CLIMAAX
climate ready regions

Deliverable Phase 2 – Climate risk assessment

CAP HM

Sweden, Håbo municipality

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2 Document Information

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2.4 Abbreviations and acronyms

Abbreviation / acronym	Description
CAP HM	Climate Adaptation Program for Håbo Municipality
CLIMAAX	CLIMAte risk and vulnerability Assessment framework and toolboX
Climate-ADAPT	The European Climate Adaptation Platform
CRA	Climate Risk Assessment
EuroHEAT	European Heat health information network
ECMWF	European Centre for Medium-Range Weather Forecasts
FSTP	Financial Support for Third Parties
GIS	Geographical Information System
LST	Land Surface Temperature
MKB	Miljökonsekvensbeskrivning (Environmental impact assessment)
NUTS	Classification of Territorial Units for Statistics (NUTS, for the French nomenclature d'unités territoriales statistiques)
PBL	Plan och Bygglagen (Planning and building act)
RCP8.5/RCP4.5	Representative Concentration Pathways (Climate Scenarios)
SMHI	Swedish Meteorological and Hydrological Institute

3 Executive summary

Climate-related hazards will affect Håbo municipality in several ways. Håbo is a small municipality in southern Sweden and is therefore exposed to a wide variety of hazards such as heavy rainfall, heat waves and wildfires. In the project Climate Adaptation Program for Håbo Municipality (CAP HM), these hazards are analyzed and will lay the background for an action plan with the overall aim of creating a climate resilient municipality.

In the first Phase of the project, global data was used to analyze heavy rainfall, heat waves, and wildfires through the workflows created by the CLIMAAX project. The result was, however, not specific enough to draw informed conclusions on which adaptive measures are needed and prioritized. The fine adjustments and local data that were used in Phase 2 provided more detailed results when the climate risks of heavy rainfall and heat waves were analyzed according to prioritization.

In Phase 1, the return period of heavy rainfall was shown to possibly decrease up to 50% at the end of the century and the rain amount to increase up to 25%. To analyze heavy rainfall in more detail in Phase 2 with regional climate data the indicators of average monthly precipitation and days with extreme precipitation were used from Swedish Meteorological and Hydrological Institutes (SMHI) climate scenario tool. The average monthly precipitation can, according to the indicator, increase 15-20% and days with extreme precipitation 2-3 times compared to the reference period.

Heat waves were in phase 1 shown to possibly increase from 5 days annually to 25 days at the end of the century using the Euro-HEAT and Climate-ADAPT methods. To further develop the hazard assessment in Phase 2, two additional indicators were included from SMHIs climate scenario tool, summer days, and tropical days. Summer days are expected to increase from 10 to 40 days annually and tropical days from 0 to 5 days.

In the risk assessment, a mapping of exposed critical buildings to heavy rainfall was used and the location of critical buildings compared to heat risk areas. The heat risk assessment of both heavy rainfall and heat waves shows that critical buildings and infrastructure in Håbo and vulnerable population groups are exposed to high risks, thus adaptation measures are highly needed.

Stakeholder engagement and cooperation is vital to spread and gather information about possible impacts. CAP HM has reached out to both internal and external stakeholders to share results and collect input to improve the analyses and gather input for the coming chapters of the project.

In the key risk assessment, both heavy rainfall and heat waves were classified as high priority due to the increasing frequency and magnitude of these risks both in the present and future climate. These risks will then be the focus of the Climate Adaptation Program that will be developed in Phase 3 of the CLIMAAX project.

4 Introduction

4.1 Background

Håbo municipality is located in East-Central Sweden, just outside of Stockholm, the capital. Håbo is a municipality of 186,47 square kilometers with both rural and urban areas. The population is 22 985 people, which means that it is a relatively small municipality and a small municipal organization. Even though the organization is small, it is of high quality and competence thanks to being located close to large cities and universities, like the university town of Uppsala or the capital. During the past decades the population has been increasing, and the estimation is that this development will continue in the foreseeable future. This will increase the importance of sustainable and resilient physical development in the municipality. As a municipal organization, Håbo has the responsibility to plan and develop the municipality in a sustainable manner and to care for its citizens and industry. This entails, e.g., physical planning, infrastructure, education, elderly care, and social services.

Håbo faces multiple climate-related hazards. Bordering to Lake Mälaren and with many paved surfaces, Håbo has a large risk of flooding when extreme rainfall strikes. The risk for landslides and collapse due to conditions in the soil intensifies when the rainfall is heavy, therefore experts give Håbo a risk level 3 on a 5-grades scale. Last year a major road and railway in north of Sweden were washed away by landslides due to an extreme precipitation event. The provision of services such as elderly care and education in rural areas is dependent on access to the road network. Håbo has large areas of both forests and agricultural land, which are both vulnerable to wildfires and droughts. At the same time Håbo municipality is growing in terms of population and industry, with expanding hard surfaces creating “heat islands”. This makes its citizens, particularly the aging population, vulnerable to increased frequency, intensity, and duration of heat waves. This wide variety of hazards demands an equally wide variety of well-informed adaptive measures, which is why Håbo is participating in the CLIMAAX project.

Håbo municipality has a risk and vulnerability analysis (Håbo-kommun, Risk- och sårbarhetsanalys, 2024) or a general understanding of different future scenarios regarding traffic accidents, accidents with dangerous goods, chemical accidents, natural disasters, disruptions in electricity supply, disruptions in electronic communications, disruptions in water supply, diseases and home preparedness. The document provides only a superficial overview of natural disasters; therefore, more in-depth analysis and comprehensive planning is required.

4.2 Main objectives of the project

The objective of this project is to provide a climate- and risk assessment of high quality following the CLIMAAX framework from which Håbo municipality can analyze how the various hazards pose risk to the municipality and improve the common understanding of the extent of those risks. Since the municipality faces several climate-related risks, this is highly important to be able to prioritize and finance adaptive measures.

The CLIMAAX framework, handbook, and workflows have been crucial to this work and have proved to be developed in a logical and user-friendly format. It has also been very beneficial to be able to perform the calculations in the workflows on the supercomputer resources of the European Centre for Medium-Range Weather Forecasts (ECMWF) as a partner of the CLIMAAX project.

By using more detailed, local and regional indata in the climate- and risk assessment in Phase 2, the results have more details and are of higher quality. This can enable wiser decisions to be made in the Climate Adaptation Program that will be produced in Phase 3.

Quantified risks

The study provides a climate- and risk assessment of high quality for heavy rainfall and heat waves from which it is possible to analyze how the various hazards pose a risk to the municipality. This improves the understanding of the risks and the necessity of adaptive measures.

Improved collaborations

Having good data and background on how climate-related risks affect the municipality enables a broad discussion of risk and resilience. Dialogues with different stakeholders will have two main impacts:
- Stakeholders bring various local knowledge of the impact of climate-related hazards, as well as possibilities for adaptive measures. This enables us to create a better risk assessment and adaptation program.
- Stakeholders gain a higher understanding of climate-related risks the municipality most likely will face, which will be a motivation to collectively address adaptive measures.

Internal and external stakeholders are involved in seminars and workshops, both by being invited to a physical meeting as well as creating the possibility to participate online, thus providing the most inclusive possibility to participate. At the seminar, the results of the project are presented, and the contributions of the stakeholders are gathered as valuable addition to the project. Internal stakeholders are the officers, workers, and politicians working at the municipality on different hierarchical levels and departments. Examples of external stakeholders include public service providers, regional governmental organizations, climate adaptation - related businesses, local citizens, and non-profit organizations.

Improved resilience

Having an advanced climate- and risk-assessment and the appropriate decision makers gathered will enable the municipality to identify relevant adaptive measures. Structures and routines will be put into place to deal with various risk situations when they arrive. This could e.g. be to set up a priority for road accessibility or routines for elderly care during heat waves. At the same time, preventative measures in the physical structures and operational functions of the municipality can reduce the impact of climate-related hazards. This could e.g. be to establish natural or technical solutions to reduce the waterflow from extreme rainfall in existing and planned structures or to prepare the citizens by providing information about civil responsibilities and available assistance in case of climate-related hazards.

The adaptation program for Håbo municipality that will be developed in Phase 3 will be aligned with the general sustainability work in the municipality, with the regional Action Plan for Climate Adaptation in Uppsala County (Robin Hedenqvist, 2023) and the National Strategy and Government Action Plan for Climate Adaptation (Ulf Kristersson, 2024).

Reduced costs

In the long term, preventing risk situations can reduce future risk-managing costs, which are predicted to be generally higher than the cost of preventative actions. More resources can then be put into the continued creation of a sustainable municipality.

4.3 Project team

The core project team consists of the municipal sustainability strategist Nina Aldén, with several years of experience with municipal sustainability and the municipality ecologist Bettina Károlyi-Donkó, who is coordinating the project and has master`s degree as a nature conservation engineer and has experience of habitat conservation and ecology, environmental policy and law. Part of the core project team are Erik Engström and Susanna Olsson from the Company Goodpoint as subcontractors, possessing the necessary skills regarding both climate knowledge and data processing, they made the climate risk assessment (CRA). Erik Engström is a doctor in atmospheric science and has worked 15 years as a climate change and adaptation expert at SMHI as well as two years as a senior sustainability consultant with a special focus on climate change and adaptation. Susanna Olsson has worked as a sustainability consultant for 4 years with extensive experience in data processing and computational programming. Revisions have been carried out by sustainability strategist Lovisa Carli.

Additional competencies involved in the project from the municipality include experienced colleagues such as a communicator, a GIS coordinator, a team manager, and two division managers.

4.4 Outline of the document's structure

This document begins with outlining the background, objectives, and organization of the project in an introductory chapter. This is followed by a chapter that describes the different steps of the CRA made in this second Phase of the project with focus on the deepening of the analysis with more detailed regional and local indata. In this chapter, there are also sections on the key risk assessment and monitoring and evaluation process. The results are analyzed and concluded in the following chapter, and an evaluation of the progress is presented after that. Finally, the report includes a summary of supporting documents and references.

5 Climate risk assessment – Phase 2

5.1 Scoping

The way of prioritizing climate risks will define the result of policy and decision making. Some risks concern planned, new buildings, while others concern existing buildings. Some required actions are more physical in nature, while others involve the development of policies and routines. The result will, however, make out the basis of a general Climate Adaptation Program for the municipality. This program will demonstrate how the activities in the municipality are affected by climate change and how adaptive measures can be implemented with the primary objective to enhance resilience of the municipality to be able to handle extreme weather and have preparedness.

Geographically, the CRA is limited to the Håbo municipality area. In Phase 1, global data provided in the CLIMAAX project was used, whereas in Phase 2, focus was on local data. More regional climate data from SMHI was planned to be included in the CRA in Phase 2 but was not feasible

within the available time and resources for the project. The intent was to use the precipitation levels from the local SMHIGridClim dataset. This dataset has higher resolution (2.5x2.5 km) than the European dataset that was prepared in the CLIMAAX analysis system. However, the data from SMHIGridClim would need to be re-formated and adapted to be able to be used in Jupyter Notebook. The needed adjustments of the python scripts of the workflows proved to be too complicated given timing and resourcing constraints.

Instead, the SMHI climate scenario tool was used to map heavy rainfall. This tool uses different indicators from the CLIMAAX tool but contributes more local information with higher resolution (4x4 km). It is based on modes, using ensamble datasets, that likely perform better in relation to Swedish conditions. The SMHI Climate Scenario Tool was also used to map heatwaves in Phase 2. CLIMAAX was in the process of developing a comparison tool for the efficiency of different climate models in different parts of Europe, which would have been useful for our analysis but was not yet available at the time of writing the report.

To deepen the CRA in Phase 2, a mapping of regional heavy rainfall and subsequent flooding hazards has been used together with local population and building data to inform the risk assessment. For heatwaves, an existing heat map that was done in the municipality has been used for the heatwave risk assessment.

Stakeholders play an increasing role in each of the three Phases of the project with more opportunities for them to engage in identifying and prioritizing adaptation actions, by engaging in seminars and workshops. Although it has so far been difficult to engage and involve external stakeholders during the completed two phases of the project, even if a lot of effort was invested reaching out and communication by newsletters, e-mails and advertisement on different platforms.

