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X-RISK-CC

TRANSNATIONAL GUIDELINES FOR MANAGING CURRENT AND FUTURE CLIMATE RISKS RELATED TO WEATHER EXTREMES IN ALPINE REGIONS

LEAD PARTNER

eurac research

PROJECT PARTNERS

Wildbach- und Lawinenverbauung Forsttechnischer Dienst

umweltbundesamt

GeoSphere Austria

Technische Universität München

Auvergne Rhône-Alpes Energie Environnement

Republic of Slovenia Ministry of the Environment, Climate and Energy Slovenian Environment Agency

Razvojna agencija Sora d.o.o.

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Environment Agency Austria

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Development Agency Sora

Auvergne Rhône-Alpes Energy Environment Agency

Forest-technical service for torrent and avalanche control, Section Tyrol

Authors:
Wolfgang Lexer, Teresa Deubelli-Hwang,
Daniel Buschmann (Environment Agency Austria)

With the support, and building on the work done,
by all project partners.

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www.alpine-space.eu/project/x-risk-cc/

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ABBREVIATIONS

ACB	*Alpine Climate Board of the Alpine Convention*
AG8	*Action Group 8 'Risk Governance' of EUSALP*
CAPA	*Climate Adaptation Platform for the Alps*
CCA	*Climate Change Adaptation*
CRA	*Climate Risk Assessment*
CRM	*Climate Risk Management*
DRM	*Disaster Risk Management*
DRR	*Disaster Risk Reduction*
EUCRA	*European Climate Risk Assessment*
EUSALP	*European Union Strategy for the Alpine Region*
MREL	*Monitoring, reporting, evaluation and learning*
NbS	*Nature-based Solutions*
PLANALP	*Natural Hazards Working Group of the Alpine Convention*
UNFCCC	*United Nations Framework Convention on Climate Change*

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1. INTRODUCTION

Driven by intensifying weather extremes, Alpine regions have experienced more and more severe climate-related disaster events in recent years and are increasingly exposed to more frequent, more intense, and spatially expanding hazards, compound impacts and cascading risks. Existing risk management capacities have repeatedly been overstrained during past extreme events, and climate adaptation and risk management policies are threatened to be outpaced by rapidly evolving climate risks. Policy readiness needs to be improved – from prevention and preparedness to response and recovery measures - to make Alpine regions become more resilient.

1.1 WHY THESE GUIDELINES?

The overarching objective of these transnational **Guidelines** is to **enable and support risk managers** in Alpine regions to **effectively reduce climate-related risks** from intensifying weather extremes and to **increase resilience** of Alpine territories by **adapting existing risk management practices to current and future climate change**.

Considering climate change and climate-driven compound impacts and cascading effects in risk management requires adoption of more pro-active, forward-looking, long-term and systemic approaches. These **Guidelines** are designed as a process-oriented, modular roadmap that shall **enable risk managers** in other Alpine regions to **organize and conduct a planning process for climate risk management**. Across the entire workflow, they build on field-tested methodologies, tools and approaches and the experiences and insights gathered in the pilot areas of the X-RISK-CC project, aiming to **transfer** and **out-scale** its outcomes and learnings to other regions across the Alps.

The need for putting into place and strengthening climate risk management has been demonstrated by the first European Climate Risk Assessment (EUCRA)[1], which has concluded that several climate risks have already reached critical levels and most climate risks identified could reach critical or catastrophic levels by the end of this century, if decisive adaptive action is not taken now. As temperature increases in the Alps surpass the European average, making them one of the fastest warming regions in the world, this creates strong and urgent need for action. The Alpine region is increasingly affected by complex and cascading climate-related risks, driven by changes in frequency, intensity and spatial occurrence of hazard processes. Most often triggered by intensifying weather extremes, hazards like storms, floods, droughts, landslides, debris flows, forest disturbances, and wildfires interact across the natural environment, economic sectors and borders, creating severe pressures on Alpine communities, ecosystems, infrastructures, and economies. Due to its unique geography, the Alpine region is particularly vulnerable to climate-driven natural disasters caused by various natural hazards, whose effects are often exacerbated by their compounding occurrence and interactions, creating multiple risks that can cascade across sectors, scales, and levels. As new evidence produced by X-RISK-CC has demonstrated, severe weather- and climate-related extreme events are projected to intensify further. It thus becomes necessary that existing risk management systems undergo a climate stress test and are adapted to new challenges of current and future climate change. The X-RISK-CC project has identified multiple critical gaps in existing risk management practices and policy frameworks, revealing that preparedness for current and future climate risks is too low and policy implementation is

