Deliverable Phase 1 – Climate risk assessment

Forsee Skåne

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Document Information

Deliverable Title	Phase 1 – Climate risk assessment
Brief Description	In phase 1 the project team in County Administrative Board of Skåne have learned and applied the CLIMAAX framework and tools to create a comprehensive overview of regional risks. The deliverable 1 presents the initial outcomes of the climate risk assessment for four different climate-related hazards: river flooding, coastal flooding, heavy rainfall and drought. The main focus was to understand how the methodology functions and how it can be useful in the Swedish planning context. This initial assessment also serves as a foundation for future phases (Phase 2 and 3), where more refined analyses will be performed using national and regional data along with insights from previous research and expert knowledge.
Project name	Forsee Skåne (Framework for climate multi-risk assessments to evaluate and adapt – Making the region of Skåne climate resilient)
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Leading Institution	The County administrative board of Skåne (CAB)
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2.0	…	CLIMAAX's FSTP team	Review completed
5.0	…		Final version to be submitted

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Abbreviations and acronyms

Abbreviation / acronym	Description
CAB	The County Administrative Board of Skåne
CRA	Climate Risk Assessment
FRMP	Flood risk management plans
GIS	Geographic Information System
MSB	Swedish Civil Contingencies Agency
SGI	Swedish Geotechnical Institute
SMHI	Swedish Meteorological and Hydrological Institute

Executive summary

Phase 1 of the Foresee Skåne project focused on exploring the CLIMAAX tools and assessing climate-related risks across the Skåne region. The deliverable was developed to provide municipalities, regional authorities, and landowners with a comprehensive understanding of the region's climate hazards, enabling informed decision-making for adaptation planning. Readers will gain insights into the main climate risks, the applicability of the CLIMAAX methodology in Sweden and the preliminary knowledge needed to guide future risk management.

The assessment identified river and coastal flooding, heavy rainfall and drought as the primary hazards affecting Skåne. River flooding poses significant risks in Kristianstad along the Helge River and in Malmö along the Sege River, with the smaller Sege River presenting higher uncertainty due to limited data. Coastal flooding is a major concern in Landskrona, Trelleborg and Kristianstad, where extreme events could disrupt societal functions, critical infrastructure, and economic activity, while drought remains a persistent challenge for agricultural systems, potentially impacting crop yields, revenue and groundwater levels despite projected increases in precipitation.

The CLIMAAX workflows successfully generated hazard and risk maps, although limitations were observed, including low spatial resolution, restricted long-term projections and limited capacity to analyze combined hazards such as elevated sea levels interacting with river floods. The assessment also highlighted that risk is shaped not only by hazard exposure but also by societal and environmental vulnerabilities, including land-use changes, urban development and historical landscape modifications. Immediate measures are needed to protect critical services, while long-term adaptation strategies must incorporate spatial planning and proactive risk management.

Phase 1 strengthened internal technical expertise and built a foundation for future engagement with key stakeholders, including municipalities, Region Skåne, the Swedish Civil Contingencies Agency and the Swedish Transport Administration. The assessment integrates previous national and regional studies, such as flood risk management plans, climate adaptation strategies and datasets from SMHI and MSB, providing a self-contained overview that supports subsequent project phases.

In conclusion, Phase 1 established a preliminary understanding of climate risks in Skåne, identified major vulnerabilities and revealed both technical and governance challenges. The results will inform Phase 2, which will incorporate higher-resolution datasets, broaden stakeholder participation and explore nature-based solutions, while Phase 3 will focus on developing actionable adaptation strategies in collaboration with municipalities and landowners to reduce flooding and drought risks effectively.

1 Introduction

1.1 Background

Skåne is the southernmost of Sweden's 21 counties with 1.422 million inhabitants, see figure 1. The landscape is characterized by a high proportion of agricultural land, which covers approximately 45% of the region's total area. This makes Skåne Sweden's leading agricultural region, supported by its fertile soils and favorable climate. Forests account for around 39% of the land area, while built-up and developed areas, including urban infrastructure and settlements, make up roughly 10%. The remaining 6% consists of wetlands, open natural land and other miscellaneous land types.

Figure 1 The region of Skåne highlighted

Skåne has a coastline of approximately 570 kilometers, making it one of the longest coastal regions in Sweden. The coastline stretches from the Öresund Strait in the west, around the southern tip of the region, and up along the Baltic Sea in the east and the Kattegat Sea in the northwest. It features a diverse range of coastal landscapes, including long sandy beaches, dunes, cliffs, wetlands and rocky shores. The coastline supports a mix of urban development, ports, nature reserves and recreational areas, making it both ecologically significant and economically important for tourism, fishing and transport.

The main climate-related risk in the region of Skåne is flooding. Nationally, the Swedish Geotechnical Institute and the Swedish Civil Contingencies Agency has identified the region's coasts as one of ten national high-risk areas. Additionally, the Swedish Civil Contingencies Agency has pinpointed seven more specific high-risk areas for flooding in the region, based on the Directive 2007/60/EC of the European Parliament and of the Council on the assessment and management of flood risks.

Flooding, as defined by the EU's Floods Directive, includes coastal and river/stream flooding, primarily due to rising sea levels and heavy rainfall. The issue has significant impacts on human health, the environment, cultural heritage, and economic activities. The negative impact based on these focus areas is particularly relevant for our region, as it holds a substantial portion of Sweden's agricultural production, important nature values and have many coastal cities and settlements, where climate-related damage could yield severe negative effects.

Coastal erosion in Skåne accounts for about 60% of Sweden's beach erosion. Additionally, Skåne has the highest proportion, 45%, of exploited land within 300 m of the shoreline in a national context, which hinders implementation of solutions to ease the risks.

The region of Skåne also suffers from problems due to heatwaves and droughts. Extended periods of drought reduce the formation of new groundwater. These sources are also affected by increased land use and increased water withdrawal for agriculture.

While flooding poses major challenges, it also presents new opportunities, particularly from a watershed perspective. By optimizing land use for regulating and storing water, we believe we can reduce flooding impacts and provide water resources for crop irrigation, creating a win-win situation for farmers while allowing climate adaptative measures that can mitigate most negative effects. However, the main challenge to do so as of today is the governance structure of climate adaptation measures in Sweden, and the resources at hand.

Another climate-related risk in the region concerns biodiversity. Skåne functions as a primary gateway for invasive non-native species entering Sweden. This is largely due to intensive trade and transport routes, approximately 80% of all transport passes through the region. As climate warms, many species previously confined to more southern latitudes are now able to survive and reproduce in Skåne, increasing the risk of local establishment and eventual spread northward.

1.2 Main objectives of the project

The overarching goal and impact are to raise awareness of climate risks and possible solutions in the municipalities of Skåne and among individual landowners. In the long term, we believe this can result in an increased understanding of costs and planning related to climate adaptation which will emphasize the importance of proactive measures today to reduce negative effects in the future. Hopefully, we can also gain an understanding of how the proposed solutions can yield positive side-effects such as a more sustainable ground water supply in the county by using more surface water for irrigation.

The way we propose to do this is by utilizing the new knowledge and data from our project involvement to support/revise our regional adaption strategies and risk management plans. Timewise, this fits well as we are currently working to revise our current flood risk management plans (FRMP) (during the period of 2022 – 2027). By using the CLIMAAX-project as part of our revising process we believe we could strengthen our knowledge of the current distribution of responsibilities, clarify the expectations on municipalities and landowners related to climate adaptation measures, and make risk mappings, proposals for solutions and collaboration opportunities more available.