5.1.1 Objectives

The climate risk assessment (CRA) will provide a comprehensive understanding of which climate risks are significant for Håbo municipality and how these climate risks affect the municipality. The knowledge then will be used as a central input to the adaptation program that will be derived in Phase 3. A crucial part of Phase 3 will be to ensure that the climate adaptation program is synchronized with other policies of Håbo municipality such as different plans and strategies regarding sustainability, climate, environment, and energy.

One limitation of the CRA is the geographical resolution of the climate model data that was available at the European scale. Climate model results with higher geographical resolution were obtained from the Swedish Meteorological and Hydrological Institute (SMHI) to improve the climate risk assessment. A first try was made with more detailed climate model data, but it proved to be too resource-intensive and technically complicated to adjust the workflow to the dataset, so instead, more aggregated and processed climate data was used. Additionally, local vulnerability and exposure position data for buildings were used in the assessment to increase the value of the results.

Another challenge was to involve and engage local external stakeholders in the assessment. Different types of communication channels were used to reach out to stakeholder groups, and different events were arranged to involve them.

5.1.2 Context

There are some prior climate risk assessments performed for the municipality, e.g. a heavy rainfall analysis with flooding risks, information about polluted soil, as well as heat mapping. However, implementation of the results has been constrained by limited resources and internal structures.

Climate adaptation is a complex issue to address in the broad forum it requires. This is mainly due to a lack of understanding of the concept and a lack of time and resources. Existing buildings are the most difficult to handle. This project addresses these problems by providing a solid knowledge base from which the municipality can form dialogues, working structures, and actions. It also enables extra resources to be placed on coordinating and addressing climate adaptation, which puts the issue higher on the agenda.

A Swedish law about plans and buildings, Plan- och bygglagen (PBL) regulates some aspects of the climate adaptation. An “MKB” (Environmental impact assessment) is mandatory in city planning, but the climate adaptation perspective is very limited. Strategic documents in the municipality are relevant, such as the sustainability strategy and the program for green structure. The regional administrative board has a climate adaptation strategy.

Internal resources that will contribute to the project will be the climate adaptation coordinator (the sustainability strategist), a person from the water and sanitation department, an ecologist, a communicator, and a GIS coordinator. Besides these resources, a sub-contractor is engaged for expert knowledge on climate change and data analysis.

Several sectors within the municipal organization are affected by climate change in various ways:

- Elderly care – dependent on access to road network and vulnerable to heat waves.
- Childcare and educational system – dependent on access to road network and vulnerable to heat waves.
- Infrastructure – vulnerable to floods and landslides
- Parks and public areas – vulnerable to floods, and can make out adaptive measures
- Water and sanitation – vulnerable to floods and landslides
- Public buildings – vulnerable to floods, landslides and heat waves
- Land and property management – vulnerable to floods, droughts and fires
- City planning – important to prevent floods, heat islands, land slides
- Industry relations – communication of risk ownership and cooperation
- Communications – spread and gather information
- Risk management – merge CRA with ordinary risk management

At present, there is no indication of external influences on the problem. At this point in the project, there is need for more information to evaluate relevant adaptative measures, but nature-based solutions should be considered as they often address several hazards. Some adaptation interventions will probably be administrative, e.g. new routines or cooperations.

5.1.3 Participation and risk ownership

Invitation for participation in the CLIMAAX project for everyone has been announced through the external and internal official channels of the municipality several times before the seminar took place. These channels were the news page on both the internal and external side of the official webpage. Facebook was also utilized, focusing on younger generations. Businesses -

approximately 300 - active in the municipality as well as local non-governmental organizations were reached out by the municipality's newsletter. Independent schools and nurseries as well as health care providers also received email invitations to the seminar. For internal engagement, all the workers, officers, and politicians were reached out by forwarded invitation link sent to the head of the departments. Individuals and business, who during Phase 1 showed interest in the project and provided contact information, also received email invitations, as well as the County climate adaptation coordinator.

Relevant external stakeholders and representatives are land- and property owners, elderly organizations, the fire department, industry and civil society organizations. By the end of Phase 1, an external stakeholder dialogue took place, to inform them about the results of the first CRA and gather input for the following Phases. Stakeholders and citizens have been invited to express their interest through an online survey during Phase 1, placing them on our CLIMAAX e-mail list and those 10 people who registered were contacted and invited to participate in the seminar held for Phase 2 in 2026 January. A dialogue has been initiated with the fire department, and their important input has been taken into consideration. A seminar gathering internal and external stakeholders was conducted at the end of Phase 2 to present the results from the CRA and receive the participants knowledge, experience and suggestions. Our results show that relevant representatives of known vulnerable groups and exposed areas are mainly municipality–owned elderly care buildings and schools.

There is no explicit numeric definition of acceptable or tolerable climate risk for Uppsala County in official documents. Instead, tolerability is defined through resilience goals, use of return periods as practical thresholds, planning, and precautionary approaches, such as planning for continuous reduction of vulnerability over time.

Building risk ownership is planned to be part of the work conducted during Phase 3.

5.1.4 Application of principles

To secure social justice, equity, inclusivity, the analysis of vulnerability and exposure focused on the most vulnerable population groups such as children, sick and elderly people, and different urban parts of the city with different socio-economical resources. Local position data for buildings associated with children (kindergartens) and elders (retirement homes) were used in the risk assessment in Phase 2. The principles of quality, rigor and transparency were taken into account following the CLIMAAX Framework that provides a state-of-the-art guideline and practices that are supported by scientific results and international standards. Also, the project objectives and results were communicated to stakeholders and citizens of the municipality. Information about the project and the results were spread through e-mails, social media, info screens, seminars and workshops (invitation uploaded to Zenodo). The precautionary approach was applied to handle uncertainties in the analysis by using several different climate scenarios, models, and time periods to get an understanding of the uncertainty and statistical spread in the results.

5.1.5 Stakeholder engagement

The engagement with stakeholders, like businesses, experts, and the public has been done through meetings, seminars, workshops and news and knowledge sharing through internet webpages, info screens and social media.

Performed events:

2025-04-29 Workshop with internal stakeholders from the municipal organization to perform climate risk scoping to ensure the decisions were well based on the knowledge of the organization.

2025-05-07 Workshop with internal stakeholders from the municipal organization to perform climate risk exploration, screening of risks, prioritization of which workflows to analyze and which climate scenarios to use to ensure the decisions were well based on the knowledge of the organization.

2025-08-25 Seminar with internal and external stakeholders and the public to inform about project Phase 1 and present the results and gather knowledge and experience from the participants. The information was shared through a presentation and a discussion, and the feedback from the participants was also collected through a Menti questioner that was performed during the seminar. The participants were both from different parts of the municipal organization and from external organizations such as the local rescue service, firefighting department, interested citizens, and property owners. The participants were interested in the results and engaged in the subject of climate change, risks and adaptation and dynamic discussions were a part of the seminar. The participants shared their view of relevant climate risks and their thoughts on how they can prepare for and adapt to the climate risks, and they expressed that they achieved and increased understanding of which types of extreme weather events they can expect to be exposed to. The participant's input was valuable information confirming the prioritization and decisions made in the project.

2025-08-30 Håbo Day (Håbo festdag) – A public event day, where CAP HM had a booth presenting the results of phase 1 and gathering input for phase 2 (invitation and input uploaded to Zenodo). Many citizens and businessowners showed interest, and around 10 gave input for phase 2.

2025-09-27 Day for societal preparedness (Beredskapsdagen) - A public event day, where CAP HM had a booth presenting the results of phase 1 and gathering input for phase 2 (invitation and input uploaded to Zenodo). Many citizens showed interest, and around 25 gave input for phase 2.

2025-10-10 Meeting with experts from the other participating organizations in Sweden, Region of Skåne and Region of Västernorrland to share experiences and explore possible cooperations. It was valuable to hear the experience of the CLIMAAX project from the other participating organizations but for the work in Phase 2 we concluded that a deeper cooperation was not profitable due to that the participating organizations had different focus and goals with Phase 2 of the CLIMAAX project.

2025-11-13 A workshop with participating internal stakeholders and experts in data processing and analyzing and communication was arranged to discuss regional climate data, vulnerability and exposure data input and communication activities in Phase 2. It was valuable for the project to take part in the expert's knowledge and abilities in choosing data and improving communication and sharing of information and knowledge.

2026-01-21 Seminar with internal and external stakeholders and the public to inform about the project Phase 2 and present the results and gather knowledge and experience from the participants. During the seminar a presentation was held and there was time for a discussion where different opinions and points of view were lifted. The participants represented a wide range of interest: both from different parts of the municipal organization – from politicians and administrative managers to civil servants working with a wide range of questions like environment

and coastal protection, nature conservation and urban planning, waste manager, GIS coordinator, communicator and gardener-, as well as from external organizations such as the climate adaptation coordinator from the County Administration Board, a risk consultant from a private company and local residents participated.

The participants were interested in the results. They were engaged in the subject of climate change risks and adaptation, and dynamic discussions were a part of the seminar. Many of them showed interest in further participating in the project. They shared their views of relevant climate risks and their thoughts on how they can prepare for and adapt to the climate risks, mostly centered around flooding caused by heavy precipitation and extreme heat and how to adapt existing building to these hazards. The participants expressed that they achieved and increased understanding of which types of extreme weather events they can expect to be exposed to. The participant's input was valuable information confirming the prioritization and decisions made in the project.

During 2026 we plan to perform workshops with internal and external stakeholders to analyze how the updated climate adaptation program will be integrated with the other governing sustainability policies in climate, environment and energy, to map existing and planned adaptation actions, to prioritize planned adaptation actions and to present the updated climate adaptation program.

5.2 Risk Exploration

5.2.1 Screen risks (selection of main hazards)

No changes in the screening of risks were made in Phase 2. Due to the available resources in Phase 2, the work focused on the climate risk and workflows of heavy rainfall and heat waves, and the climate risk of wildfire was not further analyzed in Phase 2. Due to resource limitations, analysis needed to focus on the risks most urgent for Håbo municipality. Risk of heavy rainfall and heat waves were prioritized as those express a greater threat to the majority of the population living in the central urban areas of Bålsta compared to other hazards identified in Phase 1 such as wildfire, and specifically to the vulnerable group of children, sick and elderly people. Due to the population density in the municipality and comparatively small and confined forested areas, potential wildfire was identified as being easily discoverable at an early stage. Current fire management systems were deemed to be able to manage fire risk at such a stage, and the size of the forests confine the risk of wildfire spreading. While still a risk that could impact forest, built up areas and agricultural land, it was not considered as urgent as heavy rainfall and heatwaves. Rainfall and Heatwaves were also highest prioritized by the citizens when asked in public events. Regional data and information on the climate risks of heavy rainfall and heat waves were gathered as climate data and reports from SMHI and the regional administrative board of Upsala to further support the CRA in Phase 2.

5.2.2 Choose Scenario

With the ongoing global warming -which in Sweden generally is twice as fast compared to the global average -, heat waves are expected to become stronger and more frequent. At the same time, the population in Håbo is growing, therefore the number of vulnerable people is also expected to increase. With a warmer climate, extreme rainfall events are expected to be more common and can cause flooding. In parallel, droughts and wildfires are expected to occur more often due to increased evaporation.

In order to get more detailed regional knowledge of the development of extreme events and climate hazards for Håbo municipality, regional climate data from SMHI was used in the assessment, both historical observations and future scenario model data. The climate scenario of SMHI service uses an ensemble of several different global and regional climate models to provide a robust result (Strandberg, 2026). The horizontal resolution of the regional models has been increasing from 50 mm to 12.5 km between 1951 to 2100. In the scenario tool, the meteorological reference data from SMHI for climate (SMHI GridClim) is used, which covers the period from 1961 to 2018 with a horizontal resolution of 2,5 km.

To assess the climate trend in the average and extreme precipitation, two climate indicators from SMHI were used in the assessment: the monthly precipitation and days with extreme precipitation. For heat waves the climate indicators of summer days and tropical days were used. The climate scenarios used in the SMHI service were RCP2.6, RCP4.5 and RCP8.5 (Representative Concentration Pathways) to cover three different future emissions scenarios. Three different future time periods 2011-2040, 2041-2070 and 2070-2100 were assessed to cover the possible development under the whole present decade. By using a model ensembled in the CRA a more robust result could be achieved, and the range of scenarios and time periods provides an understanding of the spread of possible extreme weather events in future climate.

