Deliverable Phase 2 – Climate risk assessment

Forsee Skåne

SE224

Version 1.0 | June 2026

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

Funded by the European Union

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

2. Summary of evaluation criteria for this deliverable

3. Document Information

Deliverable Title	Phase 2 – Climate risk assessment
Brief Description	Refined regional climate multi-risk assessment
Project name	Forsee Skåne (Framework for climate multi-risk assessments to evaluate and adapt – Making the region of Skåne climate resilient)
Country	Sweden
Region/Municipality	Skåne
Leading Institution	The County administrative board of Skåne (CAB)
Author(s)	Pär Persson, Max van Meeningen, Johan Bogaert, Mattias Lind, Petra Berggren (all CAB)
Deliverable submission date	30/06/2026
Final version delivery date	26/06/2026
Nature of the Deliverable	R – Report
Dissemination Level	PU - Public

Version	Date	Change editors	Changes
1.0	...	The County administrative board of Skåne	Deliverable submitted
2.0	...	CLIMAAX's FSTP team	Review completed
5.0	...		Final version to be submitted

4. Table of contents

5. List of figures

6. List of tables

7. Abbreviations and acronyms

Abbreviation / acronym	Description
CAB	The County Administrative Board of Skåne
CRA	Climate Risk Assessment
FORSEE	**F**ramew**o**rk for climate-multi-**r**isk a**s**s**e**ssment to **e**valuate and adapt
FRMP	Flood risk management plans
GIS	Geographic Information System
LiDAR	Laser Imaging, Detection, and Ranging
LRF	The Federation of Swedish Farmers
MCF	The Swedish Civil Defence and Resilience Agency (formerly known as MSB)
MSB	Former name of the Swedish Civil Defence and Resilience Agency
n.d.	No date
NGO	Non-Governmental Organization
RCP	Representative Concentration Pathway
SGI	Swedish Geotechnical Institute
SGU	Geological Survey of Sweden
SMHI	Swedish Meteorological and Hydrological Institute

8. Executive summary

This deliverable presents the results of Phase 2 of the Forsee Skåne project, conducted within the CLIMAAX programme (Horizon Europe, grant no. 101093864). The report documents a refined multi-hazard climate risk assessment for Skåne County, building on the preliminary assessment from Phase 1. It is intended for regional and local decision-makers, national authorities and EU project stakeholders seeking an up-to-date understanding of climate risks in the region and the basis for future adaptation planning.

Main actions and results

Phase 2 focused on four climate hazards: coastal flooding, heavy rainfall, river flooding and agricultural drought. The assessment improved significantly on Phase 1 by replacing European-level proxy datasets with higher-resolution national and regional data from SMHI, SGI, SGU and the Scalgo Live platform. CLIMAAX risk workflows from phase 1 for river flooding and coastal flooding, were compared with complemented local data and expert knowledge. The CLIMAAX methodology was also systematically compared with existing Swedish national risk and vulnerability assessment frameworks.

Stakeholder engagement was conducted through 14 activities — 10 municipal workshops, three thematic workshops and one internal expert workshop — involving municipalities, Region Skåne, national authorities, water councils, NGOs, landowners, research institutes, consultants and insurance companies. The CLIMAAX Key Risk Assessment (CRA) protocol was applied across all sessions, enabling structured cross-sectoral dialogue. Several municipalities noted that the workshops facilitated internal discussions on climate risk that had not previously taken place.

The CRA produced the following risk priorities:

- **Drought (2050): Very High.** Severity is already substantial today and projected to become critical. Immediate action is needed, as current adaptive capacity is low and both agricultural productivity and drinking water supply are at risk.
- **Coastal flooding (2100): High.** Severity is substantial today, with a 500-year event in 2150 assessed as critical by most stakeholder groups. Action must begin now, as sea level rise is accelerating and lead times for coastal protection measures are long.
- **Heavy rainfall: High.** Immediate action is needed in urban areas, where the combination of increased precipitation intensity and sea level rise may overwhelm drainage systems.
- **River flooding (2100): Moderate.** Severity is moderate today and substantial 2100, as development in the catchment area is the primary driver of increasing risk over the next 10–20 years.

Some adaptive measures are already in place — coastal protection in Vellinge and Kristianstad, flood risk management plans for seven areas, and groundwater management initiatives — but significant gaps remain in financing, cross-municipal governance and long-term solutions for drought.

Conclusions

Drought and coastal flooding represent the most urgent regional challenges, requiring action well before impacts reach critical levels. The CLIMAAX framework proved effective for structuring both technical analysis and stakeholder engagement. A key finding is that combined climate events —

such as simultaneous sea level rise, heavy rainfall and river flooding — are not adequately captured by current models, and this underestimation of compound risk should be addressed in future assessments. Governance and financing remain the principal barriers to implementing adaptation measures at larger scale.

Phase 3

Phase 3 will move from risk assessment to action. Working with municipalities and landowners, the project will identify specific locations within selected catchments suitable for nature-based solutions — including water retention, stream restoration and wetland creation — and develop concrete implementation plans with a particular focus on governance and financing mechanisms.

1 Introduction

1.1 Background

Skåne is Sweden's southernmost county, with 1.42 million inhabitants. Around 45% of the land is used for agriculture, making Skåne the country's leading agricultural region, while forests cover 39%, urban areas 10% and wetlands and other land types the remaining 6%. The region also has a 570 km coastline with diverse coastal environments that are important for biodiversity, tourism, fisheries and transport.

Figure 1-1: Skåne County

The main climate-related risk in Skåne is flooding. Nationally, the Swedish Geotechnical Institute (SGI) and the Swedish Civil Defense and Resilience Agency (MCF) have identified ten areas as special risk areas for landslides, avalanches, erosion, and flooding that are climate-related. Our region's coast is placed, "risk areas in class 2" together with "Mälardalen – Stockholm", areas already today have noticeable climate-related challenges to deal with that affect many players, industries, infrastructure, buildings, and valuable natural and cultural environments. Additionally, the MCF 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.

Rising sea levels and heavy rainfall threaten human health, infrastructure, cultural heritage, ecosystems and economic activities. These risks are particularly significant in Skåne due to its extensive agricultural production, valuable natural environments and densely populated coastal areas.

Skåne also experiences severe coastal erosion, accounting for around 60% of Sweden's beach erosion, while 45% of shoreline areas within 300 meters are already developed, limiting possibilities for adaptation measures.

Other climate-related challenges include heatwaves, drought and reduced groundwater recharge, which affect both water availability and agriculture. At the same time, improved water management and land-use planning could create opportunities to reduce flood risks while increasing water storage for irrigation and climate adaptation. However, governance structures and limited resources remain major barriers.

In addition, biodiversity is increasingly threatened by invasive non-native species. Due to extensive trade and transport routes through the region, Skåne is a key entry point for invasive species into Sweden, a risk expected to grow as the climate becomes warmer.

1.2 Main objectives of the project

Phase 2 of the project focuses on refining and improving the multi-risk assessment carried out in Phase 1 through the integration of higher-resolution local and regional data, as well as more detailed analytical methods and models. The objective is to produce a more accurate and context-specific understanding of climate-related risks affecting the region and its communities, including impacts on critical infrastructure, Natura 2000 sites and cultural heritage. By compiling and evaluating national and local analytical methods, the project will strengthen the regional capacity for climate adaptation and risk management.

The work in Phase 2 has mainly been carried out by the core team, while also drawing on the broader competences and perspectives within the organization. In addition, the phase has included interaction with external actors and stakeholders, whose local knowledge and expertise have contributed valuable perspectives to the assessment process. This collaborative approach has strengthened the relevance and anchoring of the project within the region and supported knowledge exchange between sectors and governance levels.

To support the development of refined analyses, the project includes investments in new visual mapping software and competence development initiatives. These efforts enhance the analytical capacity of the organization and improve the communication and visualization of climate risks to stakeholders and decision-makers.

The use of the CLIMAAX handbook has provided a structured and scientifically grounded framework for conducting the refined multi-risk assessment. In particular, the Key Risk Assessment methodology within the handbook has proven to be a valuable approach for engaging external actors and stakeholders in the process. The methodology supports structured dialogue, prioritization of key climate risks, and the integration of local knowledge and perspectives into the assessment. By following the handbook’s methodologies and recommendations, the project ensures consistency, comparability, and alignment with European approaches to climate risk assessment.

At the same time, the inclusion of detailed local data and locally adapted models significantly improves the relevance and reliability of the results for the region. This combination of the CLIMAAX methodology with local knowledge and data enables more targeted and effective adaptation measures, including the evaluation of nature-based solutions for flood protection and regional resilience building.

Furthermore, Phase 2 assesses and compares emerging Swedish methodologies for climate risk analyses and flood-related risk and vulnerability assessments with the approaches promoted within the project. This contributes to knowledge exchange, methodological development, and long-term benefits for both the region and the wider community by supporting evidence-based planning and climate resilience.

1.3 Project team

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

Andreas Andersson Kurdve: Project developer, Unit for Regional Growth and Investment Support, Department of Community Development.

Johan Bogaert: Water Management Officer, Water Unit, Department of Nature and Water.

Max van Meeningen: Water Management Officer, Fisheries and Restoration Unit, Department of Nature and Water.

Mattias Lind: Climate officer, Unit for Spatial Planning, Department of Community Development.

Petra Berggren: Crisis and Contingency Officer, Unit for Civil Protection and Emergency Preparedness, Department of Emergency Preparedness.

1.4 Outline of the document's structure

This report follows the CLIMAAX framework structure. Following the introduction, Chapter 2 covers scoping, risk exploration, regionalized risk analysis and Key Risk Assessment findings, with particular emphasis on stakeholder workshops. Chapter 3 presents conclusions and Chapter 4 evaluates project progress.