We also intend to utilize the results and knowledge gathered as a way to influence and provide input on the national legislation and the needs we see related to new challenges posed by increased climate change.

In addition to that we also see that the resulting knowledge, together with the support offered by the project, will give us more effective tools to create discussions about possible measures, clarify potential win-win situations, and gain support for these issues among new, but important, beneficiary groups.

1.3 Project team

Pär Persson: Project manager, Water strategist, Unit for Spatial Planning, Department of Community Development.

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1.4 Outline of the document's structure

The document starts with an introduction that provides background information, explains the main goals of the project and gives an overview of the project team. After this, the main part of the document focuses on the climate risk assessment process. This process includes several steps, such as defining the scope, exploring different risks and carrying out risk analyses for different types of hazards.

Once the process is described, the report moves on to present the first key findings about potential risks. These findings are followed by the project's conclusions and a discussion of how the results from this phase will guide the next stages of the project.

In the final part, the document includes supporting materials and references. These sections ensure that all the methods used and the results obtained can be traced back, checked and verified for accuracy.

2 Climate risk assessment – phase 1

2.1 Scoping

The overarching goal and impact of the project Foresee Skåne is to raise awareness in the municipalities of Skåne and among individual landowners of the climate risks as well as possible solutions. In Phase 1 we aim to explore the CLIMAAX tools and reflect on their strengths, limitations, and applicability within a Swedish regional context.

2.1.1 Objectives

The objective of the Phase 1 CRA is to conduct a first application of the CLIMAAX methodology to identify relevant climate hazards and provide a preliminary overview of their spatial distribution, potential impacts, and adaptation options. The main focus is to understand how the methodology functions, what types of results it produces, and to what extent these results are relevant and useful in the Swedish planning context. This initial assessment will also serve as a foundation for future phases (Phase 2 and 3), where more refined analyses will be performed using national and regional data, along with insights from previous research and expert knowledge.

Key aims of Phase 1 include:

- Identifying key climate hazards for Skåne through four selected workflows: river and coastal flooding, heavy rainfall and drought.
- Testing and evaluating the CLIMAAX tools and documenting their strengths and limitations.
- Producing an initial knowledge base for updating regional risk and climate adaptation plans.
- Preparing for the integration of high-resolution national and regional datasets in later phases.

The scope of this phase is limited in several ways:

- Only a selected number of workflows are included.
- Some workflows are applied at regional scale (e.g. drought), while others are geographically restricted to high-risk areas (e.g. Sege River, Helge River, Malmö, Trelleborg, Kristianstad and Landskrona).
- The processing of external high-resolution national datasets is largely postponed to later phases, though preparatory work will begin in Phase 1.

During the implementation of Phase 1 of the project, we have worked in accordance with the CLIMAAX framework to structure our scope and to identify regional risks. Based on the risks identified, we have selected relevant workflows for further analysis. In this report, we have begun to make preliminary assessments of the identified risks, and we will continue to do so in subsequent phases of the project. Further work with monitoring and evaluation will also be a focus onwards.

We plan to use the results and knowledge gained to influence national legislation and highlight the challenges we face due to increased climate change, especially where current governance falls short compared to other European countries. We also believe that the results from this phase will give us better tools to start discussions about possible solutions, show potential win-win outcomes, and build support among new but important target groups.

2.1.2 Context

The County Administrative Board of Skåne has been working with climate adaptation since 2008. The first identified risk was sea level rise, particularly affecting low-lying coastal areas in the region. In 2009, the County Administrative Board was given the mandate to coordinate climate adaptation in Skåne and the first regional climate adaptation plan was adopted in 2014.

Sweden's legal framework, including the Planning and Building Act, the Environmental Code, and the Civil Protection Act, provides strong support for implementing adaptation measures. At the same time, the Swedish administrative system is characterized by strong municipal self-governance, allowing for locally anchored decision-making. If political will and resources are present, municipalities have significant opportunities to plan and implement climate measures. Municipal and regional spatial planning can also support individuals and stakeholders responsible for implementing measures.

The current administrative system functions well for professional users such as municipalities, but navigating complex regulations requires significant resources and training. Without financial instruments, it is also difficult to initiate and scale up projects.

The municipal sector is a key target group, as municipalities are responsible for critical infrastructure, including drinking water, sewage systems, schools, elderly care and spatial planning. Market forces, however, influence land use patterns, often resulting in housing developments near water and increased urban density, factors that heighten the risk of flooding and heatwaves.

To enable landowners to implement adaptation measures, there is a strong need for public coordination.

Skåne features a diverse landscape with vulnerable coastlines, intensive agriculture and densely populated urban areas. This combination makes the region particularly exposed to climate-related risks such as flooding, drought and cloudbursts. The high population density, existing infrastructure and valuable cultural and environmental assets further increase sensitivity to extreme weather and long-term climate change.

Previous climate-related analyses in the region have been conducted as part of flood risk management plans, climate adaptation strategies, cultural heritage risk assessments and coastal flood impact studies. However, there remains a strong need for consistent and scalable methods to assess and compare risks across sectors and timeframes, especially in relation to future climate scenarios and socio-economic changes.

In Sweden, climate adaptation is primarily governed through regional and municipal planning. However, the division of responsibilities between national agencies, regional authorities, municipalities and local stakeholders is not always clearly defined. One of the aims of the Foresee Skåne project is to identify and clarify these gaps, and to contribute to improved coordination and governance.

This CRA focuses particularly on the following sectors:

- Buildings and infrastructure, including accessibility for emergency services and flood protection.
- Agriculture and water resources, with special attention to crop vulnerability and groundwater recharge.

- Cultural heritage, including listed buildings and historic sites exposed to sea level rise and flooding.
- Ecosystems and nature values, in relation to changes in hydrology and drought stress.

External initiatives and knowledge sources influencing this work include:

- The Swedish Meteorological and Hydrological Institute's climate scenario services.
- National guidelines from the Swedish Civil Contingencies Agency, particularly for flood risk assessment.
- Past regional projects, including GIS-based land-use change assessments, economic analysis of flood protection and groundwater modelling for the Kristianstad Plain.

2.1.3 Participation and risk ownership

A first step in Phase 1 has been to clearly define team roles and responsibilities. The work is carried out by a cross-disciplinary team within the County Administrative Board of Skåne, including expertise in hydrology, coastal processes, IT and data analysis, agriculture and climate adaptation.

In this first phase, external participation is limited, but broader stakeholder involvement is planned for Phases 2 and 3. Internal coordination is currently prioritised to establish technical competence and a shared understanding of the tools before engaging municipalities and other actors more extensively.

Climate risk ownership in Sweden is distributed across several governance levels: the national government (e.g. Swedish Civil Contingencies Agency), the regional level (Region Skåne), the County Administrative Board as well as municipalities and private landowners. The County Administrative Boards play a key role in coordinating and supporting climate adaptation at the regional level including:

- Coordinating climate adaptation efforts across the region, involving municipalities, regional authorities, government agencies, businesses and other stakeholders.
- Supporting municipalities by providing guidance, expertise and forums for collaboration to strengthen local adaptation work.
- Developing regional climate adaptation plans, based on the specific risks, vulnerabilities, and conditions in the county.
- Monitoring and reporting on climate adaptation progress and activities to national authorities, such as The Swedish Meteorological and Hydrological Institute and the Government Offices.
- Ensuring that climate risks are considered in spatial planning and permit processes, including through formal reviews under the Planning and Building Act.
- Identifying regional climate risks and vulnerabilities, such as flooding, coastal erosion or heatwaves and promoting measures to reduce them.