5.3 Regionalized Risk Analysis

As noted in 5.1, we were unable to run the local data in Jupyter Notebook. Instead, we used regional climate data from SMHI in the assessment, both historical observations and future scenario model data, using the SMHI Climate scenario tool (SMHI, Climate Change Scenario Tool, 2026) . The tool uses an ensemble of several different global and regional climate models to provide a robust result (Strandberg, 2026) (SMHI, About the Scenario Tool, 2026). The indicators used in this analysis derive from these models and are integrated in the tool. As already noted, it is likely that these indicators are more suited to the Swedish context than the European indicators used by CLIMAAX, as SMHI has chosen them specifically for Sweden. These additional datasets and sources are further described in the following sections of the report.

As reference and future periods, as well as indicators, have changed between Phase 1 and Phase 2, results cannot be considered as a direct quantitative comparison but can still display qualitative consistencies or inconsistencies in the projected change of heavy rainfall and heatwaves in Håbo municipality.

5.3.1 Heavy rainfall - fine-tuning to local context

Table 5-1 Data overview Heavy rainfall

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
	Classification of buildings based on the critical needs of children, elderly and		Local risk assessment for vulnerable groups

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
	sick residents, provided by Håbo municipality		
		Local building position data provided by Håbo muncipality	Local risk assessment for exposed critical buildings
Monthly precipitation in Uppsala region from SMHI climate scenario service	…	-	Change in regional monthly precipitation
Days with extreme precipitation in Uppsala region from SMHI climate scenario service	-	-	Change in regional extreme precipitation
Report Climate risk and vulnerability assessment for Uppsala region			Regional climate risk and vulnerability assessment for Uppsala region.

Table 5-2 Key differences between Phase 1 and Phase 2, heavy rainfall

	Phase 1	*Phase 2*
Analytical focus	Global and regional data using CLIMAAX python workflows at the Mälardalen region level (both hazard and risk assessment)	Mostly regional data using the SMHI climate scenario tool, with some global data for the risk assessment, focusing on the Mälardalen region (hazard assessment) and the local level (risk assessment).
Data sources and models	GCM: ICHEC-EC-EARTH RCM: KNMI-RACMO22e Open street maps	SMHI Climate Scenario Tool Municipal data
Spatial resolution	16x16km (EC-EARTH)	4x4km (SMHI Climate Scenario Tool)
Time frame	Reference period: 1976-2005 Future period: 2041-2070	Reference period: 1971-2000 Future periods: 2011-2040, 2041-2070, 2070-2100
Scenario/s	RCP4.5, RCP8.5	RCP2.6, RCP4.5, RCP8.5
Indicators	Not bias corrected Precipitation (ICHEC-EC-EART, KNMI-RACMO22e) Schools and hospitals (Open street map)	Bias corrected Annual average of monthly precipitation

	Phase 1	*Phase 2*
		Days with extreme precipitation (number of days when precipitation is greater than 20 mm)
Thresholds	Duration: 3 and 24 hours Intensity: 100 mm Frequency: 5 years	Duration: 3 hours Frequency: 10 years
Results	No change in either magnitude or frequency in the future scenario. Return period for 100mm rain in 24 hours fell between 100 and 500 years. The results are thought to be the consequence of the choice of climate model or too high thresholds for the Swedish context.	A significant increase in mean precipitation and a moderate increase in extreme precipitation for RCP 4.5 and RCP 8.5.

5.3.1.1 Hazard assessment

The two climate indicators from SMHI used in this assessment were annual average of monthly precipitation and days with extreme precipitation to assess the climate trend in the average and extreme precipitation. The climate scenarios used in the SMHIs service were RCP2.6, RCP4.5, and RCP8.5 to cover three different future emissions scenarios. Three different future time periods 2011-2040, 2041-2070 and 2070-2100 were assessed to cover the possible development over the course of the present decade.

In Phase 1, the CRA showed a decrease in return period of 50% for a 3-hour event with 25 mm rain, and 10% for a 24-hour event with 60 mm rain. A rain amount of 15-30 mm for a 3-hours event with a return period of 10-years in the future period of 2041-2070 was also analyzed (*Figure 2-1, left panel*). The relative change compared to the baseline 1976-2005 was also plotted. In the report for Phase 1, the conclusion was wrongly drawn that no clear trend could be seen in the relative change. In the Phase 2 analysis, it is shown that the relative change is actually as high as 25% as seen in the right panel of *Figure 5-1.* A comparison between the analysis in Phase 1 and Phase 2 can be seen in *Table 5-2*

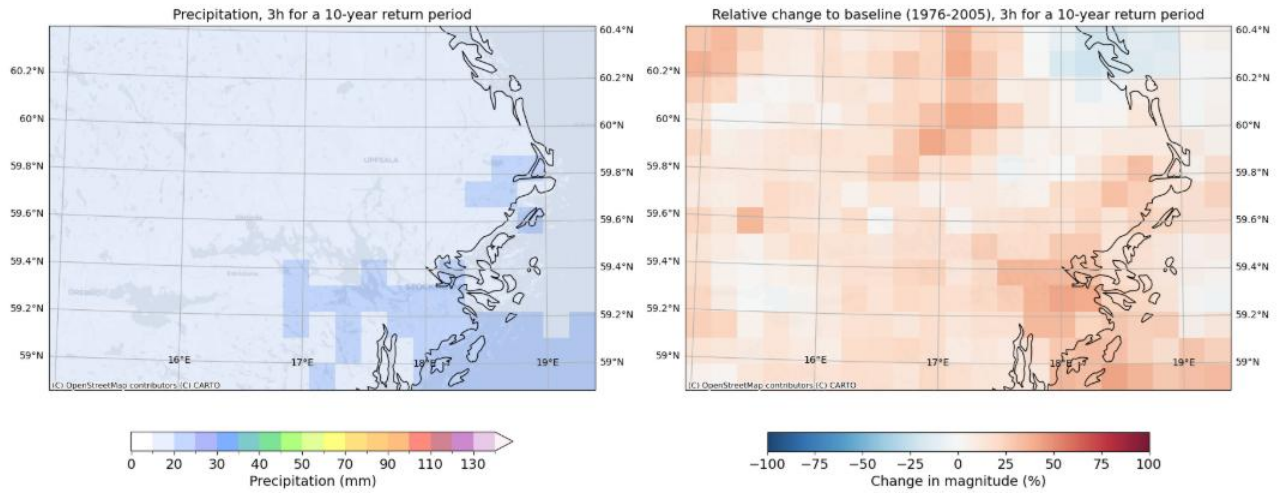


Figure 5-1 Projected 3-hour precipitation event with a return period of 10-years for the Mälardalen region for the future period of 2041-2070 (left) with RCP8.5. The relative change compared to the baseline 1976-2005 (right).

Figure source: SMHI

When analyzing the possible change in precipitation in the Uppsala region using regional climate data from SMHI, the annual mean of monthly precipitation is 50-70 mm in the period 2071-2100 using RCP8.5 (*Figure 5-2*). That is an increase in monthly precipitation of 8-10 mm compared to the reference period of 1971-2000 (*Figure 5-3*). In *Figure 5-4*, the projected increase in monthly precipitation can be seen together with observed precipitation.

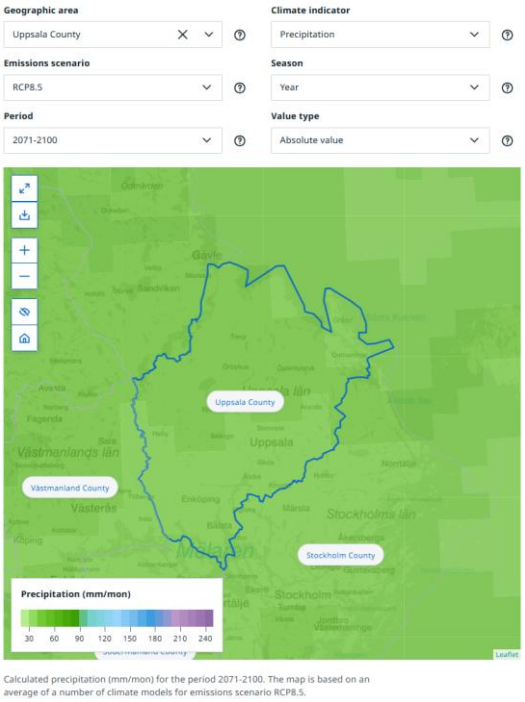


Figure 5-2 Projected annual mean of monthly precipitation in the Uppsala region in the period 2071-2100 using RCP8.

Figure source: SMHI

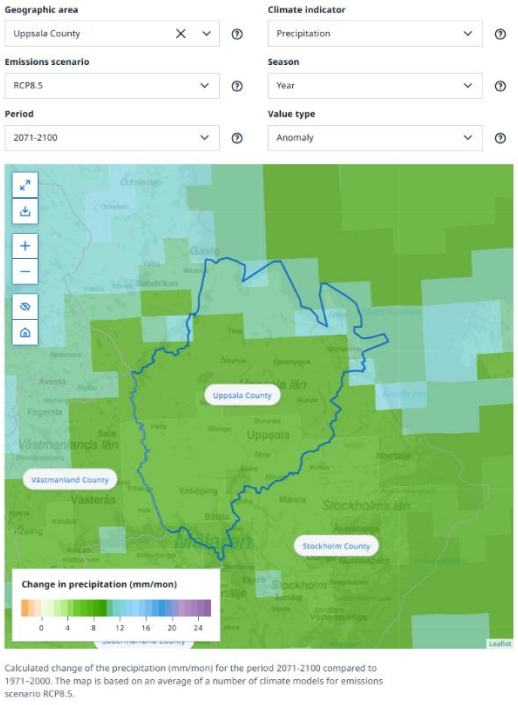


Figure 5-3 Projected change of annual mean of monthly precipitation in the Uppsala region in the period 2071-2100 using RCP8 compared to the reference period 1971-2000.

Figure source: SMHI

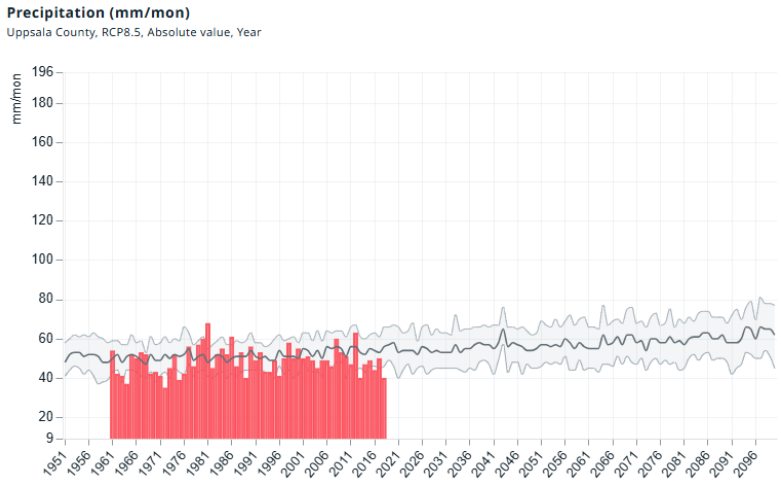


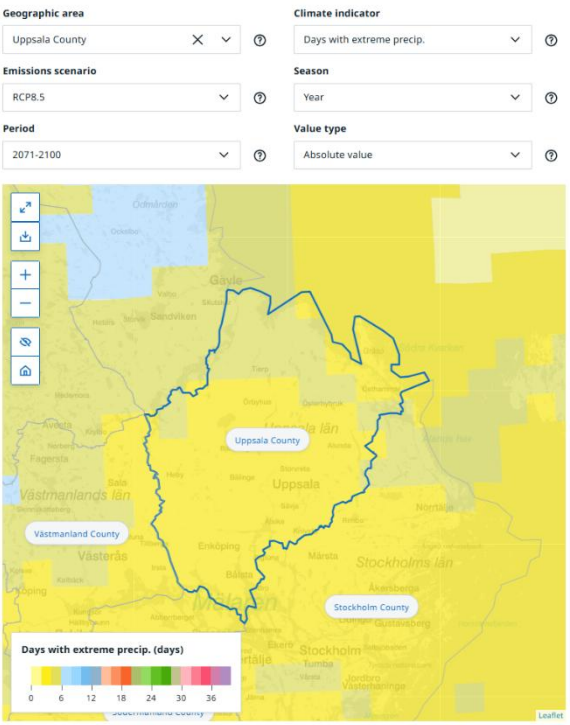
Figure 5-4 Projected annual mean of monthly precipitation in the Uppsala County during the years 1951–2100. The bars show historical data derived from observations. The grey curve shows an average value for several climate models for emissions scenario RCP8.5. The grey field shows the range of variation between the 10th and 90th percentiles.