2 Climate risk assessment – phase 2

2.1 Scoping

The scoping phase of the climate risk assessment built upon the findings and experiences from Phase 1 of the Foresee Skåne project. While the first phase focused on testing and evaluating the CLIMAAX methodology and workflows, Phase 2 aimed to refine and improve the assessment through the integration of higher-resolution national, regional and local data, together with existing knowledge from previous studies and ongoing climate adaptation initiatives in Skåne.

The assessment was designed to support climate adaptation planning and risk management in the region by improving the understanding of climate-related risks associated with river flooding, coastal flooding, heavy rainfall and drought. Particular attention was given to impacts on critical infrastructure, agriculture, water resources, ecosystems, Natura 2000 sites and cultural heritage.

A key element of the scoping process was the identification and involvement of relevant stakeholders, experts and priority groups. In addition to the multidisciplinary project team within the County Administrative Board of Skåne (CAB), Phase 2 included dialogue and workshops with external actors representing water councils, agricultural landowners, the Federation of Swedish Farmers (LRF), insurance companies, municipalities and Region Skåne. These stakeholders contributed valuable local knowledge and perspectives regarding climate risks, land use, water management, agriculture and regional development. External expertise was also provided by consultants and national government agencies, contributing technical knowledge, data and methodological support. Representants of priority groups like farmers and local elected officials will continue to play an active role. While the specific selection is yet to be finalized, particular priority will also be given by contacting vulnerable groups, like elderly individuals in care facilities and children in schools. These interactions improved the interpretation of results and helped ensure that the assessment addressed practical planning and implementation needs.

The CLIMAAX Handbook provided an important framework for structuring the work. In particular, the Key Risk Assessment methodology supported the identification and prioritization of the most relevant climate risks and facilitated discussions with stakeholders by providing a common framework for evaluating severity, urgency and adaptive capacity. This contributed to a more transparent and participatory assessment process and strengthened the relevance of the results for future decision-making.

2.1.1 Objectives

The main objective of the Phase 2 Climate Risk Assessment (CRA) was to refine and improve the preliminary multi-risk assessment developed in Phase 1 by integrating higher-resolution local and regional data, additional analytical methods and expert knowledge. The purpose was to produce a more detailed and robust understanding of climate risks in Skåne and to strengthen the knowledge base for climate adaptation planning and risk management at regional and local levels.

The expected outcome of the assessment is an improved understanding of the spatial distribution of climate risks, the underlying vulnerabilities and the effectiveness of potential adaptation measures. The work also aims to increase awareness among municipalities, landowners and other stakeholders regarding both current and future climate risks and to support more proactive adaptation planning.

The results are intended to inform and support several ongoing and future policy processes. These include the revision of the Regional Climate Adaptation Action Plan, flood risk management planning under the EU Floods Directive, municipal spatial planning processes and other regional strategies related to climate resilience, water management and sustainable land use. The project also contributes to discussions on governance structures, responsibilities and policy development for climate adaptation in Sweden.

An important objective of Phase 2 was to evaluate how the methodologies and tools provided by the CLIMAAX framework can be combined with existing Swedish risk assessment methods and datasets. The project therefore compiled and compared information from national authorities, previous regional studies and newly emerging methodologies for climate risk and vulnerability assessments.

The use of the CLIMAAX Handbook ensured a structured and scientifically robust assessment process. The Key Risk Assessment methodology proved particularly valuable for stakeholder engagement, helping external actors, contribute local knowledge and perspectives while supporting a systematic prioritization of risks. The inclusion of local data, high-resolution spatial datasets and locally adapted models significantly improved the reliability and relevance of the assessment compared to the preliminary analyses performed in Phase 1. This enabled a more detailed evaluation of climate impacts and adaptation opportunities, including nature-based solutions for flood mitigation, water retention and ecosystem resilience.

Several limitations and challenges were encountered during the assessment. One of the main challenges identified in Phase 1 was the limited spatial resolution of several European datasets available through the CLIMAAX workflows. These limitations reduced the applicability of some results at local scale, particularly in smaller catchments and urban environments. To address this challenge, Phase 2 focused on incorporating national and regional datasets from Swedish authorities and other local sources whenever possible. Additional challenges included differences between modelling approaches, data availability across sectors and the complexity of assessing interacting hazards such as river flooding, coastal flooding and extreme rainfall occurring simultaneously.

Despite these limitations, the combination of the CLIMAAX methodology, local datasets, stakeholder input and expert knowledge resulted in a substantially improved climate risk assessment. The work provides an important foundation for Phase 3, where adaptation options and implementation pathways will be further developed together with regional and local stakeholders.

2.1.2 Context

Climate Hazards are handled in different ways in Skåne. Flooding has been prioritized in our organization due to 7 areas (Helsingborg, Landskrona, Malmö, Falsterbo, Trelleborg, Ystad, Kristianstad) are pointed out according to the Floods Directive (2007/60/EC). For these areas risks are assessed and handled in the flood risk management plans (link to one of the plans Falsterboområdet Riskhanteringsplan: 4). Other climate risks are described in the regional climate adaptation plan (3). A climate risk assessment was developed for the Region in 2020 (2). Coastal erosion has also been of special interest due to the situation in Skåne with no uplift, high proportion of sandy beaches and exploited areas close to the shoreline of the coast. Our homepage includes a lot of investigations, map services, description of projects and planning material which can be used freely by different users. An example is the website for Climate adaptation from Länsstyrelsen Skåne (5).

CAB plays a central role in regional emergency preparedness by coordinating relevant stakeholders, monitoring developments and establishing a common operational picture. During crises and other societal disruptions, it supports municipalities and other relevant actors across the county while coordinating regional response efforts to reduce impacts and maintain critical societal functions. In the context of climate change, this coordination is especially relevant for managing extreme weather events and other climate-related hazards and forms an important component of regional climate adaptation efforts.

CAB has been coordinating the regional climate adaptation work since 2009. Climate risks are well known and spread among different stakeholders in the region through extensive activities during many years. However, it is difficult to mainstream climate adaptation strategies and measures. One problem is that no authority or municipality has responsibility for coordinating measures. Another problem is financing. The administrative system is complicated, and many stakeholders find the complex administrative system difficult to use because it requires large resources and much training efforts.

In FORSEE CLIMAAX we are prioritizing flood risks and agricultural drought and try to engage stakeholders who have the ability to mainstream climate adaptation actions directly or indirectly in these topics. The strong municipal self-governance gives opportunities to support, individuals responsible for measures, to act. Municipalities are also landowners and can plan and implement measures themselves and together with other landowners. The county administrative board has identified possible multifunctional solutions for flood risk and drought. Cooperation between municipalities and farmers could lead to measures that benefit both parties.

Sharing these experiences will be a key for future success in implementing measures in the Region. As coordinating the regional climate adaptation work, our responsibility includes to spread a knowledge base on climate risks and convey understanding of the administrative system to municipalities and the Region of Skåne. Communication together with the municipalities is a crucial part of mainstreaming climate adaptation. As a national authority at regional level, the County administrative board serve as a link between national government and sector agencies. We can contribute to explain the importance of regional risks and difficulties in the administrative system at national level. Lack of finance at different levels is an important barrier for implementing measures. Cooperation at all levels will be a success factor.

The legal system (Plan and building act, Construction act, the environmental code) generally gives strong support implementing climate adaptation measures. Using the complex administrative system however requires large resources and training efforts. The administrative system means strong municipal self-governance which give opportunities to anchored decisions at local level. Municipalities have great opportunities to plan and implement measures if political will and resources are present. Spatial planning at municipality and regional level can also support, individuals responsible for measures, to act.

To make it easier for municipalities and operators to implement climate adaptation measures, CAB have decided on a climate adaptation plan. The policy in the plan states:

- *Avoid new settlements in risk areas*

- *Avoid measures such as hard structures and embankments fixing the coastline*
- *Promote nature-based solutions gaining dynamic processes which give variation in habitat structure and higher biological diversity*
- *Work together with all stakeholders in the organization ”Regional coastal cooperation”*

Increased understanding of our policy can help stakeholders to be aware of risks and make it easier to implement measures.

We struggle with financing in the region. Without financial instruments it is difficult to initiate climate adaptation work. The Swedish government have discontinued our budget for climate adaptation and diminished our budget for nature conservation. We have no budget for climate adaptation measures in protected areas. There are no possibilities for the Swedish state to gain control over private land for future needs for protected areas. Municipalities are responsible for all spatial planning but lack mandate to implement measures which gain individual landowners.

The most important affected sectors in our region are listed below:

- Municipalities are our key target audience because their responsibility covers many areas, for example spatial planning, schools, elder care, water and sewage, rescue service, technical infrastructure, local environmental supervision and social services. Municipalities will be affected by all climate risks
- Agricultural sector since we are the county with Sweden's largest agricultural production. The sector is affected both from flooding and drought, as the analyses in phase 1 showed.
- The Swedish transport sector is of particular importance because roads, railways, and harbors are affected by flooding and erosion.
- Nature conservation sector will be affected both by climate effects and by measures. For example, analyses show that 97% of the salt beach meadows can disappear from the Natura 2000 area Tygelsjö-Gessie at 1 meter sea level rise.
- The cultural environmental sector is of importance. Regional analyses show buildings of cultural heritage which can be flooded from rivers and sea. A warmer and more humid climate leads to higher moisture levels, which increases the risk of rot. The breakdown of materials happens faster. This affects buildings, museums, storage facilities, and archives.
- The Finance sector must be taken into consideration because insurance companies and the banking sector can be more restrictive to approve insurance and loans.

CAB sees great potential in nature-based solutions. Nature-based measures are often flexible. With good planning, nature-based measures are robust and adaptable. Something that is often highlighted is the creation of wetlands, which can provide resilience in the landscape against climate change, purify water, and support biodiversity. In this project, we will especially work on finding solutions to store water in the landscape. Storing water in the landscape reduces downstream flooding and at the same time, the water can be used by farmers for irrigation. There are also good opportunities to get government support for such measures. Finding ways to collaborate between municipalities and farmers is a key to success.