This role helps ensure that climate adaptation is integrated into decision-making and planning at all levels within the region. The County Administrative Board is also involved in various forums and EU-funded projects related to climate adaptation and is currently in the process of updating the Regional Action Plan for Climate Adaptation.

Other stakeholders related to the Forsee Skåne project and how they will be involved is described below:

- Municipalities: We will mainly focus on physical dialogue meetings and workshops, to collect inputs and needs.

- Private landowners/farmers: We will invite key landowner and share competence about their responsibility and potential for climate adaptation measures.
- Region Skåne - The regional authority in Skåne in charge of regional planning and regional development: We will mainly focus on physical dialogue meetings and workshops.
- Banks and insurance companies: Invite representatives to workshops/conferences together with the other stakeholders.
- National authorities: We will involve authorities responsible for Swedish tools used for climate change/climate adaptation in the work developing and testing new tools and methods.
- National political level: Provide input on hinders implementing climate adaptation measures.

One of the project's ambitions is to clarify this distribution and promote greater awareness of responsibility-sharing in risk prevention and climate adaptation. Currently, there is no formal or widely agreed definition of "acceptable risk" in the region. In spatial planning the Planning and Building Act governs land use and the construction of buildings in Sweden. It regulates how new developments must be planned and approved, ensuring they are suitable for their intended purpose and location. According to the Act, new buildings may not be constructed in areas where there is a significant risk of flooding or other natural hazards. This is to ensure long-term safety, sustainability, and environmental protection in urban planning.

We hope this project may contribute to initiating a dialogue on acceptable risks, especially in relation to critical infrastructure and the protection of cultural heritage sites. Results from Phase 1 will be used primarily for internal discussions and preparations for external engagement in subsequent project phases.

2.2 Risk Exploration

The CRA is based on existing national and regional studies. These include investigations conducted by the Swedish Meteorological and Hydrological Institute, the Swedish Civil Contingencies Agency and several assessments previously carried out by us at the County Administrative Board of Skåne e.g. the regional climate and vulnerability assessment. Many of these analyses were developed in collaboration with municipalities, national agencies and industry organisations. We maintain regular dialogue with several of the stakeholders involved in those earlier efforts, ensuring that this risk assessment is well aligned with existing knowledge and priorities.

Our work in this project is also informed by our ongoing responsibility to review and support municipal physical planning. This role provides us with valuable insight into how local land use decisions affect future risk exposure, including the siting of new housing and infrastructure in flood-prone areas or the consequences of failing to preserve natural water retention capacities.

2.2.1 Screen risks (selection of main hazards)

While identifying and mapping climate hazards such as coastal and river flooding, heavy rainfall and drought are key parts of this assessment, we place equal importance on exploring the vulnerability of society. We recognise that exposure alone does not determine risk. Instead, the level of risk is shaped by how the landscape has been altered over time, how sensitive current systems are and how resilient they are to future change.

Large parts of Skåne's landscape have been significantly modified through past land drainage, canalisation and agricultural expansion. These interventions, together with increasing urban development and soil sealing, have reduced the landscape's ability to retain and buffer water. This has led to a higher likelihood of severe and costly consequences from future extreme weather events. Recent examples from Malmö, Kristianstad and other parts of the region highlight how previous land-use decisions and insufficient adaptation measures continue to influence current and future risks.

Through this risk exploration, we aim not only to understand where and how climate hazards may occur, but also to assess the underlying societal and environmental vulnerabilities. Our ambition is to develop a more holistic risk picture that supports informed and forward-looking decision-making in Skåne.

2.2.2 Workflow selection

2.2.2.1 Workflow #1 River Flooding

Kristianstad along the Helge River and Malmö along the Sege River are both exposed to river flooding, affecting urban areas as well as critical infrastructure. While Helge å represents a large catchment with well-documented flood risks, Sege å is smaller and less studied, with risks affected by interactions between river, rainfall, and coastal flooding. Flood risk is therefore an important concern for local communities and authorities across both catchments.

2.2.2.2 Workflow #2 Coastal Flooding

We will explore workflows for geographically restricted high-risk areas Landskrona, Trelleborg and Kristianstad.

2.2.2.3 Workflow #3 Heavy Rainfall

In this workflow we will do risk assessment sessions for geographical area (SE224), specifically the city of Malmö, using identified impact-based rainfall thresholds.

2.2.2.4 Workflow #4 Relative drought

We will assess and visualize drought hazards and risks for our geographical area (SE224). We will compare the results to our national data and compare in relation to neighbouring regions.

2.2.2.5 Workflow #5 Agricultural drought

We will assess hazard and risk of agricultural drought in our geographical area (SE224). We will study the potential loss of yield and revenue on 5 specific crop types that are commonly grown in Skåne, Sweden: Barley, Potato, Rape seed, sugar beets and wheat.

2.2.3 Choose Scenario

2.2.3.1 River flooding

RCP 4.5, RCP 8.5, all return period available: 1 in 10 years, 1 in 50 years, 1 in 100 years, 1 in 200 years, 1 in 500 years (considering 2030, 2050, 2080) was looked at during this phase. The RCP 8,5 with 100 and 500 for 2080, but since buildings and infrastructures have long lifetimes it would have been preferable if projections of extended to at least 2100. Also it would have been preferable to use newer SSP scenarios.

2.2.3.2 Coastal flooding:

2018 and 2050 with sea level rise corresponding to the high-emission scenario RCP8.5, return periods 50, 100 and 250 years. We would also like to be able to investigate a scenario with approximately a 100-year return period in the year 2150, SSP 8.5 (83rd percentile).

2.2.3.3 Heavy rainfall:

Period 2071-2100: 30 mm/3h, 10-year RP, RCP 8.5/4.5; 100 mm/24h, 10-year RP, RCP 8.5/4.5 and 100 mm/3h, 100-year RP, RCP 8.5/4.5.

2.2.3.4 Relative drought:

2050 and 2100 corresponding to RCP 4,5 and 8,5 would be useful in order to compare to Swedish national data. The scenarios available in the workflows that was useful for us was therefore only RCP 8,5 - 2050.

2.2.3.5 Agricultural drought:

2050 and 2090 corresponding to RCP 4,5 and 8,5. These could be made available in the workflows.

2.3 Risk Analysis

In this phase we apply selected workflows from the CLIMAAX Handbook to explore climate-related risks in the region. Based on the scoping and screening process, four primary workflows have been prioritized for this first iteration:

- River flooding (focused on Sege river and Helge river)
- Coastal flooding (focused on Landskrona, Trelleborg and Kristianstad)
- Heavy rainfall (focused on Malmö)
- Drought and agricultural sensitivity (focused on Skåne as a whole, with particular attention to Kristianstadslätten)

The selection of these workflows reflects both previous experiences of climate-related damage in Skåne and the availability of relevant datasets and stakeholder knowledge. Additionally, each workflow reflects sector-specific needs and exposure e.g. urban infrastructure, cultural heritage, agricultural systems and ecosystem health.