Figure source: SMHI

When using the RCP2.6 scenario, the projected annual mean of monthly precipitation in the Uppsala region is 40-60 mm in the period 2071-2100 and an increase of 2-5 mm compared to the reference period of 1971-2000 (uploaded to Zenodo). So disregarding choice of climate scenario a steady increase in monthly precipitation can be expected during this decade in the Uppsala region. The increase in precipitation will be stronger with higher climate change scenarios.

The indicator of days with extreme precipitation was also analyzed with the SMHI scenario tool. The indicator is a measure of the number of days when precipitation is greater than 20 mm. The number of days with extreme precipitation is expected to increase in the Uppsala region, but there are differences between counties and across seasons. During the reference period 1971–2000, the modelled mean number of days with extreme precipitation per year for the Uppsala region was 1.9. If the climate develops according to the scenario RCP8.5, the mean number of days with extreme precipitation per year will reach 2-6 for the period 2071-2100 (*Figure 5-5*). That is an increase of 1.0-2.5 days compared to the reference period 1971-2000 (*Figure 5-6*). In *Figure 5-7*, the projected increase in number of days with extreme precipitation is shown alongside observations.

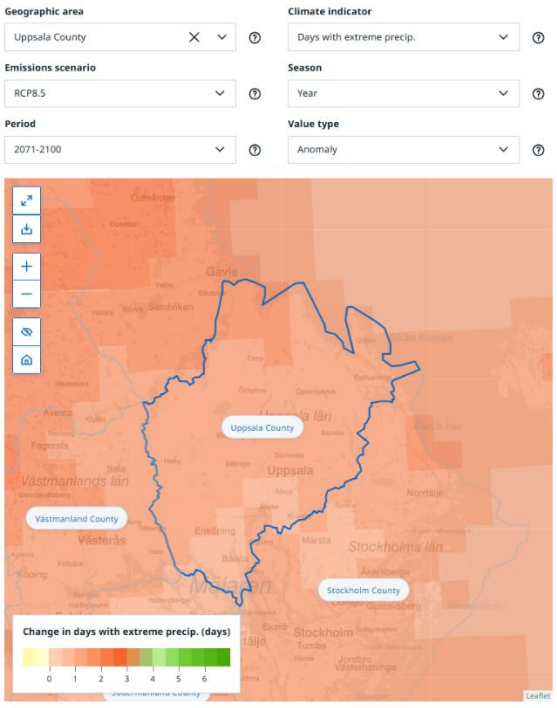
Studying the RCP2.6 scenario instead, the projected number of days with extreme precipitation is estimated to be 2-6 in the period 2071-2100, which is an increase of 0.5-1.0 days compared to the reference period 1971-2000. Also, the indicator of days with extreme precipitation shows a clear increase, independently of scenario and time period (uploaded to Zenodo).



Calculated number of days with extreme precipitation (days) for the period 2071-2100. The map is based on an average of a number of climate models for emissions scenario RCP8.5.

Figure 5-5 Projected number of days with extreme precipitation in the Uppsala region in the period 2071-2100 using RCP8.5

Figure source: SMHI



Calculated change of the number of days with extreme precipitation (days) for the period 2071-2100 compared to 1971–2000. The map is based on an average of a number of climate models for emissions scenario RCP8.5.

Figure 5-6 Projected change of number of days with extreme precipitation in the Uppsala region in the period 2071-2100 using RCP8.5 compared to the reference period of 1971-2000.

Figure source: SMHI

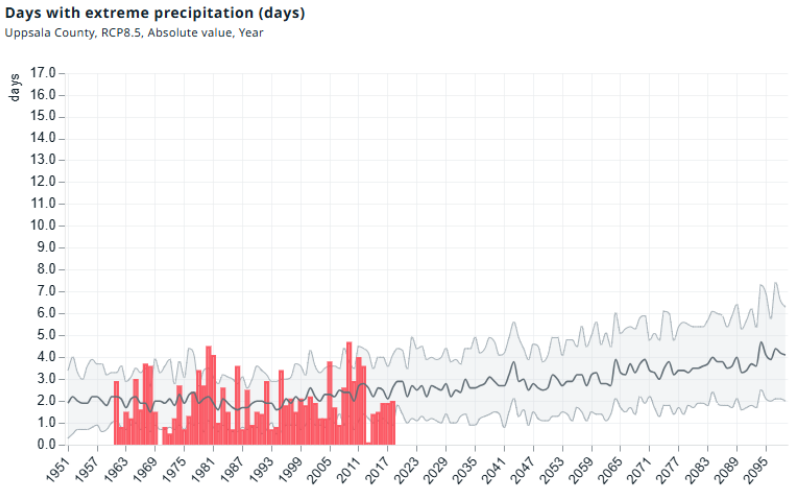


Figure 5-7 Projected days with extreme precipitation in the Uppsala County during the years 1951–2100. The bars show historical data derived from observations. The grey curve shows an average value for several climate models for emissions scenario RCP8.5. The grey field shows the range of variation between the 10th and 90th percentiles.

Figure source: SMHI

The projected future trends in changing precipitation in the Uppsala regions from the CRA based on climate scenario data from SMHI in Phase 2 show a clear increase both in mean precipitation and extreme precipitation.

A climate risk and vulnerability assessment has been performed for the Uppsala County (Gustavsson, 2022) which shows a projected increase in annual precipitation of 20-30% in the Uppsala County depending on the climate scenario RCP4.5 or RCP8.5. The winter precipitation is expected to increase by up to 40% in RCP8.5. In the assessment, maximum precipitation during a 24-hour period is suggested as a fitting indicator of heavy rainfall. Maximum 24-hour precipitation is expected to increase 25% in both RCP4.5 and RCP8.5. Accordingly, this report is in alignment with the results described above in this section.

5.3.1.2 Risk assessment

In Phase 1 critical infrastructure, such as schools and hospitals were plotted together with projected change in precipitation for a region covering the whole east of Sweden. To get a more detailed analysis of the vulnerability and exposure to heavy rainfall in Håbo in Phase 2, regional data from the Uppsala County Board (Länsstyrelsen) was used in combination with local property data which is owned by the municipality. All spatial analyses were performed in QGIS 3.44 using standard geoprocessing tools, including Buffer and Zonal Statistics.

Pluvial flood exposure for critical facilities was assessed using the Uppsala County Board's 100-year rainfall flood model (Länsstyrelsen Uppsala, 2023). To better represent the actual impact on buildings and their immediate surroundings, a 2 m buffer was created around each building footprint prior to analysis.

The use of a buffer was considered necessary because hydraulic flood models often underestimate water depths directly adjacent to buildings, as surface runoff is typically routed around building footprints within the modelling process. The buffer therefore provides a more realistic representation of flood conditions affecting entrances, access points, and nearby operational areas.

Maximum flood depth within each buffer was calculated using zonal statistics. Facilities were subsequently classified into three relative exposure categories: Moderate, High, and Very High Pluvial Flood Exposure. “Very High” represents the upper 10% of maximum depth values and “High” the values between 10% and 30%. “Moderate” exposure represents the lower 70%. The classification was intended to identify relative differences in exposure among critical facilities rather than absolute damage thresholds.

The accompanying results table (uploaded to Zenodo) should be consulted alongside the map outputs. Facilities classified as having Very High Pluvial Flood Exposure may in some cases be influenced by localised areas of deep flooding, while their mean flood depth remains comparatively low. Conversely, facilities with more widespread flooding may exhibit relatively high mean depths despite lower maximum values.

The assessment identifies five buildings with the highest exposure, four located in Bålsta and one in the township Skokloster (*Figure 5-8*). These buildings serve a range of essential community functions, including education, healthcare, and care services. Two are schools, one of which, Västerängsskolan, is municipally operated. As the school has its own kitchen, it may be particularly vulnerable to power outages and disruptions to deliveries resulting from heavy rainfall and subsequent flooding.

Three of the five most exposed buildings are associated with care services. LSS Dalvägen provides specialised accommodation for people with disabilities, while Pomona is an aged care home. Flooding affecting these facilities and their surrounding infrastructure could disrupt mobility, restrict access to care services, and impede deliveries. In Skokloster, the building identified as having the highest exposure is a healthcare clinic. Flooding could disrupt the provision of healthcare services and restrict access for vulnerable population groups. This risk is particularly significant if heavy rainfall and flooding also affect roads connecting Skokloster to other areas, potentially limiting access to alternative healthcare facilities. These five buildings, together with their surrounding infrastructure, should therefore be prioritised for further assessment during Phase 3, when the climate change adaptation plan is developed.

Buildings classified as having “High” exposure should also be examined in greater detail during this phase. These primarily comprise schools and pre-schools but also include specialised care accommodation and emergency services. Assessing their exposure and potential vulnerabilities will help identify appropriate adaptation measures to maintain the continuity of essential services during heavy rainfall and flooding events.

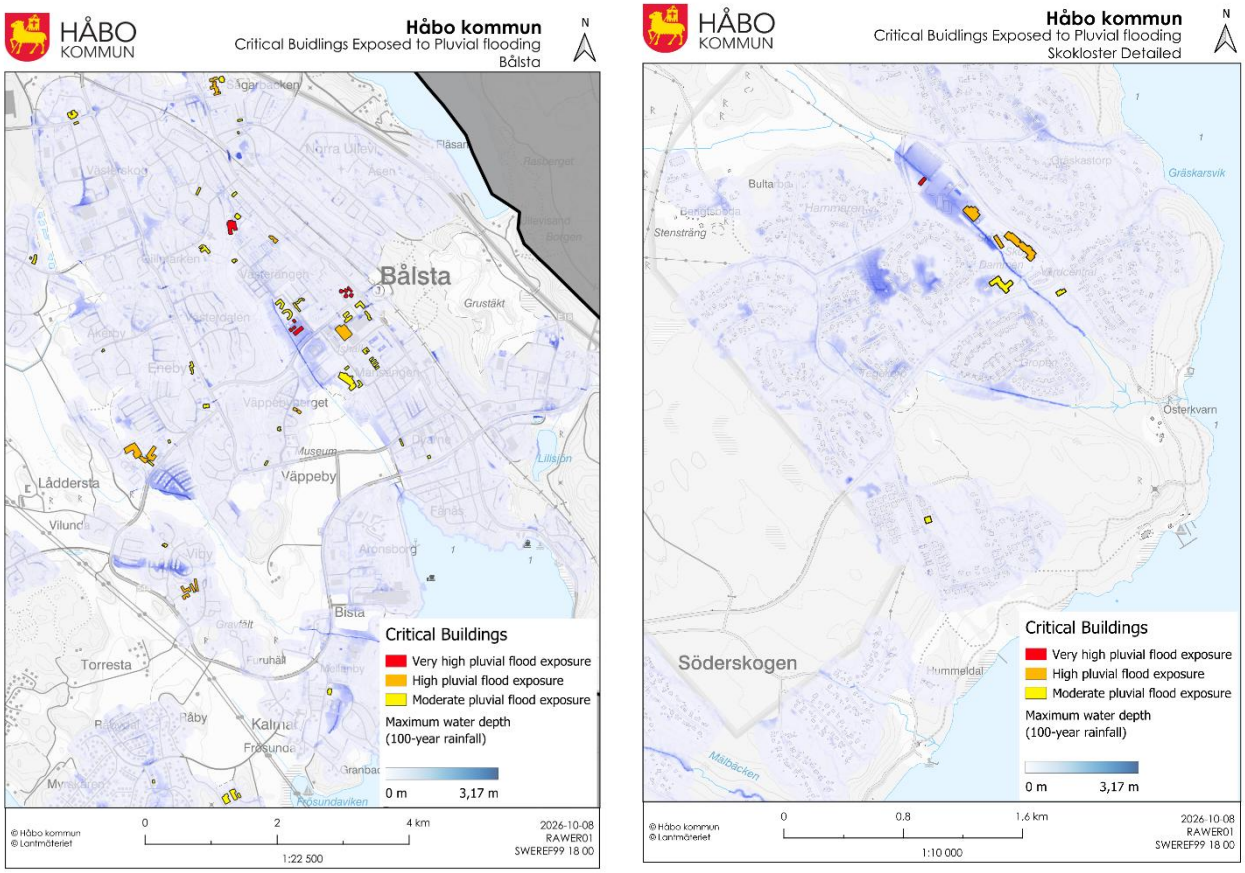


Figure 5-8 Exposure to a 100-years rain of critical buildings (schools, care facilities and rescue services) in Bålsta (left) and Skokloster (right) classified from yellow (moderate pluvial exposure), orange (high pluvial exposure) and red (very high pluvial exposure). Grey buildings are not considered critical buildings

