ROADMAP FOR CLIMATE CHANGE ADAPTATION IN NORTH KARELIA – TOOLS FOR MUNICIPAL CLIMATE WORK

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Climate Change in the Programs of North Karelia

The Regional Council of North Karelia updated the North Karelia Climate and Energy Programme (CE2030) in 2021 (Regional Council of North Karelia 2021). The goal is a climate-resilient North Karelia by 2030. In 2022, an action plan was prepared for the programme, describing actions to mitigate climate change and, to some extent, also to adapt to its impacts. However, the adaptation actions presented in the action plan remained quite general. Therefore, in 2024, it was decided to create a separate climate change adaptation roadmap to supplement the CE2030 programme. This roadmap includes more concrete means, suitable for the municipalities, actors, and organisations of North Karelia, to prepare for the impacts of climate change and to ensure their operational capacity in a changing climate. These are essential elements to be included to each municipality or other actor's own climate plans.

The climate change adaptation roadmap complements the North Karelia CE2030 programme and its action plan. Together, these three documents implement the objectives of the new regional programme of North Karelia, POKAT2029, particularly under the themes of an attractive living environment and biodiversity as well as the smart transition.

What is Climate Change Adaptation and Why is It Important?

Climate Change Adaptation

According to the Climate Act of Finland (2022), climate change adaptation refers to actions through which different actors and sectors of society prepare for and adjust to climate change and its impacts, as well as actions that allow society to benefit from the effects of climate change. Climate change and adaptation to it also include an economic perspective. From an economic perspective, climate change adaptation means changes made by economic actors in consumption, production, and investments. These actions aim to avoid economic losses or promote benefits arising from climate change, either directly or indirectly. From an economic perspective, the management of the financial risks arising from climate change is at the core of adaptation.

Table 1 below presents the direct costs of major extreme weather phenomenon in Finland. It is adapted from the Finnish Climate Panel's national report (Climate Panel 2021).

Table 1. Direct costs of major extreme weather phenomenon in Finland (adapted from the Finnish Climate Panel's national report, 2021).

Phenomenon	Average cost per year (million euros)
Inland flooding	18,4
Coastal flooding	11
Forest damage	
Storms, snow, and frost (insurance compensations)	11–18
Forest diseases (lost stumpage income)	40–60
Power outages (storms, snow)	14 (compensations paid by electricity companies)
Heatwaves (deaths)	200–400 / year, of which 30 % in the Helsinki metropolitan area
Lyme disease (number of patients)	Increase from 1,143 cases in 2004 to 2,064 cases in 2020
TBE (number of patients)	Increase from 29 cases in 2004 to 91 cases in 2020

More detailed information on the subject can be found in the Finnish Climate Panel's Finland Report. The Climate Panel used the KUITTI project as its source—a research project led by the Finnish Meteorological Institute (Finnish Meteorological Institute 2022).

Equally accurate estimates in euros for each region have not been clarified. The final report of the KUITTI project states that the impacts—and therefore the costs—of climate change vary by region, and the regional economic structure is the most significant factor influencing these costs. North Karelia, as a region with a strong forestry sector, may suffer more severely from climate change than other regions. The report also notes that a diverse economic structure helps the region adapt to losses caused by climate change. This should be a point of focus in North Karelia. The final report concludes that anticipating adaptation needs and implementing necessary actions brings economic benefits compared to a situation where reactions occur only after a change or realised risk.

Of the extreme weather events listed in Table 1, coastal floods do not concern North Karelia, but the region does have inland water bodies. Flood risk areas in North Karelia—and across Finland—can be viewed at: https://paikkatieto.ymparisto.fi/tulvakartat/Viewer/Index.html?Viewer=Tulvakartat_suppea. Additionally, the Finnish Climate Panel's Finland Report provides an assessment of flood expectations in North Karelia under a changing climate, as shown in Table 2.

Table 2. Flood risks in North Karelia and their projected changes because of climate change (adapted from the Finland Report, Climate Panel 2021).

North Karelia	Current flood risk	Flood risk in 2050
Inland (river / lake) flooding	Moderate	No change / Increasing
Stormwater flooding	Low to moderate	Increasing

Climate Change Adaptation Actions

Adaptation actions begin at the policy level (various laws, programmes, and effective decisions) and extend to practical actions. Practical actions can be implemented by every citizen, as well as by different organisations and companies in their own roles and operations. Adaptation is becoming increasingly important, as the climate has already changed and will continue to change. The extent of this change depends on the mitigation actions that are taken. Effective mitigation of greenhouse gas emissions can reduce the pressure on adaptation, but it can no longer avoid the need for it.

In the adaptation one must also consider the fact that climate change and the deterioration of biodiversity, or at least its change, are linked to each other. Climate change causes changes in biodiversity, and in turn, biodiversity loss has effects that intensify climate change, for example, by reducing ecosystems' ability to recover from natural disturbances. On the other hand, restoration of habitats can support multiple goals, such as strengthening biodiversity, improving water management, and contributing to both climate change adaptation and mitigation.

The Finnish Meteorological Institute and senior researcher Kirsti Jylhä developed a climate scenario for the North Karelia region extending to the year 2080 (as part of the FINSCAPES project). According to the scenario, the following changes are expected in North Karelia during this period:

- The average temperature is expected to rise by 4–8°C

- Annual precipitation is expected to be 700–800 mm, with winter rainfall becoming more common (precipitation as rain instead of snow)
- The length of the snow season may be reduced by half (from 90 days to 30–40 days)
- The beginning of the snow season will shift to December.

The Finnish Climate Panel's Finland Report provides a shorter-term forecast of climate change, up to the year 2050. This is presented in Table 3**.**

Table 3. Projected changes in weather and climate factors in North Karelia by the 2050s (adapted from the Finland Report, Finnish Meteorological Institute 2021; changes also color-coded).

Variable	Winter	Spring	Summer	Autumn	Year
Average temperature	Increases significantly	Increases significantly	Increases	Increases significantly	Increases significantly
Precipitation	Increases	Increases	No change	Increases	Increases
Length of thermal season	Shortens significantly	Lengthens	Lengthens	Lengthens	Cannot be determined
Daily maximum temperature	Increases significantly	Increases significantly	Increases	Increases significantly	Increases significantly
Daily minimum temperature	Increases significantly	Increases significantly	Increases	Increases significantly	Increases significantly
Number of frost days	Decreases	Decreases significantly	Decreases	Decreases significantly	Decreases significantly
Snow	Decreases significantly	Decreases significantly	Not relevant	Decreases significantly	Decreases significantly
Number of rainy days	Increases	Change uncertain	Decreases	Change uncertain	Increases
Intensity of heavy rainfall	Increases	Increases	Increases	Increases	Increases
Relative humidity	Increases	No change	No change	No change	Increases
Wind speed	Increases	Increases	No change	No change	No change
Amount of ground frost	Decreases significantly	Decreases significantly	Cannot be determined	Cannot be determined	Decreases significantly

If realised, these changes will significantly impact the vitality of the region and the well-being of its people, and they will cause costs for both society and individual residents. The natural environment will also change as the climate changes, posing challenges for maintaining biodiversity as habitats shift, as well as for the controlled transformation of nature-dependent sectors such as agriculture and forestry.