The assessment uses the default datasets provided in the CLIMAAX platform for the initial runs. In parallel, the County Administrative Board is evaluating how to incorporate higher-resolution national and regional datasets (e.g. from The Swedish Meteorological and Hydrological Institute, Swedish Geotechnical Institute and local GIS-databases) in later phases. In this initial phase, the emphasis is on learning the tool, testing the workflows and building internal capacity. Where appropriate, historical events are used to validate model assumptions and scenario projections (e.g. Malmö 2014 cloudburst and Copenhagen 2011 storm).

2.3.1 Workflow #1 River flooding (focused on Sege å and Helge å)

Kristianstad with the Helge River and Malmö with the Sege River both face risks of river flooding, affecting not only urban areas but also agricultural land. In addition, there is a potential for eutrophication impacts when nutrient-rich farmland is inundated.

The Helge River has a large catchment area of approximately 4,700 km² and an average discharge of 45.6 m³/s. It has been modelled by the Swedish Civil Contingencies Agency (MSB) with respect to the 100-year flood, the 200-year flood under RCP 8.5, and an estimated maximum flood, corresponding roughly to a 10,000-year event.

Figure 2 Sege å and Helge å catchment areas

In contrast, the Sege River is much smaller, with a catchment area of 340 km² and an average discharge of only 2.5 m³/s. It is also far less studied. The risk profile here is more complex, as it is influenced not only by river flooding but also by coastal flooding and intense rainfall events. On the vulnerability side, the picture is equally complex: Malmö is a city with ambitions to expand, while the surrounding agricultural land has been extensively modified and are considered of national importance for food security. The river has been straightened and dredged, leading to the loss of wetlands and natural floodplains that would otherwise help attenuate peak flows.

Within this CRA, we are particularly interested in exploring whether the CLIMAAX framework can be applied to such a small catchment, and whether it can be used to address the multiple, interacting challenges present in the Sege River basin. In Phase 1, a first test is carried out, which will provide the basis for more in-depth work in Phase 2 of the CLIMAAX project.

Table 2-1 Data overview workflow #1 River flooding

Hazard data	***Vulnerability data***	***Exposure data***	***Risk output***
Aqueduct Floods coarse-resolution flood maps - dataset of future river flood potential under climate change *JRC high-resolution flood hazard maps for Europe in a historical climate* *Översvämningskartering Utmed Helge å, MSB 2013 Rapport nr:7*	*JRC vulnerabilitydamage curves* *Statistiska centralbyrån SCB data on GDP per capita 2024*	*LUISA Base Map*	*Flood damage maps expressed in economic value for extreme events with different return periods.*

2.3.1.1 Hazard assessment

The workflow successfully produced hazard maps for river flooding in the selected areas, although the resolution is relatively low, see figure 7 in Visual outputs. This limitation is expected for datasets covering the whole of Europe but introduces uncertainties in the risk assessment, especially when combined with other trade-offs in the underlying data, such as the quality and resolution of elevation models. Only the lower part of the Sege River catchment has a sufficiently large upstream area to be analyzed with JRC data.

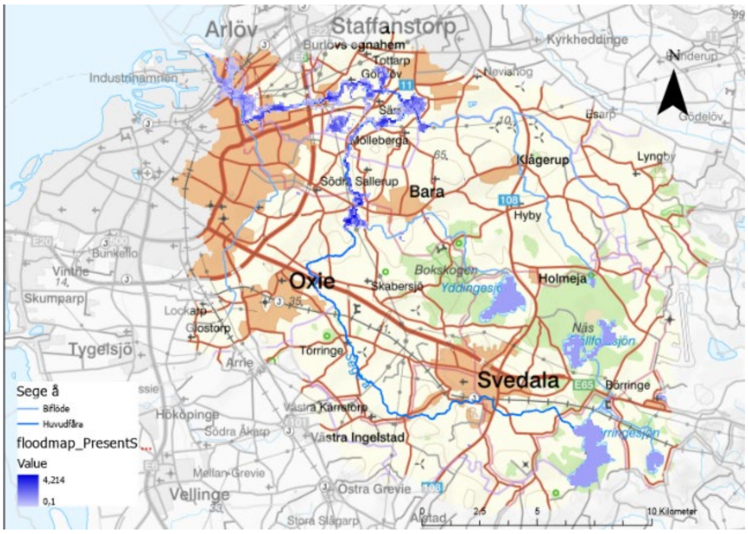

Figure 3 River flooding in lower part of Sege å catchment area with 100-year return period from JRC on regional maps

The initial ambition was to examine combined effects of river flooding and sea-level rise (where elevated sea levels hold back river water). However, this could not be carried out with JRC data, as such an assessment would require new hydrological modelling. For the Helge River, hazard maps were overlaid with previously developed flood maps from the Swedish Civil Contingencies Agency (MSB), see figure 5. The tif-files were relatively easy to import into the local GIS environment. In the main channel, JRC data indicated less extensive flooding compared with MSB, but in smaller tributaries it tended to overestimate inundation, see figure 12 in Visual outputs. Even in comparison with MSB's extreme scenario corresponding to a 10,000-year return period, JRC showed substantially larger flooded areas in the smaller rivers.

2.3.1.2 Risk assessment

The workflow also produced risk maps for river flooding in the selected areas, updated with 2024 GDP per capita data for Sweden, see figure 5 in Visual outputs.

However, uncertainties arising from the coarse resolution of the hazard maps, the underlying elevation data, and the representation of exposure and vulnerability make the results unsuitable for direct application in the Sege River catchment. The basin is too small in scale for such data, and in the Helge River more reliable risk assessments are already available. These are based on superior elevation data with 2-metre resolution, detailed measurements of flood protection walls in Kristianstad, and hydrological models calibrated against long time series of observed river flows.

Nevertheless, the workflow provides interesting insights into potential trends and highlights opportunities for further exploration, particularly regarding vulnerability, where less work has been conducted so far. In Phase 2, the large amount of existing material can be combined with higher-resolution regional hazard data to produce more robust analyses.

2.3.2 Workflow #2 Coastal flooding

Landskrona, Trelleborg and Kristianstad have been identified by the Swedish Civil Contingencies Agency (MSB) as three of seven specific high-risk areas for flooding in the region. This designation is made in accordance with Directive 2007/60/EC of the European Parliament and of the Council on the assessment and management of flood risks and is based on analyses of population and employment figures, together with potential impacts on human health, the environment, cultural heritage and economic activity within the areas.

Figure 4 Overview of Skåne with high-risk areas Landskrona, Trelleborg and Kristianstad highlighted

Table 2-2 Data overview workflow #2 Coastal flooding

Hazard data	***Vulnerability data***	***Exposure data***	***Risk output***
Deltares Global Flood Maps *Global sea level change indicators from 1950 to 2050 derived from reanalysis and high resolution CMIP6 climate projections* *IPCC 6th Assessment Report Sea Level Projections*	*JRC damage curves for land use*	*LUISA Base Map 2018*	*Flood damage maps expressed in economic value*

2.3.2.1 Hazard assessment

The workflow successfully produced hazard maps for flooding in the selected areas. The maps are available in the supporting documentation, figure 13 – 15, 19 – 21 and 25 – 27 in Visual outputs.