5.3.2 Heat wave - finetuning to local context

Table 5-3 Data overview Heat wave

Hazard data	***Vulnerability data***	***Exposure data***	***Impact metrics/Risk output***
-	-	Local building position data for 11 different classes of buildings provided by Håbo muncipality	Local risk assessment for exposed critical buildings

Hazard data	***Vulnerability data***	***Exposure data***	***Impact metrics/Risk output***
	Population groups 0-5, 65-80 from Worldpop Hub		Heat wave risk for vulnerable population groups
Fine-tuning of temperature thresholds for overheated areas using data from Climate-ADAPT	-	-	More relevant local assessment of overheated areas
Summer days for the Uppsala region from SMHI	-	-	Change in regional heat wave events.
Tropical days for the Uppsala region from SMHI	-	-	Change in regional heat wave events.
Report Climate risk and vulnerability assessment for Uppsala region			Regional climate risk and vulnerability assessment for Uppsala region.

Table 5-4 Key differences between Phase 1 and Phase 2, heatwaves

	Phase 1	*Phase 2*
Analytical focus	Global and regional data using Jupyter Notebook, focusing on both the Mälardalen region and on the local level.	Global and regional data for the Mälardalen region, using the SMHI climate scenario tool (hazard assessment) and the Jupyter Notebook (risk assessment).
Data sources and models	EuroHEAT using CDS SMHI Precipitation Temperature Hydrologiska Byråns Vattenmodell (PTHBV) Climate-ADAPT RSLab at NUTS2 level using ERA5 dataset delivered by the Copernicus Climate Change Service Worldpop Hub Landsat 8 or 9 imagery	SMHI Climate Scenario Tool Worldpop Hub Landsat 8 or 9 imagery Municipal data
Spatial resolution	12x12 km (CDS) 15-30m (LST) 4x4km (SMHI PTHVB)	4x4km (SMHI Climate Scenario Tool) 15-30m (LST)
Scenario/s	RCP 4.5, RCP 8.5	RCP2.6, RCP4.5, RCP8.5

	Phase 1	*Phase 2*
Time frame	Reference): 1986-2085 (EuroHEAT), 2014-2024 (SMHI), 205 (LST)	Reference: 1971-2000 (high summer and tropical days, SMHI), 2014-2024 (monthly mean temp, SMHI) Future: 2011-2040, 2041-2070, 2071-2100 (SMHI)
Indicators	Heat wave days (CDS) Tropical nights (ClimateADAPT) Monthly mean temperature (SMHI) Number of days with heat stress (UTCI) Land surface temperature (Landsat 8 or 9 imagery) Population groups 0-5, 65-80 (Worldpop Hub) Buildings: schools and hospitals	High summer days (SMHI) Tropical days (SMHI) Critical buildings (municipal data)
Thresholds	European heatwave definition: 90th percentile of Tappmax and 90th percentile of Tmin per month (30°C in EuroHEAT) Swedish heatwave definition: 5 consecutive days of a daily max temperature equal to or exceeding 25 °C. Universal Thermal Climate Index (UTCI) Tropical nights definition: daily min temperature exceeds 20 °C. LST: 5 classes from 20 to 60 °C	Swedish heatwave definition: 5 consecutive days of a daily max temperature equal to or exceeding 25 °C. High summer days: number of days when the daily maximum temperature is above 25 °C Tropical days: daily min temperature exceeds 20 °C LST: <10-15 °C for very low, 15-20 °C for low, 20-25°C for medium, 25-30 °C for high and 30-35 °C
Results	Increase in heatwave occurrences for RCP 4.5 and RCP 8.5 using the Swedish definition. No significant results using the European heatwave definition. Increase in tropical nights after 2050 for RCP4.5 and RCP 8.5.	Significant increase in high summer days and tropical days during the 1971-2100 period for RCP 4.5 and RCP 8.5. Higher number of potential heatwave days than when using EuroHEAT in Phase 1, most likely due to applying the Swedish threshold which is 5°C decrease compared to EuroHEAT's 30°C.

5.3.2.1 Hazard assessment

In Phase 1, by using the EuroHEAT metod, the results showed that Bålsta historically have experienced around 5 heat wave days annually according to the Swedish national definition. The heat wave days are expected to increase to 10-15 days per year according to the climate scenario RCP4.5 and to 25 days according to RCP8.5. The Climate-ADAPT service was also used in Phase 1 and provided similar results concerning the number of heat wave days for the NUTS2 region Eastern Central Sweden (Östra Mellansverige) –including the counties of Stockholm, Uppsala, Gävleborg, Västmanland, Örebro, Södermanland and Östergötland– at the end of this century.

To further develop the hazard assessment in Phase 2, two additional indicators were included using the SMHI climate scenario tool: high summer days and tropical days. A comparison between the analysis in Phase 1 and Phase 2 can be seen in *Table 5-4*.

The indicator of high summer days refers to the number of days when the daily maximum temperature is above 25 °C during the year. During the reference period 1971-2000, the number of summer days in Uppsala County was slightly over 10 annually. When using the climate scenario RCP8.5, the number of summer days is projected to increase to over 40 annually in Håbo municipality during the period 2071-2100 (*Figure 5-9*), which is an increase of over 24 days per year and an approximately 250% increase compared to the reference period (*Figure 5-10*). In *Figure 5-11* the projected increase in number of summer days is shown together with historical observations. The RCP4.5 scenario shows an increase in summer days in Uppsala County to 25-40 days for the period 1971-2100. When studying the development during the periods 2011-2040 and 2041-2070 the increase is smaller (uploaded to Zenodo). The number of summer days from the SMHI climate

scenario tool is higher compared to the number of heat wave days from EuroHEAT. A probable explanation is that the threshold for heat wave days is 30 °C in EuroHEAT, whereas it is 25 °C for summer days in the SMHI climate scenario tool.

The climate risk and vulnerability assessment of the Uppsala County (Gustavsson, 2022) describes that the mean temperature in the region will increase with 2-5 °C by the end of this century and that periods with extreme heat that previously occurred every 20 year will occur every third to fifth year in the end of the century.

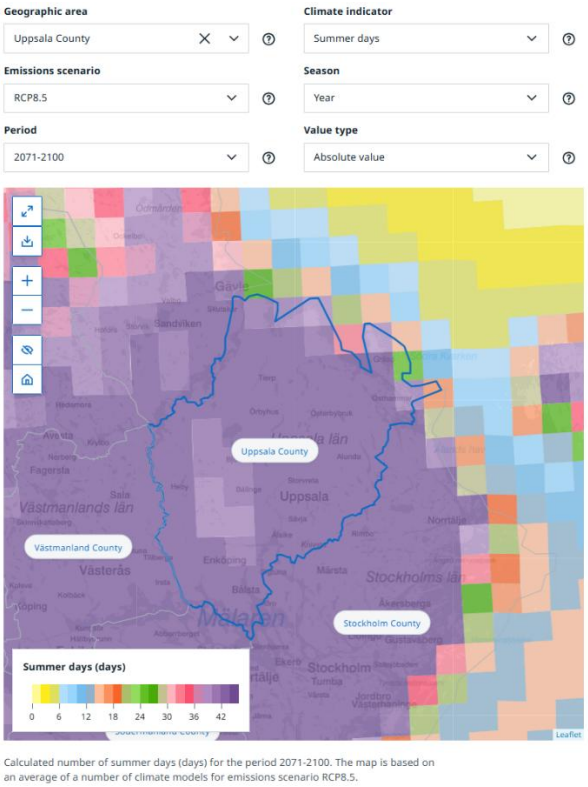
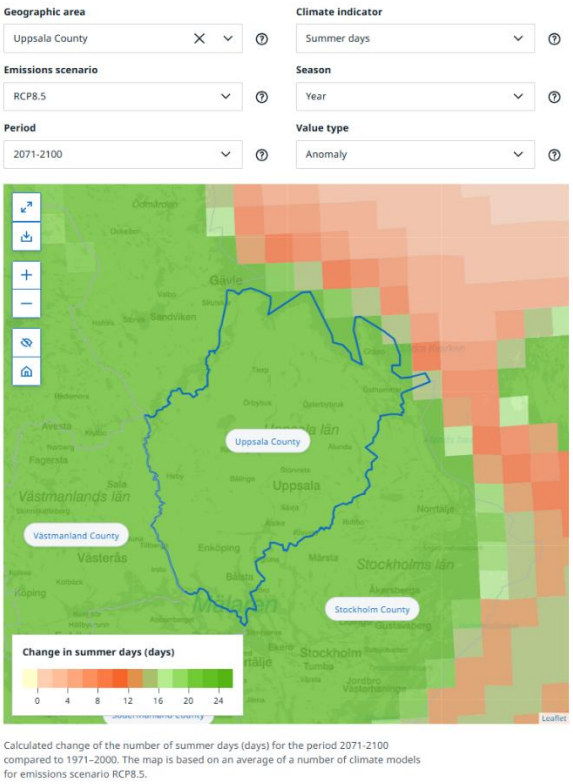


Figure 5-9 Projected number of summer days in the Uppsala region in the period 2071-2100 using RCP8.5.

Figure source: SMHI



Calculated change of the number of summer days (days) for the period 2071-2100 compared to 1971–2000. The map is based on an average of a number of climate models for emissions scenario RCP8.5.

Figure 5-10 Projected change of number of summer days in the Uppsala region in the period 2071-2100 using RCP8.5 compared to the reference period of 1971-2000.

Figure source: SMHI

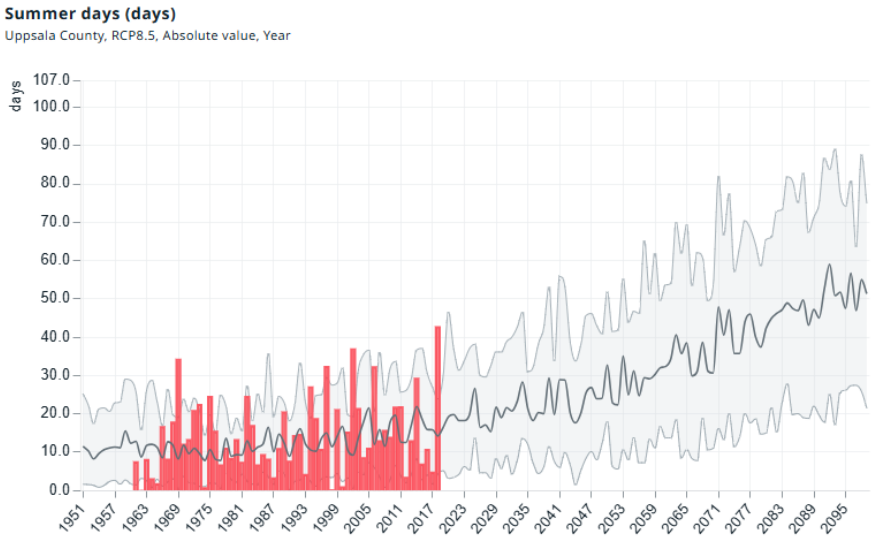


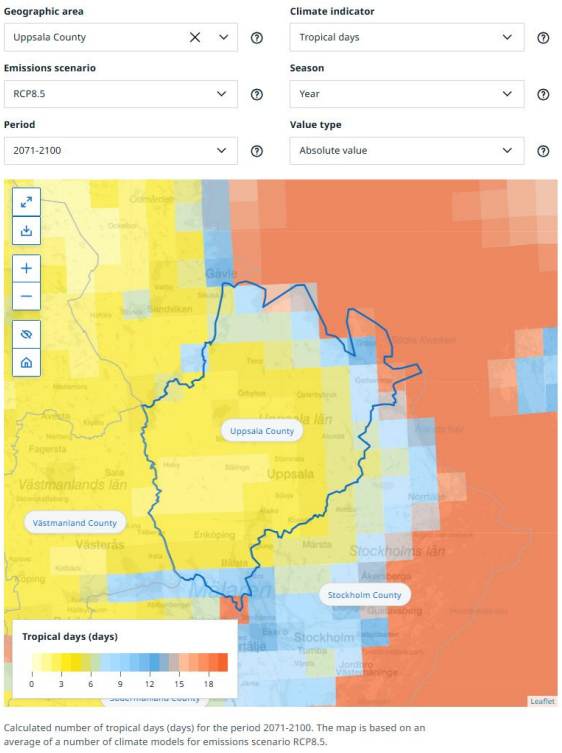
Figure 5-11 Projected summer days in the Uppsala County during the years 1951–2100. The bars show historical data derived from observations. The grey curve shows an average value for several climate models for emissions scenario RCP8.5. The grey field shows the range of variation between the 10th and 90th percentiles.

