in construction.

		Anticipatory	Reactive
Public	Administration and planning	• Climate change will be included in long-term planning and research activities in the construction sector	
	Research and information	• Surveying the local impacts and spheres of influence of climate change • Surveying flood-sensitive areas • Anticipatory systems and warning systems for extreme events will be developed • The need to rebuild rainwater drains in built-up areas and the possibilities to impregnate soil with water or direct it to basins will be surveyed • The impacts of a potential increase in wind velocity will be taken into consideration with regard to the existing building stock and new constructions. • Revision of existing structures	
	Economic-technical measures	• Guidelines will be prepared for the treatment of stormwater and the design of drainage systems	• Repair of storm damage to buildings will be developed • Different repair measures
	Normative framework	• Potential revision of design standards, instructions and regulations based on research information • Potential issue of recommendations in accordance with local stress conditions	
Private			• Different repair measures

4.1.8. Health

Adaptive capacity of actors

Industrial and economic development has made diseases originating from the environment quite rare. The industrial-technical culture that has enormously increased the general standard of education of the population is capable of protecting human beings in various ways. The fact that food and drinking water no longer pose any risks to public health has become a very decisive factor. This has been achieved by the introduction of technology that enables disinfection (e.g. chemicals) and by ensuring the cold chain for food, drugs and vaccines from the manufacturer all the way to the final consumer. On the other hand, it is easy to prevent poisoning caused by ergotic alkaloids in the industrial processing of grain, for example. Foreign trade allows huge volumes of exchange and guarantees that various fresh food products are nowadays on sale throughout the year, which ensures that vitamin deficiency diseases are a thing of the past. Increased prosperity guarantees an unparalleled level of food security, i.e. sufficient supply of food and thus sufficient calorie intake.

The negative impacts of the predicted climate change will probably be associated with the impacts of hot periods in the summer, particularly in the Greater Helsinki area, and may indeed be limited to these. There is uncertainty due to the fact that climate models mostly predict warming at night and in winter. However, it must be possible to control the health impacts of potentially increasing hot periods irrespective of whether such periods actually increase or decrease. Population concentrations are small in Finland and our northern location reduces the threat associated with hot periods compared, for example, with the metropolitan centres of Central Europe. However, hot periods have led to increased mortality especially in the big population concentrations of northern parts of the United States.

The Ministry of Social Affairs and Health has published a guide for special circumstances to support municipalities in their independent advance preparations for exceptional situations. Among other things, the guide provides instructions for controlling epidemics that may increase during heat waves and floods and investigating their reasons, but does not give instructions associated with the direct heat impacts of heat waves.

On the basis of the experience gained during the 2003 hot period in France, increased mortality was clearly observed among elderly Parisians living in welfare and public health care institutions where there was not a single air conditioned room. However, the authorities faced a special challenge in the case of elderly people living alone at home. When the temperature exceeded 25 degrees in consecutive nights, thousands of these people died. Smooth cooperation between climate researchers and the social and health care authorities through advance preparation is important in this kind of situation.

Elderly people will suffer in hot periods. In Central Europe, increased mortality associated with the hot period in summer 2003 was smaller among people under 60 years of age. Instead, serious health impacts related to cold periods are also found among children.

Unlike many other countries, Finland's advanced registers guarantee that social and health care authorities know the people living in their territory and their addresses quite well. Combined with the outpatient services in the social sector, this facilitates the actions of the Finnish authorities in connection with a hot period.

If the economy develops and stays on a steady track, both direct and indirect public health impacts caused by climate change and a possible rise in the mean temperature will remain minor. A sustained, high level of solvency within the society facilitates the financing of any additional investments in health care that could be needed.

Possible measures

The anticipated changes may require more demanding horizontal cooperation between different actors. This will mean, in particular, more intense cooperation between climate researchers and the health and social services. The direct and indirect negative health impacts caused by predicted climatic changes involve major uncertainties. Of course, this survey does not take any major discontinuities in the development of the climate history into consideration.

If summer temperatures really increased or turned into a problem, urban planners would have to be included in this cooperation. The urban heat island phenomenon can be controlled in the long run by urban planning.

The only immediate and efficient method to prevent increased mortality is to guarantee air conditioned living quarters for people in private residences as well as in retirement homes and hospitals. Even with the present summer temperatures in Finland, it should be ensured that, especially in densely built areas, institutions taking care of elderly people make preparations for sufficient ventilation capacity and/or at least one air conditioned room. This could be promoted, among other things, by including this element into the quality standards of social services and health care.

The contribution of occupational health professionals, researchers and authorities might also be needed if hot periods become common, because many types of work have to be carried out irrespective of the conditions. Authorities have already standardised minimum and maximum temperatures from the occupational safety perspective.

Advance planning should probably be used to prepare for local problems, particularly in Greater Helsinki. Finland will have to follow the international discussion on advance warning systems (such as those in Lisbon, Chicago and Toronto).

The ICARO advance warning system in Lisbon produced a warning signal five days before the uncontrolled development of events in France. However, the media was more interested in the forest fires that raged at the same time, which delayed the arrival of the health authority message and therefore a number of deaths (about 2,100 elderly people) were recorded in Greater Lisbon as well as elsewhere in Portugal, mostly in urbanised areas.

Changes in the occurrences of zoonotic or vector-borne diseases, partially due to climatic changes, also increases the need for cooperation between agriculture, forestry and health authorities, as well as research institutions. Climate change aspects must be taken into account in the development of monitoring and prevention of changes in the prevalence of infectious diseases. If algal blooms become more common in bodies of water, actions and guidance from the authorities might be required.

The development of solvency is crucial to human health. If the economy continues on a steady track, no bigger problems are foreseeable, because mankind has protected itself against environmental harm in many different ways.

Regarding the preparation for extreme climatic events, securing the distribution of electricity in all circumstances will be of primary importance from the point of view of environmental health. This can be achieved through long-term energy policy and intensified preparedness planning. The latter means investments in, for example, securing sufficient backup systems in special climatic situations.

Research on adaptation

The climate change aspect must be more systematically included in the surveying of diseases and in the examination of their risk factors, which is currently based on the infectious disease monitoring systems of the National Public Health Institute and other parties.

Together with other institutions, the National Public Health Institute must follow international development in the debate and research concerning climate change as far as it affects health protection and organising this in Finland.

Even though mainly issues related to warming are discussed above, there is still a need to increase knowledge about the health impacts of cold periods in Finland. In the light of the experience and scientific information, they are difficult to control.

Table 4.14. *Summary of indicative adaptation measures to climate change in social services and health care and preliminary timing: *Immediate: 2005–2010, **short-term: 2010–2030, ***long-term: 2030–2080.*

		Anticipatory	Reactive
Public	Administration and planning	• Securing the capacity of health care to correspond to changing climatic conditions* • Cooperation between climate researchers and health care and social services* • Supplementing of the guide for special circumstances by the Ministry of Social Affairs and Health with regard to hot periods • Energy policy must aim to secure the distribution of electricity	
	Research and information	• Information about the dangers of the changing climate, such as heat waves* • Studies related to special circumstances, following them and organising reporting related to them • Information on the dangers of algal bloom* • Information on the increased risk of infectious diseases*	• Studies related to special circumstances and organising reporting related to them
	Economic-technical measures	• Development of urban planning with regard to the control of the urban heat island phenomenon* • Preparedness planning must pay attention to backup systems for the distribution and production of electricity	• Ensuring air conditioning and sufficient ventilation in retirement homes and hospitals, for example, by quality recommendations*
Private			• Increased air conditioning***

4.1.9. Tourism and the recreational use of nature

Adaptive capacity of actors

Snow is the key factor in attracting winter tourism to Finland, which naturally makes the sector vulnerable to changes in climate and snow conditions. Summer tourism is not estimated to be as vulnerable, and the need for adaptation should be smaller. It is estimated that the planning and implementation of adaptation measures in tourism and recreation will take 5–20 years.

The Finnish Tourism Board has prepared scenarios for tourism up until the year 2020. In these scenarios the increased occurrence of winters with less snow has been taken into consideration. The Regional Councils are responsible for the regional development of tourism, and a regional tourism strategy has been prepared in nearly every province. The strategies are prepared for about three–four years at a time and provide a ready-made planning tool for taking climate change into consideration at the regional level.