The results approximately match our own calculations for similar scenarios, but we would like to investigate longer time horizons. The results differ somewhat since we use SSP climate scenarios instead of RCP; SSP is based on more recent data and is therefore more up to date.

It would facilitate future analyses if it were possible to obtain the expected sea level rise under different climate scenarios as a single figure.

The actual situation is also likely to be more severe than indicated by the maps, as the tool does not account for the combined effects of elevated sea levels or storm surge and high streamflow occurring simultaneously.

2.3.2.2 Risk assessment

The workflow also produced flood damage maps for coastal floods in the selected areas, updated with 2024 GDP per capita data for Sweden, see figure 16 – 18, 22 – 24 and 28 – 30 in Visual outputs.

The risk analysis shows economic impact in the selected scenarios. All identified sectors were affected: buildings and infrastructure, agriculture and water resources, cultural heritage, ecosystems and nature values. This is consistent with previous calculations, which indicate that extensive effects can occur on buildings, businesses, infrastructure, the environment and cultural heritage in similar scenarios.

The resolution of the maps is currently too low to draw more detailed conclusions. For all three areas more reliable risk assessments are already available in the flood risk management plans developed under the EU Floods Directive (2007/60/EC). In Phase 2, we hope to combine information from the existing studies with new data to enable more detailed and in-depth analyses.

2.3.3 Workflow #3 Heavy Rainfall

2.3.3.1 Developing Impact-based Rainfall Thresholds

The first part of the assignment is to identify our critical rainfall thresholds – location Malmö.

We are arguing for a threshold for medium impact to return period T=30 year. The threshold is defined as storage-based and drainage systems are almost, or at, their maximum capacity. Possibly causing urban floods. The current industry standard in Sweden, in a densely populated urban area, has the functional requirement for new established drainage systems according to Table 2 in appendix Heavy Rainfall.

- ➢ We set the threshold for medium impact T=30, with approximate 40mm/180min. See Table 1 and 2 in appendix *Heavy Rainfall*

When it comes to threshold for high impact, we use observed data from two extreme events in the Malmö area: the Malmö rain 2014 and the Copenhagen rain in 2011.

The critical impact-based rainfall thresholds and advisory table, Table 3 in appendix *Heavy Rainfall*, is based on the Swedish Government Official Report, SOU 2017:42, chapter 5.2.5 *Exempel på kraftiga skyfall (Malmö och Köpenhamn)*.

- ➢ We set the threshold for high impact T=100, with approximate 100mm/180min.

2.3.3.2 Hazard assessment

The hazard assessment aims to generate rainfall datasets representing current and future climate scenarios. We found the workflow to be heavy and not generating information needed for the risk assessment.

We gave it a try using the criteria Malmö (Stortorget), SSP 8.5, historical data (1976-2005), future scenario (2071-2100) and a duration of 24h.

- ➢ This would give us magnitude-duration-frequence ratio as in Table 4 in appendix *Heavy Rainfall* which is not comparable to our thresholds.

2.3.3.3 Risk assessment

To effectively assess the risk associated with extreme precipitation events and understand how the current local critical impact-based rainfall thresholds will vary under climate change scenarios, we'll need to consider the key factors Rainfall intensity (Magnitude) and "How often we can expect it"/Return period (Frequency).

In phase 1 we choose to go with Ready-to-Go datasets (Path A) – where we use the pre-calculated European datasets provided by this workflow. We chose to follow attributes as in Table 5 in appendix *Heavy Rainfall*.

For the try-out risk assessment sessions of phase 1 we made three sessions, location Stortorget (Malmö), using parameters as in Table 6 in appendix *Heavy Rainfall*.

The first real obstacle to the analysis was the lack of data sets for our analysis area when we needed to present critical thresholds in a TIFF format. A dummy method was applied to the risk assessment on recommendation from the CLIMAAX support. This was done due to the lack of maximum precipitation maps for different return periods and durations for the area of interest making it hard to create the threshold map. The dummy method created a TIFF map for the NUTS2 region SE22 with a fixed return period applied to the full map. This map was then used as the current return period map and the fixed return period was changed based on the chosen threshold. The method code summery is documented in appendix *Heavy Rainfall*.

- Using a dummy means that the shift will be in relation to a "flat" map. See shift of frequency map in Results.

Table 2-3 Results for period 2071-2100 at Sydsverige (Stortorget, Malmö) [55.606107, 13.00052], located in lower left side on the maps

30 mm/3h, 10-year return period, RCP 8.5	**If we want to maintain the same frequency (return period), the magnitude will vary by +19.00 % from the current threshold (1976-2005).**
	If we want to maintain the same magnitude, the **frequency (return period) will change from 10 to 6.0 years**
100 mm/24h, 10-year return period, RCP 8.5	If we want to maintain the same frequency (return period), the **magnitude will vary by +5.00 %** from the current threshold (1976-2005).
	If we want to maintain the same magnitude, the **frequency (return period) will change from 10 to 9.0 years**
100 mm/3h, 100-year return period, RCP 8.5	If we want to maintain the same frequency (return period), the **magnitude will vary by +25.00 %** from the current threshold (1976-2005).
	If we want to maintain the same magnitude, the **frequency (return period) will change from 100 to 43.0 years**

For phase 1 we will only make an overall analysis. For a better evaluation of the CLIMAAX method we need to extract local rainfall magnitude and frequency data. As a somewhat straightforward comparison we can see that the *SMHI Graph 1* in appendix *Heavy Rainfall* shows a 2%-4% increase in days with heavy rainfall, Skåne, year 2100, RCP 8.5. And the SMHI Map 1 in appendix *Heavy Rainfall* shows deviation value of precipitation (mm/month) 2071-2100 compared to today.

- The areas of increased precipitation patterns are comparable, but the magnitudes differ.

For a better analysis and enhanced results, it is absolutely essential to model with local data, which also has a higher resolution. We need to obtain this data from SMHI or other sources (there is generally higher temporal resolution in municipal rainfall measurements). Secondly, we need to adjust our threshold (magnitude/duration/frequency) to match the model chain. Hereby we can also present critical thresholds for our selected area and not using a flat dummy. Finally, we need to compare the model chains more thoroughly.

2.3.4 Workflow #4 Relative Drought

The workflows were executed without any issues for our regional area. The of detail of the workflows (limited to NUTS3) is however a limitation, as comparison also within the regional boundaries would be useful (for instance municipality level). Another limitation is the hazard data and methods used in the workflow, only showing calculations based on precipitation deficits. We argue that factors such as soil moisture, evaporation and evapotranspiration are also relevant to include in this workflow showing relative drought, as they have a significant impact on the exposure of vegetation[1].

Table 2-4 Data overview workflow #4 Relative Drought

Hazard data	***Vulnerability data***	***Exposure data***	***Risk output***
drought_hazard_*.csv from pre-processed data folder (droughtrisk_sample_nuts3)	*drought_vulnerability_*.csv from pre-processed data folder*	*drought_exposure_*.csv from pre-processed data folder*	*Map with drought risk for NUTS3 regions* *Map with current and projected relative drought risk in NUTS3 regions for different scenarios* *Line chart for historic and future relative drought risk in the focal area*

2.3.4.1 Hazard assessment

In the hazard and risk visualization workflow we were able to produce results based on the predetermined scenarios. The resulting data could be used for the risk assessments for relative drought.