2.1.3 Participation and risk ownership

The Phase 2 assessment extended the stakeholder engagement established in Phase 1, with a total of 14 activities: 10 municipal workshops, three thematic workshops and one internal expert workshop. Existing regional networks were used to ensure efficient reach — the Regional Coastal Cooperation for Skåne and Halland counties, the EU Floods Directive network (convening the ten designated municipalities, the Swedish Transport Administration and Region Skåne), and three dedicated workshops with water councils (vattenråd) responsible for key drainage basins.

Participants represented municipalities, Region Skåne, national authorities, water councils, NGOs, landowners, research institutes, consultants and insurance companies. All workshops were structured around the CLIMAAX Key Risk Assessment methodology, giving participants a shared framework for evaluating risk severity, urgency and adaptive capacity and allowing local knowledge to feed directly into the assessment.

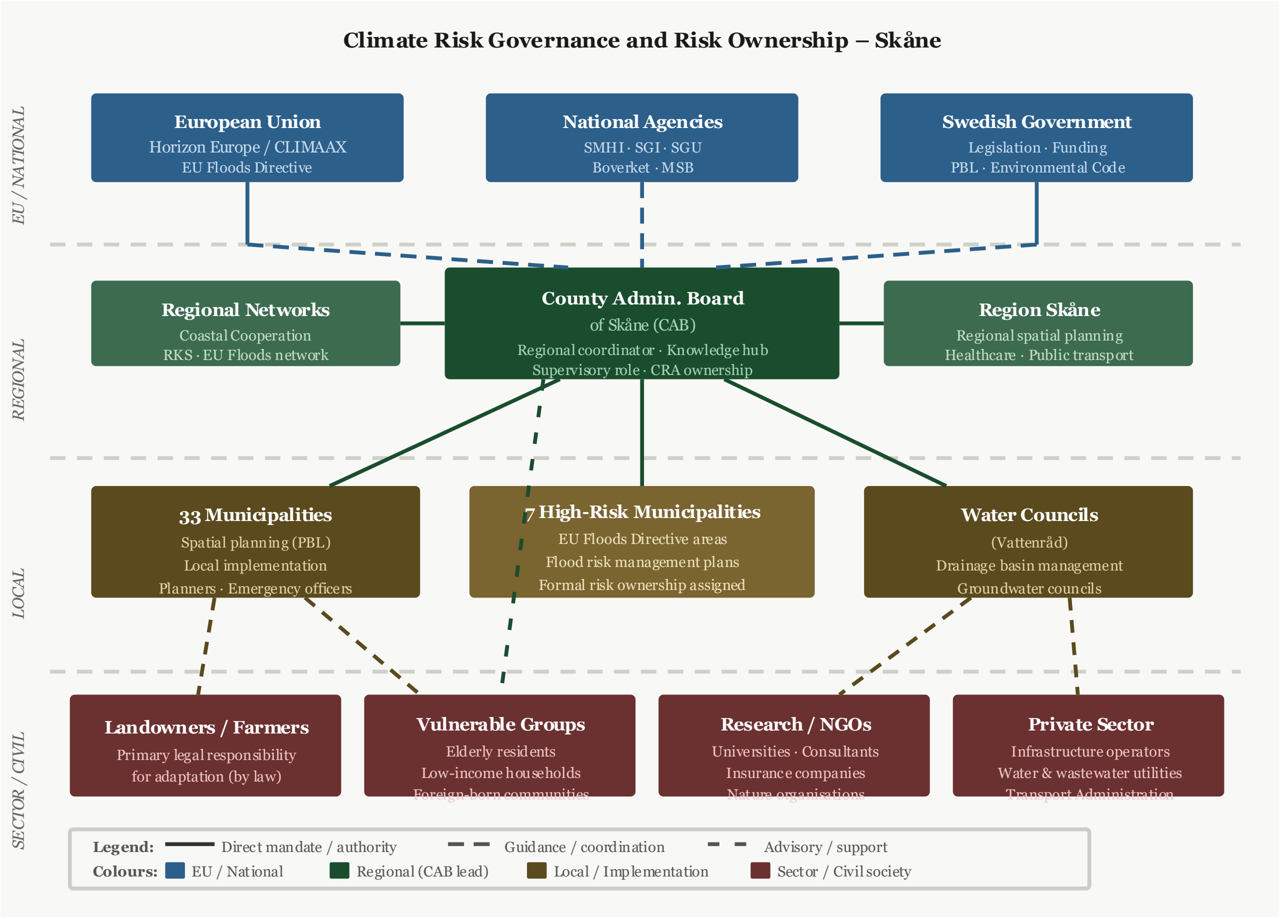

Figure 2-1. A climate risk governance and risk ownership organigram that maps the institutions and responsibilities and how they are interconnected.

Priority groups

Farmers and agricultural landowners are a central priority group in Skåne. The region has Sweden's highest share of agricultural land (approximately 45%), and both flooding and drought directly threaten agricultural productivity and water availability. Since Swedish law places primary responsibility for adaptation on property owners, many smaller landowners face this burden without sufficient financial or technical capacity to act alone. Representatives from farming communities and water councils contributed local knowledge throughout the workshops.

Elderly residents and care facility residents are a vulnerable group in relation to heat stress and extreme weather, with limited capacity to self-organize in participatory settings. Their perspectives were incorporated through the involvement of municipalities responsible for elderly care. Municipal politicians were also identified as a key audience, as political prioritisation of adaptation has been uneven across the region's 33 municipalities.

Risk ownership

Under the Planning and Building Act (PBL), municipalities are responsible for spatial planning and must integrate climate risk into plans and permit decisions. Individual property owners bear the primary legal responsibility for adapting their own properties — a decentralized structure that places implementation on a highly fragmented set of actors. CAB holds a statutory coordination mandate (Ordinance 2018:1428), encompassing knowledge dissemination, guidance and supervisory functions, but not direct implementation.

Seven areas are formally designated under the EU Floods Directive (2007/60/EC) — Helsingborg, Landskrona, Malmö, Falsterbo, Trelleborg, Ystad and Kristianstad — with flood risk management plans assigning specific responsibilities. Beyond these areas, no equivalent formal risk ownership exists for other hazards, which remains a recognised barrier to systematic adaptation. A formally defined tolerable risk level has not been established; the Key Risk Assessment workshops provided a space for stakeholders to begin articulating shared perceptions of urgency and acceptable risk.

2.1.4 Application of principles

Social justice, equity and inclusivity

Skåne has notable socio-economic heterogeneity: approximately 24% of the population is foreign-born, unemployment is above the national average, and adaptive capacity differs significantly between the urbanized west and the rural, coastal and agricultural parts of the region. Climate impacts are unevenly distributed — coastal hazards have historically attracted the most attention and resources, while heatwaves and droughts increasingly affect urban areas with the highest concentrations of socially vulnerable groups. Since Swedish law places the primary adaptation burden on property owners, financial and organizational capacity becomes a key determinant of resilience, with smaller municipalities and private landowners often lacking sufficient resources to act alone.

Through the parallel Pathways2Resilience project, the CAB developed six regional guiding principles for climate adaptation, one explicitly dedicated to climate justice. In Phase 2, stakeholder engagement was designed to surface perspectives from actors — including water councils, farming organizations and elderly care representatives — that are exposed to climate risks but not always present in formal planning arenas.

Quality, rigor and transparency

The assessment was conducted using the CLIMAAX Framework and Handbook methodology, grounded in scientific findings, international standards and European pilot region experience. Phase 2 directly addressed the key quality limitation of Phase 1 — low spatial resolution of

European datasets — by systematically integrating local and national data from SMHI, SGI and SGU and complementing the workflows with high-resolution spatial tools, including the Scalgo Live platform. All datasets are documented in the data overview tables in sections 2.3.1 and 2.3.2.

Phase 2 also explicitly compared the CLIMAAX methodology with existing Swedish risk assessment frameworks, contributing to an understanding of how EU-level approaches can be integrated with national practice. Results were shared openly through workshops and presented in ways that allowed participants to engage critically with findings and underlying assumptions.

Precautionary approach

In line with the precautionary principle and Swedish national climate adaptation goals (Prop. 2017/18:163), RCP 8.5 has been used as the primary planning scenario, with RCP 4.5 as a comparative case. Where evidence is incomplete or model confidence limited, the assessment has favored higher risk estimates, on the grounds that the costs of underestimating risk exceed the costs of prudent preparation. The long-time horizons applied — extending to 2100 and beyond for sea level rise — reflect the recognition that spatial planning and infrastructure decisions made today will shape the region's exposure for many decades, and that acting under uncertainty is preferable to waiting for certainty that will not arrive.

2.1.5 Stakeholder engagement

The project engaged stakeholders, experts and priority groups through a series of workshops and communication activities focused on coastal flooding, river flooding, heavy rainfall and drought. In total, 14 engagement activities were carried out.

We visited 10 municipalities and had also a meeting together with Region Skåne and the Swedish transport administration. Together with these stakeholders we used the template for key risk assessment applied to coastal flooding and in some cases heavy rainfall.

CAB invited organizations representing the catchment areas Sege å, Höje å and Kävlinge å. These water councils called “vattenråd” consists of stakeholders representing municipalities, companies, landowners and NGO:s. Important NGO:s participating in this event is LRF (farmers organization). Topics for this workshop was river flooding and drought.

Together with the coastal cooperation of Skåne and Halland we organized a bigger event. Many different stakeholders participated in a workshop by using the template for key risk assessment applied to heavy rain. The workshop was arranged together with the regional coastal cooperation of Skåne and Halland 20th of May.