By being aware of the risks, preparing for them, and planning adaptation actions, the harmful effects of climate change can be reduced and more easily managed. On the other hand, climate change also brings opportunities, which should be recognised and turned into advantages. These include, for example, reduced winter heating costs for households and expanded agricultural possibilities through the introduction of new crop varieties that are successful in the region.

What are the Risks, Impacts, and Actions of Climate Change?

Climate change risks are climate-related risks that have become more important due to climate change. Impacts refer to how these risks affect nature, people, and livelihoods. Adaptation actions describe how we can prepare for and adjust to the effects of climate change, benefit from changes, and reduce the risks and potential negative impacts and consequences.

According to the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC 2014), the global common risks of climate change include: warming and associated extreme temperatures, droughts, heavy rainfall, severe storms, flooding, storm surges, ocean acidification, and the increase in plant growth caused by CO2 emissions through increased photosynthesis, which can have negative effects such as water body eutrophication. These risks vary by region across the globe. The severity of a risk depends on the intensity of the climate-related phenomena, as well as the level of vulnerability and exposure (IPCC 2014). How well risks are identified and how effectively they are addressed through appropriate adaptation actions directly influences the impact of those risks. This could be illustrated, for example, with the figure below.

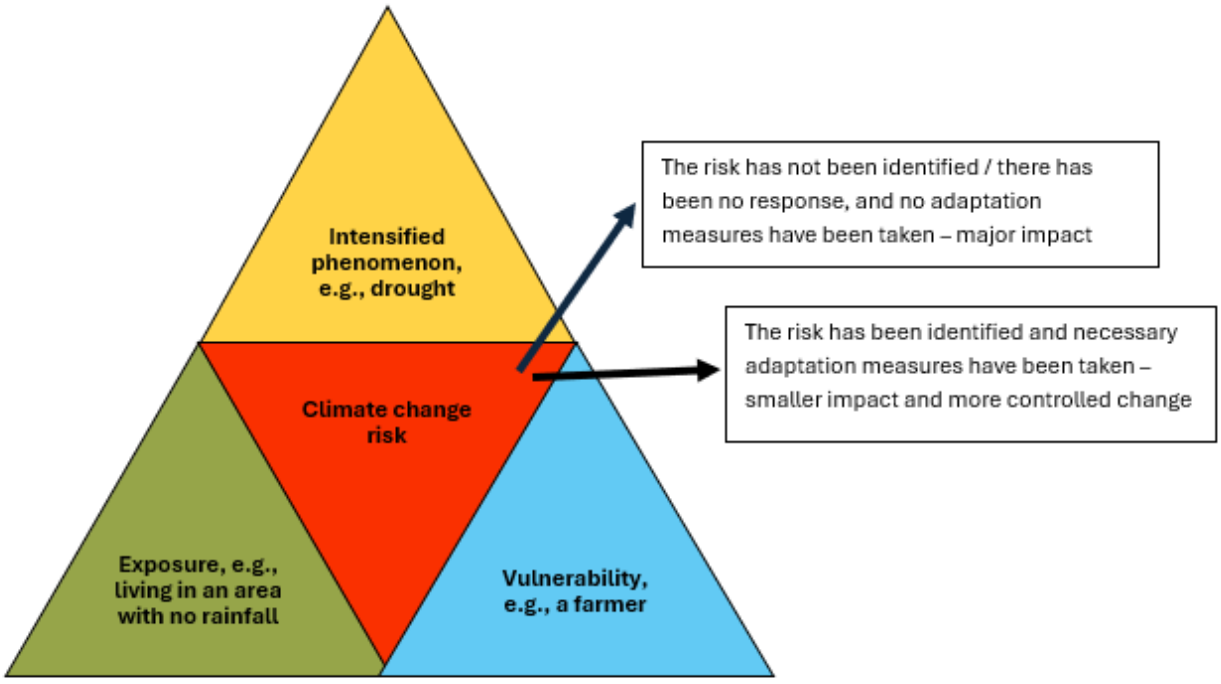


Figure 1. Factors influencing climate change risk and adaptation

Climate Change Phenomena Affecting North Karelia and Their Impacts

The significance and importance of climate change risks, their impacts, and the necessary actions become more evident when considering North Karelia's vulnerability to different phenomena. Vulnerability to climate-related risks is influenced by the severity of the phenomenon and how resilient or adaptable the affected environment, species, human, organisation, or livelihood is. For livelihoods, this also depends on how crucial the sector is as a source of income. For example, forestry in North Karelia faces major adaptation challenges if mitigation actions are not implemented in time or at a sufficient scale.

The climate-related phenomena expected to affect the region include increasing precipitation, especially in winter, changes in winter conditions, more frequent storms, and storm damages, rising temperatures, more frequent heatwaves, and droughts during the growing season, and resulting biodiversity loss or change. These will affect various sectors and areas of life in the region, such as transportation, population and public health, recreation, tourism, built infrastructure, energy production and communication networks, water systems, as well as agriculture and forestry.

Increased precipitation particularly refers to more frequent winter rainfall and more intense rainfall events. According to FINSCAPES results, the annual precipitation has traditionally varied significantly, and no clear long-term trend has been observed. However, the increase in storms is expected to bring more heavy rainfall, further intensifying rain events.

In the future North Karelia, spring will begin earlier as the thermal growing season threshold, when the daily average temperature reaches +5°C, is reached earlier. At the same time, autumns will be longer, as the onset of freezing temperatures and permanent snow cover is delayed. This can positively affect agricultural yields, as a longer growing season and milder winters enable the cultivation of later-maturing, higher-yielding crop varieties. However, the downside includes increased crop and forest damage, and weakened plant overwintering, especially if winter arrives unexpectedly and quickly, as happened in autumn 2023. In summer, intense heatwaves and droughts will become more common. At the same time, storms and associated heavy rainfall will increase, leading to surface flooding as dry soil is unable to absorb precipitation. Winters will become warmer, and snow-covered periods will shorten, which will lead to increased insect and fungal damage, changes in native species (both flora and fauna), and changes in crops and cultivated plant varieties.

Opportunities in this regard are provided by the above-mentioned increase in the length of the growing season. At best, this means a longer harvest season. This, together with the increase in the heat sum, makes it possible for agriculture and forestry to grow and use new plant, grain and tree species and varieties. This diversifies production and increases productivity. Forest growth is also expected to increase along the favourable growing conditions.

Rising temperatures also reduce energy costs, as the heating season shortens, and periods of extreme cold become less frequent and shorter. On the downside, cooling needs and associated energy consumption increase during heatwaves. In transportation infrastructure, some positive

effects include reduced need for snow plowing as winter precipitation increasingly falls as rain. Less ground frost also reduces road maintenance costs. However, storms, heavy rain, and floods will cause damage to buildings and road infrastructure. Increasing humidity will also lead to more mold damage in buildings unless construction practices take this into account.