Finland's ski resorts are estimated to operate according to a ten-year planning span, which means that, in principle, it will be possible to take climate change into account in the planning of winter tourism. In recent years, 70–80% of the investments of ski resorts have been directed towards the improvement of slope conditions. Internationally it has been estimated that most tourism entrepreneurs have limited information about climate change and limited potential for adaptation. The situation in Finland is likely to be similar.

Possible measures

The knowledge base is not yet sufficient for defining specific adaptation measures for tourism and recreation in the short run. Climate change should be integrated into regional and other tourism strategies, securing the flow of research information to tourism entrepreneurs and private actors. This will also expand the knowledge base of tourism-related actors with regard to the impacts of climate change and the adaptation to them.

Summer tourism

The extended period of unfrozen soil and the summer season will probably have to be taken into consideration in the planning of recreation areas. The extended summer season will probably raise operating pressure in summertime recreational areas, which means that there might be a need to direct tourists and recreational users of nature away from the most sensitive natural attractions that are susceptible to deterioration. Finland's improved position as a location for summer tourism is worth taking advantage of.

Winter tourism

Possible strategies for adaptation to climate change in winter tourism include the development of winter tourism or the development of alternative tourism strategies less dependent on snow. The preconditions for winter tourism can be improved by investigating the possibilities for increasing the economic efficiency of artificial snow and by developing cooperation between tourism entrepreneurs. On the other hand, particularly in Southern Finland, other attractions besides those dependent on snow in the winter season should be developed, which would reduce the industry's vulnerability to climate change. This is also important because of the ecological disadvantages related to artificial snow. However, there are no significant alternatives to snow-dependent winter tourism in view that could be widely adopted in Finland.

Research on adaptation

In addition to the impacts of climate change, the vulnerability of the sector and possible adaptation strategies for the minimisation of disadvantages and the maximisation of advantages must be studied. Actors involved in the tourism sector and recreational use of nature require cross-sectoral research, such as seasonal prognoses of temperature and precipitation, as well as associated regional changes. The challenges of applied research include impacts on sources of livelihood and the study of profitability and sustainable tourism. It is essential to conduct follow-up studies so that changes in tourism and the recreational use of nature and the reasons for changes can be assessed. Continuation of the National Outdoor Recreation Demand and Supply Assessment (LVVI) is part of the follow-up, and it is equally necessary to carry out regional visitor follow-ups in recreational areas operated by the Government and municipalities. In addition to follow-ups carried out using outdoor recreation statistics, modelling is needed to draw up prognoses.

*Table 4.15. Summary of indicative adaptation measures to climate change in tourism and the recreational use of nature and preliminary timing: *Immediate: 2005–2010, **short- term: 2010 –2030, ***long-term: 2030–2080.*

		Anticipatory	Reactive
Public	Administration and planning	• Integration of adaptation to climate change with tourism strategies* • Taking the increase of hiking in the unfrozen season into account in the planning and use of recreation areas*** • Development of other attractions besides those related to snow for winter tourism to reduce the dependence on snow*	
	Research and information	• Increased research both on the impacts of and adaptation to climate change* • Communicating research results to private actors*	
	Economic-technical measures	•	• Development of artificial snow*
Private		• Development of other attractions in winter tourism to reduce the dependence on snow*	• Improving the economy of artificial snow on ski slopes and investigating the possibilities of its use in cross-country skiing* • Change of tourism patterns*** • Change to patterns of recreational use of nature***

4.1.10. Insurance operations

Adaptive capacity of actors

More detailed information on the probabilities and impacts of climate change will be needed in order to anticipate economic changes. The events of the future will not necessarily proceed in a linear manner but may, for example, change due to human activities. Storms do not present any exceptional risk to insurance companies in general. The reinsurance market is functional and effectively diversifies geographical risk. The financing of catastrophe risks is possible today with the help of different financing instruments. The pricing of catastrophe damage and the adequacy of reinsurance cover are the greatest risks from the point of view of an individual insurance company. Finland differs from other countries in that the amount of significant damage due to natural events has been low until now. The floods of summer 2004 in Finland would hardly be noticed in Central Europe. In Finland, there is still time to prepare for damage caused by climate change within the insurance sector, but the 2004 floods will probably cause discussion in Finnish insurance companies and measures with regard to the insurability of weather events. Even though the concrete problems caused by floods are mainly concerned with planning, building supervision and municipal engineering, insurance companies estimate the flood risk and price the risk accordingly.

If some of the risks become so big that it is not profitable to insure them, they can be recategorised as ineligible for insurance, the deductible can be raised, or the maximum compensation can be reduced. In Germany, for example, construction is allowed at the very edge of river banks, but when a construction permit is granted, the owner will be notified that no flood risk insurance can be obtained from insurance companies. Also, when risks are great, the risk can be reduced by dividing the insurance burden between several insurance companies. However, it can be difficult to get reinsurance, and even if available, the costs may be so high that this is no longer economically profitable. Separate major risk insurance policies may also become too expensive for consumers, in which case their availability will have no significance.

Increasing the size of insurance companies, as well as the expansion and diversification of operations, will also influence the adaptive capacity. One possibility is to lower the risk, for example, by offering insurance premium reductions to customers who introduce certain precautions. The insurance sector has a good chance to adapt itself to the impacts caused by climate change and sustain them, because it has several means to restrict the kinds of damage that it will have to compensate. On the other hand, new and changing situations caused by climate change, which are only partially controllable, provide the insurance sector with a major development outlook in the form of new insurance products. Today some companies in Finland already compensate for damage comparable to that caused by climate change in certain situations specified in the terms and conditions of insurance. Natural catastrophes may also increase interest in insurance.

Insurance companies are generally confident in their ability to estimate economic changes in the future. However, they may have to change this premise of decision-making when taking climate change into consideration. For example, the insurance industry has shown interest in the establishment of a common insurance pool to compensate for flood damage. A model where the government's share would come from the budget and the funds contributed to the pool by insurance companies would be collected from home insurance customers as increased insurance premiums has been proposed for the compensation of flood damage. The problem for flood insurance in Finland is the fact that the insurance risk is directed at a rather small group of policyholders, which means that the majority of Finns are outside the risk of flood damage. If all policyholders had to take out flood insurance, for example, as a mandatory part of fire insurance (such as in some countries), this would mean that the majority of policyholders would be paying for the risks of a small minority in their insurance premiums.

The establishment of a common flood insurance pool would require the widespread participation of foreign companies as well, because the system distributes the risks and the incurred costs. If a company outside the pool did not have to participate in the compensation of costs caused by the risks concerned, this would be unfair towards other insurance companies. This might require changes in legislation.

The alternatives for flood insurance in the future are: 1) the Swedish model of market-based flood insurance with deductibles, associated reinsurance and the division of risks between policyholders, and 2) the Norwegian pool model in which flood insurance is linked with storm insurance. One alternative could be that flood insurance would only be compulsory in risk areas defined by flood maps. This is the case in, for example, Norway, France, Switzerland and Spain.

Possible measures

Public and/or private insurance system will be developed while ensuring that the division of tasks between public and private insurance stays clear (flood insurance, insurance pools).

Adaptation to climate change can be promoted by, for example, developing new products for the control of economic risks and by diversifying the risk with the help of bonds and derivatives. The vulnerability of the target can be reduced by controlling damage. Recovery from damage should be improved.

Risks can be reduced by technological development, environmental care, land use planning, construction design and town planning, as well as sewerage.

Vulnerability can be reduced by proactive planning and modelling, and by the operations of insurers and authorities. Such methods include, among others: raising of prices, conclusion or termination of old insurance policies, restricting the insured amount, actuarial methods for limiting liability, in other words, leaving part of the insurance risk with the policyholder (deductible), the development of insurance legislation and the compilation of national flood maps.

It is also necessary to develop precautions to avoid damage. These include guidelines issued by insurance companies, daily, seasonal and annual reports of exceptional weather, warnings for storms or hard winds in sea areas and inland waters, warnings for dangerously strong winds in land areas, forest fire warnings, drifting calculations for waters, ice accumulation warnings, assessment of the consequences of chemical accidents, radiation supervision, ozone warnings for outdoor air, etc.