CAB also took the initiative to arrange a key risk assessment about drought and river flooding in Kristianstad at a meeting organized by the “Grundvattenrådet för Kristianstadslätten” (a groundwater council a consultation body for municipalities, industries, farmers, and other stakeholders of the groundwater in the Kristianstad Plain. The purpose is to, through collaboration, be able to guarantee sustainable water management).

Finally, an internal workshop involving experts from all parts of the CAB, organized. In this key-risk assessment we focused on all climate risks described in the workflows of CLIMAAX.

In summary the participants represented 16 municipalities in the region and 6 outside the region, 2 Regions, Skåne and Halland, 5 National authorities, 2 County administrative boards, 4 water councils, 1 trade association (LRF), 2 research institutes, 3 consultants and 2 insurance companies and an unknown number of NGOs, and landowners.

Municipal workshops involved planners, climate strategists, emergency preparedness officers and technical experts responsible for water, wastewater and infrastructure.

We used existing networks to achieve stakeholder involvement. Regional Coastal Cooperation in Skåne and Halland counties is an important way to reach stakeholders affected by sea level rise. We arranged a workshop including key risk assessments during the yearly conference in May.

Our existing network for the work in the Floods directive was used to invite the ten concerned municipalities, the Swedish Transport Administration at regional level and Region Skåne. All the invited stakeholders participated in one of the ten occasions when we arranged workshops to implement key-risk assessments.

Project goals and intermediate results were communicated through interactive workshops using the CLIMAAX Key Risk Assessment methodology. Participants were provided with flood risk maps, scenario analyses, exposure data and visualization tools, including Scalgo Live. The workshops enabled participants to assess risks, vulnerabilities and organizational capacities under different climate scenarios while also discussing potential adaptation measures and nature-based solutions.

The results were generally well received. Participants considered the Key Risk Assessment framework easy to understand and useful for structuring discussions. The workshops facilitated dialogue between departments and organizations that do not normally work together on climate adaptation issues. Several municipalities highlighted that the workshops created valuable opportunities for internal discussions on climate risks and future adaptation needs.

Feedback from participants emphasized the value of combining local knowledge with risk maps and scenario-based assessments. Stakeholders particularly appreciated the visualization tools, which helped communicate complex climate risks. Discussions frequently focused on future uncertainties, governance, financing, responsibilities and the capacity of organizations to implement adaptation measures over time.

The project outcomes will be used to support ongoing climate adaptation planning, prioritization of measures and long-term risk management at local and regional levels. The workshops also helped identify future action needs, strengthen stakeholder cooperation and increase awareness of climate risks among participating organizations.

The main challenge encountered was the assessment of long-term scenarios, particularly those extending to 2150. Participants found it difficult to evaluate future societal, political, economic and technological developments and their influence on resilience and adaptation capacity. Additional challenges included uncertainties regarding future financing, governance arrangements and responsibilities for implementing adaptation measures. Stakeholders also highlighted the need for better consideration of combined climate impacts and stronger coordination from a catchment-area perspective.

2.2 Risk Exploration

The risk exploration in Phase 2 built upon the broad screening conducted in Phase 1 and incorporated insights from stakeholder engagement activities, Key Risk Assessment workshops and existing regional studies. While Phase 1 focused on testing the CLIMAAX workflows and identifying major climate hazards, Phase 2 provided a deeper understanding of local exposure, vulnerabilities, adaptive capacity and implementation challenges.

The exploration confirmed that river flooding, coastal flooding, heavy rainfall and agricultural drought remain among the most significant climate-related hazards in Skåne. These hazards were consistently identified by municipalities, Region Skåne, water councils, agricultural stakeholders, insurance companies and national authorities due to their potential impacts on settlements, infrastructure, agriculture, water resources, ecosystems, Natura 2000 sites and cultural heritage.

In Phase 2, the project further refined the understanding of both flooding-related risks and drought risks through stakeholder engagement, existing regional knowledge and additional analyses. This enabled a more detailed assessment of local vulnerabilities, exposure and adaptation needs, while building on the findings from Phase 1.

A key development in Phase 2 was the extensive stakeholder engagement process. Through workshops and discussions using the CLIMAAX Key Risk Assessment methodology, stakeholders contributed knowledge on local vulnerabilities, recurring flooding problems, critical infrastructure, future adaptation needs and barriers to implementation. The workshops also highlighted the importance of considering interconnected and cascading risks, including interactions between coastal flooding, river flooding, heavy rainfall, drought, erosion and rising groundwater levels.

The risk exploration provided a more comprehensive understanding of local conditions and adaptation challenges and formed the basis for the subsequent screening, Key Risk Assessment and regionalized risk analyses.

2.2.1 Screen risks (selection of main hazards)

The risk screening carried out in Phase 2 builds upon the hazard identification conducted in Phase 1, which identified river flooding, coastal flooding, heavy rainfall and drought as the most relevant climate-related hazards for Skåne. The main development in Phase 2 was the integration of stakeholder workshops and the CLIMAAX Key Risk Assessment process, providing a more detailed understanding of local vulnerabilities, exposure and adaptive capacity.

The screening confirmed that flooding-related hazards and drought remain among the most significant climate risks in Skåne. River flooding, coastal flooding and extreme rainfall events already affect parts of the region and are expected to increase in severity and frequency under future climate conditions. Particularly exposed and vulnerable assets include low-lying urban areas, critical infrastructure, transportation networks, agricultural land, water management systems, Natura 2000 sites and cultural heritage assets. Drought poses significant risks to agriculture, water resources, ecosystems and water supply, particularly during prolonged dry periods.

According to the Copernicus Climate Atlas and national climate assessments, southern Sweden is expected to experience more intense rainfall events, increasing precipitation extremes, rising sea levels and more frequent coastal flooding. Longer dry periods and seasonal water shortages are also projected to become more common, particularly affecting agriculture and water resources.

A key addition in Phase 2 was the use of stakeholder knowledge to complement technical analyses. Municipalities, Region Skåne, water councils, agricultural stakeholders, consultants, national authorities and insurance companies contributed information on local vulnerabilities, exposed assets, adaptive capacity and future challenges. For flooding and drought risks, existing studies, national datasets and local knowledge were combined to support discussions on future risks and adaptation needs.

Based on the screening process, stakeholder consultations and Key Risk Assessment workshops, river flooding, coastal flooding, heavy rainfall and drought were prioritized for further analysis due to their significant current and projected impacts, relevance for regional climate adaptation planning and strong stakeholder interest.

2.2.3 Choose Scenario

River flooding

In addition to the scenarios in the first deliverable focus has been on incorporating local data. River flooding was highly dependent on high resolution flood mapping and therefore limited to available national and local data. For the Helge å river, the assessments relied on an older ensemble of Global Climate Models (GCMs), with scenarios primarily based on the A1B pathway (a relatively high-emission scenario). The time horizon for the evaluations was long-term.

Coastal flooding

Coastal flooding was selected as one of the priority hazards in the climate risk assessment due to its significant potential impacts on communities, infrastructure, ecosystems and economic activities along the coast of Skåne. The region has an extensive coastline with several low-lying urban and rural areas that are already exposed to storm surges, coastal flooding and coastal erosion. Future sea-level rise is expected to increase both the frequency and severity of coastal flood events, making coastal flooding a key climate adaptation challenge for the region.

The assessment was based on future climate conditions associated with rising sea levels and increasing coastal flood risks. To support the Key Risk Assessment process, three coastal flooding scenarios were used: a present-day 50-year event, a future 100-year event in 2100 combined with projected sea-level rise, and a more extreme 500-year event in 2150. These scenarios are consistent with existing Swedish flood risk management practices and provide a useful basis for exploring future climate-related risks and adaptation needs.

The selected scenarios represent a progression from current conditions to increasingly severe future flood events and allowed stakeholders to discuss both short- and long-term adaptation challenges. The 2100 scenario reflects the time horizon commonly used in climate adaptation planning and municipal decision-making, while the 2150 scenario was included to explore longer-term consequences and adaptation needs associated with continued sea-level rise.

Future socio-economic developments were considered qualitatively through the stakeholder workshops and Key Risk Assessment process. Discussions addressed issues such as population growth, urban development, infrastructure investments, future land use, economic capacity and the long-term financing of adaptation measures. Rather than modelling alternative socio-economic pathways, the project incorporated these factors through stakeholder assessments of vulnerability, exposure, adaptive capacity and future risk.

Unlike the river flooding analyses, Phase 2 did not include the development of new coastal flood models or regionalized hazard analyses. Instead, the project focused on applying existing flood scenarios and risk maps within the CLIMAAX Key Risk Assessment framework. These scenarios are already widely used by municipalities and national authorities and therefore provided a common and well-established basis for discussions regarding future risks, consequences and adaptation options.

Local knowledge played an important role in the assessment. Municipal representatives, regional stakeholders, national authorities, consultants and other participants contributed information on exposed populations, critical infrastructure, vulnerable assets and local adaptation challenges. This knowledge complemented the existing flood scenarios and improved the understanding of how coastal flooding may affect different sectors and locations across the region.

Consequently, the coastal flooding assessment in Phase 2 builds upon the findings from Phase 1 while expanding the understanding of vulnerability, consequences and adaptive capacity through stakeholder engagement and the Key Risk Assessment process. This approach ensured that coastal flooding remained an integral part of the overall climate risk assessment while maintaining consistency with existing regional and national planning processes.

Heavy rainfall

For phase two we aimed for a better evaluation of the CLIMAAX method using local rainfall magnitude and frequency data. However, since this turned out to be too advanced, the CLIMAAX support team advised us to stick to the available data. Unfortunately, this data is far too low-resolution to be useful.

To support the Key Risk Assessment process, we used SCALGO Live which is a cloud-based planning platform used by engineers, urban planners, and municipalities to analyse flooding, manage stormwater, and plan for sustainable aquatic environments. It can visualize detailed maps showing how water flows, accumulates, and potentially causes flooding in both urban and natural areas. With the platform it is very easy to shift scenarios, depths and flows.