The health and well-being impacts of climate change require further study, especially regarding indirect effects. Various symptoms of polar night and hot-cold stress symptoms may intensify, especially as winter conditions change. Longer snowless periods during the dark winter months could increase or worsen depression. The increase in slippery conditions during the winter has a negative impact on well-being and opportunities for wintertime recreation, especially for risk groups. The shortening of cold and snowy seasons also reduces traditional winter sports and recreational activities such as skiing and ice skating. Paid, cooled ski trails help to remedy the situation, but at the same time they increase the inequality of the population: is it possible for everyone to pay for the use of the ski trail or travel to the ski trail from their home?

From a nature perspective, most of the impacts are negative, at least in terms of native species development in North Karelia. As conditions change, species are forced to shift to north, and new species will move in. For some endangered habitats and species—such as the rare deciduous groves in North Karelia—conditions may improve. However, overall, the composition of biodiversity will change: the number of species may not decrease permanently, but the types of species, their abundance, and their status (e.g. endangered vs. generalist) will shift. From an adaptation perspective, the management and restoration of ecosystems and biological communities promote their ability to adapt to climate change, along with other pressures of change.

Extreme conditions will become more frequent throughout the year, with significant year-to-year variation. For example, in spring 2024, winter in the region lasted into May, and was followed by heatwaves within a few weeks. The hot conditions continued throughout the summer in various extended heatwave periods. Sometimes, North Karelia still experiences "classic old-fashioned winters," while at other times winters are warm and rainy. These shifts also affect mood and health, as well as opportunities for hobbies and recreation.

Indirect Impacts of Climate Change

Climate change also involves indirect impacts. These are changes in temperature, precipitation, or wind conditions, occurring elsewhere which eventually affect Finland through international chains. The report from the project *Indirect Impacts of Climate Change on Finland* (2016) presents effects on ecosystems, many of which are relevant to Finland and to North Karelia:

- changes in species and loss of biodiversity (e.g., a decrease in pollinators)
- increasing and spreading harm caused by invasive species, plant diseases, and insect pests to new areas
- rising risks of waterborne diseases in drinking water due to more frequent heavy rainfall, risks in swimming waters during heatwaves
- decline in forest health and increased exposure to damages (due to stress from more extreme weather events and reduced ground frost)
- increase in pollen levels caused by improved plant reproductive conditions resulting from elevated CO_2 levels. The increased amount of pollen is linked to the symptoms of allergy and asthma sufferers who react to pollen, and indirectly to the risk of allergies and asthma.

Preparing for these indirect impacts is also part of adapting to climate change. A key example of an indirect impact that significantly affects the profitability of agriculture is the impact on the price and availability of chemical fertilisers.

Climate Change-Related Phenomena, Vulnerabilities, and Risks in North Karelia

Climate change-related phenomena and associated risks in North Karelia are presented in Table 4. The data for the table has been compiled through expert work based on the climate strategies or programmes and adaptation plans of other regions and cities, as well as various related reports (list of references at the end of this document). The results of sub-regional stakeholder work have also been used. This work was conducted by Tyrsky Consulting Ltd and included six workshops—two in each sub-region. The workshops addressed climate change phenomena, impacts, risks, and necessary actions. The aim was to specify the regional roadmap if necessary.

The final report produced by Tyrsky shows that there are clear differences between the sub-regions, so a sub-regional report produced by Tyrsky has been attached to the regional roadmap. Together, these two documents form a source of information for climate change adaptation, from which municipalities and other stakeholders can draw necessary actions for their own climate plans, depending on which climate risks are considered the most important and impactful within their municipality and operations.

From an adaptation perspective, the city of Joensuu stands out among the sub-regions due to the challenges of its dense urban structure, such as the urban heat island effect and stormwater flood risk. Stormwater flooding caused by heavy rains is also a risk in other urban areas. The most significant vulnerability and exposure factors in the sub-regions include long distances, an ageing population, and a natural environment, economy, and lifestyle adapted to winter conditions. In the Joensuu sub-region, risks to the built environment were emphasised, while in Central Karelia and Pielinen Karelia, issues related to agriculture and forestry were more prominent.

Table 4. Climate Change-Related Phenomena, Vulnerability Factors, and the Most Significant Risks Related to Them in North Karelia

Phenomenon / Impact	Vulnerability Factors	Climate Change-Related Risks and Potential Benefits
Precipitation: Increase in total rainfall (especially winter rain), heavy rainfall, driving rain, increased stormwater runoff, spring floods, increased soil moisture, erosion caused by water, extreme drought, major fluctuations in water levels across regions and differences between sub-regions	Share of clay-based land (about one fifth of agricultural land) Buildings and transport infrastructure located in flood risk areas Number of pumping stations in flood risk areas Number of impervious surfaces (e.g., in urban, industrial, and port areas) Vulnerability of drinking water wells and sewer networks (especially in rural areas) Lack of preparedness (e.g., among residents and industrial sites) Inadequate or malfunctioning field drainage Social vulnerability (e.g., due to age, illness, economic status, or lack of access to information, sites difficult to evacuate) Functions dependent on cooling water systems Increasing construction (e.g. growing urban areas, wind and solar power construction), which increases the need for land drainage and limits flows in downstream areas Unnecessary or overly deep ditching (e.g., in peatland forests),	**Transport**: Road condition deterioration, frost damage, rapid changes in ice cover and road conditions increase accident and injury risks (e.g., slipping), clay soil flooding and sludging **Population:** Reduced mobility and decline in health and well-being (e.g., due to rainy conditions and lack of sunlight affecting mental health) **Infrastructure**: Increased strain in flood- and erosion-prone areas, more mudslides, stormwater and sewer network overload, insufficient capacity (especially wastewater treatment, transport infrastructure), increased pressure on buildings **Energy:** Decreased predictability of hydropower generation, changes in bioenergy production conditions **Water bodies**: Increased nutrient runoff (surface runoff), eutrophication and darkening of waters, deterioration of groundwater quality, stronger water quantity fluctuations – increased risk of floods and droughts, increased risk of waterborne diseases in drinking water during heavy rains and in bathing waters during heatwaves

	causing rapid water flow downstream Rail network and busy train traffic in and around flood risk areas Management of the rise in the water level in the upper reaches of the River Pielisjoki -effects on the municipalities and regions downstream, Pielinen is a lake that is not regulated, so the management of droughts and floods is a crucial issue	**Agriculture and forestry:** Property damage (e.g., crop and forest damage), impacts on water resources (drought during growing season), changes in native and economically important species, impacts on logging timing, damages to grain during heavy rain (pressing the stalks down), yield losses in crop quantity and quality, increased erosion and nutrient runoff, deteriorated soil productivity
Phenomenon / Impact	**Vulnerability Factors**	**Climate Change-Related Risk and Potential Benefits**
Changes in winter conditions: shorter winter season, reduced number of frost and snow-covered days, increased freeze-thaw cycles in winter, precipitation increases during winter (winter precipitation), more frequent winter floods, changes in ground frost conditions, thinner snow cover, increased erosion, blizzards, changes in ice cover, sharper frost spikes, loss of ice roads, and reduced opportunities for traditional winter outdoor activities	Large water bodies: increased accident risk during periods of thin ice Inadequate preparedness for slippery conditions in traffic and outdoor work areas, elderly population more vulnerable (e.g., to slipping accidents) Operations in agriculture and forestry sensitive to winter changes (e.g., timber harvesting, overwintering of autumn-sown crops, perennial garden plants, and grasslands become more difficult) Inadequate snow removal capacity (e.g., rural areas where farms traditionally handled ploughing, the reduction of farms affects capacity) Long distances and limited public transport (increases need for private driving and traffic accident risk) Poor road conditions and maintenance backlog	**Infrastructure:** Degradation of road infrastructure (e.g., frost damage), freezing of sewer and stormwater networks, system overload and deterioration, increased property damage **Agriculture and forestry:** Changing harvesting conditions due to lack of snow and ground frost, increase in forest growth, increased nutrient runoff during winter rains, property damage (due to more pests and plant diseases), changes in species overwintering, reduced frost => weaker soil structure in clay soils **Tourism:** Negative effects on winter tourism and recreation (lack of snow, unsafe ice), threats to cultural heritage and potential landscape changes (e.g., damage to historic buildings and natural sites), reduced appeal for ice-fishing tourism – on the other hand, increase in visitors from other parts of Europe