Product development and active information can be used to clarify insurance policies and responsibilities. It is also important to emphasise the role of policyholders in damage prevention.

Research on adaptation

Research related to climate change within the insurance sector has been insufficient in Finland. Future needs for research include increased modelling and study of risks by utilising existing climate change scenarios rather than traditional historical material which, for example, has been used as the background for catastrophe models. This would make it possible to anticipate small scale events that are much more common than catastrophes, such as forest fires, lightning strikes and local floods. Cooperation between different insurers and climate researchers would also benefit the distribution of costs.

Table 4.16. *Summary of indicative adaptation measures to climate change in insurance operations and preliminary timing: *Immediate: 2005–2010, **short-term: 2010 –2030, ***long-term: 2030–2080.*

		Anticipatory
Public	Administration and planning	• Taking climate change into consideration and employing proactive planning and modelling in environmental care, planning of buildings and land use, town planning and sewerage* • Development of an insurance pool together with insurance companies*
	Research and information	• Modelling and study of risks utilising existing climate change scenarios* • Development of precautions to avoid damage*
	Economic-technical measures	• Development of technology to reduce risks*
	Normative framework	• Development of insurance legislation*
Private		• Clarifying insurance policies and responsibilities* • Proactive planning and modelling* • Development of private insurance systems to take climate change into consideration* • Development of new products to control economic risks* • Diversification of risk with the help of bonds and derivatives*

4.2. Need to adapt to changes taking place in other parts of the world

Adaptation as such is local in character, while the reduction of emissions will affect climate change worldwide. However, there are also global interlinkages between the adaptation and impacts of climate changes, which are communicated from one region to another.

4.2.1. Adaptative capacity ín different countries

Chapter 3.1 describes the global impacts of climate change. The adaptation capacity varies considerably between different countries. It has been estimated that the greatest challenges of adaptation will be faced in developing countries. In several of the least developed countries, the climate is already a burden to food production. In areas which suffer from drought, the situation may become even worse and may lead to the migration of the population to new locations. It would be extremely difficult to find better living conditions and work for untrained and poor people, which would further intensify poverty. The rising sea level is an example of the long-term impacts where the adaptation would involve substantial costs and changes to local inhabitants and infrastructure. Impacts like this may give rise to conflicts and may even be a global security threat. Developed countries have greater possibilities to adapt to climate change compared to poor countries. The Netherlands, for example, will be able to prepare by building dams, but the situation in Bangladesh is different, and when climate change continues, the situation could become partially uncontrolled.

The challenges of adaptation are great in developing countries. On the other hand, it is difficult to distinguish between problems caused by climate change and those caused by underdevelopment. However, climate change will make existing development problems worse. Integration of climate issues in development cooperation is necessary, for example, within the scope of water services, agriculture and forestry. This will also mean challenges in the planning of Finland's development cooperation. On the other hand, the need to adapt to climate change may also provide opportunities for poor countries (planning in the energy sector, sustainable development, technology transfer, etc.).

Adaptation concerns industrial countries as well, even though they generally have good preconditions to prepare for changes and to adapt. Adaptation to climate change and the impacts of climate change have been assessed in several countries, but concrete programmes are still rare.

4.2.2. Interrelationship between the global impacts and adaptation to climate change in Finland

The need for different sectors to adapt to changes taking place elsewhere is based on different connections. Agriculture, which is sensitive to the climate, will very likely be strongly regulated by the EU's common agricultural policy also in the future. Tourism, however, is an industry in which the impacts of climate change can be directly seen in the preferences and choices of consumers. The impacts can be general or reflected from one sector to another. For example, possible conflicts arising in areas suffering from water shortage may be reflected in Finland as global security issues. The Finnish Security and Defence Policy (VNS 6/2004) also raises the interrelationship between environmental problems and security policy, the impacts of global development such as climate change, and the anticipation and preparation for the impacts of climate change.

Only some preliminary estimates can be presented relating to Finland's need to adapt to changes taking place in other parts of the globe. Further information will be available in the future as the study of the impacts proceeds and adaptation issues have also been taken into account.

Table 4.17. *Preliminary estimates of how global climate impacts will reflect on different sectors in Finland*

Sector	Connections
Agriculture and food production	• Uncertainty concerning continuation of production in present major production areas • Increased demand for Finnish food products • Uncertainty of the food supply of developing countries in changing climatic conditions
Forestry	• Diminishing of the world's forest reserves and its impacts on Finland's forest sector • Increase in forest reserves in the boreal belt and its impacts on Finland's forest sector
Water resources	• Exhaustion of water resources in different areas of the globe; impacts on the opportunities for water exports from Finland, etc. • Increased risk of conflicts between countries in dry areas that are trying to utilise the same water resources, and the impacts in Finland
Tourism	• Regional climate impacts in the Mediterranean and the Alps, for example, may affect tourists' preferences in ways which will be reflected in Finnish tourism
Transport and communications	• Potential changes in the ice conditions of the North-East Passage will be reflected in Finland's sea traffic
Energy	• Rains in Norway and Sweden; impacts on Nordic electricity markets
Insurance	• Reinsurance

4.2.3. Financial measures and mechanisms

The adaptation strategies of developing countries and practical adaptation measures are supported through the Global Environment Fund (GEF), which is a financing mechanism under the climate agreement. In addition, adaptation measures are supported with bilateral development aid. For example, Finland has two meteorological observation projects to improve the capacity of developing countries to adapt to climate change. One of these is in Mozambique and the other on the small islands of the Caribbean.

The environment is a cross-sectoral theme in Finland's development cooperation and has to be taken into consideration in all activities. This also means that adaptation to climate change must become a part of projects concerning the development of the countryside and towns, for example. Furthermore, support for the implementation of international environmental agreements in developing countries is one of the key elements in Finland's development cooperation. Adaptation to climate change must also be taken into consideration in this work.

4.2.4. Connections between adaptation and reduction of emissions

The objective of the climate agreement is to restrict concentrations of greenhouse gases to such a level that atmospheric changes with dangerous consequences can be prevented. Emissions should be reduced so that food production and the economy will not be endangered, and that ecosystems will have time to adapt to such changes. There are connections between the restriction of emissions and climate impacts: the earlier and the more strongly the emissions are restricted worldwide, the smaller the impacts of climate change and the need to adapt will be.

IPCC's figure on the risks associated with damage caused by climate change ("reasons for concern") (*Figure 4.1.)* illustrates the connections between the development of emissions, levels of warming and estimated risks. Among the concerns presented in the IPCC report, the strategy report examines extreme weather events and impacts on diversity at the national level. Large-scale risks such as impacts on the Gulf Stream and the breaking of the glacier are not included in the scope of the survey, as stated in the introduction to the report.

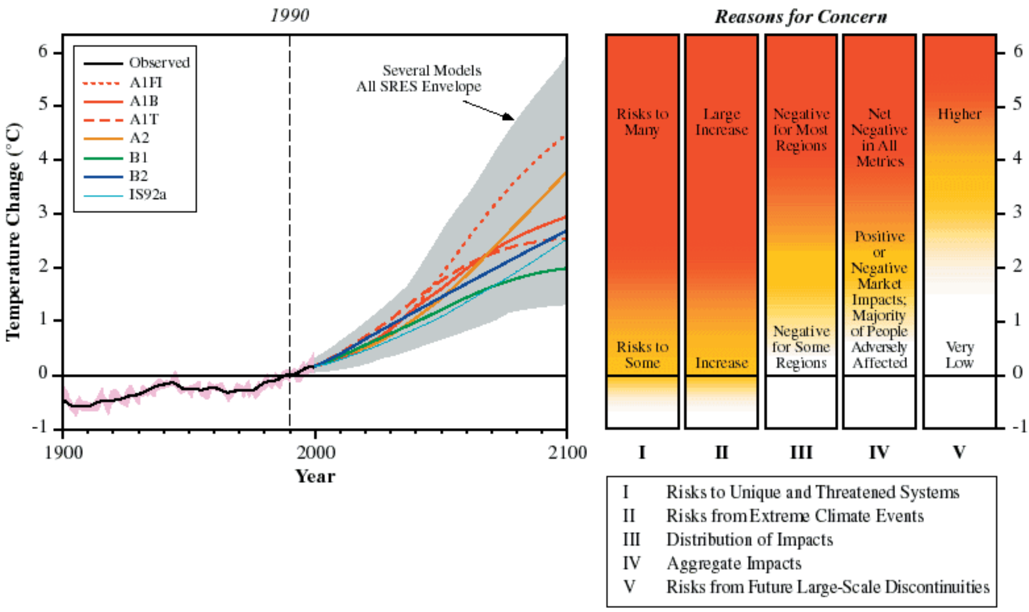

Figure 4.1. *Risks associated with damage caused by climate change. On the right, each bar corresponds to one area of risk caused by climate change. The colours of the bars describe the level of the risk or impact. White describes a risk free level or nearly non-existent impact, increased darkening of the bar colour indicates a more extensive or greater disadvantage or risk. The figure on the left provides estimates on the development of temperature change in this century calculated on the basis of the IPCC scenarios. Source: Third assessment report of the IPCC.*

