Deliverable Phase 2 – Climate risk assessment

CLIVAS

Southwest Finland

Version 1.0 | June 2026

HORIZON-MISS-2021-CLIMA-02-01 - Development of climate change risk assessments in European regions and communities based on a transparent and harmonised Climate Risk Assessment approach

Funded by the European Union

This project has received funding from the European Union's Horizon Europe research and innovation programme under grant agreement No 101093864. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Climate, Infrastructure and Environment Executive Agency (CINEA). Neither the European Union nor the granting authority can be held responsible for them.

Document Information

Deliverable Title	Phase 2 – Climate risk assessment
Brief Description	
Project name	CLIVAS
Country	Finland
Region/Municipality	Southwest Finland
Leading Institution	Regional Council of Southwest Finland / Valonia
Author(s)	• Otto Lappalainen (Regional Council of Southwest Finland) • Omar Badawieh (Regional Council of Southwest Finland) • Olli Haapanen (Regional Council of Southwest Finland) • Inkeri Leksis (Regional Council of Southwest Finland) • Sanna Kivimäki (Regional Council of Southwest Finland)
Deliverable submission date	30/06/2026
Final version delivery date	dd/mm/yyyy
Nature of the Deliverable	R – Report
Dissemination Level	PU - Public

Version	Date	Change editors	Changes
1.0	30/06/2026	Regional Council of Southwest Finland	Deliverable submitted
2.0	…	CLIMAAX's FSTP team	Review completed
5.0	…		Final version to be submitted

Table of contents

List of figures

List of tables

Abbreviations and acronyms

Abbreviation / acronym	Description
CRA	Climate Risk Assessment
FMI	Finnish Meteorological Institute
GCM	Global Climate Model
HCLIM	HARMONIE-Climate Model
NGO	Non-governmental organization
NLS	National Land Survey of Finland
NRI	Natural Resources Institute
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
SWF	Southwest Finland

Executive summary

The deliverable represents the work conducted during phase 2 of the CLIVAS project in Southwest Finland. The report showcases the scoping, risk exploration, risk analysis, and risk assessment phases. The reader of this report will learn how CLIMAAX tools, which are open for everyone, can be used to analyze and assess regional climate risks, how a comprehensive regional climate risk assessment can be done, and how stakeholder cooperation enriches the risk assessment process. The report continues the work described in the first phase report[1].

Phase 2 of the project focused heavily on two major contributions: the risk analyses made on agricultural drought and heavy rainfall, and the regional key risk assessment.

Firstly, the report focuses on the fine-tuning and localization of the risk analyses on agricultural drought and heavy rainfall that began in phase 1. Using local data with comparative and synthetic analysys resulted in more precise and usable analyses. Agricultural drought risk is expected to become severe in the coming years and worsen towards the end of the century. Especially potato and spring wheat yields will suffer from drought. Heavy rainfalls will become more common and more severe in the future. There were some conflicting results between different climate models but, in the big picture, severity will increase in the future with increasing rainfalls in many parts of the region and decreasing rainfalls in some parts.

Secondly, the report focuses on the first comprehensive climate risk assessment of the region where ten climate risks are assessed. The assessment was drafted in tight collaboration with stakeholders whose participation was key in ensuring its quality and credibility. The risks are assessed based on both current and future severity, urgency, and resilience capacity. The risks are then prioritized to help local stakeholders in deciding which of the adaptation measures should be conducted urgently. According to the key risk assessment, heavy rainfall, heatwaves, (agricultural) drought, and nature-related risks are the risks with the highest priority. The impacts of all of the risks with highest priority are already visible in the region and is expected to increase in future due to climate change.

Key takeaways:

- Agricultural drought will be a severe issue in the region. Some crops and areas will be impacted more than others.
- Heavy rainfalls will increase in frequency and intensity. The increases are predicted to be from moderate to severe depending on the area and climate models.
- The key risk assessment protocol and dashboard present an excellent formula for regions on how climate risks could be assessed, compared and prioritized.
- Cooperation with local stakeholders and researchers is key in ensuring the relevance and credibility of the results gathered from the analysis conducted using the CLIMAAX tools.
- Engaging local stakeholders in the processes is key and allows for transmission of silent knowledge, receiving feedback and development ideas, and increased ownership, knowledge and capacity of the stakeholders.

The phase 3 of the project will focus on the drafting of adaptation measures and on including them to the regional climate roadmap which is currently being updated. Spreading awareness on regional climate risks to local stakeholders and decision-makers, and the planning of the continuation of regional adaptation planning after the project ends will also be of high importance in phase 3.

[1] https://zenodo.org/records/17055421

1 Introduction

1.1 Background

Southwest Finland is a region with a diverse economic structure, a fertile, rural landscape, and a unique environment, located by the Archipelago Sea (Figure 1). The region is home to nearly half a million people of which around 200 000 live in the largest city Turku. Southwest Finland has a major role in Finnish food production: around third of wheat and field vegetables produced in Finland come from the region. Other important sectors are marine industry, car industry, health and medicine, tourism, and circular economy solutions.

Figure 1. Location of Southwest Finland. Map data: Natural Earth, Statistics Finland and NLS.

Overall, Finland can be seen as a model country for emergency preparedness, and climate change adaptation has been considered in the national level planning for a long time. Despite this, knowledge at the regional and local level is still fragmented and largely missing.

Most regional level initiatives have been focusing on mitigation. This is also the case in Southwest Finland where emissions have successfully been cut in half during the period of 1990–2025 (Valonia, 2025b). A climate roadmap for the region was drafted in 2023, and 22 of 27 municipalities have also drafted their own climate plans. Overall, however, adaptation work is still in its early phases and concrete adaptation measures have been mostly missing from the plans.

1.2 Main objectives of the project

Phase 2 of the CLIVAS project focused on refining multi-risk assessments using local data, and on producing the key risk assessment. The updating process of the regional climate roadmap began during phase 2 as well. Experts from a total of 57 organizations and common citizens took part in the participatory processes during phase 2.

The risk analyses on agricultural drought and heavy rainfall were completed during phase 2. Stakeholder feedback played an important role in the work. The agricultural drought workflow provided novel crop specific information on a variety of crops. The workflow was localized by updating the original crop data of the workflow with data on local crop varieties and by introducing new crops such as oats. The localized workflow improved the reliability of the results and provided data that can be used for preparing for the future climate impacts and for justifying the need for more adaptation measures in the region.

The heavy rainfall workflow complemented the existing national and regional knowledge on heavy rainfalls. The results show the changes in both the frequency and the intensity of heavy rainfalls using different climate models and scenarios. The result is a map-based overlook on how the situation will change in the future. Based on discussions between the project team and both local and national experts, it remains unclear whether such rare rainfall events can be predicted with the level of detail suggested by the map. Therefore, data from the individual datapoints has been aggregated to present changes in rainfall frequency and intensity as regional averages. As heavy rainfall events are already causing trouble in many parts of the region, the results further emphasize the need to increase the capacity in the built environment to handle the increased stormwaters.

The key risk assessment for Southwest Finland using the models of the CLIMAAX handbook was finished and published during phase 2. The key risk assessment provides regional actors a comprehensive report which includes all the relevant regional climate risks. The assessment gives valuable information on the impacts of the climate change and an opportunity to align their adaptation activities to match the expected climate outcomes. During the process, common citizens and experts from more than 30 regional organizations were involved.

The updating of the regional climate roadmap began during phase 2. The project team has taken part in the updating process by organizing stakeholder meetings, providing other experts support on adaptation related matters, added a completely new section on adaptation including the formulation of adaptation goals to the roadmap with adaptation goals, and begun the defining process of adaptation measures for the 5 main themes presented in the roadmap. The writing process is currently underway, and the roadmap is scheduled for a review round in the fall. The roadmap is expected to be formally approved in December 2026.

1.3 Project team

- Otto Lappalainen: Project specialist. In charge of overall coordination of the project.
- Omar Badawieh: Project specialist. In charge of the risk assessments created with the CLIMAAX tools.
- Olli Haapanen: Project specialist. Expert advisor for the project.
- Inkeri Leksis: Project assistant. Assisting in the risk analysis work.
- Sanna Kivimäki: Project specialist. Expert advisor for the project, forest expertise.
- Silja Ngobese: Project specialist. Expert advisor for the project, agricultural expertise.
- Jarkko Leka: Specialist – Water protection & Biodiversity. Expert advisor for the project, nature expertise.
- Anna Sampo: Head of Communications.
- Anni Himberg: Project planner. Communications.
- Katriina Kotomäki: Financial Expert.

1.4 Outline of the document’s structure

The document begins with an introduction to the region and to the project’s main objectives in phase 2. Next section introduces how climate risks were scoped in the project by discussing objectives, regional context, how the participatory process and stakeholder engagement were conducted, and how the principles of CLIMAAX CRA Handbook were applied in the CRA process. The main findings of the project are presented in the following sections which describe the findings gathered in the risk analyses on agricultural drought and heavy rainfall which were analyzed using CLIMAAX tools. Next section presents the key risks assessment which includes the descriptions of the severity, urgency, resilience capacity and risk prioritization of 10 regional climate risks. The last section of the document includes conclusions, progress evaluation, supporting documentation and finally, references.

2 Climate risk assessment – phase 2

2.1 Scoping

2.1.1 Objectives

The objective of the Climate risk assessment (CRA) is to produce novel knowledge and understanding on how different weather-related climate risks affect the region of Southwest Finland. The analyses conducted with the help of the CLIMAAX Handbook will help the region to assess the impacts that agricultural drought and heavy rainfall will have on different parts of the region using different timeframes and climate scenarios. The key risk assessment will provide the region its first comprehensive CRA.

Another purpose of the CRA will be to push forward regional climate change adaptation work and cooperation. The expected outcome is that the analyses, other gathered data and the key risk assessment will increase the understanding of local civil servants, decision-makers, and other stakeholders on the impacts of climate change and on measures to address them. The project outcomes will feed knowledge and adaptation measures to both municipal and regional strategies and their implementation, including the regional climate roadmap which is currently being updated.

In phase 1 report, we reported limitations and boundaries related to the relevance of the data on agricultural drought. Those limitations have mostly been cleared. With the help of the Natural Resources Institute, the project team was able to acquire crop data that includes oats as a completely new crop and also data on characteristics of local crop varieties.

Heavy rainfalls are very rare in Finland and also very sporadic in their nature which means that they can happen almost anywhere. During discussions with the experts from Finnish Meteorological Institute, it was noted that the predictability of heavy rainfall events might not be possible with the accuracy that the maps by the CLIMAAX tools show. According to the experts, forecasting heavy rainfall might not even be possible at the regional level. Instead, experts have suggested that it could be possible to create trustworthy heavy rainfall scenarios for southern, middle and northern Finland where the resolution would be hundreds of kilometers instead of a 12x12km square. Because of this, it might not be feasible to present the detailed rain maps to local stakeholders. To address this issue, the project team has aggregated the values from different map points to give a regional forecast on how both the intensity and the frequency will change in the future.

Agricultural drought risks are measured in revenue loss per area. This is a valuable communication tool when discussing effects of droughts to stakeholders. However, as the prices of crops fluctuate, the interpretation of the results is difficult. Comparing revenue losses between crops might lead to maladaptation as the prices of different crops don't rise or drop similarly. Also, the winters in Northern Europe are changing rapidly. Less snow in spring might lead to severely increased droughts during sowing. This phenomenon isn't included in the CLIMAAX workflow and might have big effects on crop yield. These issues will be considered when discussing the results with stakeholders and when possibly continuing assessments in the future.

2.1.2 Context

The governance context for Finnish regions has been described in detail in phase 1 report[2]. Since then, Centres for Economic Development, Transport and the Environment have been reorganized into new governmental structures: the regional Economic Development Centres and the national

[2] See section "2.1.2 Context" on pages 9–11 of the phase 1 report https://zenodo.org/records/17055421

bodies, the Finnish Supervisory Agency and Traficom, the Transport and Communications Agency in Finland. The regional Economic Development Centre, which in Southwest Finland also covers Satakunta region, remains the primary actor responsible for continuing adaptation work alongside municipalities and the regional council.

One of the aims of the project is to fill the gap in knowledge between regional and national level and to provide the regional and municipal actors knowledge to support local adaptation measures. While the work on regional climate change adaptation and risk assessment is still in its early phases, a variety of risks have been assessed. List of the previous assessments can be found in the phase 1 report. As a new development, the regional IKI (Ilmastonkestävät investointihankkeet) project has produced new vulnerability maps for heat island effect, and flood maps for a combined coastal and storm water flood for Turku area[3].