	Limited snow storage capacity in city centres Longer and more intense pollen seasons	**Water bodies:** The darkening of the water and the increase in the amount of solid material, the fishing industry changes (winter fishing and species changes) **Energy**: Increased power outages and energy availability problems, decreased heating costs
Phenomenon / Impact	**Vulnerability Factors**	**Climate Change-Related Risks and Potential Benefits**
Storms: Intensifying storms and thunder, stronger winds, more intense summer and winter storms and rainfall, increasing wind speeds, rising precipitation, and flood risks	Number of overhead power lines by area Trees in poor condition growing near highways, train tracks and properties are vulnerable to damage caused by strong winds and blowing snow and threatening the infrastructure Condition and location of properties in high-risk areas (e.g., areas prone to intense winds) Lack of backup systems (e.g., emergency power systems) Critical transport routes located in areas exposed to storms, intense winds, and floods	**Agriculture and forestry**: Increased property damage to fields and forests (especially in open areas such as clear-cuts and their edges, or yards), increased forest damage (e.g., fallen trees become susceptible to insect infestations and fungal diseases), increased flood damage to fields **Road and building infrastructure:** Especially in sparsely populated areas – road disruptions from fallen trees, increased property damage, urban structures can intensify impacts (e.g., wind tunnels between buildings), underpass tunnels and the inadequacy of their water management (floods), waterways are overloaded because of this, weakened condition of trees **Energy**: Increased vulnerability of power grids and energy supply, telecommunications disrupted (e.g., tall communication masts are vulnerable to storm winds), reduced availability of energy for critical systems, increased power outages, damage to

		automated systems, IT infrastructure, and physical networks **Well-being:** Increased risk of accidents and injuries – healthcare system may become overwhelmed, reduced access to medical services, mental well-being declines due to extended darkness caused by winter rains
Phenomenon / Impact	**Vulnerability Factors**	**Climate Change-Related Risks and Potential Benefits**
Rising temperatures: More frequent and intense heatwaves, reduced snow and ice cover, changes in ground frost, longer warm periods, rising water temperatures, prolonged droughts and heatwaves - impact on urban green areas, urban heat in built environments, longer and more intense pollen seasons	Number of ecosystems and species sensitive to heat (e.g., water bodies) Crops and tree species suffering from drought (e.g., spruce) Outdoor workers exposed to heat and direct sunlight Elderly people, children, and individuals in risk groups Areas prone to forest and wildfires due to heat and drought, lack of forest road infrastructure Industries dependent on cooling (e.g., food industry) Built environments that heat up easily (e.g., large asphalt-covered areas) Heat-retaining building and surface materials (urban heat island effect) Inadequate cooling systems in residential buildings Workers doing heavy labour or exposed to heat	**Population:** Special groups, especially the elderly, the sick, children and people with reduced mobility suffer from heat and reduced mobility, increased mortality, increased pollen levels affect respiratory health and diseases, outdoor working conditions worsen **Urban infrastructure**: Densely built city areas (e.g., building walls radiating heat) and old properties (lacking cooling systems) are prone to overheating, urban greenery microclimates change – soil dries out and watering demand increases **Agriculture and forestry**: Timber supply may be threatened, timing of the harvesting becomes harder due to lack of frost, potential benefits: forest growth may increase, range of tree species expands (southern species such as hardwoods), longer growing seasons. Risks: heat and drought reduce growth,

	Electricity distribution on network capacity may weaken during summer due to the peak in demand summer due to increased cooling needs	increasing risk of forest and wildfires, food security may decline if crop yields fall or quality decreases, vegetation zones shift northwards (changes in cultivated crops), increased irrigation needs, reduced frost impacts clay soil structure negatively, more plant diseases, pests, foreign and weed species, animal heat stress reduces welfare and production, animal disease risk increases, benefits: southern species may thrive, more diverse crops and rotation, warming + increased CO_2 may boost yields, lower heating needs for livestock buildings, longer grazing season for domestic animals **Culture:** Traditional biotopes and cultural landscapes may disappear or change drastically (due to unsuitable conditions) **Water bodies:** Water quality deteriorates, drought followed by heavy rain increases acidity and toxic metal runoff from acid sulphate soils and black shale areas, groundwater availability is threatened (groundwater level drops), biodiversity changes, eutrophication and algal blooms increase **Tourism:** Especially winter tourism and recreation suffer; however, more extreme heat and wildfire events elsewhere (e.g., southern Europe) may

		increase summer tourism in Finland
Phenomenon / Impact	**Vulnerability Factors**	**Climate Change-Related Risks and Potential Benefits**
Biodiversity loss / decline in natural diversity: Changes in habitats, spread of pests, harmful plant diseases, foreign and non-native species, deterioration and change in growing conditions, longer growing seasons, vegetation zones shifting, impacts on urban greenery, increased disease risks (e.g. tick-borne diseases)	Monocultures (e.g., single-species stands), and overly intensive agriculture and forestry – especially even-aged, single-species forests are more vulnerable to large-scale fungal and insect damage and recover more poorly Number of sensitive natural ecosystems (e.g., traditional biotopes, ridges, wetlands) Land connection to the east and south via Russia, potentially accelerating the spread of new plant and animal species and diseases into the region Wooden buildings exposed to pests	**Nature:** Vegetation zones are shifting to north, and habitats are changing - forest and wetland vegetation is altering, and natural areas vulnerable to storms are especially affected Ecosystem services are weakening, species diversity is declining, and the resilience of areas to damage and their recovery capacity is decreasing Foreign species and pests are increasing The overwintering ability of species, including endangered ones (e.g., the Saimaa ringed seal), is at risk. On the other hand, various and new species may survive in the area and contribute to biodiversity. **Agriculture and Forestry:** These sectors are changing due to changing conditions, with a decline in traditional crop species and an increase in new ones Species composition is changing and may become more homogeneous The ability of areas to withstand damage and recover is decreasing, while invasive species and pests are increasing **Urban Infrastructure:** Urban greenery is diminishing due to increased drought and heat,

		while heavy rainfall causes damage, the impact of pests is growing **Culture:** Traditional biotopes and cultural landscapes are disappearing or changing significantly **Water Bodies**: Water bodies are becoming more eutrophic, and water quality is deteriorating, fish populations are changing