Both adaptation and mitigation of emissions development are ways to control the risks associated with climate change. Adaptation measures are initiated due to local events and risks. Actions to mitigate climate change are, above all else, connected to the risk control of the whole climate system and in this way they lead to reductions in the need to adapt and in the damage caused by climate change.

It is difficult to make adaptation and mitigation commensurable, and the same is true for the associated global and local factors. The necessary knowledge and methods do not exist as yet, for example, for calculating the costs and benefits associated with different emissions reduction levels, adaptation measures, and the damage and advantages to the environment. The costs of emissions reduction will appear close to the present time, while their direct climate advantages, in other words the reduced need for adaptation and lower costs of adaptation and damage, will only be seen after decades. Many anticipated impacts are difficult to estimate in monetary terms.

4.3. Cross-sectoral issues

4.3.1. Development of administrative capacities

The starting point for the implementation of the National Climate Change Adaptation Strategy is that the detailed evaluation of the impacts of climate change and the definition of adaptation measures are integrated into the operations of sectors and institutions: planning, implementation and follow-up.

There are differences in the possibilities of sectors to define the impacts of climate change and the associated adaption measures. Some sectors, such as agriculture and food production, forestry, water resources, transport and communications, and power production are already in immediate connection with the climate and weather factors, and their operation is adapted according to these factors. Differences between sectors also exist in the time perspective of planning and implementation. Even though the ability of sectors for assessing the impacts and defining the adaptation measures vary, climate change will impose new challenges on the whole process of administration. All sectors will be required to analyse and develop their capacities, intensify the use of research information, as well as intensify coordination and cooperation between different branches of administration (sectoral, regional and local authorities), institutions and actors.

The general means available to authorities include administration and planning, normative (legislative) measures and economic-technical measures. The branch-specific measures were described in the previous chapters. Other measures, such as observation and warning systems, research and development, and education and communication are dealt with in Sections 4.3.2, 4.3.3 and 4.3.4 below. Authorities and actors also have a wide range of means available in exceptional situations (fire and rescue services, medical care, law enforcement), but these are not discussed in more detail in this strategy.

The development of administrative capacities relating to the impacts of climate change and adaptation can be carried out using several different tools and systems. Environmental management systems, environmental impact assessment and risk management systems, as well as their development possibilities to include climate change adaptation aspects as part of the planning, evaluation and management of sectors are described in more detail below.

The integration of the impacts of climate change and adaptation to the administrative processes requires research and development. The challenges include the fact that climate change, its impacts and adaptation measures will take place over a very long time period, the impact relations are very complex and significant uncertainties are still involved. On the other hand, the time span of several projects, programmes and plans is shorter, and the cause and effect relations of the measures and the alternatives can be more clearly defined than in the examination required by climate change. Despite this, climate change can already be incorporated into the environmental management systems, environmental impact assessment and risk management, as applicable.

Environmental management systems

In recent years, different institutions and have developed environmental management systems, to reduce negative environmental impacts and prevent environmental problems. An environmental management system is a comprehensive scheme which includes a whole institution or sector of administration, and one part of it is usually an environmental programme. The system outlines a general objective (strategy) and means to implement the objectives (programme), and links these to the follow-up and continuous improvement. As part of the implementation of the Adaptation Strategy, the impacts of climate change and adaptation will be incorporated into the environmental and other management systems of institutions and sectors of administration, as applicable.

Environmental Impact Assessment (EIA)

Environmental Impact Assessment identifies and estimates the positive and negative impacts of individual projects or plans and programmes on people, nature, the built environment and natural resources. The Act on Environmental Impact Assessment (468/1994) is applicable to projects that may cause significant harmful environmental impacts. The Decree on Environmental Impact Assessment (268/1999) lists projects subject to the EIA procedure. The Ministry of the Environment and the Finnish Environment Institute have prepared instructions for the environmental impact assessment of plans and programmes.

Main requirements for an environmental management system compliant with the ISO 14001 standard:

- **Environmental policy.** The environmental policy must define the objectives and targets of an organisation's environmental work, taking into account the nature, extent and environmental impacts of the organisation's operations. The environmental policy must include commitment to continuous improvement, prevention of environmental pollution and compliance with the relevant legislation and regulations.

- **Planning**. Crucial issues to be considered in planning include the integration of environmental aspects essential to the organisation, statutory and other requirements, objectives and targets, and environmental management programmes.

- **Implementation and functions of the system.** Implementation and functions include the organisation of and responsibilities for environmental management, training, awareness and competence, flow of information, documenting the environmental management system, document control, steering of functions, as well as preparedness and actions in emergencies.

- **Follow-up and corrective measures**. These include the collection of follow-up data, corrective and preventive measures, as well as environmental management system audits.

- **Management review**. Regular management reviews should utilise follow-up information and audit results, information related to the achievement of objectives and targets and feedback from interested parties, and analyse the applicability of the environmental management system and provide guidelines for development work.

The impacts of climate change and the considerations relating to adaptive measures can already be incorporated into environmental impact assessment at the level of plans and programmes, but further development of assessment methods and accumulation of experience will be needed.

Risk management

Risk assessment has became a common procedure for the sectors and organisations to prepare themselves for unexpected consequences affecting an individual, company, property, economic operations, society or the environment. In addition to the identification of the magnitude and probability of the risk (risk analysis), an evaluation of the significance of the risk, in other words the determination of the acceptable risk level, is needed. For example, the approach of the risk analysis standard for technical systems (SFS-IEC 60300-3-9) indicates that risk analysis is required (i) to identify dangers, (ii) to assess the magnitude of risks, their seriousness and probability, (iii) to identify approaches to prevent or reduce danger, (iv) to provide information for decision-makers, and (v) to comply with official requirements. Environmental risk generally refers to risk that causes environmental damage, in other words, the consequences are directed at soil, water or the air. Different risk management systems have also been developed to support economic activity, insurance operations, as well as health care and protection.

Experience of the application of risk analyses concerning the impacts of climate change in Finland remains small for the time being. In the United Kingdom, for example, methods and guidelines have been developed to include risks and uncertainties in decision-making. The objective of the instructions is to facilitate the evaluation of the risks of climate change in relation to other risks of the future by different decision-makers. This aims to define sufficient but not excessive measures for adapting to climate change.

Phases of the assessment of risks and uncertainties in adaptation to climate change as part of decision-making in the UK Climate Programme

Problem definition
1. Identification of problem and setting targets for assessment work
2. Defining criteria for decision making

Problem analysis
3. Risk assessment
4. Identification of alternatives
5. Assessment of alternatives

Decision making
6. Decision making

After decisions
7. Implementation
8. Follow-up, assessment of implementation and reassessment

The risks relating to the impacts of climate change can already be included in the risk assessments applied by sectors, organisations and companies. However, the implementation of the Adaptation Strategy requires that the risk assessment methods applicable to the impacts of climate change must be developed and applied further. Furthermore, assessment that coordinates different risks (such as climate, environment, economy, health and insurance operations) will be needed. These will require more exact information about the expected impacts and uncertainties of climate change.