lagging considerably behind quickly increasing risk levels. Business-as-usual development will result in constantly growing vulnerabilities, decreasing risk preparedness, and inflexible choices that are not fit for the future, such as in land-use planning and long-lived infrastructure, causing lock-ins into maladaptive pathways. To prevent and mitigate substantial damage and loss and avoid long-lasting or even irreversible consequences, Alpine risk management policies need to adapt to emerging new realities in the wake of climate change.

1.2 FOR WHOM ARE THESE GUIDELINES?

These **Guidelines** address **professionals** and **practitioners** that have a role in in **regional and local risk management** and **adaptation to climate change** in **Alpine regions**. They are thus primarily intended for public administrations, authorities, agencies, organisations and affiliated experts working at local and regional levels in **disaster risk management, civil protection, natural hazard management, emergency management,** and **climate adaptation**.

This involves the roles of risk managers as **coordination and communication hubs** towards actors needed for cross-sectoral, multi-level and transboundary coordination of risk management solutions. These secondary target groups include actors that are active: 1) in sector policy fields relevant to the reduction of climate-related risks, such as spatial planners, environmental and territorial planners, forest managers, infrastructure providers and operators; 2) at other levels of government and governance, from subnational to transnational level; and 3) in territories under other jurisdictions, such as neighbouring regions and municipalities, cross-border or transboundary areas.

The **Guidelines** address these target groups in their capacity as **risk owners**, i.e. as institutions and actors that carry responsibility for managing and reducing hazards, exposure, vulnerability and resulting risk. They are designed to support the integration of current and future climate change, including in particular the compound impacts and cascading effects of increasing weather extremes, into existing risk management systems by **coupling disaster risk reduction with climate change adaptation**, expanding both into foresighted **climate risk management**.

1.3 WHAT ARE THESE GUIDELINES ABOUT?

These **Guidelines** aim to enable actors involved in regional and local risk management to **review and enhance their capacities** to manage natural hazards, compound impacts, and cascading risks triggered by extreme weather events in Alpine regions under current and future climate change. They provide a **how-to, modular, step-by-step navigation framework** guiding users through an assessment and planning process towards developing their own, context-specific solutions and delivering an action plan for climate risk management. This includes process-oriented guidance on how to review existing risk management performance vis-à-vis key climate risks, analyse gaps in practices and policy frameworks, identify action needs and policy entry points, derive and select adaptation options, formulate tailored actions and design an action plan. Structured into **modules** and **steps**, the Guidelines support users in navigating the pathways

- → from *climate-related risks* to *adaptation priorities*,
- → from *gaps* in risk management and related policy frameworks to *action needs*,
- → from *potential options* for climate risk management to *prioritised actions*,
- → from *policy entry points* to a *regional action plan*,
- → from initiating *implementation* to a framework for *iterative climate risk management*.

The Guidelines build on the **experiences and lessons learned** during a three year long process leading to Tailored Action Plans in the **pilot areas of the X-RISK-CC project**. They draw on approaches, methods and tools developed and applied in the project and use them as **examples** to demonstrate their usability and practicability and to illustrate results. Project-based applications are complemented by selected examples, methods and tools from **other authoritative sources**, including international manuals and support tools, methodological frameworks, ISO standards, and policy documents. Methods, tools

and application examples are presented throughout the workflow, in a technical Annex, or by cross-referencing to external web links.

These Guidelines **focus** on the **planning phase of climate risk management**. Its workflow requires robust climate risk information as an input and assumes that some kind of knowledge about current and future climate-related risks is already available for your region. The Guidelines thus attach to the X-RISK-CC Risk Manual, which provides a framework for regional climate risk assessment, and support translation of risk assessment results into risk management planning and future-proof solutions. In its final step, the present document gives guidance on how to move from a politically supported action plan to implementation in practice and towards a process framework for iterative climate risk management. However, more detailed guidance on the implementation process and on monitoring, evaluation, and learning is beyond the scope of this publication.