For the workshops we used two scenarios, a heavy rainfall (100mm) today, and a heavy rainfall where discharge by gravity is limited due to planned coastal protection measures. These mappings were supported by risk mapping data from MCF.

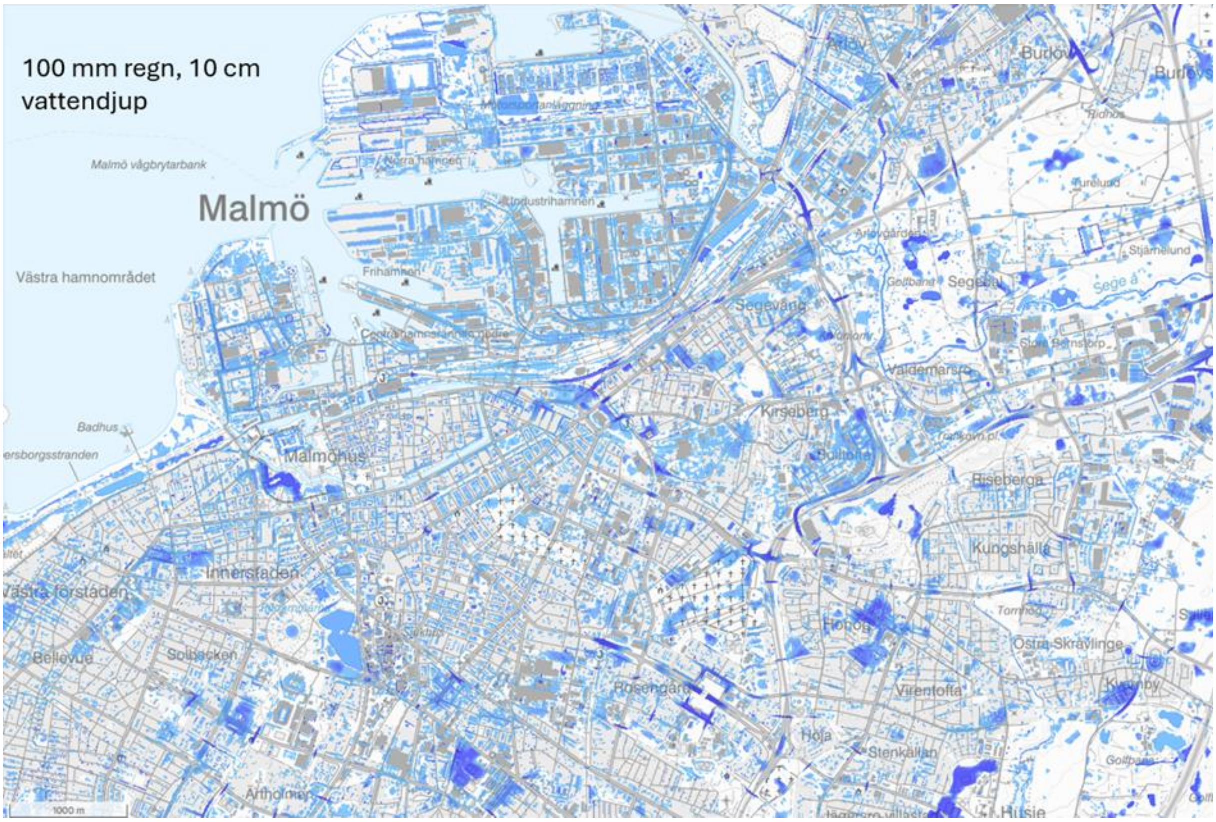

Figure 2-2. SCALGO Live mapping of heavy rain, 100mm depths +10cm, over Malmö municipality.

Drought

No new drought modelling was undertaken. Instead, existing drought assessments and stakeholder knowledge were used to refine the understanding of vulnerabilities and adaptation needs.

2.3 Regionalized Risk Analysis

2.3.1 River flooding - fine-tuning to local context

The Phase 1 assessment demonstrated that the spatial resolution of the flood hazard data was a major source of uncertainty and could lead to both overestimation and underestimation of flood risk, depending on local conditions. To improve the analysis, high-resolution local flood hazard data were incorporated for the Helge River (Helge å) catchment in Skåne. The workflow and resulting maps are documented in the accompanying visual outputs.

The local flood hazard data were based on the MCF flood mapping program, which combines hydrological modelling by the SMHI with a high-resolution hydraulic model. The hydraulic model is based on a 1-meter resolution LiDAR-derived elevation model and field-surveyed cross-sections. Flood depths were derived by combining flood extent maps with LiDAR elevation data. For practical processing and calculation times, the analysis was conducted at a spatial resolution of 5 meter.

The objective was to improve the reliability of the flood risk assessment through the use of more detailed flood hazard information and to evaluate whether the exposure assessment could be improved through local datasets. Comparisons between the land-cover data used in the CLIMAAX workflow and local datasets were performed in ArcGIS using the Swedish Environmental

Protection Agency's land-cover map and the National Topographic Map from Lantmäteriet. Overall agreement was considered satisfactory. In Kristianstad, land-cover classes representing built-up areas corresponded relatively well with the actual distribution of buildings, although differences in classification systems limited direct comparison.

The analysis identified several important limitations affecting the risk estimates. Along smaller watercourses, natural floodplains adapted to periodic flooding were often classified as economically exposed land despite containing little or no flood-sensitive infrastructure. This is considered a likely explanation for the overestimation of flood damage costs in the initial assessment. In addition, the use of a 5 meter resolution analysis, while necessary to maintain feasible processing times, resulted in some loss of detail compared with the original 1 meter hazard data.

A key source of uncertainty in Kristianstad is the performance of the flood protection embankment system. Large parts of the urban area, including critical infrastructure, are located below surrounding water levels and rely on the protection provided by the embankments. If the embankments perform as intended, flood impacts are substantially reduced. However, overtopping or failure of the system could result in severe flooding of low-lying areas, including Kristianstad Central Hospital, as well as a large proportion of the urban area located behind the embankments. Consequently, assumptions regarding embankment performance and the return periods at which the protection level may be exceeded represent one of the most significant uncertainties in the overall flood risk assessment.

To evaluate the applicability of the workflow at a broader scale, the analysis was also tested for the whole of Skåne and for the Kävlinge River and Höje River catchments. These catchments, together with the previously prioritized Sege River catchment, were discussed during stakeholder workshops due to their similar flood-related challenges and the availability of supporting local studies and datasets.

Although the risk assessment results indicated a probable overestimation of economic losses in some areas, the outputs remained useful in subsequent Key Risk Assessment workshops by illustrating the magnitude of assets potentially exposed to flooding. Greater emphasis was therefore placed on local flood hazard datasets when interpreting the results. The outputs were also used to evaluate and validate results from other workflows where similar datasets were applied.

Table 2-1: Data overview workflow #1 River flooding

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/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, MCF 2013 Rapport nr:7* *Hotkarta Kristianstad, MCF Översvämningsportalen (6)* *Översvämningskartering Utmed Höje å, MCF 2015 Rapport nr:47*	*JRC vulnerabilitydamagecurves* *Statistiska centralbyrån SCB data on GDP per capita 2024* *National Topographic Map from Lantmäteriet* *Swedish Environmental Protection Agency's land-cover map*	*LUISA Base Map* *National Topographic Map from Lantmäteriet* *Swedish Environmental Protection Agency's land-cover map*	*Flood damage maps expressed in* *economic value for extreme events, (same as deliverable 1)* *Maps och landuse affected by flood* *Comparison of LIUSA Base Map with local data*

2.3.2 Coastal flooding - fine-tuning to local context

The coastal flooding assessment in Phase 2 builds upon the results from Phase 1, where comparisons between CLIMAAX outputs and national and local datasets showed that the spatial resolution and level of detail of the CLIMAAX coastal flood data were insufficient for local-scale analyses, similar to the findings for river flooding. Phase 2 therefore focused on improving the understanding of local vulnerabilities, consequences and adaptive capacity through stakeholder engagement and the application of the CLIMAAX Key Risk Assessment methodology. Unlike the river flooding assessment, no new regionalized hazard modelling was undertaken for coastal flooding, as existing national flood scenarios and risk maps were already available and widely used in Swedish planning processes. Instead, the project adapted the CLIMAAX framework to the regional context by combining existing coastal flood scenarios and risk maps with local knowledge, stakeholder expertise and information from regional and municipal planning processes.

The selected coastal flood scenarios were based on existing Swedish flood risk management practices and represented both current and future climate conditions. Three scenarios were used during the stakeholder workshops: a present-day 50-year event, a future 100-year event in 2100 combined with projected sea-level rise, and a more extreme 500-year event in 2150. These scenarios provided a common basis for evaluating future risks, adaptation needs and societal consequences.

A key development in Phase 2 was the integration of local knowledge and stakeholder perspectives into the risk assessment process. Municipalities, Region Skåne, national authorities, consultants, insurance companies and other stakeholders contributed information regarding exposed populations, critical infrastructure, vulnerable assets and local adaptation challenges. This information was used to complement the existing flood scenarios and improve the understanding of local exposure and vulnerability across the region.

The assessment utilized existing hazard information, including national flood risk maps, coastal flood scenarios and visualization tools used in Swedish flood risk management and adaptation planning. In addition, the web-based GIS platform Scalgo Live was used as a complementary tool to support the assessment and stakeholder discussions. Scalgo Live provided a more accessible and interactive visualization environment and enabled the consideration of flooding associated with smaller watercourses, which are not fully represented in the national flood risk maps. Information on land use, settlements, infrastructure and other exposed assets was considered during the workshops together with local knowledge provided by participating stakeholders. Existing regional studies and previous climate adaptation assessments were also used to support the interpretation of results.