The most important sectors in the region of Southwest Finland are agriculture, marine industry, automotive industry, health and medicine, tourism, and circular economy solutions. These industries face the impacts of climate change to varying degrees. A more detailed overview on different sectors can be found in the phase 1 report.

The overview on outside influences, current initiatives and adaptation interventions is found in the phase 1 report.

2.1.3 Participation and risk ownership

The regional council of Southwest Finland has close ties to most regional actors. Regional actors know each other and they get well together. Table 1 shows the overview on different types of stakeholders relevant to regional climate change adaptation work and their connectiveness.

Table 1. Regional stakeholders for the climate change adaptation work.

National	Regional	Municipal	Others
Ministries	Regional Council of Southwest Finland	Municipalities	Industry interest groups
Governmental agencies and research institutes	The Centre for Economic Development, Transport and the Environment	Municipally owned companies	Other non-governmental organizations
	Southwest Finland rescue department		Enterprises
			Universities and research institutes
			State church
			Citizens

A more detailed list of stakeholders that took part in the work can be found in section 2.1.5.

The responsibilities for assessing and mitigating risks have been divided in the region between municipal and regional (the Regional Council, Southwest Finland Centre for Economic Development, Rescue Department & The Wellbeing Services County of Southwest Finland) actors. The municipalities are responsible for adaptation planning and a variety of actions. The Rescue Services are responsible for emergency response, and the Wellbeing Services are responsible for the health care sector. The Centre for Economic Development is responsible for assessing flood, drought, and transport-related risks. The Regional council is responsible for the strategic coordination of regional

[3] The maps are accessible on https://karttapalvelu.lounaistieto.fi/

development. Regional working groups like the Turku Coastal Flood group which consists of local stakeholders are responsible for strategic planning related to certain risks.

The main representatives of vulnerable groups have been identified. These groups include farmers, senior associations, disease and disability organizations, nature protection organizations and other NGOs. Representatives of the groups were invited in our workshops. Besides NGOs, we also reached out to common citizens by organizing a participatory citizen workshop.

Representing the whole region has been a key focus point for the project. We have invited actors from all around the region to workshops, one of which was organized in Salo and another one in Turku. We made sure that the key risk assessment does not focus only on risks the large cities are facing but also on those that affect sparsely populated areas. We communicated project results to a variety of audiences from experts to citizens via different channels such as social media, local press, radio, and larger publications.

Acceptable risk levels have not been discussed in detail in the region. As Finland has been a highly functioning and safe country where extreme weather events and thus damages have been rare, the accepted risk level is generally quite low when compared to regions where economic damages and even lives lost are more common. The tolerance for economic damages is very low. There is basically no tolerance for lives lost or severe injuries but as they are so rare, they are often considered once-in-a-lifetime accidents. The exception to this is heat-related mortality. Heatwaves can lead to hundreds of extra deaths (Kollanus et al. 2021) but as they mostly happen to people that are already weak, they are usually not seen as seriously as other risks. In comparison, a child almost drowning in a flooded underpass in February 2026 was featured in the news and sparked debate that such event should never be able to happen again. As impacts of climate change are becoming more visible, the need for discussion on acceptable limits increases. One such example is the plans to build residential apartments to a coastal flood risk area on the coast of Turku.

2.1.4 Application of principles

Social justice, equity and inclusivity: Recognizing vulnerable groups and vulnerabilities has been important in the project. Impacts to different vulnerable groups such as sick, elderly and disabled people, those with financial difficulties, and farmers have been highlighted in the publications on risk analyses and the key risk assessment. Invites to CLIVAS workshops were sent to organizations that deal with these themes. In the key risk assessment and climate road map processes, the importance of conducting adaptation measures that make both cities and countryside safe and healthy for everyone, including different species, was highlighted. The adaptation goals defined in the CLIVAS project have a strong emphasis on making sure that justness and vulnerabilities are considered in all planning.

Quality, rigour and transparency: We paid a lot of attention to ensuring that our results are credible, accepted by stakeholders, and of high quality. We checked that the results are in line with scientific consensus by comparing them to the existing scientific studies and by consulting researchers from Finnish Meteorological Institute, Finnish Environment Institute and Natural Resources Institute. We have discussed the results of the workflows thoroughly with local stakeholders taking part in the project working group and steering group and gathered feedback, suggestions, and even localized data from them to improve the trustworthiness of the results. For key risk assessment, we organized workshops and provided local stakeholders an opportunity to comment and suggest corrections to the draft version before it was published.

Precautionary approach: The results obtained from CLIMAAX tools were assessed critically. Uncertainties and complexities have been reflected on and emphasized throughout the CRA process and with stakeholders. We have emphasized that the climate risks covered in risk analyses and the key risk assessment are not destined to happen as presented but that they are possible outcomes to which the stakeholders in the region can impact to. We have emphasized throughout the project that climate change mitigation is of utmost importance in adaptation.

2.1.5 Stakeholder engagement

In phase 2, the CLIVAS project reached out to 57 organizations. Stakeholders from 42 regional organizations, 11 national organizations and 4 other Finnish regions took part in the work. The stakeholders include 13 cities and municipalities, 12 companies (incl. 3 municipally owned companies), 14 non-governmental organizations, 12 public authorities, 5 research institutes, and the local congregation (Table 2).

The stakeholders were involved via private consultations, different cooperation network meetings in the region, a climate risk webinar for municipalities and a climate risk workshop organized for professionals. A separate climate risk workshop was organized for common citizens. We also consulted three Finnish regions that are further in their regional adaptation planning work.

Table 2. Stakeholder engagement during phase 2.

	Organizations	
Project working group	City of Turku (municipality); Finnish Meteorological Institute (research institute); Natural Resources Institute (research institute); Pyhäjärvi Institute Foundation (NGO); Regional Council of Southwest Finland (public authority); Southwest Finland Centre for Economic Development, Transport and the Environment (public authority)	
Steering group	Archdiocese of Turku (congregation); City of Turku (municipality), Finnish Environment Institute (research institute); Finnish Forest Centre (public authority); Maintenance and Supply Security Centre (public authority); the National Climate Unit of the ELY Centers (public authority); Southwest Finland Centre for Economic Development, Transport and the Environment (public authority); Union of Agricultural Producers (NGO); Union of Agricultural Producers Southwest Finland (NGO)	
Workshops, stakeholder meetings and webinars	Municipalities	City of Salo, City of Paimio, City of Loimaa, City of Parainen, Municipality of Kemiönsaari, City of Naantali, Municipality of Nousiainen, City of Raisio, City of Kaarina, City of Uusikaupunki, Municipality of Masku, City of Somero
	Public authorities	Association of Finnish Local and Regional Authorities, The Wellbeing services county of Southwest Finland, Southwest Finland Rescue Department, Turku region traffic FÖLI
	Research institutes	University of Turku, Turku University of Applied Sciences
	NGOs	Kiskon-Kirkkojärven hoitoyhdistys, Salon sydänyhdistys, Aura River Foundation, Paimio River Foundation, The Finnish Association of People with Physical Disabilities, Turku Chamber of Commerce, Varsinais-Suomen Yrittäjät, SKAL ry, Pro-Agria Western Finland, Unicef Finland, The Student Union of the University of Turku
	Companies	Turku Energia, Elomatic, North Green Energy, Lounais-Suomen jätehuolto, Qvidja Kraft Ab, Yrityssalo, Port of Turku, Turku Free Zone Company, Varsinais-Suomen Asumisoikeus Oy, Ramboll, Afry
	Other regions	Helsinki-Uusimaa region, Kymenlaakso region, North Savo Centre for Economic Development, Regional Council of Päijät-Häme
	Common citizens	

The project goals and results have been communicated to stakeholders actively in phase 2. For a more detailed overview on communications, see the attachment on communication outputs.

Two major publications were published sparking interest both within local stakeholders and in the local media. The preliminary results of the climate risk analysis on agricultural drought and heavy rainfall workflows were published in October 2025 and finalized at the end of phase 2 (Valonia 2025a). The key risk assessment was published in May 2026 (Valonia 2026b). The publications were published on Valonia's homepage and communicated to stakeholders using email, newsletters, social media and press releases. The publications were featured in local newspapers and radio.

At the beginning of the project, the project working group and the steering group consisting of regional and national actors were set up. Both groups have been actively involved by taking part in the risk analysis and assessment processes, by being informed on newest developments, and by providing feedback on the work. The project working group works closely with the project team, supporting and advising the work. The steering group is responsible for helping the project team with broader national and institutional context. The aim of the groups is to ensure that the results have the support of local stakeholders. The project working group met 4 times and the steering group twice in phase 2.

Other stakeholders participated in the project in different ways. We organized workshops, smaller meetings, and discussed the climate risks in different regional networks such as the regional climate group, Archipelago Sea programme working group, and Turku Coastal flood management group. The project organized workshops for both experts and citizens and a climate risk webinar for municipalities during phase 2. The project presented the findings to a European audience at the CLIMAAX Virtual Forum in March.

Overall, the results were received very well by the stakeholders and both the scope and the activities have been considered important. Based on feedback, stakeholders see the risk assessment work as valuable and the results credible and mirroring the current reality of the region. The stakeholders have provided constructive feedback and valuable insight throughout the project which has helped in localizing the abundant data available. The project team has ensured that relevant stakeholders have been heard and that the findings are also in line with the existing assessments.

The regional CRA will support the updating of the regional climate roadmap. Adaptation measures will be added to the roadmap during the updating process to complement mitigation measures. The climate risks assessment is key in the identifying, prioritizing and targeting of the measures. Fragmented data sources and lack of a comprehensive assessment has previously been a major challenge for the regional actors - a gap that the CRA directly addresses. The CRA can be used by municipalities and other actors to easily learn about expected regional climate risk impacts. With the help of the CRA, various stakeholders can proceed to make their own municipal or sectoral risk assessments and further integrate climate adaptation in all their plans.

We engaged a large group of local stakeholders successfully in the project. Overall, the stakeholders were eager to participate, provide their expertise for the common cause, and learn about climate risks. Reaching all stakeholders was not straight forward but we succeeded to get into touch with the most relevant stakeholders in the region. The stakeholders who took part in the work represent different parts and groups in the region well.

2.2 Risk Exploration

2.2.2 Screen risks (selection of main hazards)

In phase 2, the project team continued with agricultural drought and heavy rainfall hazards which were considered the most relevant for the region. Flood building damage and population exposed, and heatwave workflows were tested and compared with local or national studies. Flood building damage and population exposed workflow was unusable for the region because the resulting damages were clearly overestimated according to both the project team and local stakeholders. Another project in the region is currently producing more detailed flood maps for the area. The flood building damage and population workflow will be run again using these maps in the third phase to see whether the results become usable. Satellite-derived risk assessment for urban heatwaves was tested. The results were promising, but constraints on time prevented from continuing that work. More detail on screening can be found in phase 1 report.[4]

2.2.3 Choose Scenario

The choosing of the scenarios is described in detail in the phase 1 report.[5]

As was the case in phase 1, RCP scenarios 4.5 and 8.5 were used in the CRA. In phase 2, every available climate model and year range were used to ensure the comprehensiveness of the analysis. Studying various year ranges aids the adaptation work because it allows for better identification on which risks require immediate action and which are realized later in the future. In the analysis, all the available GCM/RCM model pairs were used. Combined with research data, it was possible to calculate the average of the models and to consider which of them best suit the region.

Models, scenarios and year ranges used in workflows are discussed more in detail in chapter 2.3.

2.3 Regionalized Risk Analysis

2.3.1 Workflow #1: Agricultural drought - fine-tuning to local context

Risk analyses were conducted using workflows from CLIMAAX Handbook[6]. The workflows were not suitable for the region as such which meant that modifications and additions to the Python code had to be done. Workflow code for agricultural droughts was further developed to extend analysis and to merge different runs for more thorough analysis.

Table 3. Data overview for agricultural drought workflow.