In Alpine regions, risk management follows a combination of international standards and region-specific guidelines to address natural hazards and disaster risks. Similarly, guidance and support tools as well as international standards are available for policy-making and planning in climate adaptation. The present Guidelines draw on some of these sources[2], which are referenced in endnotes. Most importantly, the process framework and structure of the guidelines is based on, and coherent with the following **international standards**: ISO 31000:2018 (Risk Management – Guidelines) for risk management; ISO 14090:2019 (Adaptation to Climate Change – Principles, requirements and guidelines) and ISO/TS 14092: 2020 (Adaptation to Climate Change: Requirements and guidance on adaptation planning for local governments and communities) for climate adaptation.

The modules and steps represent a recommended workflow, based on project experiences and above-mentioned standards. However, they can to some extent be handled in a flexible way as regards their sequence and completeness. The work steps do not necessarily need to be conducted in a strictly linear manner, and short-cuts from one module to another are possible, e.g. depending on pre-existing knowledge and other context-related specificities.

Despite drawing on existing sources for structuring the workflow and gap-filling, there are several **unique features** that distinguish the present Guidelines from other guidance documents for disaster risk management and climate adaptation:

- **Alignment of climate change adaptation (CCA) and disaster risk management (DRM) towards climate risk management (CRM):** The Guidelines intend to integrate CCA and DRR approaches by explicitly considering (future) climate change and mainstreaming CCA into existing DRM systems. Vice versa, DRM concepts and tools are taken up and applied to CCA. This integrated CCA and DRM perspective implies that the modules and steps cut across all phases of the DRM cycle (***FIGURE 2***), while the process framework follows to a large extent the concept of the iterative CCA cycle (***FIGURE 3***).
- **Focus on complex risk dynamics:** Particular attention is given to consideration of compound impacts, cascading risks, emerging climate risks, and a systemic perspective on risk management.
- **Bridging risk assessment and action:** A special emphasis is on how to translate climate risk information into actionable options, in particular by giving guidance on risk evaluation and by recommending a comprehensive gap analysis, which links climate-related key risks to constraints and action demands in existing risk management regimes.
- **Transnational perspective:** The Guidelines build on experiences in regions of Alpine countries and are generally applicable in all Alpine regions. Moreover, they highlight cross-border, transboundary and transnational aspects of planning and governance.

1.4 HOW TO USE THESE GUIDELINES?

At the core of the present Guidelines are the modules and steps in ***CHAPTER 2***, providing a process-oriented roadmap for a planning process towards a climate risk management action plan. A diagram at the beginning gives an overview of the workflow, including the necessary key input and the overall key output. Each ***MODULE*** is organised in a common structure, starting with an overview of the entire module by stating its *purpose*, listing *guiding questions* to be answered, visualising the *workflow*, and defining the *expected outcomes*. The four modules each comprise two to three ***STEPS***, which follow the same structure, providing information to the following questions:

- *What is the purpose of the step?*
- *Which inputs are needed?*
- *What does this step involve?* Description of sub-steps and how methods and tools can be applied. Examples from X-RISK-CC, complemented by materials from other sources, are used to illustrate the how-to and outcomes.
- *Which methods are applicable?* Listing of distinct methods, with examples in boxes and cross-references to external sources, where applicable.
- *Which tools are available?* Recommended tools, linking to a compendium of work aids, materials, and further illustrative examples from X-RISK-CC in the Annex.
- *Which outputs can be expected?*

The present ***CHAPTER 1*** introduces the Guidelines by stating the rationale and objective, specifying the target groups, outlining what users can expect, framing key concepts related to climate risk management, and contextualising the X-RISK-CC project. A comprehensive technical ***ANNEX*** compiles useful tools, methods, work aids, and other materials, which are cross-referenced in the modules and steps. This includes a **glossary** (→ ***ANNEX 1***) with explanations of technical key terms used throughout the document.

1.5 UNDERSTANDING OF KEY TERMS AND CONCEPTS

The following section introduces the most important key concepts and terms. Definitions and explanations have been summarized and adapted from a range of authoritative sources[3]. Further key terms are defined in the glossary (→ ***ANNEX 1)***.