2.3.4.2 Risk assessment

The Risk assessment for relative drought- and relative drought hazard and risk visualization workflows was completed without any issues. The scenario used in the workflow that was of most use for us was RCP 8,5 for 2050 as this result could be compared with available national data (SMHI). It would be good if a long-term option (2100) was also available for further comparison with the data we have available.

The workflows shows that the relative drought risk in the focal area is expected to decrease in the coming years based on selected scenarios. This is most likely due to the fact that precipitation in our county is expected to increase. However, this should probably be investigated further, as other factors (as noted earlier) influence how much impact precipitation has on the soil's absorption capacity and where the water accumulates. In the workflows created for agricultural drought, we see in the results that despite a reduced risk of drought based on future scenarios, we can expect an increased yield loss for several of our commonly grown crops in the county during drought conditions.

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[1] *Ohlsson, A., Asp, M., Berggreen-Clausen, S., Et al.: Framtidsklimat i Skånes län: enligt RCP-scenarier, Framtidsklimat i Skånes län - enligt RCP-scenarier — SMHI, 2015*

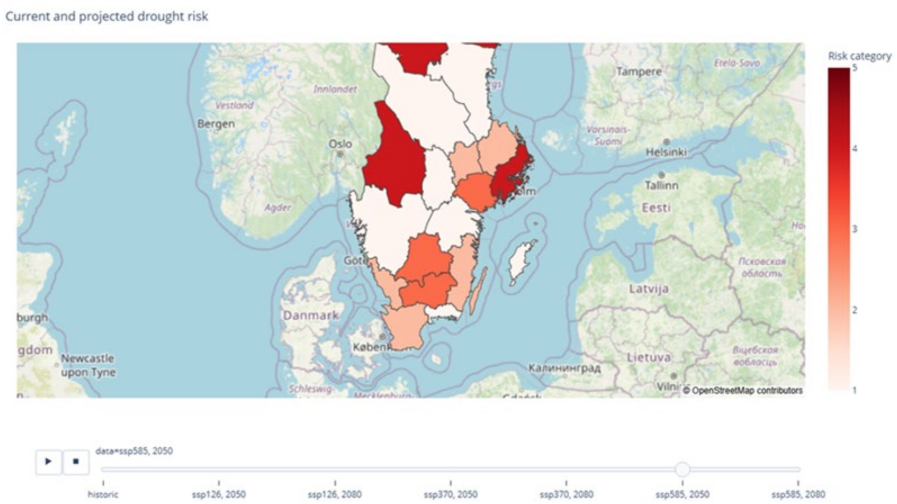

Figure 5 Current and projected drought risk for NUTS3 regions in the southern part of Sweden. RCP 8,5, 2050

Onwards it would be interesting to compare available national data with the data available in the CLIMAAX workflows more specifically, to see if the results differ. It would also be valuable to adjust the CLIMAAX dataset to identify which factors and indicators that contributes both to the hazard and to the given risk category. This would allow us to more in depth analyze and evaluate the factors that makes the counties of Kronoberg (SE212) and Jönköping (SE211) being placed in a higher risk category than Skåne.

2.3.5 Workflow #5 Agricultural Drought

After some initial issues we were able to successfully perform all the workflows for Agricultural drought for our region. We performed the workflows with data from the climate model “mpi_m_mpi_esm_lr” with the RCP 4,5 and RCP 8,5 scenarios, for the 5 years period of 2046-2050 and 2086-2090. For the workflow studying yield loss of crops we focused on five crop types that are commonly grown in Sweden: Rape seed, Wheat, Sugar beets, Barley and Potato.

Table 2-5 Data overview workflow #5 Agricultural Drought

Hazard data	Vulnerability data	Exposure data	Risk output
CORDEX regional climate model data on single levels *NUTS 2 Coordinates for “Sydsverige”* *Available water capacity tif file from Hengl and Gupta (2019)* *Elevation data from the USGS GDTEM 2010 digital elevation model* *Thermal climate zones from the FAO repository* *crop_table.csv*	*Cropland full-irrigation availability from from FAO Global Agro-Ecological Zones (GAEZ) data portal*	*Crop production [ton] data from the MapSPAM repository on Harvard Dataverse* *Crops aggregated value from FAO Global Agro-Ecological Zones (GAEZ) data portal*	*A revenue loss from precipitation deficit plot per crop*

2.3.5.1 Hazard assessment

The data generated by this workflow, unlike workflow #4, incorporated the effects of evapotranspiration, which is a positive for evaluating impacts on vegetation and crops and relevant for our regional scenarios. The results regarding yield loss of chosen crop types indicate a relatively large impact and a reduction in yield for water-demanding crops such as wheat, rape seed and barley. However, it also showcases a quite large yield loss for potato, which is not as water demanding. At the same time Potato is often grown on sand/light soils that are more sensitive and less suited for storing water over long periods, which could be an explanation for the results. Going forward, the factors affecting the yield loss of these crops will have to be studied further.

2.3.5.2 Risk assessment

We successfully got results regarding revenue loss from precipitation deficit (without irrigation) for all our selected crops and scenarios. We made an addition to the code to adjust the dollar values for inflation (to 2025 values) before converting to EURO. Compared to the results showing yield loss for specific crops, the revenue loss was relatively less alarming for our region.

Before running the workflows, we expected to see that the area around Kristianstad in the eastern part of the region would be most affected by drought, as the area has drier climate and sensitive ground water resources. According to the results of some of the crops was shown to be affected as we initially expected, but we also saw that the southern part of the county is expected to be more severely affected by revenue loss. This do however align with scenario forecasts indicating lower precipitation and increased evaporation due to rising temperatures in those areas in the future. The area also has a higher degree of sandy/light soil, which affects its ability to store water. We aim to investigate why this pattern appears more closely in the next phase of the project.

Since our plots also cover eastern Denmark, we can see that the results for revenue loss are more consistent with the yield loss patterns there. Another factor in this workflow worth examining further is the type of crops and their characteristics. For example, wheat varieties that are more resistant to drought and cold are continuously being developed and are also used by farmers to reduce the impact of climate change on yield and revenue yield. Certain crops are also more commonly grown in certain areas within our region, affecting yield and revenue loss more in these areas.

2.4 Preliminary Key Risk Assessment Findings

2.4.1 Severity

2.4.1.1 Workflow #1 River flooding (focused on Sege å and Helge å)

A major flood in the Helge River that overtops the flood protection walls in Kristianstad would result in human casualties and massive financial losses. Such an event would likely require a flood of greater magnitude than the current 100-year return period in current climate[2]. Even if the flood protection walls hold will a flood cause lots of economic damage. And combination of elevated sea level, storm surge together with high river discharge — each with shorter return periods on their own — could pose a serious threat if they occur simultaneously.

[2] *Översvämningskartering utmed Helge å, MSB 2013 Rapport nr:7*

Sege river has similar severity but on a smaller scale and without flood protection walls at risk. There is also more uncertainty since it is less studied and less is known on vulnerability.

Relatively frequent like a flood with a one-year return period in current climate has negative impact on environment in the catchment areas and in the sea with eutrophication with nutrients depleted from farmland.