Hazard data	Vulnerability data	Exposure data	Impact metrics/Risk output
Yield reduction	Irrigation availability	Aggregated Crop Production Value	Potential revenue loss from irrigation deficit in for the selected crops

[4] See section “2.2.1 Screen risks”, pages 13–15 of the phase 1 report https://zenodo.org/records/17055421
[5] See section “2.2.3 Choose scenario”, page 16 of the phase 1 report https://zenodo.org/records/17055421
[6] https://handbook.climaax.eu/intro.html

Agricultural drought workflow uses the datasets on Available Water Capacity, Elevation and Thermal Climate Zones with crop-specific information for calculating the yield reduction under different RCP scenarios and given years (Table 3). In the workflow, different climate models (mathematical models simulating drivers of climate and their interaction) can be chosen for simulation. In the risk assessment phase, crops production, crops value and irrigation data are incorporated to the assessed hazard data to calculate expected revenue loss for each assessed crop.

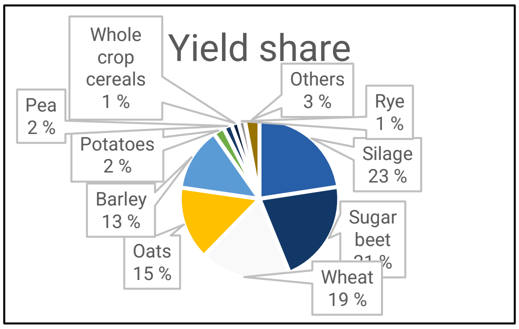

Figure 2. Yield share of Southwest Finland (2023). Data: Luonnonvarakeskus 2025.

The original crop table was lacking some of the most important crops in the area, especially oats which amounts to 15% of the total yield in our area (Figure 2). On top of that, there are local varieties that have been developed especially for the climate in Northern Europe. To tackle these problems, we collaborated with Natural Resources Institute to build an updated table that includes values for local crop varieties and crops not originally included in the CLIMAAX handbook.

With the localized values, it was possible to finetune the precision of the analysis. As CLIMAAX provided an updated and faster script, the team was able to calculate values for each local crop using the updated table making the results more precise and comprehensive. With so many crops with every model pair available and several year ranges are used, the amount of data becomes massive: each of the seven crops produced over 6000 yield reduction values. This report will thus focus on the most important results. All the gathered data is shared as attachments to this report. The data will also be shared with stakeholders.

The analyzed crops were the following (SWF = Southwest Finland: spring wheat (SWF), winter wheat (SWF), barley (spring barley) (SWF), potato (SWF), sugar_beet (SWF), rapeseed (spring) (SWF), and oats (SWF). The full crop table with all the parameters is included in the data package.

2.3.1.1 Hazard assessment

Mean yield values aggregated by year ranges fall between 1 % and 9 %. Potato has the highest yield reduction values varying from 7 % to 9 %. Barley, oats and spring wheat also have higher values. Yield reduction rates between different RCPs do not differ significantly (Table 4).

Using year ranges of 20–30 years diminishes the effect of single dry years which are thus not visible in the results. Similarly, model and geographic variations cannot be seen from these mean results. This will be discussed later on in this report.

Different models produced different values. The model pair cnrm_cerfacs_cm5/cnrm_aladin63 produced constantly the highest mean yield reduction values along with cnrm_cerfacs_cm5/knmi_racmo22e (Figure 3).

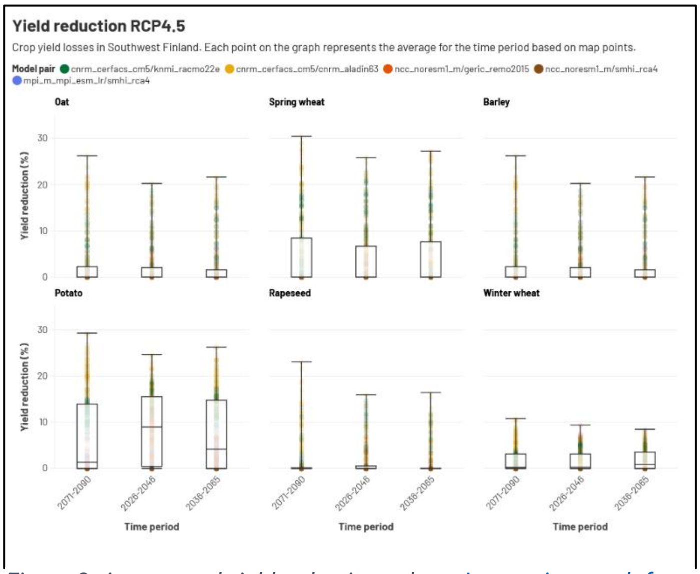

Figure 3. Aggregated yield reduction values. [Interactive graph for RCP4.5 available here]() and [interactive graph for RCP8.5 here]().

Using the bias uncertainty dashboard[7], cnrm_cerfacs_cm5/cnrm_aladin63 was found to be the least biased of the models available for the workflow. The dashboard uses historical temperature and precipitation data to calculate bias that "represents the difference between the observed climate and the model representation over the historical record". The bias is calculated at NUTS2 level while this report is at NUTS3 level which shouldn't, however, bring up significant differences. Compared to other model pairs, the results of cnrm_cerfacs_cm5/cnrm_aladin63 model pair hold more significant information in Southwest Finland. This report will therefore focus more specifically on that model pair, but the results of other models will not be dismissed. When planning and implementing adaptation measures, all available information is important as there is uncertainty in all the models and using several models reduces the uncertainty.

Using only the cnrm_cerfacs_cm5/cnrm_aladin63 model pair, the aggregated mean yield reduction values are constantly higher and now fall between 2 % and 14 % (Table 4). Again, potato has particularly high yield reduction values. With this model pair, also spring wheat has high values followed by barley and oats. RCP4.5 and RCP8.5 produce similar results.

Table 4. Mean yield reduction values of studied crops.

Mean yield reduction				
	All models		**cnrm_cerfacs_cm5/cnrm_aladin63**	
Crop	**rcp4.5**	**rcp8.5**	**rcp45**	**rcp85**
barley (spring barley) (SWF)	2 %	2 %	7 %	6 %
oats (SWF)	2 %	2 %	6 %	7 %
potato (SWF)	8 %	8 %	13 %	14 %
rapeseed (spring) (SWF)	2 %	2 %	4 %	4 %
spring wheat (SWF)	4 %	5 %	11 %	11 %
sugar_beet (SWF)	1 %	1 %	2 %	2 %
winter wheat (SWF)	2 %	2 %	4 %	3 %

Mean yield reduction values diminish the variation between years and locations. For this reason, the analysis was continued by calculating the cutoff value of the highest decile. The value shown is the minimum value of the analysed set that is included in the highest 10%. In other words, the highest decile of the set has yield reduction rates at least the amount shown in the table. With this, attention can be paid to the most affected areas and years. When examining the highest decile cutoff value for each crop, the severity of the yield reductions in those high-risk areas becomes more visible.

When compared to the mean yield reduction values, spring wheat has a significantly high decile cutoff value, especially with the average of all climate models. Only the highest values of sugar beet, rapeseed and winter wheat fall under 10 %. (Table 5).

Table 5. Highest decile cutoff values for studied crops.

Highest decile cutoff value				
	All models		**cnrm_cerfacs_cm5/cnrm_aladin63**	
Crop	rcp4.5	rcp8.5	rcp45	rcp85
barley (spring barley) (SWF)	10 %	9 %	10 %	8 %

[7] https://handbook.climaax.eu/dashboards/bias-uncertainty/

oats (SWF)	10 %	9 %	9 %	9 %
potato (SWF)	19 %	18 %	11 %	11 %
rapeseed (spring) (SWF)	6 %	8 %	6 %	6 %
spring wheat (SWF)	17 %	17 %	12 %	10 %
sugar_beet (SWF)	2 %	3 %	3 %	4 %
winter wheat (SWF)	5 %	4 %	4 %	3 %

In phase 1, there was slight decrease in reduction rates across all crops when going further in time. Looking at the change in yield reduction throughout years in the new results, there is a slight increase in each crop. The increasing rate in future is still rather small. The combination of increasing dry seasons and heavy rainfall events combined with longer growing period probably results in increasing yield reduction rates going towards the end of the century in this analysis. (Table 6).

Table 6. Mean yield reductions by climate scenario and year range using the least biased model pair.

	Mean yield reduction (%) / RCP4.5 / cnrm_cerfacs_cm5/cnrm_aladin63			**Mean yield reduction (%) / RCP8.5 / cnrm_cerfacs_cm5/cnrm_aladin63**		
	Year range			**Year range**		
Crop	2026-2046	2036-2065	2071-2090	2026-2046	2036-2065	2071-2090
barley (spring barley) (SWF)	5 %	7 %	10 %	6 %	6 %	7 %
oats (SWF)	5 %	7 %	10 %	6 %	6 %	7 %
potato (SWF)	17 %	19 %	21 %	17 %	18 %	19 %
rapeseed (spring) (SWF)	3 %	4 %	7 %	5 %	5 %	7 %
spring wheat (SWF)	8 %	12 %	15 %	10 %	12 %	14 %
sugar_beet (SWF)	2 %	2 %	3 %	2 %	3 %	3 %
winter wheat (SWF)	2 %	4 %	6 %	3 %	2 %	3 %

Plotting the yield reduction values on map shows the spatial distribution of the values. Potato seems to be affected in the whole of Southwest Finland with fairly constant and high values although the coastal region and archipelago have the highest reduction values. Yield reduction values for spring wheat are more unevenly distributed. Coastal areas have high reduction values, especially the southern parts with several squares having reduction rates of 25–30%. Inland areas have clearly lower values. The same pattern can be seen in the highest decile cutoff and mean yield reduction tables. Barley and rapeseed have lower reduction values. With barley, the higher yield reduction rates concentrate again on the coastal areas. (Figure 4).

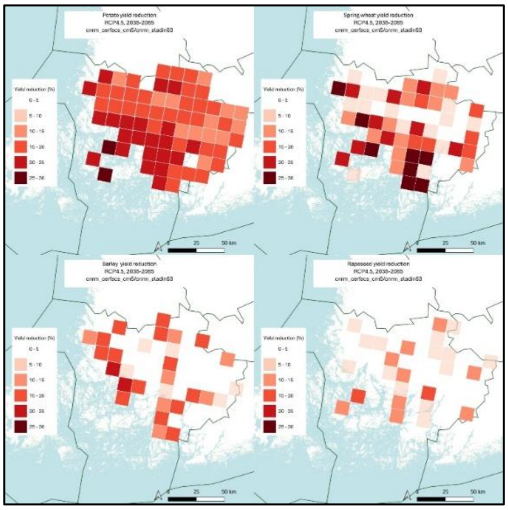

Figure 4. Yield reduction maps for different crops with RCP4.5, 2036-2065 and cnrm_cerfacs_cm5/cnrm_aladin63. Top left: Potato, top right: spring wheat, bottom left: barley, bottom right: rapeseed. Scale from 0-30 with 5% increments.

The next map shows the concentration of the highest decile points for each crop. Using heat map to show the most affected areas, adaptation measures can be concentrated more precisely where they are needed the most. The most severely affected areas are predominantly situated in the coastal areas. Especially the southwestern corner of the coastal area and part of the archipelago have the highest yield reduction rates (Figure 5).

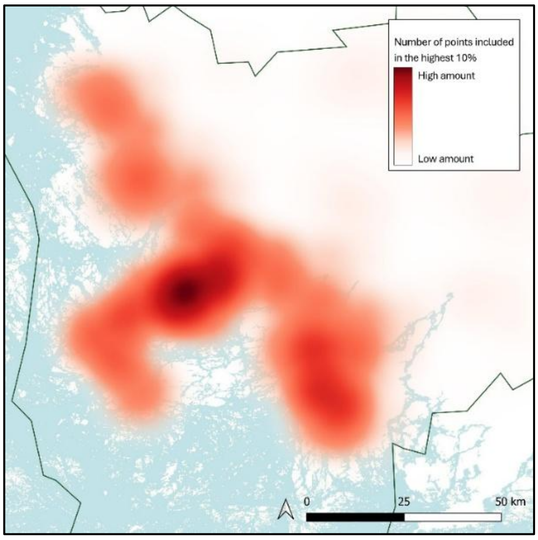

Figure 5. Heatmap of the highest percentile areas using the cnrm_cerfacs_cm5/cnrm_aladin63 model pair. The more points that are part of the highest decile of the whole data is in the area the darker the point is.

Using RCP4.5 and year range 2036-2065 as an example for available water capacity, precipitation and evapotranspiration rates, the coastal areas of Southwest Finland can be seen to have both low precipitation and available water content, and high evapotranspiration rates in the future. These phenomena seem to produce low yield rates in the future (Figure 6).