4.3.2. Observation and warning systems

Observation and monitoring systems of the present climate

Finland's present climate can be characterised quite well through the averages of climatic variables and their natural variation. The extreme values related to the natural variation of the climate are indicated by means of their observed return periods. Due to the short observation time series, the information about the occurrence of rare extreme events is limited. The observation and monitoring systems of the present climate must be able to describe both the average conditions and the occurrence of various kinds of extreme events.

The network of observation stations maintained by the Finnish Meteorological Institute is part of the global observation system. The network is extensive within Finland and highly automated, and guarantees high-quality monitoring of the temporal and regional variation of the climate. An evaluation of the whole observation activity of the Finnish Meteorological Institute is in progress. It is especially important to climate research to guarantee the continuity of the existing long and uniform time series of observations. The Institute's weather radar network covers nearly the whole country and produces valuable information about precipitation areas and their movement. Weather radar information can be used in the compilation of short-term (up to three hours) rain forecasts and as climatic basic material for Finland's rain distribution. The lightning location network can be used to survey the occurrence of the strongest thunder areas.

The Finnish Meteorological Institute continuously measures solar UV radiation at six locations in different parts of Finland. The strength of the ozone layer is monitored by radio sounding in Jokioinen and Sodankylä. Measurements made on the surface of the Earth are supplemented by several long-term satellite remote sensing programmes.

A follow-up study of air quality produces information about air quality and radioactivity. Finland's measurement network for air quality outside densely populated areas covers 16 measuring points. The background concentrations of atmospheric impurities obtained in this way offer a good reference for measurements taken near densely populated areas and industrial facilities. They are also used to monitor the impact of international emissions reduction agreements on air quality and the concentrations of fine particles.

Finland's weather radar network

- The quantities measured using weather radar include the intensity of the radar echo, and in the case of Doppler radars, the velocity of the radar echo (wind) in the direction of the radar beam. The intensity of the radar echo can be used to calculate instantaneous intensity of rain, which can further provide an indication of the depth of rainfall (over an hour, for example).
- The weather radar network produces the greatest benefit for the observation of current weather, particularly rain and snowfall, and forecasting for the next few hours, because the observation density is at least a thousand times higher than that of the conventional rain recorder network. Wind measurements by Doppler weather radars are utilised by the aviation weather service in particular. Weather radars can detect dangerous phenomena such as heavy rain, hail, thunder and tornados, but the accurate determination of these will require a lot of further research and development.
- A single weather radar provides approximately 50,000 measurement values at 5 minute intervals, covering rainfall as well as velocity up to a distance of 250 km from the radar site. In the horizontal direction, there are observation points at approximate intervals of one kilometre.
- The Finnish Meteorological Institute's seven Doppler radars for the weather service are located at Korppoo, Vantaa, Anjalankoski, Ikaalinen, Kuopio, Utajärvi and Sodankylä (Luostotunturi). An eighth radar will be installed in 2005 at Vimpeli. The University of Helsinki has a weather radar for research purposes, and Vaisala Corporation is developing a prototype for the next generation of radars. There are approximately 100 weather radars in continuous service in Europe. The price of a single weather radar system is approximately 2 million euros, and the service life is approximately 15 years.
- The availability of radar information from the radar network of the Finnish Meteorological Institute is the best in the world (99.4% in 2003), and the high standard of the Institute's competence is internationally recognised.
- The Institute provides its customers with thousands of data and image files based on weather radar measurements each hour. Major users of radar data include the Finnish Road Administration (road maintenance during snowfall), the Defence Forces, the broadcasting networks YLE, MTV and HTV, as well as enterprises and individuals (fee-based Internet and WAP services can provide radar images to mobile phones, for example).

The Finnish Meteorological Institute monitors the weather around the clock. Today weather forecasting is strongly based on numerical weather forecasting models. These models use weather observations as their source of information and produce weather forecasts several times a day, with the longest forecasts extending to ten days. Atmospheric modelling is one of the most important users of observation information. The most extreme atmospheric events related to weather are often small and regional. The spatial resolution of the models is very significant from the point of view of predicting extreme weather events. The most exact model currently used by the Finnish Meteorological Institute describes atmospheric events on a scale that is about 10 km at its smallest. Models will probably not achieve the level of detailed prediction of thunderstorm damage, but even the current models can anticipate weather conditions and areas susceptible to thunderstorm damage.

Weather observations create a foundation for planning several functions of the society, assessing risks caused by weather and the climate, and setting standards such as the safety standards applicable to construction. The statistical analysis of the return periods of extreme values is one of the central tasks. For example, it can be estimated that rainfalls similar to those corresponding to the three-day rain accumulations causing the flooding of the River Vantaanjoki in the summer of 2004 will be repeated at one or more Finnish measurement stations at intervals of about three years. If, however, an individual rain station is examined, similar rainfall will only be repeated after several centuries. What was exceptional with the heavy rains in the summer of 2004 was their extent: abundant rains reaching such a wide area occur in Finland less than once every 15 years.

Numerical weather prediction models develop rapidly and are able to describe not only actual weather variables, such as wind and temperature, but also other variables closely related to the atmosphere, such as sea currents and waves, air quality, the spread of dangerous substances, harmful UV radiation and the state of the upper atmosphere. The information produced by the models, together with observation data, will produce the information needed in future society.

The Finnish Institute of Marine Research monitors the situation in the Baltic Sea with regard to ice, water level and waves. The databases on ice, water level and waves form an important and widely used starting point for studying climate change in sea areas and its impacts. The wave and water level service carries out measurements and surveys e.g. for harbour and route planning, charting and construction operations, accident investigation and navigation. Water level observations are conducted using 13 mareographs on Finland's coasts. The taking of measurements began in 1850 and the majority of the continuously registering mareographs were built in the 1920s. This is an extraordinarily long time series of exact water level measurements. The height, period and direction of waves are measured using three wave buoys. The taking of these measurements began in 1972 (in 1990 for the direction of waves).

The ice situation of the Baltic Sea has been monitored since 1915. Observations concern ice coverage, thickness, ice types and banking up. The ice service of the Finnish Institute of Marine Research monitors the ice situation every day and prepares ice charts and ice reports based on the information collected and analysed. The service also produces an ice movement forecast for the next few days and a development forecast for the ice situation covering slightly more than a week. The service is used by:

- Shippers, charterers, icebreakers (the Finnish Maritime Administration) and other vessels,
- Pilots, the Coast Guard and port authorities,
- Fishermen and the fishing industry,
- Researchers,
- Weather service, media and the general public.

Forty per cent of Finland's sea transports are carried out in the winter, and more than 90% of international sea transports are bound to schedules, which is why a quick and reliable ice service is needed. The majority of users need ice information daily, but long-term information is also needed for strategic planning.

The information society has brought new demands on the information to be produced. The Finnish Meteorological Institute continuously observes the events of the upper atmosphere at approximately 30 magnetic field measurement points. Eight aurora cameras record aurora activity in the area of Lapland. Variations in space-weather may cause so-called geomagnetically induced currents (GIC) in the natural gas and high-voltage power grids. The Finnish Meteorological Institute can use observations of the Earth's magnetic field and a mathematical model to indirectly calculate these electrical currents everywhere in Finland, thus anticipating the corrosion of natural gas pipes and the disturbances caused to transformers within the power grid.

The present warning systems

The Finnish Meteorological Institute's weather service system is responsible for issuing warnings associated with extreme weather events. The Institute's climate service is responsible for other reporting related to climatically exceptional weather situations and compiles statistical data on monthly temperature and rain conditions.

The central tasks of the Finnish Meteorological Institute's weather service include the production of weather and air quality forecasts, spreadout calculations and warnings related to weather, as well as informing interested parties about them. The Communications Market Act and the decree that entered into force on 15 October 2003 oblige the Finnish Meteorological Institute to provide warnings with an emergency notice or other official notice in case of a danger or threat to industry. The European Union regulates the supervision and reporting of air quality through directives.