Figure source: SMHI

The Climate-ADAPT service also included the indicator of tropical nights, which is the count of days when daily minimum temperature remains above 20°C (number of days). The Climate-ADAPT

service showed an expected number of 5-10 tropical nights at the end of this century, according to the RCP8.5 scenario.

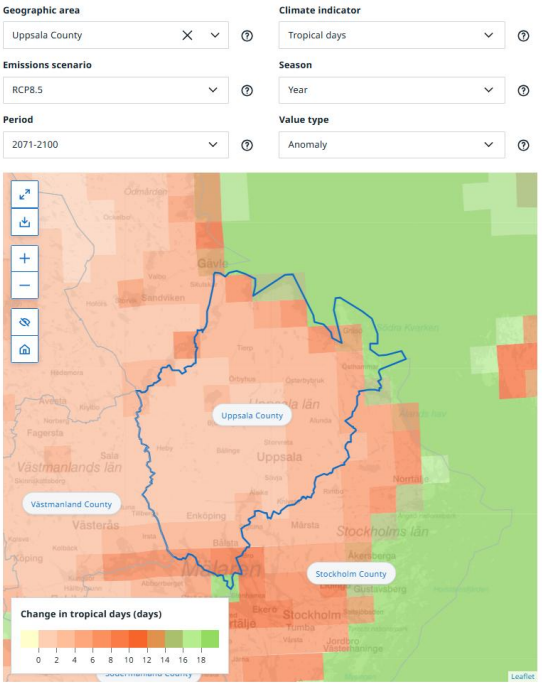
The indicator tropical days (a 24 hours time period including both days and nights) in the SMHI scenario tool refers to the number of days per year when the minimum temperature of the day exceeds 20 °C. Despite the different terminology, it is the same indicator as tropical nights. This indicator is relevant to show if vulnerable population groups have the possibility to recover during the cooler night hours during a heat wave event. If the number of topical days (or nights) increases, the ability to recover during heat waves for these groups will decrease. During the reference period 1970-2000, tropical days almost never occurred. With the RCP8.5 scenario, the number of tropical days is expected to increase to an average of 5 per year, with a range of 1-12 by the end of the century (*Figure 5-12, Figure 5-13 and Figure 5-14*). When using scenario RCP4.5, the number of tropical days is expected to increase to an average of 1-2 annually for the period 2071-2100. RCP2.6 shows almost no increase. When studying the development during the periods 2011-2040 and 2041-2070, the increase is smaller or non-existent (uploaded to Zenodo). This is consistent with the results of Climate-ADAPT from Phase 1.



Calculated number of tropical days (days) for the period 2071-2100. The map is based on an average of a number of climate models for emissions scenario RCP8.5.

Figure 5-12 Projected number of tropical days in the Uppsala region in the period 2071-2100 using RCP8.5.

Figure source: SMHI



Calculated change of the number of tropical days (days) for the period 2071-2100 compared to 1971–2000. The map is based on an average of a number of climate models for emissions scenario RCP8.5.

Figure 5-13 Projected change of number of tropical days in the Uppsala region in the period 2071-2100 using RCP8.5 compared to the reference period of 1971-2000.

Figure source: SMHI

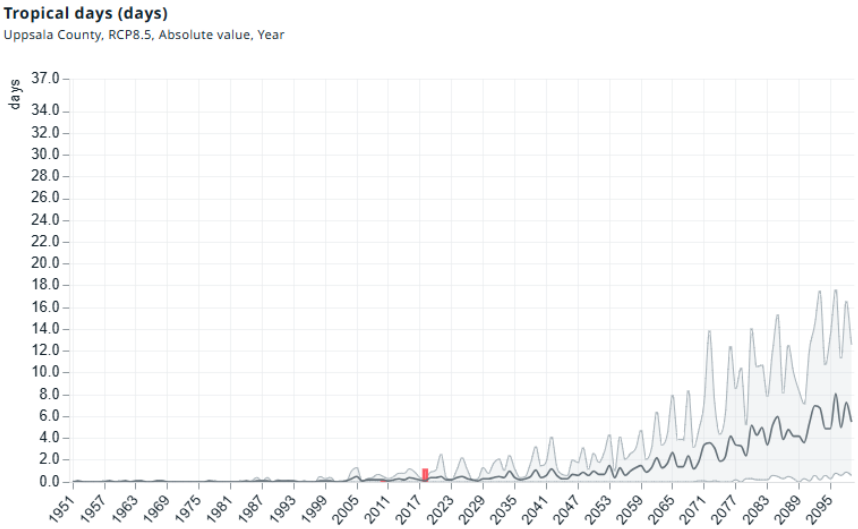


Figure 5-14 Projected tropical days in the Uppsala County during the years 1951–2100. The bars show historical data derived from observations. The grey curve shows an average value for several climate models for emissions scenario RCP8.5. The grey field shows the range of variation between the 10th and 90th percentiles.

Figure source: SMHI

5.3.2.2 Risk assessment

In Phase 1, overheated areas in the urban center of Bålsta and the geographical location of vulnerable population groups were identified. The thresholds were, however, considered too high for Swedish conditions. In Phase 2, the temperature thresholds for the categorization of overheated areas in Bålsta have been updated to better represent Swedish conditions. The new

thresholds are <10-15 °C for very low, 15-20 °C for low, 20-25°C for medium, 25-30°C for high and 30-35°C for very high. The warmest temperature ever recorded in Sweden is 38°C (SMHI, n.d.) During the heatwave of 2018, the highest recorded temperature was 34,7°C. These thresholds are therefore more realistic than those used in Phase 1.

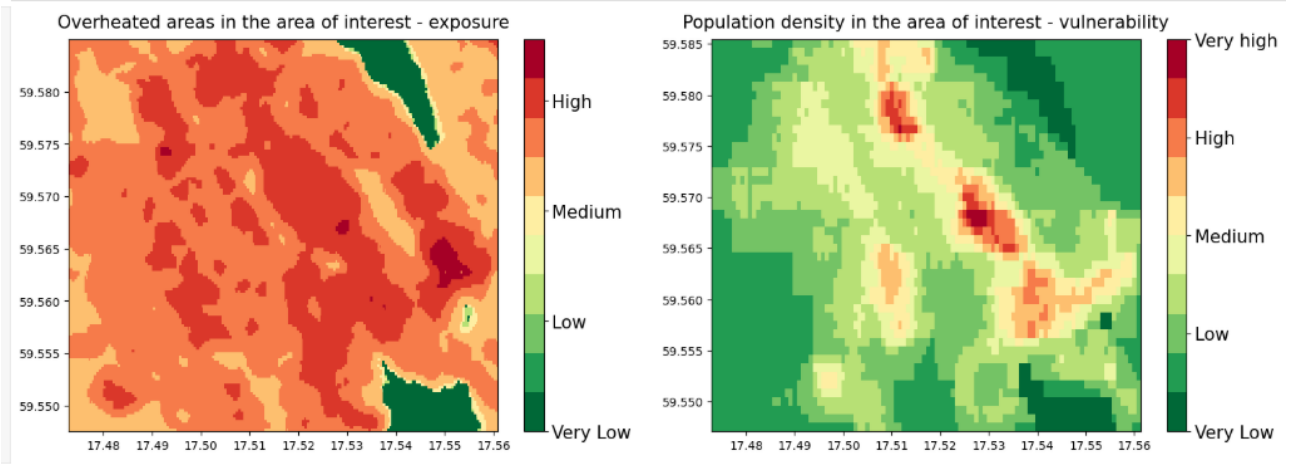


Figure 5-15 Classification of overheated areas in Bålsta (left). Density of vulnerable population groups for the age groups 0-5 and 65-80 years (right panel).

The new classification of overheated areas in Bålsta was analyzed together with the location of vulnerable population groups to merge hazard, vulnerability and exposure, to produce a heat wave risk map (*Figure 5-15*). To get a more detailed analysis of local exposure to heat waves, geographical location data for 11 different critical building types, provided by the municipality, were added to the analysis and plotted with the heat wave risk map (*Figure 5-16*). These buildings are the following: kindergarten, primary schools, secondary schools, sport facilities, rescue service building, healthcare centers, transport hub, townhall with a library, cultural and historical buildings (such as churches and castles), retirement homes, the waste recycling center and the water treatment plan. Separate plots for each building type were uploaded to Zenodo.

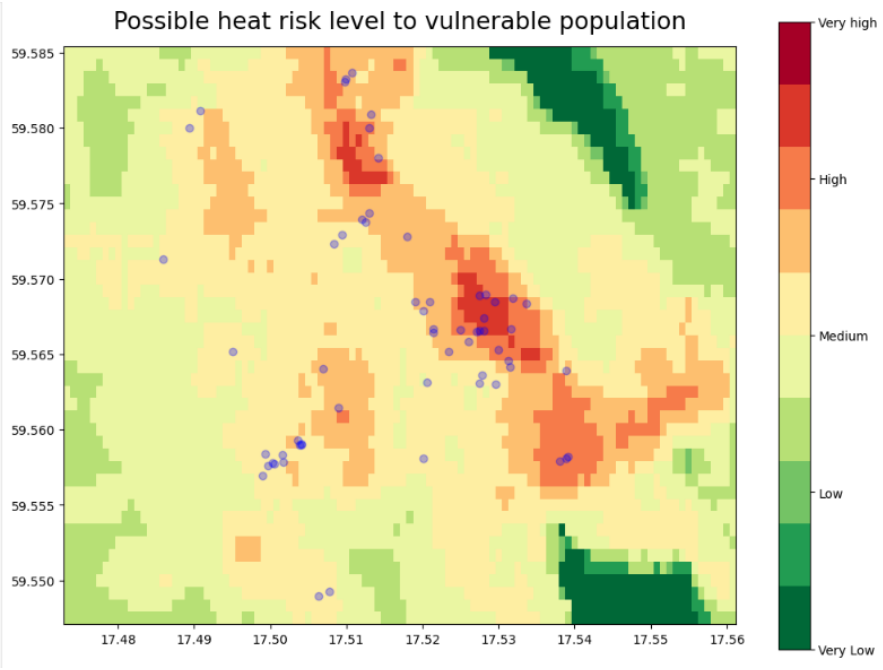


Figure 5-16 Heat wave risk for vulnerable population groups and critical infrastructure (all 11 building types).

With the separate plots for each critical building type, the risk for different vulnerable population groups could be assessed. Kindergartens, where children spend their days, are evenly distributed in and around the urban areas of Bålsta in residential areas. Healthcare centers and retirement homes, where sick and elderly people live and are treated, are more concentrated in the central parts of the city center and therefore are more exposed to extreme temperatures.