The results differ somewhat from the first phase results. Using local crop parameters and the updated CLIMAAX workflow where, for example, the initial soil moisture value is set to 100%, are likely causing the difference. The analysis can't consider all the changes expected in the area. With the climate change, the amount of snow before sowing season will reduce and droughts in the spring and early summer are expected to be more common. These two phenomena will likely reduce the crop yield even further.

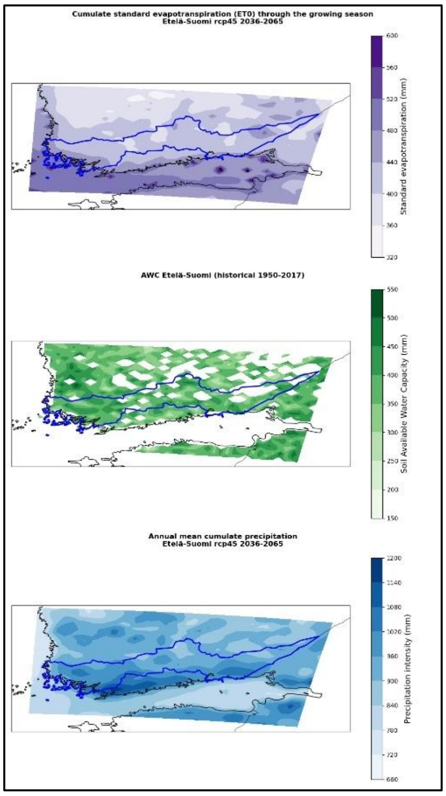

Figure 6. Evapotranspiration, available water capacity and mean precipitation in South Finland.

2.3.1.2 Risk assessment

Using the hazard assessment values, the most significant year ranges and crops were chosen for risk assessment. The complete hazard data is however available to use if the team or stakeholders are interested in further risk assessments. Oat can't be included in the risk assessment as it is not included in SPAM files used for the crop production evaluation. SPAM data does not differentiate between spring and winter wheat which is why spring wheat is used for the wheat assessment.

Using the climate model most fit for the region, cnrm_cerfacs_cm5/cnrm_aladin63, the geographical spread of the highest revenue loss areas differs between crop species as the analysis uses current production areas to calculate the future revenue loss. High revenue loss areas of potato and sugar beet concentrate on the north-eastern part of the region while those of barley and spring wheat mainly on the coast. The scale of the different maps differs so it must be noted that, for sugar beet and potato, the coastal area has similar or higher values than those for barley and spring wheat. (Figure 7).

High yield value rates, high production and relatively high price make potato's revenue loss higher than those of other analysed crops. Sugar beet is the next most affected crop among the studied crops.

With these results, adaptation measures for agricultural drought can be planned with more precision. Nature-based water management solutions, agricultural area placement, and choosing the right crops for the right area are some of the measures that can help mitigate the agricultural impacts of droughts in the future.

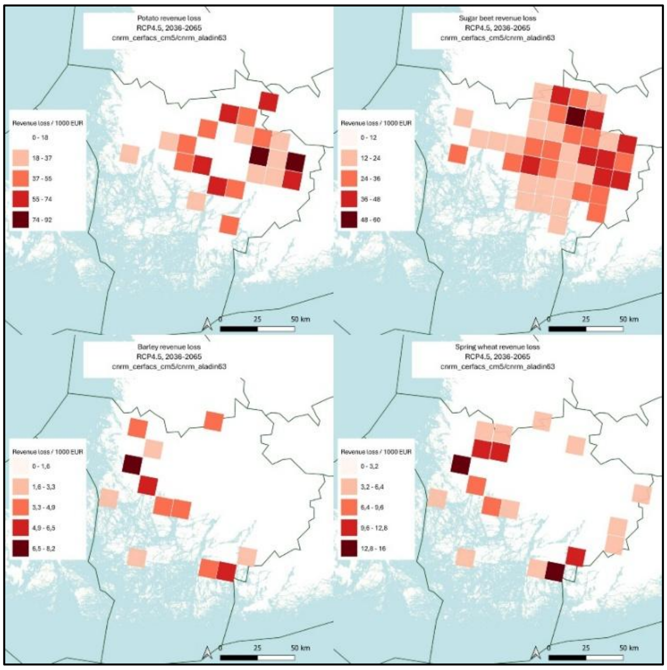

Figure 7. Revenue loss maps for different with RCP4.5, 2036-2065 and cnrm_cerfacs_cm5/cnrm_aladin63. Top left: Potato, top right: sugar beet, bottom left: barley, bottom right: spring wheat.

2.3.2 Workflow #2: Heavy rainfall - fine-tuning to local context

Heavy rainfall workflow uses historical precipitation data to calculate changes in precipitation in the future under chosen RCP scenarios for given years. In the workflow, different climate models can be chosen for the simulations. Precipitation level changes are compared with locally specified rainfall threshold levels to assess the change in frequency and magnitude of heavy rainfall. (Table 7). The results will then be assessed with geographical information of critical infrastructure, like hospitals and fire stations, to assess the risks for these points.

In the second phase, aggregation and compilation of data was done similarly when compared to the agricultural drought workflow. The precipitation analysis was, however, deemed highly uncertain going further into the future. After discussions with stakeholders, it was concluded that large scale analysis of heavy rainfall is the most useful way of approaching this issue. This was done using several climate models, scenarios, threshold values, and using statistical analysis for analysing the whole area of Southwest Finland instead of focusing on smaller areas inside of our region.

The risk assessment was partly finetuned to local context already in phase one and continued in phase 2. The team is still waiting if Finnish Meteorological Institute (FMI) can provide data using the HCLIM climate model which models northern Europe especially well. The model is not part of CLIMAAX workflow and due to licencing issues, FMI must conduct the analysis by themselves.

Table 7. Data overview for heavy rainfall workflow.

Hazard data	Vulnerability data	Exposure data	Impact metrics/Risk output
Precipitation intensity for a given return period, impact rainfall thresholds	Stormwater solutions Flood preparations	Critical infrastructures and population density	Impact rainfall thresholds Shift in magnitude and frequency

			Heavy rainfall events on critical infrastructure

2.3.2.1 Hazard assessment

Ready-to-go and bias-corrected datasets were used in this assessment. These datasets are provided by the CLIMAAX team and are calculated to be used by regions.

Climate models (both global and regional) often contain systematic errors, such as too many rainy days and underestimated rainfall extremes. Using uncorrected model outputs can therefore lead to unrealistic results in impact assessments. Thus, various bias-corrected datasets were used in the analysis.

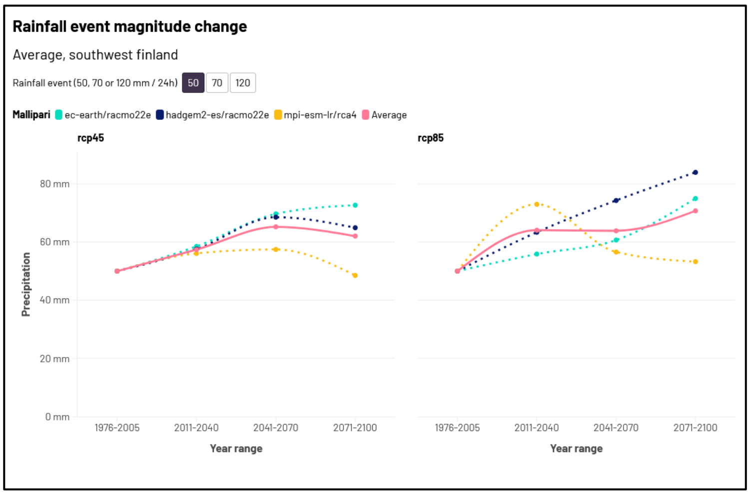

Figure 8. Rainfall event magnitude changes for event of 50mm/24h. *[Interactive graph with all different rainfall events available here.](#)*

The rainfall event precipitation level change in time was assessed using the Finnish national weather forecast thresholds. Three nonbiased model pairs were available for use in this workflow. All of them were used to calculate average values for the whole Southwest region area. Projecting future rainfall events in local scale is uncertain. Averaging the whole area made it possible to minimize errors in the analysis and to still get comprehensive and useful information for adaptation measures.

Table 8. Rainfall event magnitude changes for different rainfall events

Time period	50mm/24h		70mm/24h		120mm/24h	
Climate scenario	**rcp45**	**rcp85**	**rcp45**	**rcp85**	**rcp45**	**rcp85**
2011-2040	15 %	28 %	17 %	37 %	15 %	39 %
2041-2070	30 %	28 %	36 %	34 %	38 %	27 %
2071-2100	24 %	41 %	27 %	49 %	25 %	46 %

Rainfall magnitude will increase in the future according to all climate scenarios and all available climate models. Rainfall magnitude in the area increases on average from 15 % to 49% giving different results based on the time period, rainfall event and climate model. RCP8.5 results in higher increase in magnitude, except interestingly for the time period 2041–2070, the change in magnitude is inexistent or negative. Generally speaking, magnitude increase is more severe going to future and with higher rainfall event threshold values. Even the increase of the lowest magnitude by 15 % is high enough to cause several issues in the region.

Precipitation levels increase for each of the studied rainfall event. For rcp4.5, there is a slight decrease in the far future scenario (2071-2090). With rcp8.5 the increase is more severe and continues also far into the future. The differences between climate models are small and, in the big picture, all the models show clear increase in the magnitude of rainfall events. (Figure 8 and Table 8).

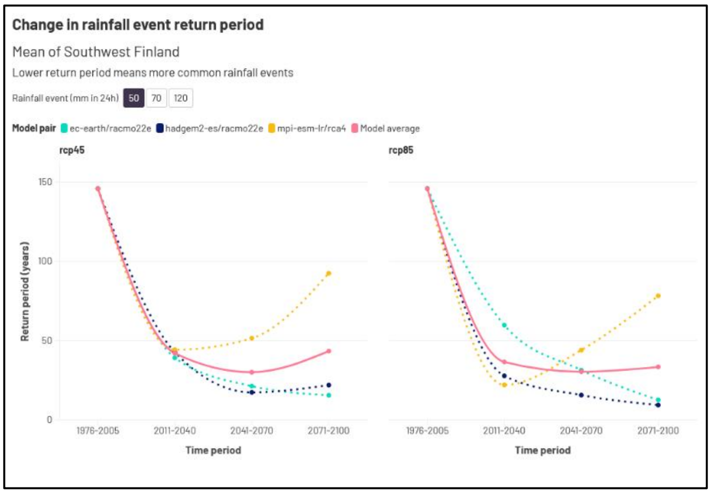

Figure 9. Change in rainfall event return period for event of 50mm/24h. [Interactive graph with all different rainfall events available here.]

According to the analysis, the rainfall event return period decreases dramatically. Historically, 50mm/24h events used to occur every 150 years but, according to the analysis, they will occur around every 30 years in the future. The return period of 70mm/24h events decreases from 500 years to around 120-160 years. The heaviest rainfalls of 120mm/24h face severe increase in frequency from once in 2000 years to once in 80-300 years. Again, the difference between models is small, except for mpi-esm-lr/rca4, which shows higher return periods especially for the far future scenario. According to the CLIMAAX bias dashboard, mpi-esm-lr/rca4 model pair has over +22% precipitation bias in our NUTS2 region which might explain at least partly the difference of this model compared to others. (Table 9).

The results show clearly that there is an urgent need to prepare for heavy rainfall events that will become both more frequent and with higher magnitude in the future. The results are consistent with national climate analysis' results.

2.3.2.2 Risk assessment

As the data is very comprehensive and the number of pages is limited in the report, examples of the results are shown in this chapter. All the data is available included in the data set, however. In phase 2, comparative and synthetic analysis was done for the risk assessment phase. Using all the available data, the analysis is more comprehensive and provides deeper knowledge for adaptation measures. More analysis has been done in the project than can be included in the reports. However, the results are usable internally and to stakeholders. In this example, hadgem2es/racmo22e model pair is used because, according to CLIMAAX model bias dashboard, it has the lowest bias of all the model pairs used. The middle rain threshold (70mm/24h) is used because of its severity and frequency. Visualising the results using constant scale and colours helps in understanding the differences between the results. The importance of clear visualisation is extremely important when presenting climate risk scenarios to stakeholders.