The Radiation and Nuclear Safety Authority and the Finnish Meteorological Institute are responsible for the atmospheric radiation monitoring network. When values deviating from the ordinary are detected, a warning is issued to other authorities involved in national radiation supervision (the Ministry of the Interior, the Ministry of Social Affairs and Health, and the Defence Forces). The Finnish Meteorological Institute prepares forecasts on the propagation of radioactivity, and has the operational facilities for producing information about the spread of other dangerous substances in case of accidents. Designated monitoring and warning systems exist for the ozone content of surface air and the intensity of harmful UV radiation. The general public will be warned of a high ozone concentration when the limits set by the EU are exceeded. The Finnish Meteorological Institute is also equipped to warn of GIC currents appearing in connection with space-weather storms.

Needs for development in the changing climate

The pace of the ongoing climate change sets its own demands on the needs for the development of warning and monitoring systems: the faster the climate changes, the less can we rely on experience when predicting weather events and estimating their return periods. This emphasises the significance of wide understanding and modelling of atmospheric events. Because of the special circumstances in Finland, it is indeed important to maintain our own strong expertise in weather and climate issues. Due to our extreme northern location no-one can understand the living conditions in Finland better than we do ourselves.

Adaptation to climate change can be promoted in Finland by producing information about the Earth's climate system and the detailed impacts of climate change in the different sectors of the society, and by choosing the adaptation measures best suited for each sector. For example, the rain intensity observations conducted by the Finnish Meteorological Institute should be extended to cover some 50 population centres in addition to the current four or five. Likewise, the observation of ground water should be extended.

Possibilities for utilising information in different sectors

Existing warning and monitoring systems produce great amounts of useful. In addition to the sectors described in Section 4.1, a number of other parties utilise the information and participate in the transmission of weather forecasts and warnings, the monitoring of radioactivity in surface air (the Radiation and Nuclear Safety Authority, the Ministry of the Interior and the Defence Forces), the monitoring of gas and power grids and the securing of the functionality of telecommunications in connection with space-weather storms. New sectors of society utilising monitoring data will emerge continuously. Studies on the impacts of harmful UV radiation have been initiated by the rubber industry, plastics industry, paper industry and coating industry, among others. A study on the public health impact of UV radiation has also begun.

Case studies could be used to improve the readiness of many sectors to face the ongoing climate change. For example, extremely precise meteorological and hydrological observation data exists on the 2004 flooding of River Vantaanjoki. Plenty of recent and documented information also exists on the impacts of floods in different sectors of society. This means that researchers of climate change impacts are provided with a favourable research frame for testing the functionality of impact models and simultaneously evaluating the impact of various adaptation measures. It is expected that the ongoing climate change will change the return periods of extreme weather events. Tested impact models could therefore be used to study the cost efficiency of different adaptation measures in changed climatic conditions.

4.3.3. Research and development

Present state of research and development

In international comparison, research on climate change and its impacts started early in Finland, but the adaptation to climate change has not been studied very much as yet.

The Finnish Research Programme on Climate Change (SILMU), funded by the Academy of Finland (approximately 16 M€), was carried out in 1990–1995. The programme produced the first scenarios on the changes to the Finnish climate and included impact assessment in key sectors. Adaptation issues were dealt with at a very preliminarily level.

The second programme of the Academy of Finland, 1999–2002, the Finnish Global Change Research Programme (FIGARE, approximately 7 M€) updated the climate scenarios and extended the field of research from the natural sciences to economic and social issues. Its objective was also to look for social, economic and technical solutions aimed at influencing climate change and facilitating adaptation. The results of the programme focused on the impacts of climate change.

The objective of the Technology and Climate Change programme 1999–2002 (Climtech, approximately 5 M€) conducted by the National Technology Agency (Tekes) was to promote technology that restricts climate change and to support the achievement of climate targets. The results achieved in the programme laid the foundation for research and investment decisions associated with energy and emissions technology and measures for adapting to climate change. As a continuation to the Climtech programme, the Business Opportunities in Mitigating Climate Change programme was launched for the years 2004–2008 (ClimBus, 70 M€). The programme promotes the opportunities of Finnish actors to utilise the new market situation created by measures restricting global emissions.

The Finnish Environment Institute prepared a preliminary report on adaptation to climate change in Finland in 2003. According to the report, climate change impacts have been studied in sectors directly affected by climate change, such as agriculture, forestry and sectors associated with water resources. However, the level of knowledge reached by actual adaptation research remains quite low in all sectors. The environment cluster started the FINADAPT project (0.3 M€), which will prepare an estimate on the adaptive capacity of the Finnish society and environment to the impacts of climate change in 2004–2005 and attempts to identify the shortcomings of information and the needs for further study.

The Finnish Meteorological Institute, the Finnish Institute of Marine Research, the Centre for Scientific Computing and the Universities of Helsinki and Kuopio are involved in the international joint development of the COSMOS model for describing the climatic system (MinTC funding 0.7 M€ for 2004–2007). The objectives include, among other things, the reduction of the uncertainties of climate simulations related to atmospheric fine particles, clouds and sea ice, and serving the information needs of Finnish climate change impact and adaptation studies.

Research work related to climate change is international. Research institutions located in different countries are developing models that predict climate change, produce climate change scenarios and investigate the impacts of climate change. The Intergovernmental Panel on Climate Change (IPCC) compiles information and prepares comprehensive evaluation reports on climate change, its impacts, adaptation and mitigation. An extensive description of the impacts of climate change in Arctic regions was prepared in 2004, commissioned by the Arctic Council. Nordic meteorological institutions have networked in the NORDADAPT project to satisfy information needs for the study of climate change impacts and adaptation. Furthermore, research institutions, universities and the Academy of Finland are involved in wide international, EU and bilateral scientific cooperation. National research projects and research institutions apply research information obtained from international sources in their own work.

Research carried out in many sectors in Finland is also indirectly connected to climate change research even though the main purpose has been to respond to other information needs. Research associated with adaptation to climate change has been carried out within certain sectors (for example, forestry, agriculture, navigation, road traffic) in recent years, but as a whole there is still an obvious need to expand the knowledge base. Also, the report on the implementation of the climate strategy submitted to the Finnish Parliament in 2003 refers strongly to the need to develop adaptation research.

Research needs

Research concerning the impacts of climate change and adaptation calls for further development in Finland. Information supporting decision-making in the society can be best produced by integrating information on climate change, its impacts and different adaptation measures. This means that adaptation research always requires both climate research and impact research. In addition to the examination of average changes, the research must include preparation for extreme weather events.

The research needs of the sectors have been described in this report in the section dealing with each sector. In addition to sector-specific studies, compiling and coordinating research is required to respond to the information needs of society regarding adaptation to climate change. It is particularly important that researchers find a common and understandable language for conveying research results to decision-makers. From the point of view of decision-making, the significance of economic analysis receives considerable emphasis. These studies have been only preliminary until now, and there is still plenty of work to do in the development of research methods.

Research must be of a high scientific standard, but at the same time it must produce practical information about the possible adaptation measures. The requirement for a high scientific standard ensures that adaptation will be based on as reliable information as possible, and the requirement for practicality ensures that the information can be utilised in practice. Furthermore, it must be ensured that science and practice are in mutual interaction. Research supporting adaptation to climate change must observe some aspects associated with research methods and contents:

- Cross-sectorality (including the relation of climate change to other change factors)
- Comparability of research results from different sectors
- International research cooperation
- Multidisciplinarity (the integration of research on the impacts of climate change and adaptation measures with other environmental research and with social and technological research)
- Information requirements for decision-making and practical measures

- Common real-time climate information to meet the needs of research and practical operations (developing a climate data bank and distributing information for research and the planning of adaptation actions)
- Uncertainties (climate change scenarios, impact assessments, effectiveness of adaptation measures)
- Connection with climate change mitigation (coordination of impact and adaptation research and research aimed at mitigation)
- Development of research, planning and assessment methods (cost-benefit, cost efficiency, risk and multicriteria analyses, development of public participation)
- Economic impact assessments (optimisation of mitigation and adaptation, uncertainty estimates).

Further measures for research and development

As part of implementing the National Adaptation Strategy, it is necessary to intensify existing research and development in accordance with the policies specified above. Furthermore, a five-year adaptation research programme should be started to improve adaptive capacity. The research programme should be prepared in cooperation between ministries in the latter half of 2005. The objective of the research programme is to strengthen the adaptation research cooperation in different sectors and to start research projects in critical sectors. Furthermore, information would also be produced for the purposes of projects outside the programme itself. Another objective of the programme would be to transfer information and suitable methods to decision-makers and interest groups. The planning of the research programme would observe the Adaptation Strategy as well as research needs identified in other research programmes.