Adaptation to Climate Change in North Karelia

Adaptation to climate change refers to the ability of societies and natural systems to function in the prevailing climate, the ability to prepare and act in a changing climate, and the ability to quickly recover from possible damage. The goals of adaptation are to:

1. Increase knowledge about the impacts of climate change and prepare stakeholders for the changes
2. Strengthen the capacity to respond quickly enough to changes and enhance the flexible actions
3. Strengthen the ability to withstand damage and to recover and bounce back from destruction and damage
4. Aim for socially and equitably sustainable adaptation, ensuring that adaptation is especially enabled and supported for those in the most vulnerable and exposed positions
5. Increase capacity and competence in anticipating and managing risks
6. Promote climate resilience and provide new and concrete alternatives to support it
7. Increase cross-sectoral cooperation
8. Benefit from the positive impacts of climate change

Table 5 presents necessary actions to reduce the impacts and the risks of climate change. The information has been compiled through expert work based on climate strategies, programmes, and adaptation plans from other regions and cities, as well as various relevant reports (list of references at the end of this document). The results of sub-regional stakeholder collaboration have also been used, and those results are included in the accompanying regional report.

The purpose of both parts of this roadmap — regional and sub-regional — is to serve as a source of information and a repository of actions for the adaptation actions that municipalities can include in their own climate plans.

The proposed actions may require considerable financial investments, but it should be noted that repairing damages due to the clime change is even more expensive. Decision-making should consider, for example, the costs of repairing flood damage: draining water from buildings, repairing moisture damage, fixing, or replacing equipment and technology left in flood-prone areas, and treating health hazards in health services. The construction costs of potential flood control structures — such as dams, sedimentation basins, and vegetated depressions — should be compared with the costs of repairing the damage. Floods are expected to increase because of climate change, as was extensively experienced in Finland in the autumn of 2024.

Table 5. Necessary actions to reduce the impacts and the risks of climate change.

Phenomenon / Impact: Agriculture and Forestry	**Necessary Actions**
Increased rainfall and precipitation	Compensation for damages to landowners Change of cultivation techniques and the field structure (crop rotation, polyculture, ProAgria and MTK guidance, wetland cultivation) Develop new skills related to required cultivation methods Maintain soil condition, improve drainage and irrigation systems (technology, water resource management) considering water bodies Ensure sufficient buffer zones (to reduce nutrient and sediment runoff) Use grass and deep-rooted plants for carbon sequestration and soil loosening Maintain vegetative cover on fields, increase organic matter in soils Expand the use of growth tunnels Develop small, agile, and lightweight machines for forest harvesting (due to lack of frost, waterlogged soil) Maintain forest roads Support sustainable transformation of native species (nature management, conservation, securing green corridors and buffer zones, wetland construction)
Changes in winter conditions	Implement climate-resilient forest management Use damage-resistant and climate-adapted seeds and seedlings (improved plants and seeds, appropriate site selection) Apply continuous cover forestry where suitable Develop harvesting equipment suitable for changed winter conditions (small, agile, light machinery) Support sustainable transformation of native species and protect biodiversity Diversify crops and rotation Maintain good soil health and prevent erosion (vegetative cover, buffer zones) Enhance pest and disease resistance through improved plants Control invasive species and diseases Pay special attention to animal welfare and health Ensure up-to-date crop, livestock, and forest insurance Support biodiversity (e.g., invasive species control, protect valuable habitats, maintain sufficient buffer zones) Implement catchment-based water management to

	promote collaboration and prevent drought and flood risks
Increased / intensified storms	Adopt storm-resilient forest management practices (thinning's on time and proper fertilisation) Diversify tree species Map the forest damages and collect data to better target actions needed Prepare storm damage response plans for clearing and utilising fallen trees Keep crop and forest insurance up to date
Rising temperatures	The growing season is longer: new farming arrangements: with farm arrangements, adaptation can be promoted when, e.g. irrigation can be invested more efficiently in concentrated farming areas Introduce new crops – potential for increased yield and income (depends on rainfall) Choose crops resilient to pests, diseases, high temperatures, and/or drought Apply diverse cultivation methods (incl. wetland farming) Control invasive species when necessary Implement climate-resilient forestry practices (e.g., longer rotation periods, mixed species, fertilisation) Increase forest biodiversity to improve resilience Develop forest management and logging methods for changing conditions
Biodiversity loss	Expand and preserve buffer and edge areas (e.g., between water bodies and farmland/forests) Map and control invasive species Develop and increase climate (resilience) knowledge and operational models in agriculture and forestry Increase biodiversity (e.g., mixed forests, deadwood, use of diverse crop varieties and species) Develop and implement biological control methods Utilise ecological compensation Apply continuous cover forestry where appropriate Increase agricultural biodiversity through crop rotation and use of diverse crop varieties (enhances biodiversity, yield stability, and risk management)
Phenomenon / Impact: Transportation	**Necessary actions**
Increased rainfall and precipitation	Prepare for increased needs in de-icing, snow ploughing, and snow storage (ensure snow ploughing equipment and storage areas are ready in advance) In rainy winters, ensure stormwater is effectively drained from roads and streets (check the condition and ability of the sewer networks, stormwater management plans)

	Improve surfaces, storm drains, vegetated swales, and open ditches to manage water runoff Increase water retention capacity Maintain the entire road network, including secondary roads Clear the roadside vegetation when needed and ensure sufficient distance between trees and roads
Changes in winter conditions	Increase resources and apply new methods for road and pathway maintenance Enhance de-icing and snow removal Prepare for increased snow storage needs in advance Resize and reassess road culverts Use more durable road surfacing materials Implement actions to manage snowmelt and urban flooding (build retention basins, infiltration structures, swales, and open ditches) Build dams in flood-risk areas Integrate snow storage planning into zoning and municipal infrastructure planning
Increased / intensified storms	Improve preparedness and develop storm warning systems Build storm protection structures if needed Construct wetlands (e.g., stormwater basins) and other water protection infrastructure Ensure there are plans and resources to remove fallen trees from transport routes (critical for evacuation and emergency access to storm areas) Create stormwater plans Check the condition of culverts Ensure sufficient resources for route maintenance
Rising temperatures	Ensure consistent road and infrastructure maintenance during freeze-thaw cycles (when temperatures fluctuate above and below zero)
Biodiversity loss	Control invasive species along roadsides and intersections Use native plant species where site conditions allow (e.g., meadow and grassland species) Use clean soil materials in road construction and earthworks related to road infrastructure
Phenomenon / Impact: Population and wellbeing	**Necessary actions**
Increased rainfall and precipitation	Allocate additional resources to healthcare, particularly for emergency and first aid services (develop contingency plans for temporary surges in demand) Develop and diversify well-being services; this could also be an opportunity for new businesses (e.g., mental health support, fitness services)