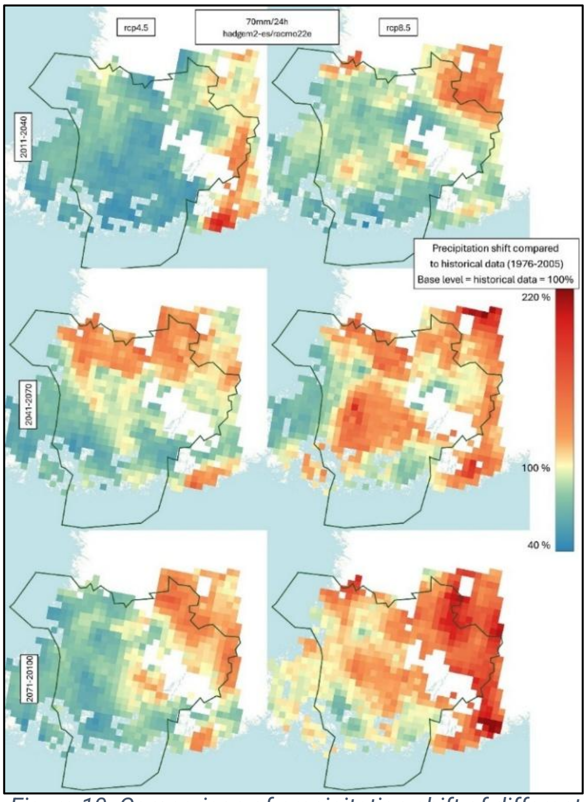

Figure 10. Comparison of precipitation shift of different climate scenarios and time periods using hadgem2-es/racmo22e models and rainfall event of 70mm/24h. Basemap: NLS.

The figure shows geographical precipitation shift compared to historical data for scenarios rcp4.5 (left) and rcp8.5 (right) and for time periods of 2011-2040, 2041-2070 and 2071-2100 (top to bottom). The maps show clear geographical distribution. Eastern and northern parts of the region have moderate to high positive precipitation shift. Southern and western parts, which are the coastal and archipelago area, show mild to moderate negative precipitation shift. Comparing climate change scenarios, eastern part has higher precipitation shift values in rcp8.5 than rcp4.5. Also, southwestern coastal area in the center has clearly higher values in rcp8.5 than rcp4.5. For other parts of the region, the increase in precipitation is milder. (Table 10).

Going from near future to far future, the big picture is that precipitation increases. Northern and northwestern parts of the region have consistently high precipitation shift values with the eastern parts getting more prominent in the future. Interestingly in rcp4.5 between 2011-2040 and 2040-2070, the areas with increased precipitation shift from eastern to northern parts.

Biggest cities of the area are located in the coastal areas, especially in the southwestern coastal area. In this analysis, rainfall precipitation change isn't severe in those areas except for the climate scenario rcp8.5 using middle and late future scenarios. This might relieve the area from the most severe risks, as rcp8.5 is considered not very probable. Still, adaptation measures should be conducted in especially the areas with high precipitation shifts. The area around the city of Salo has high positive precipitation shift values and it's one of the biggest cities of the region with heavy flood history already. The area around the town of Loimaa has exceptionally high precipitation magnitude increase. It's not a big town, but agriculture is prevalent in the area. Increased droughts combined with heavier rainfalls could have dramatical effects on the agriculture. Unfortunately, the analysis didn't produce results for southern and western parts of Salo. (Figure 11).

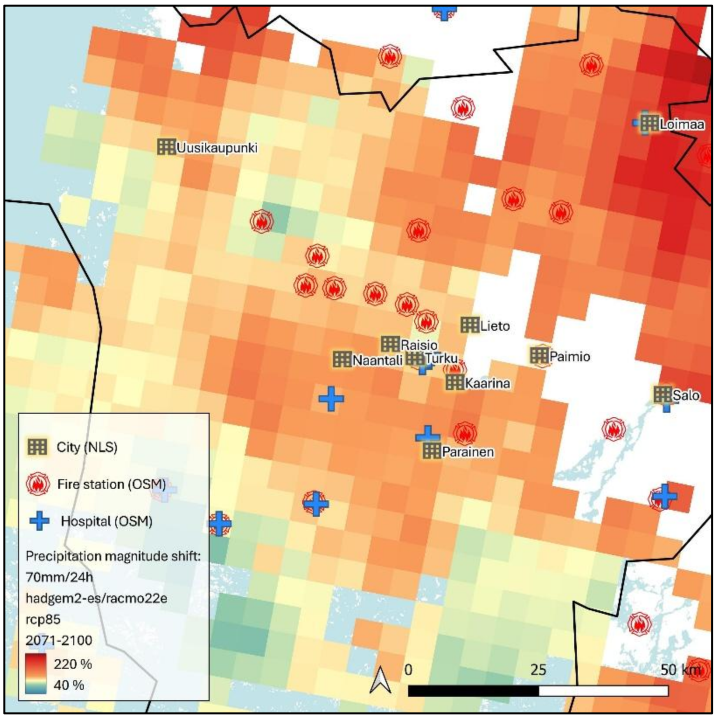

Figure 11. Key infrastructure and the ten most populated municipalities in Southwest Finland. Basemap: NLS.

These results call for more specific rainfall analysis and appropriate adaptation measures for the area around Salo. The results also strengthen the results of agricultural drought analysis as the negative precipitation shift falls in the coastal areas. High negative shift values can be seen especially in near future and rcp4.5 scenario. This confirms the urgent need for agricultural adaptation measures found in the agricultural drought analysis.

Key infrastructure analysed in the figure are hospitals and fire stations. These have usually good flood preparedness capacity but in smaller urban areas, big floods might affect their operations. Many locations of key infrastructure (for example sewage pump stations and plants) in the area are not open access and the project team couldn't use them in the analysis. Results will be shared with municipalities and other shareholders so that they can assess the risk for key infrastructure.

2.4 Key Risk Assessment Findings

Key Risk Assessment was conducted during phase 2 of the project using the guidelines of CLIMAAX handbook. Based on discussions with various stakeholders, the project team decided to customize the model to suit the needs of the region as well as possible. The assessment was published at Valonia's home page in Finnish (Valonia 2026b). See table 9 in section 2.4.6. for an overview.

Three new risk categories were added to the model:

- Heavy snowfall was replaced with Winter-related risks. The winters are expected to become milder in the future and there will be more rain, sleet, and ice. (FMI; Luomaranta et al., 2025) The region will thus face a wide array of new winter-related risks.
- Biotic risks was added as a new category. Climate change will bring new pests, diseases and invasive alien species to the region which has previously been protected by a cold climate. (Huhta & Melin, 2023)
- Nature-related risks was added as a new category to further emphasize the connections between climate change and nature. Climate change intensifies the impacts of other drivers for biodiversity loss. On the other hand biodiversity loss and ecosystem degradation weaken resilience and adaptation capability towards a variety of climate risks.

In addition to acute weather-related risks, the assessment also pays close attention to slow on-set chronic risks such as the increased moisture burden of buildings, increased winter-time attrition of roads, and biodiversity loss. In addition to risks, four thematic multi-risk assessments were produced on Archipelago Sea, agriculture, soil impacts, and global cross-border impacts.

2.4.1 Mode of engagement for participation

The mode of engagement for participation has been described in detail in section 2.1.5.

2.4.2 Gather output from Risk Analysis step

The results from agricultural drought and heavy rainfall analyses were used to bring in new localized data for the assessment. The agricultural drought analysis was especially valuable as the region has previously lacked crop-specific data on the impacts of droughts both currently and in the future.

2.4.3 Assess Severity

Every climate risk except windstorms is expected to increase in severity in the future in the region.

River floods (Current (C): moderate, Future (F): substantial): The severity of river floods has recently decreased due to successful flood control measures conducted in the most flood-prone areas. There are currently no high flood risk river areas in the region. (Gregow et al. 2021, vesi.fi a) In the future, the heavier rainfalls and increased winter-time rainfalls will increase the flood risk. The damages are expected to be mostly economic while human lives are likely not in danger. In 2024, an exceptional winter flood occurred in the northern parts of the region. The event resulted from a combination of factors: an extensive snowpack melted rapidly within a short period accompanied with a concurrent heavy rainfall. Based on discussions with local stakeholders, authorities had not anticipated a flood of this magnitude, and it is thus possible that flood risk areas have to be reassessed. It has been estimated that such winter flood events will become increasingly common in Finland due to climate change (Mäntykannas 2024). Awareness on flood risks is high in the region.

Coastal floods (C: moderate, F: substantial): The coast around the city of Turku is identified as a high flood risk area where storm winds occasionally increase the sea level significantly causing damages worth millions of euros every 5–10 years. Measures at the Turku harbour have limited damages. (Turun tulvaryhmä, 2022) The global rise in seawater level is expected to increase the coastal flood risk in the future. The post-glacial land upheaval reduces the impact of global rise of sea level. The pace of the rising is expected to surpass that of land upheaval around mid-century, and the flood risk will increase towards the end of the century. (Gregow et al., 2021; FMI, 2023) Identified high risk coastal flood areas around the coast of Turku are attractive for construction of new residential buildings which increases exposure of humans and infrastructure. There are several proposed projects currently under planning for those areas. The increasing risks have not yet been sufficiently considered in planning and awareness spreads slowly. Discussions with local stakeholders led to increasing the risk level of coastal floods in this assessment.

Heavy rainfall (C: moderate, F: substantial): During the participatory process, it became very clear that heavy rainfalls are already a problem in the built environment. Stormwater management systems cannot handle current stormwater loads and there are not enough permeable surfaces in the cities capable of absorbing the stormwater. Heavy rainfalls cause mostly economic damages. Based on the risk analysis made with CLIMAAX tools, the intensity of heavy rainfall events is expected to increase 15–49% and the frequency to be from 2 to over 20 times more common in the future increasing the risk substantially. Increased heavy rainfalls in winter increase the winter flood risk. Increased droughts weaken the ground's ability to absorb water during heavy rainfalls. Heavy rainfalls increase the risk of landslides which can have severe consequences. (Ahokangas, 2026) The increasingly intense heavy rainfalls put current stormwater management systems under significant stress if not improved. In serious cases, the rainfalls can cause significant damage to infrastructure, cause delays to transport and rescue services, and even threaten ecosystems and human lives. The risks are widely known among those working with stormwaters but funding to improve them has been scarce. Nature-based solutions have been planned for small projects instead of larger entities.

Heatwaves (C: moderate, F: substantial): Heatwaves have significant health impacts in Finland and the risk was highlighted very strongly by stakeholders. Awareness to the risk, however, is rising slowly among decision-makers and significant measures are missing. The population is adapted to a cooler climate and mortality starts to rise when the daily average rises above 15 °C and significantly when it rises above 20 °C. Heatwaves can already cause hundreds of extra deaths making it the only climate risk in the region with serious human impacts. The buildings are built for winter and cooling has not been sufficiently considered in planning. (Kollanus et al., 2021; Kollanus et al., 2023) The amount of hot days (>25 °C) has already risen and will continue to rise significantly in the future. Their amount might triple by the end of the century which will increase the risk posed by heatwaves. (FMI) Heatwaves impact also nature, especially rivers, lakes and the Archipelago Sea killing species not accustomed to warm water and increasing blue-green algae.

Drought (C: moderate, F: substantial): Many parts of the region are considered high drought risk areas with various unfavourable conditions (Snellman & Todorovic, 2023) Droughts were strongly emphasized by the stakeholders during participatory process and their impacts are well recognized. Water supply for the most populated area around the city of Turku has been secured with artificially infiltrated groundwater. (Turun seudun vesi) Droughts impact especially agriculture but also the water supply of sparsely populated areas which was specifically highlighted by stakeholders. Droughts cause almost annual losses to farmers many of whom are simultaneously coping with financial difficulties. According to the risk analysis made in the project, the impacts of agricultural droughts are expected to increase in the future with possible cascading financial impacts on farmers. The region is a nationally important agricultural area, and droughts can have an impact on food supply, especially in potential crisis situations. The droughts also impact heavy rainfalls as dry and hardened ground is unable to absorb the rain which can lead to flooding and increased nutrient runoffs to the Archipelago Sea. The droughts have various negative impacts on both flora and fauna.

Wildfires (C: limited, F: moderate): Wildfires are under control in the region and widespread fires remain rare. Wildfires are detected and extinguished quickly and they have not caused severe threat to lives or infrastructure. According to a risk assessment conducted in CLIMAAX project (Kühn et al. 2025), the fire hazard is not expected to increase substantially in the region. There are, however, uncertainties in the analysis. As winters shorten in the future, the wildfire season will start earlier in the spring than before. Droughts and heatwaves will increase in the future which might increase the wildfire risk. Discussions with stakeholders led to the rising the risk level for future. The risk is well recognized and prioritized by stakeholders and decision-makers.