Rather than developing new quantitative risk metrics, Phase 2 focused on improving the understanding of risk through the structured Key Risk Assessment process. Stakeholders assessed the severity, urgency, adaptive capacity and overall risk associated with each scenario. This provided additional information on perceived risks, implementation challenges and adaptation priorities that could not be captured through hazard modelling alone. The assessment therefore produced a more comprehensive understanding of risk by combining technical information with stakeholder knowledge and practical experience.

The workshops also highlighted several indirect and cascading impacts associated with coastal flooding. Participants identified potential effects on transportation networks, drinking water supply, wastewater systems, emergency response capacity, regional economic activities and ecosystem services. Concerns were also raised regarding long-term adaptation financing, responsibilities for protective measures and potential conflicts between adaptation objectives and other societal goals. These indirect impacts were incorporated into the discussions and risk evaluations conducted during the Key Risk Assessment process.

Future socio-economic conditions were considered qualitatively through discussions on urban development, population growth, future land use, infrastructure investments and economic capacity for adaptation. Rather than modelling alternative socio-economic pathways, these factors were incorporated through stakeholder assessments of future vulnerability, exposure and adaptive capacity under the different coastal flooding scenarios.

A limitation of the assessment is that no new coastal flood modelling was undertaken in Phase 2. Consequently, the hazard assessment relies on existing scenarios and available flood risk maps. In addition, the CLIMAAX risk workflows do not account for the combined effects of elevated sea levels or storm surges occurring simultaneously with high river discharge. The spatial resolution of the available datasets is also insufficient for detailed local analyses in some areas. More detailed and reliable assessments are already available for specific locations through the flood risk management plans developed under the EU Floods Directive. However, the scenarios and datasets applied in this study are widely used in regional and municipal planning processes and therefore provide a robust basis for evaluating future coastal flood risks. The integration of stakeholder knowledge, local information, complementary visualization tools and the CLIMAAX Key Risk Assessment methodology significantly improved the understanding of local vulnerabilities, consequences and adaptation needs compared with the Phase 1 assessment.

Table 2-2: Data overview workflow #2 Coastal flooding

Hazard data	*Vulnerability data*	*Exposure data*	*Impact metrics/Risk output*
Existing coastal flood scenarios used in Swedish flood risk management (50-year event, 100-year event in 2100 including sea-level rise, and 500-year event in 2150). Developed within the framework of the EU Floods Directive by national authorities. *Flood hazard and risk maps for the following areas: Falsterbo, Helsingborg, Kristianstad, Landskrona, Malmö, Trelleborg, Ystad.* *The Swedish Civil Defence and Resilience Agency (MCF) Flood Portal*	*Stakeholder assessments of vulnerability and adaptive capacity.*	*The Swedish Civil Defence and Resilience Agency (MCF) is the authority in Sweden for the implementation of the EU Floods Directive. In accordance with the Directive, flood hazard and risk maps assess the potential adverse consequences of flooding for four focus areas: human health, the environment, cultural heritage and economic activity.*	*Severity, urgency, adaptive capacity and risk ranking from the Key Risk Assessment workshops; identification of vulnerable sectors, exposed assets and adaptation needs.*

2.3.2.1 Hazard assessment

Coastal flooding is a significant climate-related hazard in Skåne due to the region's extensive coastline, low-lying coastal settlements and the concentration of people, critical infrastructure and economic activities in exposed areas. Existing national climate projections indicate that sea-level rise will continue throughout the coming centuries, increasing both the frequency and consequences of coastal flood events. Storm surges, coastal erosion and rising groundwater levels may further amplify impacts in vulnerable locations.

The hazard assessment was based on existing coastal flood scenarios and risk maps that are widely used in Swedish flood risk management and climate adaptation planning. Three scenarios were used in the assessment process:

- Present-day 50-year coastal flood event

- 100-year coastal flood event in 2100 including projected sea-level rise
- 500-year coastal flood event in 2150 representing a more extreme future scenario

These scenarios provided a common basis for exploring both current and future coastal flood risks and adaptation needs. The selected time horizons allowed stakeholders to evaluate medium- and long-term consequences of coastal flooding and to consider how adaptation measures implemented over time may influence future risk levels.

The assessment confirmed that coastal flooding may affect settlements, transportation infrastructure, water management systems, agricultural land, Natura 2000 sites, cultural heritage assets and other important societal functions. Stakeholders also emphasized that coastal flooding should not be viewed as an isolated hazard. Interactions with heavy rainfall, river flooding, coastal erosion and rising groundwater levels may significantly increase future impacts and contribute to more complex risk situations than those represented by individual hazard scenarios alone.

2.3.2.2 Risk assessment

The coastal flood risk assessment combined existing hazard information with local knowledge and stakeholder perspectives gathered through the Key Risk Assessment workshops. Rather than developing new coastal flood models, the assessment focused on understanding how the selected scenarios may affect exposed populations, infrastructure, ecosystems and societal functions throughout the region.

The assessment demonstrated that future risk levels are influenced not only by the magnitude of coastal flooding but also by the capacity of society to plan, finance and implement adaptation measures over time. Stakeholders highlighted governance structures, political priorities, financing mechanisms, technical development and responsibilities for adaptation as important factors affecting future risk levels. In addition, the concentration of assets and infrastructure in coastal areas, continued urban development in exposed locations and dependencies between critical societal functions were identified as important contributors to risk. Stakeholders also emphasized that historical landscape modifications and previous development decisions continue to influence current vulnerability and adaptive capacity.

The workshops revealed variation in how stakeholders assessed future risks, particularly for the long-term 2150 scenario. Some municipalities considered the scenario to represent a very high risk due to potentially severe consequences and the need for extensive and costly adaptation measures. Others emphasized that adaptation measures are likely to be implemented gradually over time, thereby increasing society's capacity to manage future risks. These discussions highlighted the importance of adaptive capacity and long-term planning when evaluating future coastal flood risks.

The assessment also highlighted the importance of considering indirect and cascading impacts. Stakeholders noted that the consequences of coastal flooding may be amplified through interactions with river flooding, heavy rainfall and rising groundwater levels. Secondary impacts such as coastal erosion, pollution spreading from contaminated land, failure of pumping stations, impacts on wastewater and drinking water systems, disruption of transportation networks and increasing groundwater levels were identified as potentially significant consequences that are not fully represented by flood extent maps alone. Challenges related to the long-term financing, governance and implementation of adaptation measures were also recognized as important aspects of the overall risk picture.

Rather than generating new quantitative risk metrics, Phase 2 produced risk outputs through the CLIMAAX Key Risk Assessment methodology. Stakeholders evaluated the severity, urgency, adaptive capacity and overall risk ranking associated with each scenario. These outputs improved the understanding of local vulnerabilities, future adaptation needs and implementation challenges and provided a structured basis for identifying priority risks and supporting regional and municipal climate adaptation planning.

2.3.3 Additional assessments based on local models and data

2.3.3.1 Hazard assessment

The use of local and regional models and data in the hazard assessments is documented within the respective workflow sections (2.3.1 and 2.3.2). No additional standalone hazard analyses were conducted beyond those described there.

2.3.3.2 Risk assessment

Local data contributions to the risk assessments are similarly documented under sections 2.3.1 and 2.3.2 respectively.

2.4 Key Risk Assessment Findings

2.4.1 Mode of engagement for participation

The risk assessment process involved **workshops (WS)** with stakeholders, experts, and priority groups (e.g., municipalities, water councils, farmers, and drinking water companies). Key observations from engagement:

- **Workshop effectiveness**: The matrix and protocol were well-received, enabling structured discussions across diverse actors (e.g., internal municipal teams, water councils). Participants appreciated the clarity of the framework, though some noted a lack of expertise to independently assess risks.
- **Cross-sectoral dialogue**: Workshops facilitated discussions between actors with different responsibilities (e.g., urban planners, environmental units), which many municipalities had not previously conducted.
- **Challenges**:
    - Long-term perspectives (e.g., 2150) were difficult to apply due to uncertainties about future political, economic, and technological developments.
    - Stakeholders highlighted **interest conflicts** (e.g., land use for flood protection vs. development) and **organizational capacity gaps** (e.g., unclear funding responsibilities).
- **Feedback on risk assessment**:
    - Some municipalities spontaneously categorized risks into "with/without planned measures," reflecting their existing adaptation plans.
    - **Visual tools** (e.g., dynamic maps like SCALGO Live) were critical for engaging stakeholders, while static maps were less effective for real-time discussions.

2.4.2 Gather output from Risk Analysis step

The following outputs from the *Risk Analysis* step (Chapter 2.2 and 2.3) were used for the risk evaluation:

- **Hazard data**:
  - Coastal flooding: Sea level scenarios were based on the MCF flood mapping program, which combines hydrological modelling by the Swedish Meteorological and Hydrological Institute (SMHI) incorporating sea-level rise (SSP 8.5) with a high-resolution hydraulic model. three coastal flooding scenarios were used: a present-day 50-year event, a future 100-year event in 2100 combined with projected sea-level rise, and a more extreme 500-year event in 2150.
  - Heavy rainfall: a 100-year event today, a future 100-year event (climate factor 1.3), based on local rainfall data. The workshop together with the organisation"Regional coastal cooperation" also used SCALGO Live and adopted a scenario for heavy rainfall where gravity drainage is limited.
  - River flooding: MCF flood mapping program, based on flow data from SMHI and local hydrological models. River flood scenarios used were a current 50-year event and a 100-year event 2100.
  - Drought: Scenarios for RCP4.5 (year 2050) from workflow in phase 1.
- **Exposure data**:
  - Coastal flooding: flood extent and water depth in relation to land use from maps used in FRMP Översvämningsportalen
  - Heavy rainfall: flood extent and water depth in relation to land use from maps used in FRMP Översvämningsportalen supplemented with maps from SCALGO Live.
  - River flooding: flood extent and water depth in relation to land use from maps presented by MCF Översvämningsportalen
  - Drought: the extent of the drought on cultivated land.