5.4 Key Risk Assessment Findings

5.4.1 Mode of engagement for participation

The engagement with stakeholders has already been described previously in this report (see section 2.1.5 above). The stakeholders were active in the prioritization process to narrow down the scope of the project to the climate risks of heavy rainfall and heat waves. The discussions were mostly centered on flooding caused by heavy rainfall, where some of the stakeholders had experienced water intrusion into buildings, mostly into basements. Some discussions arose concerning heat waves, increased need for cooling in buildings, and wildfires, which have been severe in other parts of the country in recent years.

5.4.2 Gather output from Risk Analysis step

The risk assessment maps and graphs showing the increase in frequency and magnitude of heavy rainfall and heat waves have been used in risk evaluation. Heat maps with critical buildings were also a valuable output, as well as the mapping of critical buildings in central Bålsta which are exposed to flooding during a 100-year rain event.

5.4.3 Assess Severity

The severity of the identified climate risks (primarily extreme precipitation and heat waves) has been assessed by combining quantitative risk analysis outputs with a contextual understanding of local conditions in Håbo municipality. This follows the four-category framework —limited, moderate, substantial, and critical— outlined in the Key Risk Assessment Protocol.

At present, the severity of climate risks in Håbo can generally be considered limited to moderate. Historically, the municipality has not experienced severe flooding due to extreme precipitation, and while heat waves have occurred, there is no clear evidence of increased mortality or large-scale societal disruption.

However, some localized vulnerabilities exist. For example, critical infrastructure, such as a road tunnel —leading to the old city center of Bålsta— beneath the railway is at risk of flooding during heavy rainfall, and water treatment and drinking water systems may also be affected. These indicate that while impacts have so far been manageable, they are not negligible.

From a frequency and impact perspective, current risks have not yet resulted in widespread human loss, large-scale economic damage, or major disruption of key sectors. Therefore, the current severity remains relatively contained, though with identifiable weak points.

Looking ahead, the severity is expected to increase from moderate to substantial, with the potential to reach critical levels under certain scenarios. Both extreme precipitation and heat waves are projected to become more frequent and intense in the future.

Future impacts may include:

- Damage to infrastructure such as roads, water systems, and urban areas.

- Increased strain on healthcare systems during heat waves.
- Economic losses for businesses and disruptions in logistics.
- Negative impacts on agriculture and forestry, including reduced yields and pest outbreaks.

These risks may threaten essential societal functions and could lead to systemic effects, aligning with the definition of substantial severity where community functioning and wellbeing is at risk. In more extreme cases, cascading failures—such as infrastructure breakdown leading to economic disruption—could elevate severity toward critical levels.

Both extreme precipitation and heat waves have the potential to cause irreversible impacts, although such outcomes have not yet been clearly observed in the municipality. Possible consequences include:

- Damage to ecosystems and biodiversity.
- Loss of agricultural and forest land productivity.
- Long-term impacts on human health.

In addition, there is clear potential for cascading effects. For example:

- Infrastructure damage may disrupt transport and supply chains.
- Economic losses for businesses could lead to unemployment.
- Weakened forests may become more vulnerable to pests.
- Increased healthcare demand during heat waves.

These interconnected risks highlight how even initially moderate impacts can escalate into broader systemic challenges.

Currently, climate risks in Håbo are not among the most severe in terms of observed impacts or frequency. However, their future relevance is high, particularly as climate change is expected to intensify both sudden events (e.g., heavy rainfall) and longer-lasting events (e.g., heat waves).

Urban development patterns, such as increased surface sealing, may further amplify local impacts, increasing both exposure and vulnerability. This suggests that while current severity is moderate, the trajectory points toward higher impact and frequency in the future.

The assessment of severity is enriched by input from a broad range of stakeholders, including municipal experts, regional authorities, businesses, civil associations and residents. Stakeholder input highlights sector-specific vulnerabilities (e.g., agriculture, forestry, infrastructure) and reveals indirect and cascading risks that may not be captured in quantitative models alone. It also underscores uncertainties, such as the lack of clearly identified irreversible risks despite plausible scenarios. At the same time, there are indications that decision-makers may face capacity constraints, particularly due to limited financial and human resources within the municipality. While awareness and engagement exist, varying levels of institutional capacity may influence how severity is perceived and addressed.

5.4.4 Assess Urgency

The urgency of the identified climate risks —primarily extreme precipitation and heat waves— has been assessed using the four categories defined in the Key Risk Assessment Protocol: no action needed, watching brief, more action needed, and immediate action needed. The assessment

considers both current conditions and future projections, as well as the timing, persistence, and dynamics of the hazards.

Urgency was evaluated by examining how quickly risks are expected to evolve, when their impacts are likely to become significant, and how long adaptation measures may take to implement. The assessment also considers whether hazards are sudden or slow-onset, and whether they are expected to intensify over time. A key factor in determining urgency is the observed and projected increase in both extreme precipitation and heat waves, which signals a need for forward-looking action.

At present, the urgency of climate risks in Håbo can be characterized as watching brief to more action needed. While current impacts have been relatively limited, there are clear indications that risks exist and may already affect critical infrastructure and local systems. The municipality is not yet experiencing widespread or persistent damage, which suggests that immediate large-scale emergency action is not required. However, early signs of vulnerability —combined with increasing climate variability— indicate that passive monitoring alone is insufficient. Thus, the current situation requires preparedness and gradual scaling of adaptation efforts rather than no action.

Looking ahead, the urgency is assessed as more action needed, with potential to approach immediate action needed. Climate hazards are expected to significantly worsen in the near future, particularly in terms of frequency and intensity of both heavy rainfall and heat waves.

This anticipated escalation means that:

- Risks will likely have major impacts within the coming decades, if not sooner.
- Action is needed already now to minimize future damage, given that adaptation measures (e.g., infrastructure upgrades, planning processes) can take years to implement.
- Delayed action may lead to higher costs and reduced effectiveness of adaptation.

The urgency assessment is strongly influenced by the temporal characteristics of the hazards:

- Extreme precipitation is a sudden-onset hazard, occurring rapidly (on a minute scale) and often locally. This increases urgency because impacts can occur with little warning, requiring robust preparedness and response systems.
- Heat waves can develop relatively quickly (on a daily scale) but may also persist over longer periods, especially under stable weather conditions. This persistence increases cumulative impacts on health, infrastructure, and ecosystems.

The combination of sudden shocks and prolonged stressors reinforces the need for both short-term response capacity and long-term adaptation planning. Both hazards are expected to worsen significantly in the near future, which is a key driver of urgency. In particular, the persistence of heat waves raises urgency because prolonged exposure can strain healthcare systems, reduce productivity, and amplify environmental impacts.

Urgency is further reinforced by the expected increase in severity from current to future conditions. While current risks are mostly limited to moderate, future risks may become substantial or critical. This shift implies that waiting until impacts become severe would be too late. Instead, proactive measures are required now to address risks before they escalate.

The urgency assessment has been informed by input from a wide range of stakeholders, including municipal departments, regional actors, businesses, and community representatives.

These perspectives highlight:

- Sector-specific concerns, such as impacts on agriculture, infrastructure, and public health.
- The importance of considering vulnerable groups who may be disproportionately affected by heat waves or infrastructure disruptions.
- The need for improved coordination and long-term planning within the municipality.

Stakeholder engagement also reveals that while awareness of climate risks is increasing, institutional and resource constraints may limit the speed of response. This reinforces the perception that action should begin early to compensate for limited adaptive capacity.

5.4.5 Understand Resilience Capacity

The resilience capacity of Håbo municipality to respond to climate risks— primarily extreme precipitation and heat waves— has been assessed using the four categories defined in the Key Risk Assessment Protocol: low, medium, substantial, and high. The assessment considers existing climate risk management (CRM) measures and evaluates financial, human, natural, physical, and social capacities, as well as planned interventions.

Based on the available evidence, the overall resilience capacity in Håbo is assessed as low to medium. While there is clear awareness of climate risks and several strategic initiatives are in place, limitations in financial resources, institutional capacity and implementation reduce the ability of the municipality to effectively respond to both current and future risks.

Håbo municipality has initiated several climate risk management measures that contribute to reducing climate-related risks. These include available strategic frameworks and planning tools such as the regional climate and vulnerability analysis for Uppsala County (Gustavsson, 2022), the regional climate adaptation action plan (Robin Hedenqvist, 2023) and the ongoing development of a municipal Climate Adaptation Program within the CLIMAAX project. In addition, forecasting and warning capacities are supported by national early warning systems provided by SMHI, which are adapted to regional conditions.

The municipality is also working with nature-based and ecosystem-based approaches, including the rewetting of peatlands to improve water retention, reduce greenhouse gas emissions from drained peatlands and strengthen ecosystem resilience, as well as the integration of ecosystem services into planning and policy documents. A key planned structural intervention is the Gröna Dalen stormwater park (Håbo-kommun, Detaljplaneprogram för Gröna dalen, 2026), for which funding has already been secured. This project involves the construction of a stormwater management system consisting of ponds, wetlands, and overflow areas designed to handle heavy rainfall, improve water quality, and enhance biodiversity. The system will include sedimentation basins, vegetated wetlands, and floodable areas that can store excess water during extreme events, thereby reducing flood risk and supporting ecosystem services.

Together, these measures indicate a transition toward a more proactive and adaptation-oriented approach to climate risk management, although many of them are still in early stages or have yet to be fully implemented.

5.4.6 Decide on Risk Priority

The process of assigning risk priorities to the analyzed risks of heavy rainfall and heat waves considered the present and future trends in frequency and magnitude, severity and urgency as described above, and the adaptation capacity of the municipality. Also, inputs from internal and external experts and stakeholders were taken into account. The dashboard rankings were based on the information arising in discussions and ended as high priority for both two analyzed climate risks. (Håbo-kommun, Detaljplaneprogram för Gröna dalen, 2026)

Risk Workflow	Severity		Urgency	Capacity	Risk Priority
	C	F		Resilience/ CRM	
River flooding					
Coastal flooding					
Heavy rainfall	2	3	3	1	High
Heatwaves	2	3	3	1	High
Drought					
Fire					
Snow					
Wind					

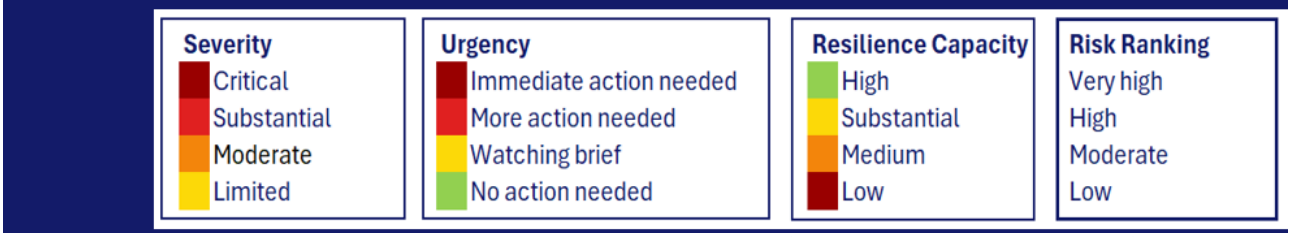


Figure 5-17 Key Risk Assessment through risk ranking, considering severity (of current – C and future – F risk), urgency and resilience capacity.

5.5 Monitoring and Evaluation

The regional and local administration has valuable knowledge and data concerning the situation, challenges and capacity for climate change effects and adaptation. This knowledge and data are crucial to be able to produce a relevant climate risk assessment and adaptation program.

It is easy to reach out to but difficult to engage external stakeholders in the municipality. Even though external communication was aimed at a broad group of people living and working in the municipality, several of the contacted external stakeholders did not reply to the invitations. Finding a suitable time for discussions was also a challenge, as external stakeholders have a wide range of working schedules, making it difficult to accommodate everyone. Stakeholders were invited to take part in the discussions of the results of the CRA and the adaptation program as well as to suggest improvements. The feedback received has been positive, indicating that the participating

stakeholders recognize that it is important to improve climate adaptation in cooperation with local organizations.

The monitoring and evaluation were ensured by each step discussing the findings and future plans with stakeholders to gather comments and suggestions and make use of the local knowledge, expertise, and experience.