Winter-related risks (C: moderate, F: moderate): Winters are expected to become significantly milder and the region will face a wide array of new winter-related risks. (FMI; Luomaranta et al. 2025) As the risks will be of significant impact for the region and they were highlighted in many stakeholder discussions, the project team included a new risk category to the assessment. The winters will become shorter and darker, snowy and subzero days will decrease, and there will be more ice, rain and sleet in the future. The winters have already changed significantly and the changing will continue to be quick in the future. (Gregow et al., 2021; FMI, Luomaranta et al. 2025) The risks will increase in near-future but as the climate change proceeds, some of the risks will start to decrease in the far future. The changing winters have several impacts on nature, productivity of agriculture and forestry, long-term moisture burden of buildings, durability of infrastructure, and the safety and health of citizens (street dust, accidents, mental health issues due to grey and dark winters). Increased rainfall in the winters will increase both the flood risk and nutrient runoffs to the Archipelago Sea which already suffers from them. Awareness of the severeness of the risks brought by the changing winters and the need for actions is rising among stakeholders and decision-makers.

Windstorm (C: limited, F: limited): Overall windiness is not expected to become worse in the future. For the strongest windstorms, it is unclear whether the storms stay the same or whether they become stronger. Winter-time damages to the forests, however, are expected to increase due to decreasing ground frost. (Gregow et al., 2020; Ruosteenoja et al., 2019) Falling trees can close roads and cause damage to infrastructure, buildings and people. Stakeholders did not consider the windstorms a major risk for the region.

Biotic risks (C: moderate, F: substantial): Biotic risks are risks caused by living organisms like insects, fungi, bacteria or viruses. The cold winters have previously protected Finland from many common pests and diseases but as the winters become milder, more species can survive the winters better. This category was suggested by stakeholders during the participatory process. Climate change will increase disease and pest risks in agriculture and forestry and thus also economic losses. Invasive alien species and diseases worsen the impacts biodiversity loss and can pose even cascading risks to the nature. (Huhta & Melin, 2023; Paulomäki et al., 2023) For humans, the pollen season will start earlier and the amount of pollen will increase which worsens the allergic symptoms. (Allergia-, iho- ja astmaliitto, 2025) The amount of ticks has already increased significantly and many parts of the region are high-risk area for tick-borne encephalitis. Other species able to spread diseases such as tiger mosquito might find their way into the region. (FMI 2025) Blue-green algae, norovirus and vibrio bacteria that are present in very warm seawater pose health risks. (Varha 2025)

Nature-related risks (C: substantial, F: critical): Nature-related risks refer to ecosystem degradation and biodiversity loss. The inclusion of nature-related risks to the assessment was strongly suggested by stakeholders. The species and ecosystems have adapted to a climate that no longer exists. Some species can move to another place, but many cannot. The state of nature is already alarming and with current trajectories, it is expected to become critical in the future. The region suffers from the sudden change of nature's cycles, the worsening condition of the Archipelago Sea and other water bodies, and of overall ecosystem degradation which are all fuelled by the climate change. The Archipelago Sea is the most critical ecosystem in the region, suffering from impacts of several climate impacts with potential cascading and irreversible effects. Increased precipitation has intensified freshwater runoff and nutrient loading from the catchment areas, increasing eutrophication and making the brackish water less saline. Together with the long-term warming of the seawater, they cause change-induced transformation in the Archipelago Sea. (BSAG; Ilmasto-opas 2014; Itämeri.fi) Biodiversity loss and ecosystem degradation have the potential to cause severe disruptions to ecosystem services and adaptation capabilities of different ecosystems and local communities.

2.4.4 Assess Urgency

Six out of ten risks assessed were identified to need either more actions or immediate actions. Three of the risks assessed were identified as needing to watch brief on the development of climatic conditions. Only one of the risks, windstorm, was seen to not require any significant actions.

River floods (Watching brief): The changing climate is bringing heavier rainfalls and increased winter-time rains in the near future already. The situation must be followed closely, and new measures should be implemented if flooding becomes regular.

Coastal floods (More action needed): The risk is expected to become increasingly severe towards the end of the century. There are currently several initiatives to build new residential buildings on the coast around the city of Turku which has been identified as a high-risk coastal flood area. There needs to be more action to take the risk into account already at the construction phase which was also strongly emphasized during the participatory process.

Heavy rainfall (Immediate action needed): Heavy rainfalls are already causing problems in the region and especially in cities. The frequency and intensity of the events is expected to increase in the near future calling for immediate action, strongly emphasized by local stakeholders as well.

Heatwaves (Immediate action needed): Heatwaves are already causing significant mortality among people who belong to vulnerable groups such as sick and elderly. The situation calls for immediate actions to decrease heat-related mortality. Cooling solutions to residential buildings and conducting nature-based solutions in urban areas to decrease the impacts of the heat island effect must be implemented. As conducting cooling measures to existing buildings is expensive and many housing companies face financial restraints, adapting to increased heatwaves can take a long time. The urgent need for the actions was strongly emphasized by stakeholders.

Drought (More action needed): The droughts have the most severe impacts on agriculture where immediate actions are needed. The losses are already almost annual and the situation is expected to worsen. As increasing artificial irrigation is challenging due to high costs and lack of water sources, the farmers must focus on improving soil condition at the fields. Water retention capacities at the water basin level must also be improved. Implementing these measures takes time and resources which makes making changes slow in the large scale. More actions are needed to improve the water supply security of sparsely populated areas and capacity for water delivery during crisis situations. No actions are needed to improve the water supply of most populous areas in the region around Turku which receive artificially infiltrated groundwater.

Wildfire (Watching brief): Wildfires are under control in the region. As droughts and heatwaves are becoming more severe in the near future already, the risk must be followed closely.

Winter-related risks (More action needed): There are both acute and chronic winter-related risks. Icy conditions and recurring freezing-melting cycles are increasing until around mid-century and make roads dangerously slippery. Immediate attention should be paid to de-icing of and snow removal from sidewalks to ensure that the sidewalks are safe for everyone, including those with disabilities who might currently not even be able to leave their homes in the winter. Immediate attention should be paid to the significant health hazard caused by street dust which is a by-product from various anti-slippery measures. Winter-time flood risk must be followed closely, and more actions must be taken if the risk seems to grow significantly. Immediate actions to decrease the nutrient runoffs to the Archipelago Sea must be conducted. Immediate actions are needed to consider changing climate in all renovation and construction projects on a wide variety of issues. In agriculture and forestry, more actions are needed to address changing winter conditions. More attention to impacts of changing winters on mental health must be paid.

Windstorm (No action needed): Overall, there is currently little need for actions. Windiness does not seem to be changing much and there is conflicting research on whether windstorms will increase in the future. As ground frost decreases, forest damages are projected to increase in the future calling for more actions in forest planning.

Biotic risks (Watching brief): As biotic risks are slowly worsening chronic risks, their development can be monitored. Agriculture and forestry are sectors where the risk should be followed the closest. As these risks are new, capacity building and training are needed. Invasive alien species can spread into nature quickly and cause significant damage which means that they must be followed closely and actions must be conducted if needed. Biotic risks have potential to persist.

Nature-related risks (Immediate action needed): Nature-related risks are mostly chronic and slowly worsening risks in their nature. Acute weather-related risks can cause harm to species and ecosystems. The nature protection initiatives have not been able to reverse biodiversity loss and ecosystem degradation, and immediate actions are needed to strengthen them everywhere. Several climate risks and cascading effects have an impact on Archipelago Sea which is in a bad condition already. If the condition of the sea reaches a tipping point, there might be irreversible consequences. Immediate actions to decrease nutrient runoffs and other actions are needed. The high urgency to increase actions for nature was strongly emphasized by stakeholders.

2.4.5 Understand Resilience Capacity

Many impacts of the climate change have either recently become or are soon becoming visible. As many risks are new, the region has been lacking robust adaptation measures and strategies in the large scale. Overall, the potential of the region to respond to the challenges posed by the climate change is high. The climate change is not expected to bring catastrophic impacts to the region and Finland is, in many ways, a very highly functioning welfare state. The weak state of national and municipal economy poses challenges for finding sufficient funding for actions.

River floods (Medium): Authorities are legally required to address flood risks due to flood risk management act (620/2010) which means that the risks must be considered and actions conducted. River floods seem to be under control with current measures. Areas with the highest flood risk are known and monitored. Due to the measures implemented recently, there are no flood risk river areas of the highest category in the region anymore. (Vesi.fi a) Despite this, there are still no means to control the flow of the rivers in the region which means that there are no acute measures to have an impact on floods if one arises.

Coastal floods (Medium): Authorities are legally required to address flood risks due to flood risk management act (620/2010) which means that the risks must be taken into account. Regional Flood Management Group monitors the situation at the strategic level. Measures conducted at the Turku Harbour have succeeded in limiting the damages. (Turun Tulvaryhmä 2022) Planned construction of residential buildings in areas of high flood risk is a pressing matter. According to many stakeholders, flood risks and measures to address them have not been sufficiently considered in the planning so far. If flood risks are not considered during planning and construction phases, it might be difficult and expensive to consider them afterwards. On the other hand, the solutions to respond to the risk should not be too difficult to implement.

Heavy rainfall (Medium): Current capacity to respond to increasingly heavier rainfalls is limited. The capacity of stormwater systems is not sufficient to handle the heaviest rainfalls and measures for the absorption and retention of stormwater in the cities are already insufficient. Stormwater management systems suffer widely from maintenance backlog and the current trend of cutting down public spending does not help the situation. Awareness on the benefits of nature-based water retention and absorption solutions is increasing. Cities are starting to require solutions for new construction projects and also for renovation projects. Older residential districts are, however, problematic because it is not easy to force binding regulation to areas which have been built using old standards. In agriculture, heavy rainfalls cause financial losses. In many farms, the capacity for water management in the fields should be improved to address the changing climate.

Heatwaves (Low): Residential buildings have been designed against cold winters and cooling solutions have not been considered sufficiently. Many apartments have high temperatures at rather low summer temperatures which peak during heatwaves. Cooling solutions are available, but they are usually energy-intensive, expensive and limited to single apartments instead of the whole building. Such solutions have been piloted for residential buildings, but they are yet to become common in the large scale. Newer buildings are more often equipped with cooling solutions, but older apartment blocks lack them. (Valonia 2026a) Financial difficulties and maintenance backlog limits the implementation of cooling solutions in the large scale. Heat island effect has been recognized and nature-based measures to address it by increasing vegetation and permeable surfaces are spreading. City of Turku uses blue-green factor in urban planning that makes it possible to require measures that limit the impact of heatwaves. (Turku.fi) Vulnerable groups like poor and sick might not have the possibility to have an impact on their living conditions. Awareness for the heatwave risk and demands for more actions are spreading in the society.

Drought (Medium): Water supply for the majority of the region is secured with artificially infiltrated ground water. (Turun seudun vesi) Securing the water supply of households in the sparsely populated areas should be addressed. Households depending on wells and/or situated in the archipelago are the most exposed ones. Water delivery capacity in crisis situations is not sufficient. Most enterprises that are dependent on water are trusting the capacities of water supply facilities to supply water at all times which means that they are not prepared for interruptions. (Turun kauppakamari, 2025) The region is lacking robust measures to address agricultural drought. There are very few lakes or other natural water storages in the region suitable for increasing artificial irrigation capacity (Snellman & Todorovic, 2023). The capacity of rivers and creeks in the region is not sufficient. Many farmers are suffering from financial difficulties which decreases their capacity to address the issue. Actions on improving water management at farms can be done but there is lack of awareness, time and resources. Measures that are conducted at the water-basin level are direly needed but funding for the measures is lacking. In forestry, there is knowledge, and adaptation to changing climate is considered important but the long growth cycles that can range from 60 to 100 years mean that making changes in forests takes time.

Wildfire (High): Wildfires are detected and extinguished quickly. Widespread wildfires are very rare in the region. In case of rare situations with multiple wildfires, the rescue services might become strained and not fully capable of answering to all tasks. The vast majority of the forests in the region are within 1,5km from the nearest road which makes extinguishing easier. Forest and private roads have a lot of maintenance backlog and changing winter conditions make maintenance more difficult. Winters are becoming shorter and the wildfire season begins earlier in the spring (Kühn et al. 2025) which means that roads can be in rough condition after the winter. Wildfire warning system works well and has good media coverage. There are regular campaigns for forest fire awareness. Majority of forest fires still result from human activities which means that there is room for improvement.