	Improve water quality monitoring and enhance water treatment disinfection capabilities Relocate water intake wells if needed, secure backup water sources, and implement stormwater delay and retention solutions
Changes in winter conditions	Develop public preparedness plans (e.g., addressing mobility challenges during winter rain or heavy snowfalls) Implement smart lighting for energy-efficient lighting during extended dark periods Create a road weather information service Ensure reliable operation of drinking and wastewater systems and prepare contingency plans for disruptions Explore ways to maintain usability and comfort of recreational areas, especially as insect risks increase (e.g., ticks, deer flies)
Increased / intensified storms	Integrate storm resilience more deeply into land use planning (e.g., snowdrift management during snowstorms, preventing formation of wind tunnels) Plant vegetation to windbreak Ensure accessibility of different areas in all weather conditions Update or develop healthcare preparedness plans (e.g., ensuring smooth emergency response in storm-affected areas) Check whether rescue and emergency plans adequately address the needs of vulnerable groups (e.g., elderly, ill, disabled, immigrants with limited Finnish language skills)
Rising temperatures	Increase air conditioning and enhance monitoring of the air quality Prepare healthcare services for heatwaves by ensuring access to cooling methods (especially in home care of the elderly people) Increase urban greenery for cooling and construct protective shading structures Invest in the development of effective cooling solutions
Biodiversity loss	Develop green infrastructure and build parks to increase access to local recreation Encourage public participation in nature stewardship and adaptation actions (e.g., removing invasive species, establishing meadows, planting trees)
Phenomenon / Impact: **Built Infrastructure**	**Necessary Actions**
Increased rainfall and precipitation	Increase funding for damage compensation and maintenance resources; ensure adequate expertise is available Preserve and increase urban greenery (e.g., replacing

	asphalt areas with grass) Prevent moisture damage by inspecting building structures and fixing deficiencies in advance Improve weather resistance of building foundations (e.g., material choices, drainage systems) Adapt construction methods (e.g., roof overhangs to protect against driving rain) Use new planning tools in land use planning for green areas, stormwater management, and mobility Improve stormwater handling and conduct stormwater assessments (construction and land use planning) Redirect stormwater away from sewage systems to avoid overloads Ensure proper weather protection during building construction Increase use of permeable surfaces and green infrastructure Upgrade sewer systems to withstand heavy rainfall Build channels and wetlands for water management Construct dams in flood-risk areas
Changes in winter conditions	Find out and assess maintenance costs caused by freeze-thaw cycles and ensure sufficient maintenance capacity Develop and apply more durable surfacing materials Design and implement effective management of snowmelt and urban flooding (e.g., retention basins) Ensure adequate snow storage capacity through land use planning
Increased / intensified storms	Emphasise the importance of land use and building design in storm resilience Ensure urban planners and builders stay up to date with necessary skills (e.g., preparation for heavy snow conditions, preventing wind tunnel effects) Pay more attention to shoreline construction (e.g., permit processes) Enhance storm preparedness and develop warning systems Construct storm protection structures as needed
Rising temperatures	Assess infrastructure risks and create preparedness plans for increased maintenance needs Introduce drought- and heat-tolerant plant species in urban greenery Preserve and increase cooling green areas in cities In new and renovated buildings, adopt designs that mitigate heavy rain and solar heat (e.g., eave structures) Invest in the development of cooling solutions
Biodiversity loss	Improve spatial planning (e.g., use green factor tools in land use planning) and increase green areas

	Use drought- and heat-tolerant plant species and learn their maintenance Add buffer zones and increase the number of species in the parks Choose pest-resistant species and remove invasive species Protect the remaining vegetation (trees) near new building plots to increase resilience Better implement nature-based and climate-smart forest management practices
Phenomenon / Impact: Energy	**Necessary actions**
Increased rainfall and precipitation	Hydropower will increasingly serve as balancing energy; assess if capacity is sufficient Use fresh wood chip boilers and adopt innovative technologies (for more efficient heat production and lower emissions) Improve young forest management (e.g., lighter machinery) Develop new sources to maintain supply security (e.g., energy storage) Increase decentralised energy production to ensure energy availability in sparsely populated and remote areas during disruptions Improve access to backup power in rural areas
Changes in winter conditions	Increase energy self-sufficiency and security of supply by supporting and building renewable energy production Develop decentralised energy solutions Prepare for cold spells (availability & price of energy) Develop a warning application for maintenance
Increased / intensified storms	Increase backup power capacity (backup sources and batteries) Expand underground cabling Ensure lightning and high-voltage protection Ensure sufficient distance of trees from power lines and remove vegetation if necessary
Rising temperatures	Prepare for energy consumption peaks in summer due to increased cooling needs Develop methods to store or convert waste heat generated during summer into electricity
Biodiversity loss	Ensure that renewable energy production and energy transmission lines are not located in ecologically valuable areas
Phenomenon / Impact: Water systems	**Necessary actions**
Increased rainfall and precipitation	Prepare for damage compensation

	Update groundwater area management plans to include adaptation actions (to keep the water clean and available) Secure access to clean water (e.g., drinking water) Strengthen and protect buffer zones near water bodies Develop catchment-based water management Retain runoff on land using sedimentation basins, constructed wetlands, and overland flow fields where necessary Improve stormwater management Integrate water management into land use planning (e.g., reserved areas for blue-green infrastructure in the land use planning)
Changes in winter conditions	Increase expertise and actions in land use planning (e.g., snow storage, management of meltwater, directing and treating stormwater – avoiding discharge into natural water bodies) Construct wetlands in suitable locations Prepare for the alternation of freezing and thawing and its effects on the waterways and groundwater of the catchment area (e.g., build protective embankments and infiltration areas) Restore peatlands Reduce nutrient loading from agriculture and forestry (e.g., reduce drainage, increase vegetation cover)
Increased / intensified storms	Manage potential flooding using structural solutions (many listed above under increased rainfall)
Rising temperatures	Ensure water supply and create contingency plans Control surface runoff near natural waters and groundwater areas (e.g., increase buffer zones, build necessary retention basins) Monitor drinking water quality and the availability of clean water Prepare an action plan for water stress scenarios
Biodiversity loss	Increase the number of protected buffer zones Enhance actions to prevent eutrophication and contamination of water bodies (especially related to agriculture and forestry as mentioned above) Restore aquatic ecosystems
Phenomenon / Impact: Tourism and Recreation	**Necessary actions**
Increased rainfall and precipitation	Promote cool and rainy conditions as a unique tourism advantage – develop tourism activities suited for cooler climates Ensure weather resilience of popular outdoor destinations (e.g., softened ground, lack of frost, erosion control)