The CRA from Phase 2 of the CLIMAAX project provides new, detailed information concerning the climate risks affecting Håbo municipality, which is a crucial foundation for the following development of the adaptation program. Ensuring the availability of adequate resources and knowledge in the municipal organization is required to develop a robust adaptation program and to implement the planned actions. More research and analysis are needed concerning multiple benefits of more green areas in the urban center and other nature-based solutions in order to strengthen the premise of the ecosystem services in the municipality.

To share the results of the project with the public, announcements were scheduled for Phase 2 and are scheduled for Phase 3 via local media as well as the different social media sites of the municipality. Several seminars to share the acquired information and knowledge with stakeholders and citizens are also planned during Phase 3.

The resources in the project in terms of time and staff have been used efficiently with external consultants as experts performing the CRA. During the CRA, weekly meetings have taken place to discuss the progress and findings to secure the local foundation in the assessment. This approach had a positive impact on the CRA.

One part of the work, which was collaboration with the other CLIMAAX participant-organizations in Sweden, did not deliver as expected. Discussions took place with the regions of Skåne and Västernorrland as well as with SMHI to investigate possible cooperation in Phase 2 of the CLIMAAX project. However, the regions of Skåne and Västernorrland –most likely due to differences in geographical size– did not intend to perform similar analyses as Håbo municipality, thus no obvious opportunity of collaboration was found. SMHI could possibly have cooperated in research activities connected to the project, although financial compensation would have been needed to provide processed and tailored datasets, and these were out of scope of this project. Even in the absence of results, considerable working time was invested in the pursuit of potential cooperations with other Swedish partners in Phase 2.

5.6 Work plan Phase 3

The plan to develop a Climate Adaptation Program for Håbo Municipality is described in the following section.

5.6.1 Purpose and overall approach

The objective of Phase 3 is to develop a structured and operational Climate Adaptation Program for Håbo Municipality, building on existing analyses, and focusing on the prioritization and implementation of adaptation measures. The Climate Adaptation Program will focus on the climate risks of heavy rainfall and heat waves as both got high priority in the key risk assessment.

The implementation plan is based on the SMHI climate adaptation framework, the project plan of the municipality, the methodology for ecosystem services developed by the Swedish Environmental Protection Agency, results from the CLIMAAX Phase 1 and 2, the key risk

assessment created in Phase 2, and different regional as well as national climate adaptation assessments. The work aims to ensure that the Climate Adaptation Program is fully integrated into the municipality's governance, objectives and planning processes, and can function as a practical tool for both strategic decision-making and day-to-day operations. A key objective is to connect and align existing policies, programs, and planned measures into one coherent structure.

5.6.2 Main activities in Phase 3

5.6.2.1 Consolidation of risk and vulnerability analysis

Existing climate risk and vulnerability assessments (including CLIMAAX outputs) will be compiled, validated, and interpreted in a municipal context. The analysis will focus on the key hazards heavy rainfall and heat waves as well as their impact on infrastructure, ecosystems, public health, and critical public services.

5.6.2.2 Identification of adaptation measures

Based on the prioritized risk profile, potential adaptation measures will be identified through workshops and dialogue with relevant municipal functions. The scope includes:

- Nature-based solutions and ecosystem services
- Measures for stormwater and drinking water management
- Adaptation of built environment and infrastructure
- Governance-related measures (guidelines, planning principles, routines)

All measures will be explicitly linked to identified risks and vulnerabilities.

5.6.2.3 Prioritization of measures

A structured prioritization process will be conducted, aligned with SMHI guidance and the CLIMAAX framework. Measures will be assessed based on:

- Risk reduction potential
- Feasibility and implementation capacity
- Cost and time horizon
- Synergies with other objectives (e.g. biodiversity, public health)

This step ensures a transparent link between risk assessment outcomes and selected actions.

5.6.2.4 Implementation structure and integration

The program will define how prioritized measures are to be implemented within existing municipal processes. This includes:

- Allocation of responsibilities
- Integration with existing plans (e.g. spatial planning, water management, green infrastructure)
- Phasing of measures over time

The focus is on ensuring that the program is actionable and embedded in existing governance structures within the municipality and the County.

5.6.2.5 Follow-up and continuous improvement

A framework for monitoring, evaluation and revision will be developed. This includes:

- Indicators linked to prioritized risks and measures
- Routines for follow-up and learning
- Mechanisms for updating the program based on new data or changing conditions

This ensures long-term adaptability and alignment with evolving climate risks.

5.6.2.6 Scope limitations

Phase 3 focuses on synthesis, prioritization, and structuring of measures based on existing analyses. It does not include:

- New large-scale quantitative risk modelling
- Detailed technical design of individual measures
- Full implementation of measures

These are expected to be addressed in subsequent phases, outside of the scope of the CLIMAAX project.

5.6.3 Conclusion

Phase 3 translates existing climate risk knowledge into a prioritized, actionable and integrated Climate Adaptation Program. By explicitly linking risk assessment outcomes to concrete measures and implementation structures, the work ensures that climate adaptation becomes an operational and strategic part of Håbo Municipality's governance.

6 Conclusions Phase 2 - Climate risk assessment

In Phase 2 of the CLIMAAX project, more detailed regional and local indata were used to deepen the CRA of the climate risks of heavy rainfall and heat waves. To improve the available climate data, the SMHI climate scenario tool was used with data for the Uppsala County.

The hazard assessment of heavy rainfall showed an expected increase of 20-40% depending on indicators and scenarios- by the end of the century, with alignment between Phase 1, Phase 2 and external reports such as the CRA from Uppsala County. Average monthly precipitation and days with extreme precipitation for Uppsala County were used by the climate scenario tool of SMHI.

The risk assessment of heavy rainfall was based on an assessment of critical buildings in Bålsta and Skokloster. It showed that several crucial buildings in these two towns can be exposed to flooding during a heavy rainfall event and suitable adaptation measures are needed to be performed to protect these buildings.

The hazard assessment of heat waves showed that with continuing climate change the heat waves will become hotter, longer and more common. The indicators of summer days and tropical days were used as proxies for heat waves and indicate that these types of events will go from rare to common during this century. The number of summer days from SMHIs climate scenario tool was higher compared to the number of heat wave days from EuroHEAT, which could be explained by that the threshold of heat wave days in EuroHEAT is 30 °C while it is 25 °C for summer days in SMHIs climate scenario tool.

Local position data for critical buildings in Bålsta was mapped in the risk assessment of heat waves. 11 different building types **were** included, and the majority of the buildings are shown to be located in high-risk areas, whereas a minor proportion was located further from the city center, where the risk was comparatively lower.

The involvement and feedback from stakeholders have provided valuable input throughout the project. This also increased the knowledge and understanding of possible climate risks in the municipality. The need to take strategic precautionary adaptation measures was shown in the Phase 2 of the CLIMAAX project to increase the preparedness and resilience of the society in Håbo municipality.

The key risk assessment identified that the severity of the two analyzed climate risks of heavy rainfall and heat waves are expected to increase from moderate to substantial in line with the risk trends showing an increase. It was concluded by the urgency analysis that more actions are needed and with the adaptation capacity of the municipal being low, the priority was concluded to be high for both risks.

7 Progress evaluation

Table 7-1 Overview key performance indicators

Key performance indicators	*Progress*
2 workflows with local data successfully applied on Deliverable 2	The workflows of heavy rainfall and heat waves were analyzed in Phase 2, completed 15 March 2026 with revisions submitted 12 October 2026. The workflows followed the CLIMAAX methodology but were unable to be applied in Jupyter Notebook, with the exception of the heatwave risk assessment.
5 municipal stakeholders involved in the activities of the project	The municipal sustainability strategist, Bettina Károlyi-Donkó, is coordinating the project. The CRA is made by Erik Engström and Susanna Olsson. Additional competences that were involved in the project from the municipality were a communicator, a GIS coordinator, and a strategist from the Water and sanitation department. A team manager and two division managers have also taken part in discussions and planning of the project. Two politicians from the Municipality also participated in the seminar.
30 external stakeholders involved in the activities of the project	In Phase 1 and 2, the participants represented a wide range of interest: both from different parts of the municipal organization - from politicians and administrative managers to civil servants working with a wide range of questions like environment and coastal protection, nature conservation and urban planning, waste manager, GIS coordinator, communicator and gardener, as well as from external organizations such as the climate adaptation coordinator from the County Administration Board, a risk consultant from a private company, the local rescue service, and property owners and local residents participated. The public events and seminars that were arranged reached at least 40 external stakeholders combined.
2 activities involving external stakeholders in the project	Seminars involving external stakeholders were arranged on 25 August 2025 and 21 January 2026. Two public events shared results and gathered input from external stakeholders on 30 August and 27 September.
4 communication actions taken to share results with your stakeholders	Communication of the project and results have been done through e-mail to the non-governmental associations of the municipality and the businesses located and operating in the municipality. The seminar was advertised on different social

Key performance indicators	*Progress*
	media platforms (Facebook and Instagram) 3 times in December and in January as well as on the info-screens at the main building of the Municipality in December and January. The event was also registered in the digital calendar of the Municipality, available on the official website. The seminar was held on 21 January.

Table 7-2 Overview milestones

Milestones	*Progress*
M1: Internal resources and subcontractor secured by April 2025	Contract signed with sub-contractor "Goodpoint AB" 29 April 2025. Internal resources secured by March.
M2: First multi risk assessment initiated by May 2025	Workflow for heavy rainfall initiated 5 May, followed by workflows for heat waves and wildfire.
M3: Attend the CLIMAAX workshop held in Barcelona in June 2025	Two representatives from Håbo municipality attended the workshop.
M4: First external stakeholders meeting done by August 2025	Meeting with external stakeholders took place on 25 August 2025.
M5: Second multi risk assessment initiated by December 2025	The workflows of heavy rainfall and heat waves were initiated in September 2025.
M6: Second external stakeholders meeting done by January 2026	Second external stakeholders meeting was held on 21 January 2026.
M7 and D1: Analysis of multi risk assessment made by August 2026	Analysis of multi risk assessment done by 15 March 2026.
D2: Refined regional/local multi-risk assessment	Refined regional/local risk assessment including local data and comparison of results by 15 March 2026.

8 Supporting documentation

Table 8-1 Supporting documentation

Documentation title	*Description*	*Zenodo reference number*
Deliverable Phase 2 – Climate risk assessment	This report describes the work, process and results of Phase 2	DOI 10.5281/zenodo.23311451
Ensamble_models_SMHI_climate_scenario_service_2026	A list with the climate models included in the ensemble of SMHIs climate scenario tool	DOI 10.5281/zenodo.23311451
Climate risk – heavy rain	Compressed folder containing maps of flooding in Bålsta and Skokloster due to heavy rainfall	DOI 10.5281/zenodo.23311451
Exposed critical buildings at heat waves	Compressed folder containing mapping of exposed critical buildings in Bålsta at heat waves	DOI 10.5281/zenodo.23311451
Monthly precipitation	Compressed folder containing monthly precipitation in Uppsala County from SMHIs climate scenario tool	DOI 10.5281/zenodo.23311451
Days with extreme precipitation	Compressed folder containing days with extreme precipitation in Uppsala County from SMHIs climate scenario tool	DOI 10.5281/zenodo.23311451
Summer days	Compressed folder containing summer days in Uppsala County from SMHIs climate scenario tool	DOI 10.5281/zenodo.23311451
Tropical days	Compressed folder containing tropical days in Uppsala County from SMHIs climate scenario tool	DOI 10.5281/zenodo.23311451
Seminarium FB	Invitation to seminar	DOI 10.5281/zenodo.23311451
Internal stakeholders workshop	Input on prioritisation from the external workshop meeting.	DOI 10.5281/zenodo.23311451
Håbo Day (Håbo festdag)	Online event for Håbo Day where the CLIMAAX team (“planerings- och utvecklingsenheten”) participated.	DOI 10.5281/zenodo.23311451
Societal Preparedness Day (Beredskapsdagen)	Online event for Social Preparedness Day where the CLIMAAX team participated.	DOI 10.5281/zenodo.23311451

Documentation title	*Description*	*Zenodo reference number*
RMK_118 SMHI Gridded Climatology	Report describing the regional climatological dataset that we tried to use in the CRA in Phase 2	DOI 10.5281/zenodo.23311451

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