  Vulnerability data:
  - Coastal flooding: Existing data from work with FRMP, based on the impacts on key areas, people's health, the environment, cultural heritage, and economic activity for example, number of inhabitants potentially affected, effects on transportation networks, drinking water supply, wastewater systems, Natura 2000 areas.
  - Heavy rainfall: the same type of data as for coastal flooding.
  - River flooding: the same type of data as for coastal flooding.
  - Drought: Yield loss from precipitation deficit with different crops as examples.

2.4.3 Assess Severity

Severity was assessed in the workshops with the stakeholders for current and future risks using the categories described in the key risk assessment protocol: limited, moderate, substantial, critical. Aggregated results from the workshops are presented below.

Coastal flooding

The assessment for a 50-year event today is limited for 12 of 16 workshop groups. Six of the groups assessed a 100-year event 2100 substantial and six groups found this scenario critical. A 500-year event 2150 was assessed critical by 13 of the 16 groups. The expert team from CAB assessed severity for coastal flooding moderate today and substantial for a 100-year event 2100.

A finding mentioned by many stakeholders is as follows. Since scenarios do not show the combined effects of different events, selected scenarios, which are relatively extreme on their own, do not give an accurate picture of what the consequences of a flood will be. Combinations of rain, rising sea levels, and increased river flows that are less extreme on their own can lead to significant consequences even before 2100.

Heavy rainfall
The severity for a 100-year event differed from moderate to critical among the groups who participated in the workshop. The relatively large difference in results between groups might be because the participants were randomly assigned and therefore didn't have local knowledge. However, all groups found severity substantial or critical for the scenario where gravity drainage is limited. The expert team from CAB assessed severity for heavy rain substantial today and critical in 2100.

Municipalities that participated in the workshop on both coastal flooding and heavy rain felt that their own capacity is better for dealing with rising sea levels by 2100 compared to heavy rainfall. Even though there are some emergency measures to handle heavy rain, there's a lack of planning for preventative actions to avoid the problems.

River flooding
The water councils as well as the expert team from CAB assessed a 50-year event today as moderate. The severity for a 100-year event differed a lot between catchment groups from moderate to critical. A likely explanation for variation in results is that the proportion of urban land that can flood differs between the catchment areas. The expert team from CAB assessed moderate severity for river flooding for the county as a whole in the 2100 scenario.

The workshops identified cascading effects, ecosystem collapse, increased spread of invasive species, risk for population growth in flood zones and erosion risks.
Irreversible consequences mentioned were loss of agricultural land, ecosystem destruction, and infrastructure damage. An identified catchment perspective, it is difficult to coordinate measures between municipalities.

Drought
Drought in 2050 was assessed as substantial across all catchments and substantial to critical for the groups participating at the groundwater council for Kristianstad Plain (1). The results from the expert team from CAB assessed drought as substantial today and critical by year 2100. Obvious future impacts are reduced groundwater, crop failures, and drinking water shortages.
Potential irreversible consequences and cascading effects identified in workshops were saltwater impact on groundwater resources in coastal areas due to increased irrigation needs. Emergency slaughter, economic losses, and social unrest were also identified.

The results from workshops showed some variation but overall showed similar results between municipalities and also for experts. Municipalities that are already exposed to risks and have started working on physical measures see bigger challenges in handling the worst-case scenario far in the future compared to those that have not started working on physical measures. The key risk assessments helped us to deepen the dialogue with municipalities. The consequences of secondary effects of flooding, even in moderate scenarios, such as the spread of pollutants from soil and landfills as well as bacteria due to pump stations being knocked out, were highlighted as a serious issue by many municipalities. For coastal areas, it was particularly noted that erosion is extensive even in moderate flood events and causes serious consequences, especially if waves and wave height are strong. Increased erosion also leads to a higher flood risk, for example, if a coastal ridge disappears. With a permanently higher sea level, groundwater levels also rise, which is not visible or included as a factor in models. Increased water saturation along the coast also raises the risk that the effects of erosion will be greater.

2.4.4 Assess Urgency

Urgency was assessed based on temporal aspects (when risks are expected to occur), rate of change, and need for immediate action. Results are shown below:

Table 2-3: Urgency assessment

Risk	Urgency (today)	Urgency (future)	Rationale
Coastal flooding	More action needed	Immediate action needed (year 2100)	**Year 2100** : Sea level rise is accelerating, and **measures must start now** to implement coastal protection in time. **Year 2150**: Uncertainties about political will and technology lead to varying urgency assessments among municipalities.
Heavy rainfall	More action needed	Immediate action needed	**Cities**: Need for **preventive measures** (e.g., green infrastructure) to handle increased precipitation. **Combination with sea level rise**: May lead to **acute situations** if drainage systems are blocked.
River flooding	Watching brief (Kävlinge å)	More action needed (Höje å)	**Höje å**: Increased development in the catchment area requires **measures within 10–20 years**.

			Sege å/Kävlinge å: Lower urgency as floodplains are less developed.
Drought	More action needed	Immediate action needed	**Agriculture**: Need for **water storage and irrigation systems** now. **Drinking water**: Groundwater levels are declining, and **restrictions may be necessary** within 5–10 years.

Perspectives from participants:

- Municipalities agreed that coastal flooding by 2100 requires immediate action, but opinions differed on whether 2150 is too distant to prioritise.
- Water councils emphasised that drought is more urgent than flooding, as effects are already being felt (e.g., groundwater shortages in 2018).
- Research institutes (e.g., SMHI) noted that uncertainties in climate models make it difficult to assess urgency for long-term scenarios.
- Municipalities with existing adaptation plans rated urgency lower.
- Uncertainty about future political will and funding reduced urgency scores for long-term risks.

2.4.5 Understand Resilience Capacity

Measures already in place:

- Coastal protection: Vellinge and Kristianstad has begun constructing protective barriers; Malmö is planning pump stations and raised quays.
- Heavy rainfall: Kristianstad and Malmö have flood risk maps and emergency plans.
- Drought: Kristianstad's groundwater council is working on water-saving measures and artificial groundwater recharge.
- Warning systems in place for river flooding in many catchments
- Land use planning in all municipalities – reserving place for future measures.

Future challenges, substantial:

- Political uncertainty: Future priorities may shift, especially if adaptation costs increase.
- Responsibility: Unclear who should finance and maintain measures (e.g., coastal protection).
- Combined effects: Existing models do not capture interactions between risks (e.g., flooding + erosion + pollution).
- High awareness in catchments but potential underestimation of costs
- No long-term solutions for drought (e.g., reservoirs).

Weak spots:

Financial-Unclear funding for private property protection.

Social-Lack of cooperation frameworks between municipalities and landowners.

Natural-Erosion and groundwater rise not fully modelled.

2.4.6 Decide on Risk Priority

Risk prioritisation was conducted using the CLIMAAX evaluation dashboard, where severity, urgency, and capacity were weighed together, aggregated results from all workshops. The results are shown in **Figure 2.4-1** below.

Table 2-4: Summary of risk priorities

Risk	Risk ranking	Rationale
Coastal flooding (year 2100)	**High**	**High severity** (substantial) and **high urgency** (more action needed). **Low future capacity** if measures are not initiated now. Medium if planned measures take place **Critical infrastructure** (e.g., hospitals, ports) is threatened.
Drought (year 2050)	**Very High**	**High severity** (substantial today and critical in future) and **high urgency** (immediate action needed). **Low capacity** today, with few measures in place. **Agriculture and drinking water supply** are threatened.
Heavy rainfall	**High**	**Medium-high severity** (substantial) but **high urgency** (immediate action needed) in cities. **Low capacity** for preventive measures. **Combination with sea level rise** increases risk.
River flooding (Höje å, year 2100)	**Moderate**	**High severity** (critical) but **lower urgency** than coastal flooding. **Medium capacity** today, but **development** reduces future capacity.

Next steps:

- Key risks (coastal flooding and drought) require immediate action and should be prioritised in climate adaptation plans and risk management strategies.
- High risks (heavy rainfall and river flooding) should be monitored and addressed through preventive measures (e.g., green infrastructure, floodplains).
- Less urgent risks (e.g., coastal flooding in 2150) should be included in long-term planning and scenario analyses.

2.5 Monitoring and Evaluation

Phase 2 generated several important lessons for ongoing monitoring and future phases of the assessment.

The Key Risk Assessment workshops proved to be the most effective format for structured learning and knowledge exchange. Bringing together actors with different institutional responsibilities — planners, emergency preparedness officers, water managers and technical experts within the same municipality — enabled discussions that many participants said had not previously taken place internally. This cross-sectoral dialogue is itself an outcome of value, independent of the quantitative risk outputs.

Stakeholder feedback confirmed that the CRA protocol and dashboard were well understood and appreciated for their clarity. However, many participants noted a lack of confidence in applying the matrix independently without facilitation, suggesting a continued role for the CAB in supporting future risk evaluation processes at local level. The workshops also revealed recurring themes around governance and financing — particularly the lack of clarity over who is responsible for funding adaptation measures across administrative boundaries — which will need to be addressed as part of the transition to Phase 3.

On the data side, significant gaps remain. Models for predicting shoreline retreat due to sea-level-driven erosion are not yet adequate for local planning purposes, and the effects of sea level rise on groundwater levels are not fully captured in available datasets. Municipalities consistently requested higher-resolution local data, though an important learning from Phase 2 is that higher resolution does not automatically mean higher reliability — in some cases it can create a false sense of precision. The CLIMAAX approach of focusing on vulnerability and adaptive capacity, rather than the traditional probability-times-consequence framing of risk, was found to resonate better with stakeholders and supported more productive adaptation discussions.