2.4.1.2 Workflow #2 Coastal flooding

Coastal flooding during storms has been a problem in Skåne for several years and leads to significant negative consequences. For Kristianstad severity is same as river flooding. In Landskrona and Trelleborg, all identified sectors (buildings and infrastructure, agriculture and water resources, cultural heritage, ecosystems and nature values) are affected, and extreme events are expected to significantly undermine societal functionality, essential services, and critical dependencies, while also resulting in substantial economic costs.

2.4.1.3 Workflow #3 Heavy Rainfall

The identified impact rainfall thresholds, medium and high, are interesting to follow in scenarios for their own sake as they mark a standardized manageable level and a critical very costly level respectively. We can see from preliminary data in the risk assessment that both thresholds will be crossed more frequently in the future. This naturally raises questions about the standardized level and that more calculations and, by extension, measures need to be implemented in the future.

2.4.1.4 Workflow #4 and #5 Droughts

Droughts are an increasing problem for our county, especially in terms of its impact on the agricultural and primary sector. With a warmer climate, the growing season is extended, while shorter winters and more irregular precipitation negatively affect our groundwater levels. The scenarios we have examined indicate that precipitation in our region may increase in the future. However, we do not believe this eliminates the risk, as increased precipitation does not always compensate for other factors, such as the increased soil evaporation caused by higher average temperatures estimated by future scenarios and increased winter runoff (as a result from prolonged periods of soil saturation) which prevents effective groundwater recharge.[3] If we do not monitor the area and act based on the knowledge generated, there is (as we saw in our workflows) a risk of crop yield loss and revenue loss in the agricultural sector. From a preparedness perspective, this also poses a risk, as our national ability to produce essential food and nutrition is weakened.

2.4.2 Urgency

2.4.2.1 Workflow #1 River flooding

The situation is problematic now with lives and large financial values at stake. One type of solution is required to protect essential services and critical dependencies in an acute event today, while another type is needed to safeguard future developments through regulated spatial planning.

[3] *Persson, G., Eklund, D., Åström, S., Et al.: Klimatanalys för Skåne län,* SMHI 2011-52 Klimatanalys för Skåne län, 2011

2.4.2.2 Workflow #2 Coastal flooding

The situation is problematic now, but it will become much worse in the future. One type of solution is required to protect essential services and critical dependencies in an acute event today, while another type is needed to safeguard future developments through regulated spatial planning.

2.4.2.3 Workflow #3 Heavy Rainfall

Breaking critical rainfall thresholds will be more common in the future.

2.4.2.4 Workflow #4 and #5 Droughts

Drought is expected to pose a major problem for our region in the future, even though precipitation levels are expected to increase compared to current/historical levels. Rising temperatures and seasonal variations will result in increased evaporation and runoff, which hinders and prevents the ability of soils to absorb and retain water. Therefore, the risks and consequences must be monitored, and appropriate measures must be taken to secure food production and local economic ecosystems. Water management is one important method to secure steady ground water levels and to avoid eutrophication of our seas and lakes. Another approach to avoid yield loss of crops in the future is too closer examine which type of crops that fits a new changed climate in the region and how they can withstand various types of hazards.

2.4.3 Capacity

The county administrative board of Skåne have mandate to coordinate climate adaptation efforts in the region. The county has developed an action plan for climate adaptation and climate risk assessments. The county is also responsible for flood risk management plans and have developed and adopted plans for seven designated areas based on the Directive 2007/60/EC in 2021. The flood risk management plans contain measures including prevention, protection and preparedness. Our homepage Klimatanpassning | Länsstyrelsen Skåne contain information about future climate risks, results from climate analysis and give advice about suitable measures. The climate adaptation plan and advises can be used by municipalities and landowners as guidance for implementing concrete measures. Since 2024 we have financial challenges. The Swedish government have discontinued the counties budget for climate adaptation.

Several Swedish authorities have produced a knowledge base to support regions and municipalities. The knowledge base covers a variety of topics including data and warning systems. Our county board support stakeholders by activities through the regional coastal cooperation (Regional kustsamverkan Startsida - Regional kustsamverkan Skåne Halland). The cooperation involves neighbouring county, municipalities and national authorities. This is done through meetings, website, guidelines, reports and movies. Municipalities have great opportunities to plan and implement climate adaptation measures if political will and resources are present. However, the Municipalities lack mandate to implement measures which gain individual landowners. Spatial planning at municipality and regional level can support, individuals responsible for measures, to act.

Most of the municipalities in the region takes climate changes into account in their comprehensive plans. Some municipalities have developed climate adaptation plans to be able to adapt to heatwaves and sea level rise. The Municipalities of Vellinge and Kristianstad are already implementing climate adaptation measures to prevent flooding by constructing dikes. The municipalities Ystad, Lomma and Helsingborg has completed beach nourishment, dune restoration and other nature-based solutions in different scale.

2.5 Preliminary Monitoring and Evaluation

We learned to apply the CLIMAAX framework to create a comprehensive overview of regional risks. We explored the key climate hazards for Skåne through four selected workflows: river and coastal flooding, heavy rainfall and drought. We enhanced our knowledge base in preparation for updating regional risk and climate adaptation plans.

Difficulties we encountered was that the code failed to function in certain workflows, the level of detail was insufficient and it was not possible to analyze longer time horizons.

The stakeholders are all positive about continuing work within the project and they look forward to the results. Those who have received information so far is the municipalities, Region Skåne (the regional authority in Skåne in charge of regional planning and regional development), the Swedish Civil Contingencies Agency and the Swedish Transport Administration.

2.6 Work plan

Phase 2: We will compile national and local analytical methods and data to supplement the findings in phase 1 where we will include the broad competences and perspectives found in our organization. Our activities will include incorporating new tools and methods for implementing nature-based solutions to protect regional infrastructure, nature values (Natura 2000) and cultural heritage. There are many previous studies and data available which we can add to the data gathered in phase 1. There are also new proposed methodologies in development for climate risk analyses and risk and vulnerability assessments regarding flooding risks initiated in Sweden, which we see potential in evaluating and comparing in relation to the methodologies of the project.

Phase 3: With the knowledge at hand from the work carried out in phase 1 and 2 we are planning to engage identified important regional stakeholders (municipalities, landowners) in formulizing suited scenarios and complement our strategies for risk management. We are hopeful that we will be able to leverage our participation in the project to create synergies where the regional stakeholders will be able to understand and utilize the created knowledge material to identify plausible options and create implementation plans. Our intention is to especially focus on two aspects: (1) identifying locations in the region with high risk of cloudbursts and flooding from a catchment area perspective where implementation of nature-based solutions is plausible. And (2) planning together with municipalities and landowners for the restoration of streams, wetlands and lakes to reduce flood risk.

3 Conclusions Phase 1- Climate risk assessment

Phase 1 of the Foresee Skåne project aimed to explore the CLIMAAX tools and assess climate-related risks in the Skåne region. The main goal was to gain a preliminary understanding of regional climate hazards, evaluate the applicability of CLIMAAX methodologies in Sweden, and prepare a knowledge base for future risk and adaptation planning.