Winter-related risks (Medium): The changing winters have both acute and chronic impacts calling for capacity building, awareness and best practices. Milder winters cause more wear and tear to roads (Haulos et al. 2023) Funding for maintenance has been insufficient for long and many roads have significant maintenance backlog. De-icing dangerously slippery sidewalks is already challenging. Efforts to maintain sidewalks safe and accessible for everyone should be emphasized. The serious health hazard created by street dust calls for new best practices for de-icing and de-snowing to be developed and implemented. In the archipelago, measures to improve transportation during times when the sea ice cover hinders normal transportation methods should be increased. Increased rains during winters increase the flood risk. (Mäntykannas 2024) The region was surprised by the combination of heavy snowfall, ground frost, melting waters and heavy rainfall in November 2024 which was a wake-up call for authorities. The floods exposed the need for more research on the probability of such event and measures to address the risk. Changing winters challenge the longevity of materials used in buildings and infrastructure due to increased moisture stress and wind-driven rains. Long-term moisture burden of buildings is expected to increase which might increase symptoms of sick building syndrome. (Lahdensivu et al. 2023) Measures to address building material related issues exist but they require awareness, knowledge and financial resources, all of which are often lacking. Milder winters allow for introduction of new agricultural pests and diseases and make the overwintering of the crops more difficult. (Huhta & Melin 2023) Knowledge and awareness of farmers on how to address the issues must be increased. Winter rains and flooding increase the nutrient runoffs to the Archipelago Sea significantly. (vesi.fi b) Measures to address the issue are being implemented but more are needed. Increasing them is challenging due to lack of funding, awareness and often also will.

Windstorm (Substantial): Finland has a robust wind warning system. Organizers of public events are required to follow the wind forecasts and protection from winds must be considered. Absence of ground frost increases forest damages in the future (Gregow et al. 2020) and it will become more important to consider wind sensitivity of trees especially around buildings and critical infrastructure. As the electrification of the society goes on, the vulnerability to power outages increases. Electricity network companies have protected their networks by moving from overhead lines to underground lines. The work is continuing in sparsely populated areas of the region.

Biotic risks (Medium): As the warmest region in continental Finland, the region faces the impacts of new pests, diseases and invasive alien species among the first regions. The risk is chronic in its nature and expected to worsen in the future. Research and best practices are needed to address the risks in the region and to prepare the rest of the country for the impacts. Knowledge, awareness, and measures to address the risks are needed especially in agriculture and forestry. Invasive species have already a major impact on certain ecosystems especially in the archipelago. The situation is expected to worsen in the future for which increased funding and resources are needed. While the risk of human disease is rising, health care sector in Finland is highly developed and capable of addressing challenges related to human health. Future budget cuts can still have an impact on it.

Nature-related risks (Medium): There are many initiatives and programmes to address biodiversity loss and ecosystem degradation, but they have not been enough to reverse the ongoing trend. The first regional biodiversity strategy is currently in the making, but many municipalities are still lacking one. Data regarding nature is incomplete, shattered and difficult to understand. The value of nature is often put against other values like economic values in decision-making. The state of nature is in many ways alarming and there is a dire need to increase actions everywhere in the region. Due to interconnectedness of nature, there is need to strengthen activities at national, European and international levels. There are ongoing initiatives such as the Archipelago Sea Programme that have succeeded in decreasing nutrient runoffs to improve the condition of the Archipelago Sea. Climate change intensifies the impacts of nutrient runoffs, desalination, water temperatures, and invasive species. More funding and resources for actions for the Archipelago Sea are needed.

2.4.6 Decide on Risk Priority

The risk priority was decided based on the severity of the risks both current and future, urgency and existing capacity. The project team conducted the initial prioritization which was then adjusted based on stakeholder feedback. The prioritizing process was rather straight-forward and simple. Summary of the risk assessment can be seen below in Table 9.

Heavy rainfall and drought were recognized as most important risks before the project began and the participatory process further strengthened the view. Heavy rainfalls cause problems already and the risk is expected to increase severely already in the near future. Droughts were classified to be of very high priority especially due to the already visible impacts on agriculture that are expected to worsen in the future. The high priority for heatwaves and nature-related risks emerged from stakeholder cooperation where they were considered both severe and in need of immediate actions. Heatwaves were prioritized very highly due to high mortality, strong increase of heatwaves in the future, and low capacity. Nature-related risks were prioritized very high because of the already alarming state of nature, strong impacts on the Archipelago Sea, the dire need for immediate action, and for the fact that the adaptation capacity of nature and its ecosystems is key to successful adaptation. Coastal floods were considered of high priority especially due to the expected increase of the risk in the future and construction projects planned at high flood risk areas in the region.

River floods, winter-related risks and biotic risks were given a moderate prioritization. River floods were considered moderate because the situation seems to be under control, but the climate change might have unexpected effects on it, especially related to winter-time flooding. Winter-related risks are various in their nature with some risks prioritized higher and some lower due to which they were given a moderate prioritization as a compromise. Biotic risks were given moderate prioritization because the situation can be monitored due to them being slow-onset risks and because they are not as pressing as others in higher categories. Wildfires and windstorms were given a low prioritization because the situation is well under control, capacity is strong and the risk is not urgent.

Table 9. Summary of the key risk assessment.

Summary of the risk assessment					
Risk	**Severity (current)**	**Severity (future)**	**Urgency**	**Capacity**	**Risk priority**
River floods	Moderate	Substantial	Watching brief	Medium	Moderate
Coastal floods	Moderate	Substantial	More action needed	Medium	High
Heavy Rainfall	Moderate	Substantial	Immediate action needed	Medium	Very high
Heatwaves	Moderate	Substantial	Immediate action needed	Low	Very high
Drought	Moderate	Substantial	More action needed	Medium	Very high
Wildfires	Limited	Moderate	Watching brief	High	Low
Winter-related risks	Moderate	Moderate	More action needed	Medium	Moderate
Windstorm	Limited	Limited	No action needed	Substantial	Low
Biotic risks	Moderate	Substantial	Watching brief	Medium	Moderate
Nature-related risks	Substantial	Critical	Immediate action needed	Medium	Very high

2.5 Monitoring and Evaluation

During phase 2, the biggest learning experience was related to finding out the abundance of silent knowledge among stakeholders. Even though there are numerous written reports that are rather new, the data may already be outdated due to the rapidly progressing climate change. This will undoubtedly be the future of this CRA as well meaning that the outputs must be kept up to date in the future to retain their importance which requires funding and resources.

The CRA process has been considered challenging but successful. Local stakeholders participated in the work with great enthusiasm to learn more about the risks and how to adapt to them which surprised the project team positively. While there is always room for improvement in the participatory process, the project team succeeded in involving a great number of local stakeholders across the region and different sectors. Transparency and participatory approach were positively acknowledged by the stakeholders. Judging uncertainty and credibility of the severely fragmented data sources, and the vastness and interconnectedness of regional climate risks made the CRA work a challenging but also a fruitful learning experience which built invaluable capacity within the project team and the regional council. The rather vague guidance for the key risk assessment model made the process a bit challenging. While the assessing criteria were rather clear, the project team would have preferred to have instructions on how the assessment workshops could be organized, and how the end-product should be constructed besides the evaluation dashboard, for example. On the other hand, this made it possible for the project team to produce a CRA that fits the region the best.

The region has neither a robust monitoring system in place nor are there clear indicators for climate change adaptation which need to be considered in the future. The roles of different stakeholders in monitoring and evaluation are still to be agreed upon in the region. It is likely that the Regional Council, Centre for Economic Development, major cities, rescue services, and health care providers have the most important roles in it.

The key risks assessment and the regional climate roadmap have been drafted together with stakeholders and for them to use. The importance of climate adaptation as a common cause for the region has been stressed throughout the work. The regional council and Valonia are funded by the municipalities which are also the beneficiaries of all the work conducted. The learning process of the stakeholders on regional climate risks has been ensured by communicating the issues efficiently via various communication channels and by giving consultations when needs and opportunities arose. The project team has been invited to give presentations on the theme and the organizing of a public final event is under planning. The assessments have been featured in local media.

The resources have been used efficiently in the project and the entire salary budget is expected to be used by the end of phase 3. The budget change in February was much needed as funds were allocated from subcontracting to internal personnel costs. The budget change allowed the project to include more expertise to the CRA work, to developing adaptation measures for the regional climate roadmap, and communications. The efficiency of the project team was remarkable and all actions were completed as planned.

The key risk assessment provided the region with its first comprehensive CRA and was widely applauded as a meaningful and valuable contribution for the whole region. It was considered a much-needed starting point for a variety of stakeholders who can now build on it and begin to create their own municipal and sectoral assessments and roadmaps. The CRA work has significantly improved the understanding of regional climate risks in Southwest Finland and the participatory process brought together different stakeholders regarding climate change adaptation sparking also new cooperation initiatives. The events, communication materials and publications have increased the awareness of both stakeholders and the wider public which was low at the start of the project.

2.6 Work plan Phase 3

In phase 3, the project team will focus on transforming the findings of the CRA into adaptation measures and on updating the regional climate roadmap. The work on adaptation measures and climate roadmap began during phase 2 and the project team has had a major influence in drafting adaptation measures together with stakeholders. The climate roadmap will include adaptation measures for 5 sectors (energy, transportation, agriculture, construction, and spatial planning, forests & other green structures). The CRA is used as an important resource to ensure that the measures address the most significant climate risks. The project team is also looking into possibilities of gathering measures from fields that are not present in the roadmap. In phase 3, the project team will identify next steps and measures that are needed in the region the future to build upon the CRA and adaptation planning work which were set to motion in the project. If possible more workflows will be tested in the phase 3 as they might give important information for climate change adaptation. Urban heatwaves have been assessed in the region, but only for the city of Turku. Spreading the analysis on other cities might be feasible if time and resources allow for that.

Phase 3 will be important for dissemination of project findings which began in phase 2. The updated regional climate roadmap will be the main publication in phase 3 and should be finalized and formally accepted by the end of 2026. The project team will organize an adaptation seminar for the municipalities at the end of the project, produce a policy brief and reports on the deliverables, and disseminate project findings in a national scale climate conference. The project team will also organize smaller meetings with local stakeholders to present findings and discuss future collaboration opportunities. The project team will also support local stakeholders in their work, if and when needs arise. The project team will take part in the CLIMAAX workshop in Brussels at the end of the project.

3 Conclusions Phase 2 – Climate risk assessment

The phase 2 of the project saw the finalizing of the regional climate risk analyses conducted using CLIMAAX tools on agricultural drought and heavy rainfall, and the completion and publication of the regional key risks assessment. Both main results increase the climate risk related knowledge base in the region significantly. The updating process of the climate roadmap began in phase 2.

The risk analyses on agricultural drought and heavy rainfall both show that the risk is expected to worsen already in the near future. For heavy rainfalls, the risk is expected to increase significantly. The intensity of heavy rainfall events is expected to increase 15–49% and the frequency to be from 2 to over 20 times more common. As heavy rainfalls can already cause significant problems in the region, more emphasis must be put on the measures to increase the capacity of stormwater systems and nature-based solutions. For agricultural drought, the expected losses vary depending on the timeframe, scenario, crop and the location in the region. Some crops like potato and spring wheat, and areas like the archipelago are expected to suffer significant losses in the future. As increasing irrigation in the region is challenging, the efforts must be put in advancing nature-based solutions conducted both at fields and at the water basin level.

Based on the CRA, the regional climate change adaptation measures should especially address the risks posed by heatwaves, heavy rainfall, agricultural drought, and nature-related risks. The increased coastal flood risk in the future, water supply of the sparsely populated areas, and some of the winter-related risks like increased slipperiness, street dust, and weakened material durability also require strong emphasis. The built environment, agriculture, and nature (especially the Archipelago Sea) were seen to require special attention. For many risks, it is important to monitor the development of the risk and increase actions when the situation calls for it.

Making the climate risk analyses and assessments in-house with the help of local stakeholders and researchers was challenging requiring expertise and human resources but which, on the other hand, created deep understanding and ownership, and allowed for knowledge transfer both within the regional council and local stakeholders. Reaching out to researchers was key in ensuring the credibility and trustworthiness of the results. While the CLIMAAX tools provide rather trustworthy results overall, they cannot be trusted blindly as was the case with river flood damage and population exposed workflow which produced untrustworthy results. Critical thinking and the ability to compare results with existing data and assessments was important in maximizing the benefits of the climate risk analysis tools. The CLIMAAX handbook and helpdesk were of great help during the phase 2.