	Anticipate and respond to increased need for energy-efficient lighting in local recreation areas (especially during winter rains)
Changes in winter conditions	Enhance ice cover monitoring Ensure additional resources for road and building maintenance Improve skills in renovation and maintenance construction Develop new forms of winter mobility Ensure weather resilience of popular outdoor destinations (softened ground, lack of frost, erosion control) Increase energy-efficient lighting in local recreation areas (especially during winter rains)
Increased / intensified storms	Develop a warning system to prevent people from venturing outdoors when storms are forecasted
Rising temperatures	Prepare for wear and tear of popular recreation and tourism areas during dry periods Prevent wildfires by educating and guiding nature visitors on safe and responsible behaviour
Biodiversity loss	Design and implement hiking trails to prevent terrain degradation and erosion Educate tourists and nature visitors on respecting nature and practicing sustainable outdoor recreation
Phenomenon / Impact: Natural Environment	**Necessary actions**
Increased rainfall and precipitation	Prepare flood management plans Manage catchment areas to prevent nutrient runoff into water bodies (to mitigate eutrophication) Construct protective buffer zones and sedimentation basins where necessary
Changes in winter conditions	Prepare for changes in species composition – some current native species may migrate northward, while new species spread from the south, impacts on for example, berry and mushroom yields.
Increased / intensified storms	Repair storm damage in areas where it poses danger or causes economic harm In protected areas (e.g., nature reserves), intervene only if significant impacts on recreation or tourism occur (e.g., compare with storm beetle damage in Koli National Park, where infected trees have not been removed)
Rising temperatures	Traditional biotopes: Climate change mitigation becomes increasingly important Preserving these areas will require substantial actions and funding Promote small-scale grazing, avoid chemical fertilisation, control invasive species Accept that traditional biotopes may change as environmental conditions shift

Biodiversity loss	Restore degraded habitats Map and control invasive species, prevent their spread (e.g., ensure soil used in construction is clean) Increase public awareness, including among homeowners and holiday cottage residents (e.g., effects of pesticides, benefits of pollinator-friendly plants) Develop and implement biological control methods - Traditional biotopes: Mitigate climate change and raise public awareness on these issues as well

Monitoring Adaptation to Climate Change

Listed below are the indicators presented in other roadmaps and plans to measure success in adapting to climate change. The lists are extensive and are not intended to be fully adopted for all monitoring purposes. Each actor can select the indicators that best reflect their own activities. The source of each indicator is also provided.

Indicators Describing the Progress of Climate Change (*Source: Finnish Meteorological Institute*)

- Change in annual average temperature
- Change in annual precipitation
- Duration of ice and snow cover periods
- Sum of effective temperature
- Length of the growing season
- Number of hot days

Indicators Describing the Occurrence of Climate Risks, Vulnerability, and Exposure to Risks

- Share of population over 65 in the region *(Source: Statistics Finland)*
- Population living in flood risk areas *(Source: Flood risk maps)*
- Disposable income per capita *(Source: Ecoreg / Statistics Finland)*
- Implementation of the METSO forest biodiversity programme *(Source: Ecoreg / Statistics Finland)*
- Fragmentation of natural areas, percentage of edge zones in nature areas *(Source: Liiteri / Finnish Environment Institute SYKE)*
- Floods outside designated flood risk areas *(Source: Flood Centre)*
- Tree species composition, % of forest land *(Source: Natural Resources Institute Finland - Luke)*
- Grain yields per hectare (trend analysis is of interest) *(Source: Luke)*
- Grain crop quality (share of yield meeting quality standards) *(Source: Luke)*
- Share of mixed grain cultivation area from total agricultural land *(Source: Luke)*
- Nitrogen and phosphorus balance in cultivation *(Source: Ecoreg / Luke)*
- Degree of self-sufficiency in electricity production *(Source: Ecoreg)*
- Health index *(New national data collection starting in 2023; Source: Kela / THL)*
- Emergency response operations *(Source: Rescue Services' PRONTO system)*

Indicators Describing the Implementation of Adaptation Actions

- Number of traffic accidents in winter months *(Source: PRONTO; sectors: transport, social and health services, rescue services)*
- Causes of forest damage that reduce forest stand quality on production forest land (%) *(Source: Luke; sectors: forestry, biodiversity)*
- Conservation areas in privately-owned commercial forests (hectares) *(Source: Luke; sectors: forestry, biodiversity)*
- Area of clear-cut logging (share of all logging based on forest use notifications, ha) *(Source: Luke; sectors: forestry, biodiversity)*
- Establishment and maintenance agreements for wetlands *(Source: Finnish Food Authority / ELY Centre; CAP program output indicator; sectors: forestry, agriculture, biodiversity)*
- Buffer zone management agreements *(Source: Finnish Food Authority / ELY Centre; CAP program output indicator; sectors: forestry, agriculture, biodiversity)*
- Farm investments promoting environmental quality and sustainable production *(Source: Finnish Food Authority / ELY Centre; sectors: agriculture, biodiversity)*
- Area and share of winter-time plant cover on agricultural land in North Karelia *(Source: Finnish Food Authority / ELY Centre)*
- Implementation of flood risk management actions *(Source: Environmental Administration Flood Information System; all sectors)*

The implementation of the North Karelia Climate and Energy Programme 2030 and its action plan will be monitored every two years. During this process, the indicator data will be updated, and it will be reviewed whether mitigation actions need to be revised. The regional adaptation roadmap will, however, be reviewed according to council terms. This is justified as significant changes may not be visible within just two years.

Climate change in North Karelia is assessed based on forecasts and modelling. The progression of climate change brings uncertainty to current assessments – there is no absolute truth yet, only projections. This emphasise the importance of continuous monitoring and updating of actions.

It is essential to evaluate and update actions and methods as latest information becomes available or as circumstances change. The adaptation actions proposed are quite concrete, making monitoring necessary to ensure the effectiveness and timeliness of the actions. This also helps to ensure cost-effectiveness and that resources are directed toward the right actions.

Municipalities are responsible for updating their own adaptation roadmaps or plans and for monitoring the implementation of actions according to their own schedules. The goal of this roadmap is to provide information and suggested actions to support municipalities' planning.

Communication and information dissemination are important parts of the process. A key role in this will be played by the Climate and Energy Programme Expert Group (Theme Group CE2030), which consists of representatives from key stakeholders, including municipalities. *The Climate Path tool* being developed for municipalities is also an important instrument for communication, coordination, and monitoring. It enables monitoring the progress of climate measures for both the regional and municipal levels and increases transparency regarding the impacts of actions across sectors. From a communication perspective, it helps ensure that both internal municipal actors and residents are better informed about climate actions and their outcomes. For the residents of North Karelia, communication should be conducted through multiple channels and in numerous ways, so that all residents can access information if they wish.

In summer 2024, North Karelia was accepted into the EU Mission on Climate Adaptation. This group includes European pioneer regions in climate adaptation, with the opportunity to disseminate and develop good adaptation practices across regions. It provides a strong international interface and offers opportunities to gain experience from other areas while also highlighting local expertise.

Climate Change Adaptation by Sub-region

North Karelia, like all regions in Finland, has its own vulnerability factors that expose its environment, livelihoods, and residents to climate change in diverse ways. Each area also has its own strengths that can support both climate change mitigation and adaptation efforts.

In the preparation of North Karelia's Climate Change Adaptation Roadmap, the sub-regions (Joensuu sub-region, Central Karelia sub-region, and Pielinen Karelia sub-region) were examined individually. The final report of the sub-regional workshops on climate change adaptation, conducted by Tyrsky Consulting, is included as an appendix to this roadmap. While there are many similarities between the sub-regions, there are also clear differences. Since adaptation actions are closely tied to local conditions, a more localised analysis supports the implementation of effective adaptation work. In municipalities, climate change adaptation is a current issue, and many have already taken concrete steps to prepare for and adapt to the impacts of climate change.