Climate risk monitoring in the region will continue to be linked to national reporting structures, in particular through SMHI and the Regional Climate Adaptation Action Plan (RHP). The CRA results from Phase 2 will feed directly into the forthcoming revision of that plan, ensuring that the findings have a traceable policy pathway beyond the CLIMAAX project itself.

2.6 Work plan Phase 3

Building on the knowledge gained in Phases 1 and 2, Phase 3 will engage municipalities, landowners, and other key regional stakeholders to develop tailored scenarios and refine our risk management strategies. The aim is to create synergies where stakeholders can apply the project's knowledge base to identify feasible measures and develop concrete implementation plans.

The work will focus on two key areas:

- Identifying High-Risk Areas for Cloudbursts and Flooding
  Using existing GIS data and studies, we will pinpoint areas within selected catchments where nature-based solutions—such as flow attenuation and natural water retention—can reduce flood risks and enhance drought resilience. Areas will be prioritised in consultation with stakeholders based on risk levels, feasibility, and alignment with other land-use interests.
- Restoring Streams, Wetlands, and Lakes
  In collaboration with municipalities and landowners, we will plan for the restoration of watercourses, wetlands, and lakes to mitigate flood risks. Measures will combine nature-based solutions, spatial planning, and technical protection, with a particular focus on governance and financing challenges.

For coastal flooding, Phase 3 will translate the risk assessments and Key Risk Assessments from Phase 2 into actionable adaptation planning. We will identify priority risks, vulnerable sectors, and locations requiring adaptation measures under future sea-level rise scenarios. The work will evaluate adaptation options—including nature-based solutions and technical defence strategies — in dialogue with stakeholders, building on existing flood scenarios and risk maps to directly support implementation.

3 Conclusions Phase 2- Climate risk assessment (1-2 pages)

Please follow these guidelines:

- *Include the main conclusions reached in this project phase (challenges addressed and not addressed).*
- *Include the main key findings.*

Phase 2 of the Forsee Skåne project successfully refined and extended the multi-hazard CRA initiated in Phase 1. By integrating higher-resolution national and regional datasets — from SMHI, SGI, SGU and the Scalgo Live platform — and conducting 14 structured stakeholder engagement activities with 42 participating organizations and 199 individuals, the assessment produced a substantially improved understanding of climate risks and their distribution across Skåne.

Key findings

Four climate hazards were assessed: coastal flooding, heavy rainfall, river flooding and agricultural drought. The Key Risk Assessment, conducted through workshops with municipalities, water councils, landowners and other regional actors, produced the following priority findings:

Drought is assessed as Very High risk, with high severity already today and critical severity projected by 2050. Both agricultural productivity and drinking water supply are directly threatened, and current adaptive capacity is low. Coastal flooding and heavy rainfall are both assessed as High risk. Sea level rise accelerates the urgency of coastal measures given the long lead times for protective infrastructure; in urban areas, heavy rainfall combined with sea level rise may overwhelm drainage systems before existing plans can be fully implemented. River flooding is assessed as Moderate risk overall, with urgency increasing in the Höje å catchment due to continued development pressure.

A cross-cutting finding is that compound events — the simultaneous occurrence of sea level rise, heavy rainfall and river flooding — are not adequately captured in current models, meaning that risk levels may be systematically underestimated across all hazard types.

Challenges addressed

Phase 2 directly addressed the main limitation of Phase 1: the low spatial resolution of European-level datasets. Local and national data were systematically integrated across the risk workflows. The CLIMAAX methodology was also explicitly compared with existing Swedish risk assessment frameworks, contributing to understanding of how EU-level approaches can complement national practice. Stakeholder engagement was substantially expanded, and the CRA workshops facilitated cross-sectoral dialogue that many municipalities had not previously conducted internally.

Challenges not yet addressed

Several important challenges remain open. Adequate models for predicting shoreline retreat from erosion and the effects of sea level rise on groundwater are not yet available at local planning resolution. Governance and financing for adaptation — particularly regarding responsibility for measures that cross administrative boundaries — remain unresolved. Long-term solutions for drought, including regional water storage capacity, are not yet in place. Formal risk tolerance thresholds have not been established for most hazards, limiting the basis for systematic risk management decisions.

Outlook

The results of Phase 2 provide a solid foundation for Phase 3, which will shift focus from assessment to action. Working with municipalities and landowners, Phase 3 will identify specific locations in key catchments suitable for nature-based solutions and develop concrete implementation plans with particular attention to governance and financing. The CRA findings will also feed directly into the forthcoming revision of the Regional Climate Adaptation Action Plan, ensuring a traceable policy pathway beyond the CLIMAAX program.

4 Progress evaluation

Phase 2 of the Foresee Skåne project has successfully delivered a refined and locally adapted Climate Risk Assessment (CRA) for the region, building upon the screening and methodological testing undertaken during Phase 1. The main outputs of this deliverable include improved risk assessments for river flooding, coastal flooding, heavy rainfall and drought, the integration of higher-resolution national and local datasets, and the application of the CLIMAAX Key Risk Assessment methodology through an extensive stakeholder engagement process. These activities have significantly strengthened the understanding of regional vulnerabilities, exposure, adaptive capacity and implementation challenges related to climate adaptation in Skåne.

A key achievement during Phase 2 has been the successful adaptation of the CLIMAAX framework to the Swedish and regional context. Comparisons between CLIMAAX outputs and national and local datasets demonstrated limitations in the spatial resolution and level of detail of several European datasets. Consequently, national, regional and local information sources, together with stakeholder knowledge and existing planning material, were systematically integrated into the assessment. This approach improved both the robustness and practical relevance of the results and provided valuable experience regarding how European methodologies can be combined with existing Swedish risk assessment frameworks and planning processes.

Strengthening climate adaptation capacity among municipalities and regional stakeholders was a central objective of the original project proposal. During Phase 2, this objective was addressed through a comprehensive stakeholder engagement process involving municipalities, national authorities, water councils, farmers, consultants, insurance companies, research organizations and other relevant actors. The workshops facilitated cross-sectoral dialogue, improved information sharing among stakeholders and increased awareness of climate risks, vulnerabilities and adaptation challenges. The engagement activities also created new opportunities for collaboration between actors with different responsibilities and perspectives, thereby contributing to increased regional capacity for climate adaptation and risk management.

The outputs produced in Phase 2 constitute an important basis for the following phase of the project. The prioritized climate risks, identified vulnerabilities, adaptation needs and implementation barriers will be used during Phase 3 to co-develop adaptation pathways and identify feasible adaptation options together with stakeholders. Particular emphasis will be placed on identifying suitable nature-based solutions and catchment-scale adaptation measures that can reduce flood risks while providing additional societal and environmental benefits. The strengthened stakeholder network established during this phase will continue to support discussions concerning governance arrangements, financing mechanisms and implementation responsibilities related to climate adaptation.

Furthermore, the knowledge generated through Phase 2 will support the ongoing revision and implementation of regional climate adaptation strategies and flood risk management plans in Skåne. The results will also provide evidence and practical experiences that can contribute to discussions on governance structures, responsibilities and future policy development related to climate adaptation in Sweden. In this way, the project contributes not only to improved local and regional risk management, but also to broader institutional learning and capacity building.

The activities carried out during Phase 2 have largely followed the Individual Follow-up Plan. Planned milestones and Key Performance Indicators related to stakeholder engagement, climate risk assessment development, application of the CLIMAAX methodology, capacity building and dissemination of results have been achieved. The summary tables below provide an overview of completed activities, achieved milestones and Key Performance Indicators during this reporting period.

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 droughts successfully executed.
[2] of workflows successfully applied on deliverable 2	Completed.
[40] of stakeholders involved in the activities of the project (Phase 2 and Phase 3)	Completed, 42 stakeholder organizations were involved in Phase 2.
[8] of communication actions taken to share results with your stakeholders (Phase 2 and Phase 3)	14 communication actions were taken to share results in Phase 2.
[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)	Achieved
M5: Finalizing the refined regional climate multi-risk assessment including strategies for nature-based solutions to avoid risks (Phase 2)	Achieved
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 (1-2 pages)

- Main Report (PDF or Word)
- Visual Outputs (infographics, maps, charts)

All figures and tables from the workflows are found in the Visual outputs document.

6 References

1. **Grundvattenrådet.** (n.d.). *Groundwater Council for Kristianstad Plain*. Retrieved June 10, 2024, from https://grundvattenradet.se/
2. **Länsstyrelsen Skåne.** (2020a). *Appendix 1 – Climate and vulnerability analysis (KSA) for Skåne County* [Report]. https://www.lansstyrelsen.se/download/18.7ef10b0318df2d313955047b/1710426233405/Bilaga%201%20–%20Klimat-%20och%20sårbarhetsanalys.pdf
3. **Länsstyrelsen Skåne.** (2020b). *Regional action plan for climate adaptation 2020–2024*. https://www.lansstyrelsen.se/skane/om-oss/vara-tjanster/publikationer/2020/regional-handlingsplan-for-klimatanpassning-2020-2024.html
4. **Länsstyrelsen Skåne.** (2021). *Falsterbo area: Risk management plan* [Report]. https://www.lansstyrelsen.se/download/18.792af7217dc2822143b89a/1640084579966/Falsterboomr%C3%A5det%20Riskhanteringsplan.pdf
5. **Länsstyrelsen Skåne.** (n.d.). *Climate adaptation*. Retrieved June 10, 2024, from https://www.lansstyrelsen.se/skane/samhalle/klimatanpassning.html
6. **Swedish Civil Contingencies Agency (MSB).** (n.d.). *Flood portal: Hazard and risk maps – Kristianstad*. https://gisapp.msb.se/Apps/oversvamningsportal/avancerade-kartor/hot-och-riskkartor/kristianstad