The research programme will require new resources and it would be suitable to carry it out in two stages. In 2006–2008 the research programme would concentrate on the further development of information material on climate change in addition to adaptation research, as well as filling in the gaps in impact information in different sectors. After mid-term evaluation, the research would be focused on improving the adaptation capacities of different sectors in 2009–2010. The information obtained through the research programme would be used for purposes such as revising the Adaptation Strategy and communication of adaptation to climate change.

4.3.4. Education and communication

Education

Education and training have an important role in increasing the awareness of all citizens on climate change. Sustainable development is included as a thematic subject in the new curricula in comprehensive schools as well as upper secondary schools. Issues related to climate change are part of the sustainable development programme. In vocational education, the promotion of sustainable development is part of curricula in all sectors. This represents a very concrete measure for awareness building. The environmental awareness of children and adolescents is also developed at day care centres and schools. From day care to vocational education, institutions can apply for a green flag or environmental certificate indicating compliance with certain environmental criteria. The use of the system will be extended in the future.

Climate change and impacts and adaptation should be integrated into the curricula at all levels of education. For example, higher education must be supplemented so that there will be experts on climate change issues in Finland.

Climate Change Communications Programme

In its statement regarding the previous climate strategy 2001, the Finnish Parliament stated that extensive dissemination of information on climate change and the ways in which citizens, enterprises, organisations and communities can influence its mitigation in their own activities will be needed.

The Climate Change Communications Programme launched in September 2002, funded by the Ministry of Trade and Industry (approximately 1.2 M by the end of 2004), is carried out in close cooperation between the Ministry of the Environment, the Ministry of Transport and Communications, the Ministry of Agriculture and Forestry and the National Board of Education. The programme provides funding for 35 communications projects directed at different target groups: for example, enterprises in the energy and waste sectors, organisations and municipal bodies, teachers, and entrepreneurs in agriculture and forestry. The projects are used, for example, to raise awareness of how each and every person can contribute to the mitigation of climate change through his or her own actions.

Communication of the Adaptation Strategy

Successful communication can be used to raise the level of public awareness and, through this, the capacities for adaptation. The objective is to convey information produced by the Adaptation Strategy and the proposed adaptation research programme to interest groups, actors and decision-makers in different sectors.

So far, the climate change communication programme has focused on providing information on the impacts of climate change and the measures required to mitigate such impacts. The communications programme could be aimed at information on adaptation to climate change as well. Furthermore, adaptation to climate change will be included in the communications of different sectors. When the sectors and the proposed adaptation research programmes start to produce more detailed information and views after five years or so, the planning of sector-specific guides and other material on adaptation to climate change could be prepared. If started well in advance, communication would also support the building up of the capacities for crisis communications.

5. Impacts and follow-up of the Adaptation Strategy

5.1. Impacts of the Adaptation Strategy

The National Adaptation Strategy for climate change describes the scenarios of climate change, socio-economic development and natural systems. The impacts of climate change and adaptation to it have been assessed on the basis of existing information up until the year 2080. The estimates still include uncertainties. Some of the definitions of policies that have been presented in the strategy are still preliminary or they will be scheduled over a long time period. The most immediate measures, such as research, communications, revision of preparation and risk assessment systems, preparation for extreme weather events and the inclusion of adaptation aspects in sector-specific planning and international cooperation are "win-win" measures. These have positive impacts on the development of sectors and on sustainable development.

The sector-specific examinations of the Adaptation Strategy describe the characteristics and objectives of the sectors, including environmental objectives. The impacts of climate change have been assessed from the perspective of the development and environmental aspects of each sector. The definitions of policies presented are in line with objectives and measures aimed at improving the state of the environment.

The positive or negative impacts of climate change concern different groups of citizens. Based on present knowledge, the nature of Northern Finland and its inhabitants will be particularly sensitive to the impacts of climate change. Launching of the Adaptation Strategy measures will allow more detailed determination of how the impacts of climate change concern different groups and what kind of adaptation measures can be used to promote equal social development. However, this will require the development of research and assessment methods.

It is difficult to assess the economic impacts of climate change. Section 2.2.2 describes the estimates prepared in the SILMU research programme on changes due to climate change within certain sectors. However, the strategy does not include an overall estimate of the economic impacts of climate change in Finland or the costs of implementing the Adaptation Strategy.

The preparation of the National Adaptation Strategy for Climate Change has been an open process. The views of various authorities, experts, interest groups and citizens on the impacts of climate change and the policies for adaptation measures have been taken into consideration in the preparation of the strategy.

The key elements of the Adaptation Strategy for Climate Change will be included in the National Climate and Energy Strategy, which will be revised in 2005. An environmental impact assessment of the National Climate and Energy Strategy will also be carried out.

5.2. Follow-up

Implementation and follow-up of the Adaptation Strategy

The National Adaptation Strategy for Climate Change will be implemented within the sectors of the ministries in cooperation between different actors. Practical implementation will primarily be carried out through the actions of the sectors, i.e. various kinds of strategies and programmes. The present programmes and strategy usually cover a relatively short time period (five to ten years), but adaptation to climate change will allow the inclusion of a longer time perspective into the planning. Most of the independent adaptation measures carried out by the private sector and citizens may be expected to take place later in the future. The Adaptation Strategy will also be implemented through the planning of the ministries' operations and economy, as well as performance guidance of the bodies subject to the ministries. The implementation of the Adaptation Strategy for Climate Change will be monitored through the follow-up measures of each individual strategy and programme, and partly as regular follow-up carried out by administration.

With regard to cross-sectoral definitions of policies and international cooperation, monitoring and reporting will be carried out as part of the preparation pf climate policy, both nationally and internationally.

Indicators as follow-up tools

Various types of indicators for the monitoring of sustainable development, sectors, subject areas or strategies have been prepared in Finland and internationally for many years. A set of indicators will be compiled for the follow-up of the Climate Change Adaptation Strategy using existing indicators and supplementing them. The indicators describe the impacts of climate change and our adaptation to them. The compilation and reporting of data required by the adaptation follow-up indicators will be coordinated with other indicator work. Examples of preliminarily indicators are presented in Table 5.1.

Table 5.1. Preliminary set of indicators associated with the impacts of climate change and adaptation. (An individual indicator can describe both the impacts of climate change and adaptation. In this context, the indicators have been divided on the basis of their primary character.)

Subject area	Description of impacts	Description of adaptation
General indicators concerning climate change	• Development of temperature (the indicator of sustainable development in Finland) • Breaking up of ice on River Tornionjoki (the indicator of sustainable development in Finland) • Starting time of ice coat and time of breaking up of ice in water systems (new) • Beginning and ending of snow cover (new) • Heat sum of the growing season (new) • Recurring times of extreme weather events (new)	
Natural resources	• Quality of soil in arable land (natural resource indicator) • Diversity of natural species in agriculture (natural resource indicator)	• Food self-sufficiency (natural resource indicator) • Use of pesticides and environmental risks (natural resource indicator)
	• Damage caused by biotic and abiotic agents (criteria and indicators for sustainable forestry, indicator 2.4) • Endangered and vulnerable species and species with special demands (indicator 4.2) • Area of forestry land in protected forest areas (indicator 5.5)	• Carbon balance (indicator 1.8) • Increment of growing stock and total drain (indicators 3.2 and 3.3) • Silviculture and forest improvement measures (indicator 3.6) • Tree species composition (indicator 4.5) • Pure and mixed forest stands (indicator 4.6) • Gene reserve forests (indicator 4.8)
	• State of fish populations (natural resource indicator)	• State of production (natural resource indicator)
	• Ecological carrying capacity of the reindeer herding area (natural resource indicator)	• Productivity of reindeer stock (natural resource indicator)
	• Game stock (natural resource indicator) • Game richness (natural resource indicator)	• Hunting (natural resource indicator)
	• Usability of water resources and ecological state of water systems (water resource indicator 4)	• Functionality of the water supply and sewerage in exceptional situations (water resource indicator 2) • Dam safety (water resource indicator 5) • Protection against floods (water resource indicator 6) • State of basic drainage (water resource indicator 7) • Availability of real-time water information (water resource indicator 8) • Condition and functioning of the state's water system structures (water resource indicator 11)
Biodiversity	• Threatened species (indicator of sustainable development in Finland) • Threatened species by habitat (indicator of sustainable development in Finland)	
Transport and communications	• Snowfall in road traffic (new) • Occurrence of exceptional situations caused by weather events on sea traffic, air traffic and road traffic (new)	• Length of the ice breaking assistance season (new) • Length of the ice restriction period (new) • Number of snow ploughings on roads (new) • Number of de-icing salt applications on roads (new)

Review of the Adaptation Strategy

The National Adaptation Strategy will be revised in connection with the revision of the national climate and energy strategy. The evaluation of the implementation of the Adaptation Strategy and the determination of additional measures should be completed within six to eight years, once research and sector-specific work has provided new and more detailed information and experiences on climate change, its impacts and adaptation.