The project team paid strong attention to stakeholder engagement during phase 2. A total of 57 organizations and also common citizens took part in the climate risk analysis and assessment work during phase 2. Stakeholders were key in the co-creation of climate risk analyses. Stakeholders provided suggestions and invaluable localized data for the risk analysis process. Stakeholder engagement was also key in ensuring the ownership, quality, and credibility of the CRA. While there is an abundancy of published open-access data and studies from various climate risks available, the participatory process revealed the vast amount of silent knowledge present in the region on a variety of climate risks without which the assessments wouldn't have turned out as comprehensive as they did. It was also an important finding that climate risks are of great interest among local stakeholders and once engaged in the work, stakeholders take part in the work with great enthusiasm.

Communicating the findings to stakeholders in an understandable and targeted fashion is of great importance. Providing a bigger picture is more important than exact numbers and graphs. The knowledge level of local stakeholders on climate risks is often low and risks to their operations have not been considered sufficiently. This calls for increased capacity-building and spreading of awareness in the region so that stakeholders understand the impacts of different climate risks and the importance of adapting to them.

4 Progress evaluation

Table 10. Overview key performance indicators.

Key performance indicators	*Progress*
Phase 2: 2 workflows successfully applied on Deliverable 2 (2)	Completed and reported in Deliverable 2.
Phase 2: 20 of stakeholders involved in the activities of the project.	Stakeholders from 57 organizations took part in the project during phase 2. Common citizens took also part in the project.
Phase 2–3: Climate risk webinar for municipalities (1)	The webinar was organized on April 21, 2026.
Phase 1-3: Reports on each deliverable (3)	With the submission of this report, 2 reports on deliverables have been published on Zenodo.
Phase 2: 1 report on 2 risk workflows (1)	The preliminary report on the risk workflows was published in November 2025 and updated at the end of phase 2.
Phase 1-3: 3 articles in regional media mentioning the project (3)	7 news articles directly mentioning the project were published in regional media. Besides these, one more article based on a press release was published where the project's name did not make the press. The project coordinator was interviewed for a local radio channel. More mentions may follow during phase 3.

Table 11. Overview milestones.

Milestones	*Progress*
M6: Two workflows successfully applied (Month 12: 28/2/2026)	Two workflows were successfully applied.
M7: Key Risks Assessment and defining adaptation goals (Month 15: 31/5/2026)	Key Risk Assessment was published at the end of May. Adaptation goals were defined, discussed, and agreed upon during the project team and steering group meetings in May. Adaptation goals are included in the regional climate roadmap and must still go through a public consultation before the roadmap is formally accepted in December.

5 Supporting documentation

The report includes

- Main report as PDF
- Visual outputs of the report
- Communication outputs include (for more comprehensive list, see attachment on Zenodo)
    - Regional climate risk assessment published on Valonia's website
    - Climate risk analyses on agricultural drought and heavy rainfall published on Valonia's website
    - 3 news articles and 3 event pages on Valonia's website, one news article on Regional Council's website
    - Climate risk webinar for municipalities organized in April
    - 2 press releases
    - 8 news articles on local media and 1 radio interview
    - Several newsletters by Valonia, 1 newsletter from Varsinais-Suomen kylät and Regional Council of Southwest Finland.
    - Several publications on Valonia's Linkedin, Facebook and Instagram profiles
    - Presentation at CLIMAAX Virtual Forum. A recording and 2 news articles were published.
- Datasets on agricultural drought and heavy rainfall workflows.

6 References

Ahokangas, E. (2026). *Turun seudun maaperään kohdistuvat ilmastonmuutosvaikutukset.* https://sites.utu.fi/turclim/wp-content/uploads/sites/83/2026/02/IKI-hanke_TY_maantiede_Turun_seudun_maaperaan_kohdistuvat_ilmastonmuutosvaikutukset.pdf

Allergia-, iho- ja astmaliitto (2025). *Ilmastonmuutos lisää siitepölyallergioita – astman riski kasvaa.* https://allergia.fi/ilmastonmuutos-lisaa-siitepolyallergioita-astman-riski-kasvaa/

Baltic Sea Action Group (BSAG). *Ilmastonmuutos muuttaa Itämerta.* BSAG.fi. https://www.bsag.fi/itameri/ilmastonmuutos/

Gregow, H., Mäkelä, A., Tuomenvirta, H., Juhola, S., Käyhkö, J., Perrels, A., Kuntsi-Reunanen, E., Mettiäinen, I., Näkkäläjärvi, K., Sorvali, J., Lehtonen, H., Hildén, M., Veijalainen, N., Kuosa, H., Sihvonen, M., Johansson, M., Leijala, U., Ahonen, S., Haapala, J., Korhonen, H., Ollikainen, M., Lilja, S., Ruuhela, R., Särkkä, J. & Siiriä, S-M. (2021). *Ilmastonmuutokseen sopeutumisen ohjauskeinot, kustannukset ja alueelliset ulottuvuudet.* Suomen ilmastopaneelin raportti 2/2021. https://doi.org/10.31885/9789527457047

Gregow, H., Rantanen, M., Laurila, T.K. & Mäkelä, A. (2020). *Review on winds, extratropical cyclones and their impacts in Northern Europe and Finland.* Finnish Meteorological Institute, Reports, 2020:3. http://hdl.handle.net/10138/320298

Haulos, S., Meskanen, P., Brander, K., Vauramo, S., Dettenborn, T. & Metsävuo, J. (2023). *Ilmastonmuutokseen sopeutuminen väylänpidossa - Nykytilaselvitys*. Väylävirasto. https://www.doria.fi/bitstream/handle/10024/186931/vj_2023-27_978-952-405-063-0.pdf?sequence=1&isAllowed=y

Ilmasto-opas (2014). *Itämeren erityispiirteet saattavat kadota ilmaston muuttuessa.* Ilmasto-opas.fi. https://www.ilmasto-opas.fi/artikkelit/itameren-erityispiirteet-saattavat-kadota-ilmaston-muuttuessa

Finnish Meteorological Institute. *Taustaraportti – Ilmastonmuutos Suomessa.* https://www.sitra.fi/wp-content/uploads/2026/01/Taustaraportti_ilmastonmuutos_suomessa.pdf

Finnish Meteorological Institute (FMI) (2023). *Maankohoamisilmiö suojaa Suomen rannikkoa merenpinnan nousulta, mutta ei loputtomiin.* https://www.ilmatieteenlaitos.fi/uutinen/2c59AGOY0XKMpwD8Vqj4gy

Finnish Meteorological Institute (FMI) (2025). *Lämpenevä ilmasto tuo uusia tauteja Eurooppaan – punkit, hyttyset ja muut eläimet vektoreina.* https://www.ilmatieteenlaitos.fi/artikkeli/5EFM1NWddpHkQVykAtm6Bk

Itämeri.fi. *Ilmastonmuutos vaikuttaa vääjäämättä Itämereen.* Itämeri.fi. https://itameri.fi/itameren-tila/ilmastonmuutos/

Kollanus, V., Halonen, J.I. & Lanki, T. (2023). *Helteen vaikutukset ja varautuminen terveydenhuollossa.* Lääketieteellinen Aikakauskirja Duodecim, 139:13, 1127–1133. https://www.duodecimlehti.fi/duo17765

Kollanus, V. & Lanki, T. (2021). *Helteen terveyshaitat ja niiden ehkäisy Suomessa.* Terveyden ja hyvinvoinnin laitoksen työpaperi 14/2021. https://www.julkari.fi/items/c58c3eef-42bd-4018-b68a-5cc9c5776213

Lahdensivu, J., Pakkala, T., Pikkuvirta, J., Räsänen, A., Alastalo, S., Karvonen, A., Täubel, M., Pekkanen, J., Juntunen, M., Farahani, A.Z., Jokisalo, J., Kosonen, R., Jylhä, K., Lanki, T., Leino, O. & Kollanus, V. (2023). *Rakennusten kosteusvauriot ja ylilämpeneminen muuttuvassa ilmastossa – RAIL*. Valtioneuvoston selvitys- ja tutkimustoiminnan julkaisusarja 2023:2. https://urn.fi/URN:ISBN:978-952-383-278-7

Luomaranta, A., Rantanen, M., Lehtonen, I., Virman, M. & Ruosteenoja, K. (2025). Ilmastonmuutos-ennusteet – Rakennusperinnön ilmastoriskeihin vaikuttavia näkökulmia. https://suomenlinna.fi/wp-content/uploads/2026/01/Raportti-Ilmastonmuutosennusteet-FMI-2.pdf

Luonnonvarakeskus (2025). *Sato- ja luomusato 2024*. Luke.fi. https://www.luke.fi/fi/tilastot/satotilasto/sato-ja-luomusato-2024

Mäntykannas, M. (2024). *Talvitulvat tulevat jäädäkseen – katso kartalta Suomen merkittävät tulvariskialueet.* Foreca.fi. https://www.foreca.fi/meteorologilta/ntx4uuve

Paulomäki, H., Boström, C., Häyrynen, S., Jokimäki, J., Kallio, K. P., Kulmala, L., Laine, I., Oksanen, E., Silfverberg, O., Sinkkonen, A., Sääksjärvi, I. & Kotiaho, J. S. (2023). *Haitalliset vieraslajit ja niiden torjuminen Suomessa - Hallitustenvälisen luontopaneelin (IPBES) raportin mukautus Suomen olosuhteisiin*. Suomen Luontopaneelin julkaisuja 2/2023. https://luontopaneeli.fi/wp-content/uploads/2023/09/luontopaneelin-julkaisuja-2-2023-haitalliset-vieraslajit.pdf

Snellman, R. & Todorovic, S. (2023). *Kuivuusvaara ja -haavoittuvuuskarttojen tuottaminen Suomessa.* https://vesi.fi/aineistopankki/2990-2/

Turku.fi. *Siniviherkerroin.* Turku.fi https://www.turku.fi/rakentaminen/rakentamisen-ohjeet-ja-lomakkeet/siniviherkerroin

Turun kauppakamari (2025). *Lounaissuomalaisista yrityksistä kolmannes ei ole vielä varautunut disinformaatioon.* Turunkauppakamari.fi. https://turunkauppakamari.fi/news/lounaissuomalaisista-yrityksista-kolmannes-ei-ole-viela-varautunut-disinformaatioon/

Turun tulvaryhmä (2022). *Turun rannikkoalueen tulvariskien hallintasuunnitelma vuosille 2022–2027.* Elinkeino-, liikenne- ja ympäristökeskus, Raportteja 2/2022. https://urn.fi/URN:ISBN:978-952-314-995-3

Valonia (2025a). *Maatalouden kuivuudesta ja rankkasateista tehtyjen ilmastoriskiarvioiden tuloksia*. Valonia.fi. https://valonia.fi/materiaali/maatalouden-kuivuudesta-ja-rankkasateista-tehtyjen-ilmastoriskiarvioiden-tuloksia/

Valonia (2025b). *Varsinais-Suomen päästöt jatkavat vähenemistään.* https://valonia.fi/uutinen/varsinais-suomen-paastot-jatkavat-vahenemistaan/

Valonia (2026a). *Ilmastokestävä taloyhtiö – käytännön tapaukset.* Valonia.fi https://valonia.fi/materiaali/ilmastokestava-taloyhtio/

Valonia (2026b). Varsinais-Suomen ilmastoriskiarvio. Valonia.fi. https://valonia.fi/materiaali/varsinais-suomen-ilmastoriskiarvio/

Varha (2025). *Itämeren rannikkovesissä vibriobakteereita ja sinilevää.* Varha.fi. https://www.varha.fi/fi/ajankohtaista/itameren-rannikkovesissa-vibrio-bakteereita-ja-sinilevaa

Vesi.fi. a. *Tulvariskien aluesivut – Tulvat Varsinais-Suomessa*. Vesi.fi. https://www.vesi.fi/tulvariskien-aluesivut-varsinais-suomi/

Vesi.fi b. *WSFS-Vemala: Kokonaiskiintoainekuormitus Saaristomeren alueelle Suomen vesistöistä*. Vesi.fi. https://wwwi2.ymparisto.fi/i2/98/89/fi.html