CLIMATE RISK denotes the potential for adverse consequences from climate variability, climate change or climate-related extreme events for human or ecological systems and their functions. Climate risk results from the dynamic interaction of climate-related ***hazards*** with the ***exposure***, ***vulnerability*** and ***adaptive capacity*** of the affected system. It describes how, to what extent, and why climate change and weather extremes could cause harm to people, assets, sectors, or systems and, if possible, how likely adverse consequences are today or could become in the near or far future. Relevant adverse consequences include those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species.

In this document, the terms *'climate risk'* and *'climate-related risk'* are used synonymously to refer to potential consequences that are driven by climatic factors. While 'climate risks' refer to any current or future risk related to the changing climate that can lead to extreme weather events and slow-onset processes (i.e., related to gradually changing temperature or precipitation regimes), the focus of the X-RISK-CC project and the transnational guidelines presented in this publication is on changing *weather extremes* as a trigger for natural hazards. The concept of 'climate risk' focuses on the adverse and severe consequences on relevant human and ecological systems that need to be managed, i.e. that should be avoided or reduced. It offers a system perspective that considers the complex interplay of climatic and non-climatic *risk drivers* (hazard, exposure, vulnerability, and other underlying risk drivers). The system perspective considers in particular the importance of ***compound risks*** – where multiple hazards occur simultaneously or sequentially – and ***cascading impacts***, where an initial

hazard sets off a chain of effects across systems or sectors, whose resulting impact is significantly larger than the initial impact. Understanding these complex dynamics is essential for developing integrated, cross-sectoral approaches to risk assessment, *risk management* and disaster *preparedness*.

CLIMATE RISK MANAGEMENT, as applied in this guidelines document, means all policies, actions, measures, tools and mechanisms to avoid and reduce current and future climate-related risks, i.e. to avert, minimize and address losses and damages that may result from potential impacts related to natural and climate-induced hazards. Climate Risk Management integrates ***Disaster Risk Reduction (DRR)*** and ***Climate Change Adaptation (CCA)***, including *risk transfer* and financing mechanisms (such as insurance) to address damages and losses from *residual risk*.

The management of current risk to climate extremes is typically covered by existing ***Disaster Risk Reduction*** systems, which include the strategic and instrumental measures employed for preventing new and reducing existing disaster risk and managing residual risk, typically by reducing existing exposure, hazard, or vulnerability under current climatic conditions. Disaster Risk Reduction is the policy objective of ***Disaster Risk Management (DRM)***, which applies strategies, policies and measures for continuous improvement of disaster *prevention*, *preparedness*, *response* and *recovery* practices to strengthen *resilience*. However, traditional DRM approaches often rely on historical events, using past experiences, observations and statistical data to design *structural* and *non-structural risk management measures*, which may fail to account for increasing intensity and frequency of extreme meteorological events due to climate change, leaving Alpine regions insufficiently prepared for new or unprecedented weather extremes.

CLIMATE CHANGE ADAPTATION (CCA) is the process of adjustment to actual or expected climate change and its effects, in order to moderate harm or exploit beneficial opportunities. CCA explicitly considers future and long-term climate change, its influence on changing intensity and frequency of climate extremes, and emerging climate risks. However, where CCA strategies and plans exist, they often underestimate the severity of extreme events and frequently lack actionable measures to manage associated compound and cascading risks.

Climate Risk Management (CRM) combines both CCA and DRR as integral components of managing climate-related risks and understands measures of both realms as complementary parts of the same toolbox, aiming at the smartest and most effective policy mix for a given situation. Essentially, CRM systematically considers future climatic and non-climatic developments and seeks to adapt existing DRR/DRM approaches to new challenges arising from climate change. It requires mainstreaming of CCA into DRM systems, i.e. natural hazard management and civil protection, as well as, vice versa, uptake of DRM methods and practices into CCA. CRM aims to reduce climate-related risks mainly by lowering the – generic and specific - vulnerabilities of exposed systems, containing or reducing the degree of exposure to climate-related hazards, mitigating cascading impacts, enhancing *adaptive capacity*, and by direct protection against hazards (e.g., flood defences). The overall goal of CRM is to support climate-resilient development.