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APPENDIX: IPCC emission scenarios

Future emissions of greenhouse gases cannot naturally be known in advance. Therefore a set of *emissions scenarios* has been created. These are potential and internally logical estimates of the development of emissions in the future.

Emissions scenarios are presented in detail in an IPCC[23] Special Report (Nakicenovic et al., 2000). It examines four storylines, the first of which is further divided into three sub-scenarios. The following is a general description of the consumption society scenarios (A scenarios) and the scenarios aimed at sustainable development (B scenarios).

The A1 scenario family describes a future world where economic growth is very rapid and the global population increases until the middle of this century, after which it starts to gradually diminish. Technological development is rapid and new technology is quickly introduced all over the world. Differences between the development of different regions of the world are estimated to be reduced, and the distribution of income will become more even. The A1 scenario family is divided into three sub-scenarios. The A1FI scenario assumes that energy production in the future will be based particularly on fossil fuels, while the A1T scenario assumes production by non-fossil sources. The A1B scenario is an intermediate form between these alternatives.

In the A2 scenario, the differences in development between industrialised countries and developing countries will remain great. The different regions of the globe strive for self-sufficiency and the preservation of their special characteristics. Technology transfer to developing countries is minor, and differences in income between different countries remain great. Overall economic development on the global scale is slower than in the A1 scenarios. Population growth continues at a rapid pace in developing countries, and the global population increases.

In the B1 scenario, differences between industrialised and developing countries even out, which makes population growth calm down like in the A1 scenarios. The difference in comparison to the A scenarios is that the economy is more directed towards the development of services and information society rather than the production of goods. Sustainable development is highly appreciated, and the development and introduction of environmentally

[23] www.ipcc.ch

friendly technology is rapid. Effort is made to find global solutions to problems that are fair to the entire human race and take the conservation of the environment into consideration.

The B2 scenario also aims to take environmental aspects into consideration in decision-making, but decisions are more determined on the basis of local interests. Differences between the development of different regions remain great and population growth continues, although at a less rapid pace than in the A2 scenario. Economic and technological development is moderately rapid but unbalanced between the regions of the globe.

Figure L1 illustrates the estimated development of carbon dioxide emissions by 2100 in each of the six scenarios. Only in two scenarios (A1T and B1) are the emissions lower in 2100 than at present. Figure L2 illustrates future concentrations of atmospheric carbon dioxide calculated by carbon circulation models. With the exception of the A1T and B1 scenarios, the concentration will still be clearly increasing in 2100. In the A1FI and A2 scenarios, the concentration at that time is approximately three times the natural level before the industrial revolution. It should be noted that the CO_2 concentrations anticipated by the different scenarios will only start to clearly diverge in the middle of the century.

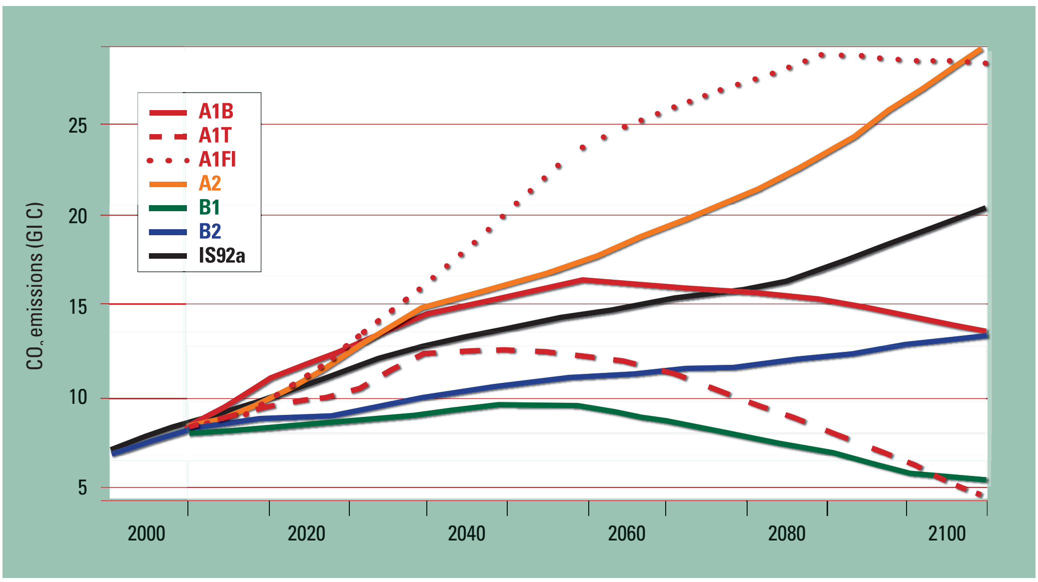

Figure L1. *Anthropogenic CO_2 emissions in 1990–2100 according to the different scenarios (in addition to the six SRES scenarios, the older IS92 scenario is shown for comparison). Source: IPCC, 2001; Technical summary, Figure 17.*

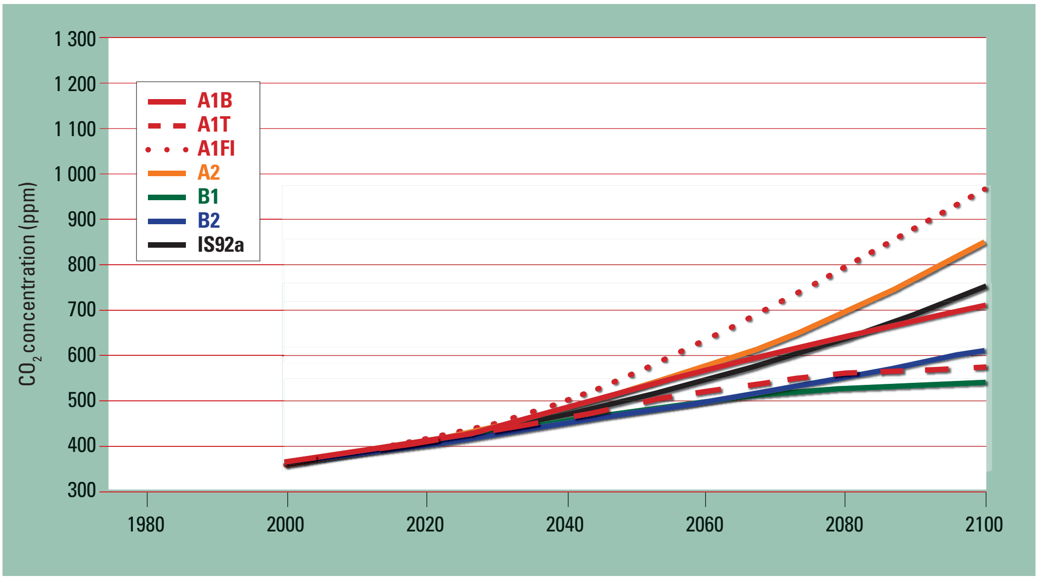

Figure L2. *Atmospheric CO_2 concentrations in 1990–2100 calculated on the basis of the emissions scenarios in Figure L1. Source: IPCC, 2001; Technical summary, Figure 18.*