The five climate risks identified in the roadmap prepared by the Regional Council of North Karelia are significant for each sub-region. Among the climate risks, the impacts of changing winter conditions on the population, built environment, and livelihoods are particularly emphasised. In addition, the effects of precipitation on built environments, heatwaves on the population, and storms on infrastructure are highlighted.

The unique characteristics of the sub-regions reflect different vulnerability and exposure factors. The sub-regions differ in terms of natural environments and livelihoods – although forests and lakes are typical of all North Karelia, the hill landscapes, and lakes of Pielinen Karelia differ from the clear lakes of Central Karelia. All sub-regions are service-oriented in their economic structures, but primary production plays a more prominent role in Central and Pielinen Karelia.

Differences related to the population and built environment are more internal to sub-regions than between them. North Karelia has vast, sparsely populated areas with declining populations. On the other hand, there are also vibrant urban centres and a densifying city in Joensuu. In terms of climate change impacts and adaptation, the challenges vary between urban centres, smaller towns, and rural areas: in densely built areas and towns, challenges related to stormwater flooding and heat stress are more prominent, whereas in sparsely populated rural areas characterised by long distances, residents and livelihoods are more affected by changes in winter conditions and storm impacts.

The key vulnerability factors for the population include ageing, living in sparsely populated areas, low income, and social isolation. There are no significant sub-regional differences in these vulnerabilities, although the impacts of climate change may differ between urban and rural contexts. For the population, it is anticipated that ageing, increased morbidity, and decreased physical activity will increase vulnerability. It is also quite likely that multiple vulnerability factors may accumulate for the same individuals.

Conclusion

In climate change adaptation, it is essential to safeguard the functioning and climate resilience of critical sectors. These include energy, well-being, and important livelihoods such as agriculture and forestry. Adaptation actions initiated in time help ensure the continuity and security of these functions. The natural environment holds a special role in this context. Diverse nature is the backbone of both human well-being and livelihoods. Therefore, integrating nature and biodiversity considerations into adaptation work across sectors is highly significant.

Security in various conflict situations must also be considered, although it is often linked to vulnerabilities and actions related to infrastructure and well-being. In such situations, the speed, efficiency, and equity of official responses are crucial. Each authority has its own plans for these scenarios.

Municipalities need information on the impacts of climate change to plan and implement effective adaptation actions. The regional adaptation roadmap contributes to this by serving as a guiding tool. It is reviewed and updated every four (4) years. To support continuous knowledge sharing and skills development, additional supporting practices could be considered, such as an annual adaptation seminar.

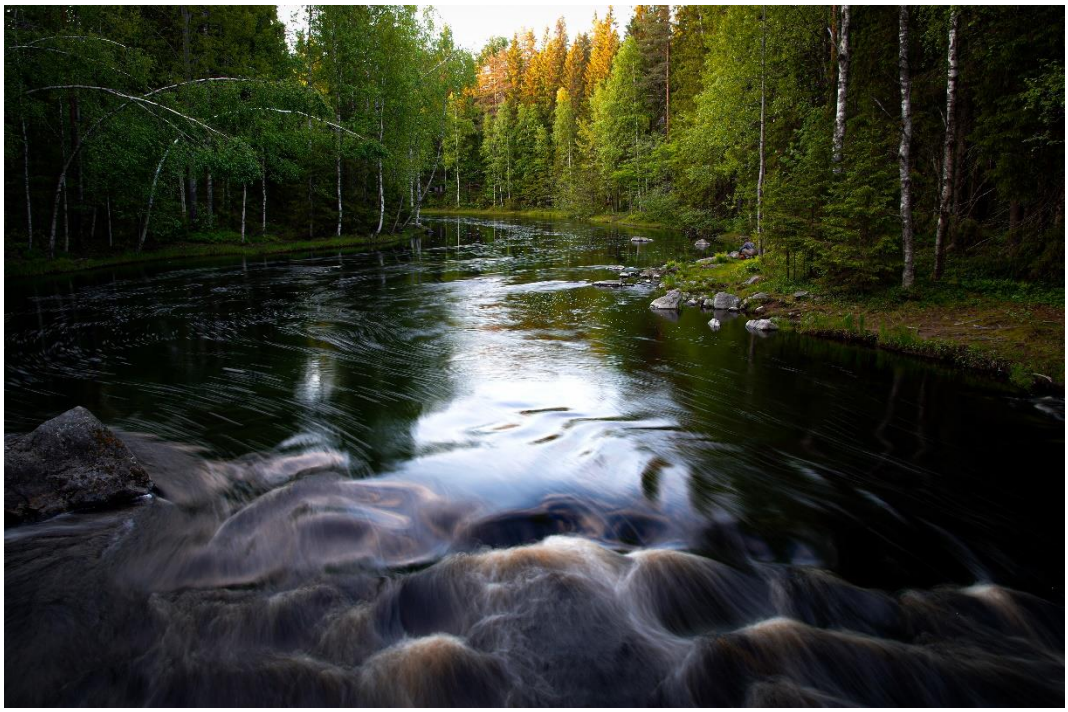
Although the impacts of climate change are local, the solutions and actions are not necessarily unique. Collaboration and peer learning are essential for sharing and spreading best practices and effective solutions, especially in small municipalities with limited resources.

The region can support municipalities and sub-regions by bringing various actors together through cooperation groups and networks. The ELY Centre (Centre for Economic Development, Transport, and the Environment) can function as an expert in adaptation-related efforts. The regional adaptation roadmap serves as a general-level document, but it does not account for the unique characteristics of every municipality and sub-region. Municipal resources are limited, making systematic adaptation work—and drafting a local adaptation plan—challenging for many. The Regional Council encourages municipalities to include a climate change adaptation section in their own climate plans, drawing on content and actions from this roadmap. Alternatively, similar small municipalities could create joint adaptation plans, as their climate risks, vulnerabilities, and needed actions are often alike. In both cases, the municipality is responsible for implementing the actions and monitoring their progress.

The adaptation actions proposed vary in scale and therefore require a broad and diverse range of implementers—from decision-makers and organisations to entrepreneurs and individual citizens. That is why it is important to understand the bigger picture and the role of each part in achieving the common goal: a climate-resilient and adaptively robust North Karelia.

North Karelia's Climate Change Adaptation Roadmap complements the CE2030 Programme's Action Plan. While the CE2030 Action Plan addressed adaptation and necessary actions at a general level, the roadmap is aiming to refine this by translating the actions into more concrete and practical terms—because the time for climate change adaptation is now. The vulnerabilities and risks identified in the roadmap, along with the outlined adaptation strategies, form the foundation for building a climate-resilient region.

Achieving this goal requires the participation of all municipalities, actors, and residents in the region. Climate change mitigation and adaptation require collaboration and expertise across sectors and actors. This is the only way to reach the goal: a climate-resilient North Karelia, where the inhabitants are well and live in the middle of a diverse nature that is resistant to destruction and able to recover from it.



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