3.1 Main Conclusions

3.1.1 Climate hazards and risk exposure

The assessment identified river and coastal flooding, heavy rainfall, and drought as key hazards for Skåne. The workflows provided hazard and risk maps for selected areas, highlighting both current and potential future impacts. Notably:

- **River flooding**: Kristianstad (Helge River) and Malmö (Sege River) face significant risks. The Helge River has well-documented flood risks, while Sege River, being smaller and less studied, presents greater uncertainty in vulnerability. Hazard maps produced with CLIMAAX highlighted potential trends but had limited resolution, making them unsuitable for detailed planning in small catchments.
- **Coastal flooding**: Landskrona, Trelleborg, and Kristianstad are high-risk areas. All identified sectors (buildings, infrastructure, agriculture, cultural heritage, ecosystems) are vulnerable. Extreme events are expected to significantly disrupt societal functions and critical services while causing substantial economic costs.
- **Heavy rainfall**: The Malmö area is frequently exposed to heavy rainfall, both historically (see the Malmö rainfall 2014 example in appendix *Heavy Rainfall*), and as noted from the assessment even more in the future.
- **Droughts**: Drought is expected to be a critical risk factor for our region in the future. This is due to the fact that increased precipitation cannot compensate for the heightened levels of evaporation caused by rising temperatures and seasonal variations which contribute to increased winter runoff compared to current levels. Agricultural yield is expected to be affected, and adaptation measures are required to safeguard food production and local economies.

3.1.2 Tool performance and limitations

The CLIMAAX workflows were successfully applied for most hazards, but several limitations were noted:

- Some workflows failed in certain areas due to technical or data constraints.
- The resolution of hazard maps was low, limiting the detail and accuracy of risk assessments.
- Long-term projections (e.g., 2100 or SSP scenarios) were not fully available, restricting the assessment of future risks over extended horizons.
- Combined effects of hazards, such as elevated sea levels with river flooding, could not be fully analyzed with the current data.

- A dummy method needed to be applied to the risk assessment for workflow Heavy Rainfall.

Despite these challenges, the tools provided valuable insights and helped establish an initial knowledge base for future work.

3.1.3 Vulnerabilities and societal impacts

The assessment emphasized that exposure alone does not determine risk. Land-use changes, soil sealing, urban development, and historical modifications of the landscape amplify vulnerabilities. The workflows also highlighted the need to differentiate between:

- Immediate measures to protect essential services and critical dependencies today.
- Long-term planning solutions to safeguard future developments through spatial planning and adaptation strategies.

3.1.4 Stakeholder engagement and capacity

Internal coordination has strengthened technical expertise within the County Administrative Board of Skåne. Phase 1 involved limited external engagement, with municipalities, Region Skåne, the Swedish Civil Contingencies Agency, and the Swedish Transport Administration informed of progress. Stakeholders expressed strong support for continued work.

The assessment confirmed that municipalities have significant opportunities to implement climate adaptation measures, provided political will and resources are available. Regional coordination and guidance from the County Administrative Board remain essential to enable effective adaptation across sectors.

3.1.5 Key findings and lessons learned

- Hazard mapping at regional scale is feasible with CLIMAAX, but local-scale analyses require higher-resolution data.
- Combining multiple datasets and integrating national and regional information will be critical in Phase 2.
- Preliminary findings support the need for both short-term protection measures and long-term, spatially informed adaptation planning.
- Agricultural and water resource sectors are particularly sensitive to drought, while urban areas remain highly vulnerable to flooding.
- Existing governance structures can support adaptation, but clear definitions of acceptable risk and improved coordination are needed.

3.1.6 Next steps

Phase 2 will incorporate high-resolution national and regional datasets, expand stakeholder engagement, and include new methods for nature-based solutions. Phase 3 will focus on developing actionable strategies in collaboration with municipalities and landowners, prioritizing high-risk areas and interventions for flood and drought mitigation.

In conclusion, Phase 1 successfully established a foundation for understanding climate risks in Skåne, highlighted major vulnerabilities, and identified both technical and governance-related challenges that need to be addressed in subsequent phases.

4 Progress evaluation and contribution to future phases

Phase 1 of the Foresee Skåne project successfully established a foundational understanding of climate-related risks in the Skåne region. By applying the CLIMAAX methodology, the project team was able to identify key hazards, including river and coastal flooding, heavy rainfall, and drought, and to produce preliminary hazard and risk maps for selected areas. These outputs provide a self-contained knowledge base that integrates regional and national data, previous flood risk management plans, climate adaptation strategies, and stakeholder insights, thereby supporting informed decision-making and future planning.

The results of Phase 1 directly inform the planned activities for Phases 2 and 3. In Phase 2, the focus will shift toward refining risk assessments through the integration of high-resolution national and regional datasets. The preliminary findings highlighted the limitations of low-resolution hazard maps and constrained long-term projections, which will be addressed in Phase 2 by incorporating more detailed elevation data, hydrological models, and extended climate scenarios. Additionally, Phase 2 will expand the technical analysis by evaluating the effectiveness of nature-based solutions to mitigate flood and drought risks, as well as assessing interactions between multiple hazards, such as combined river flooding and elevated sea levels.

Phase 1 also clarified societal vulnerabilities and governance challenges, providing the basis for enhanced stakeholder engagement in subsequent phases. Phase 3 will leverage this understanding to collaborate closely with municipalities, landowners, and regional authorities in order to develop actionable adaptation strategies. The early identification of high-risk areas, critical infrastructure, and sensitive agricultural zones allows targeted interventions, ensuring that adaptation measures are both efficient and relevant to local conditions. Moreover, the knowledge generated in Phase 1 supports dialogue on acceptable risk levels and facilitates alignment with national legislation and regional planning frameworks.

In summary, the outputs of Phase 1 contribute to future project phases by establishing a preliminary but comprehensive risk picture, identifying data and methodological gaps, and strengthening internal capacity within the County Administrative Board of Skåne. These achievements lay the groundwork for more detailed analyses, broader stakeholder involvement, and the implementation of concrete, location-specific adaptation measures, ensuring continuity and coherence throughout the project lifecycle.

Table 4-1 Overview key performance indicators

Key performance indicators	***Progress***
[2] of workflows successfully applied on deliverable 1	Completed. Workflows for river flooding, coastal flooding, heavy rainfall and drougts successfully executed.
[2] of workflows successfully applied on deliverable 2	
[40] of stakeholders involved in the activities of the project (Phase 2 and Phase 3)	
[8] of communication actions taken to share results with your stakeholders (Phase 2 and Phase 3)	
[15] of new locations identified (in catchment areas) suitable for nature-based solutions (Phase 3)	

Table 4-2 Overview milestones

Milestones	***Progress***
M1: Learning and implementing the CLIMAAX methodology and tools (Phase 1)	Achieved
M2: Attend the CLIMAAX workshop held in Barcelona (Phase 1)	Achieved
M3: Finalizing the climate multi-risk assessment (Phase 1)	Achieved
M4: Evaluate/incorporate local data, tools and methodologies in the assessment together with Municipalities (Phase 2)	
M5: Finalizing the refined regional climate multi-risk assessment including strategies for nature-based solutions to avoid risks (Phase 2)	
M6: Locations in the region identified where implementation of nature-based solutions is plausible to reduce risk of cloudbursts and flooding from a catchment area perspective (Phase 3)	
M7: Planning together with municipalities and landowners completed for the restoration of streams, wetlands, and lakes to reduce flood risk. (Phase 3)	
M8: Attend the CLIMAAX workshop held in Brussels (Phase 3)	

5 Supporting documentation

- Visual Outputs (infographics, maps, charts)

All figures and tables from the workflows are found in the Visual outputs document, shared in the Zenodo repository.

6 References