FIGURE 1 illustrates the components and interactions that shape ***climate-related risk***, particularly in the context of extreme events under climate change, and the entry points for ***Climate Risk Management***. Triggered by climatic extremes (such as heavy precipitation), a climate-related *hazard* (such as a flood, debris flow or drought) interacts with *exposure* (who or what is in harm's way), *vulnerability* (how prone people and assets are to harm), and available *risk management capacity* (resources and policies in place to reduce risk), which are influenced by other underlying *risk drivers* (such as demographic development or urban development into hazard zones). These interactions, which may involve *cascading* and *compound impacts*, determine the overall *risk* to natural and human systems, their assets and functions. Actions of climate risk management seek to reduce risk and to strengthen *resilience* by reducing hazards, exposure, vulnerability and impacts.

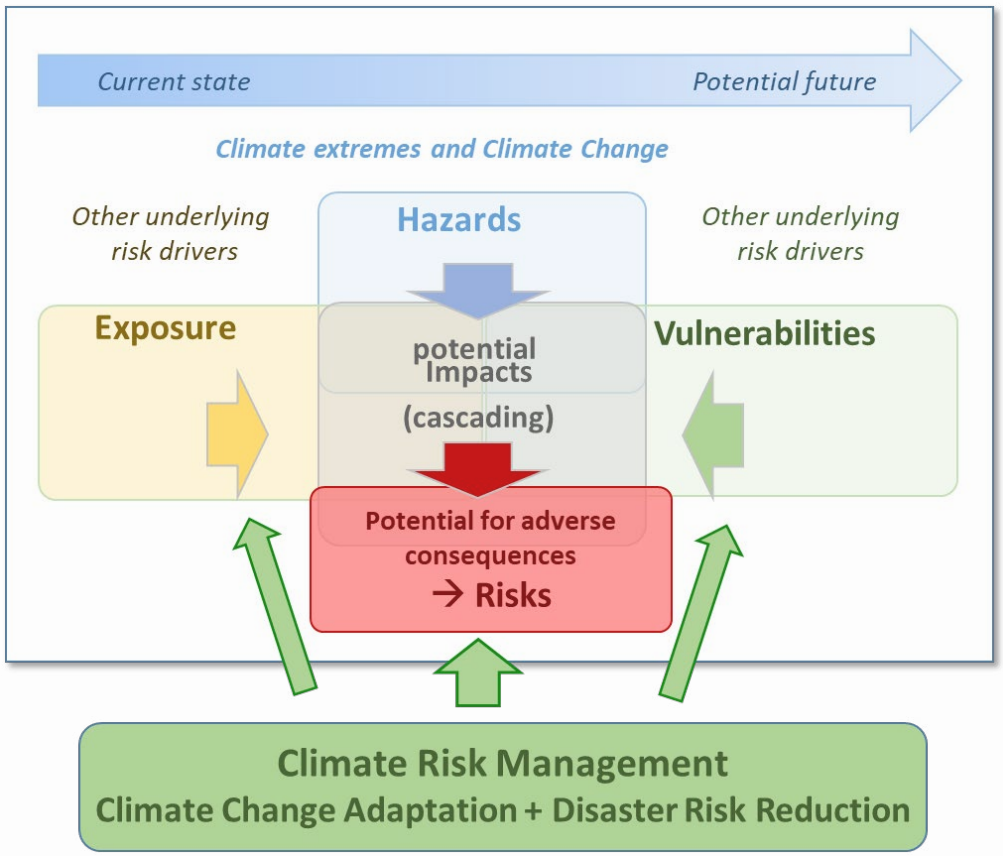
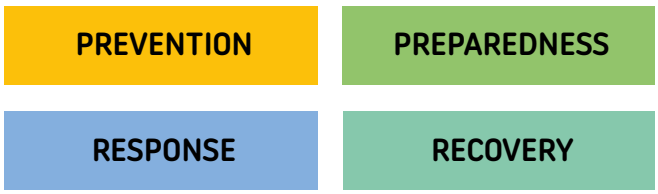


FIGURE 1: *Key components and interactions shaping climate-related risk and the role of climate risk management in reducing risk (source: Zebisch et al., 2023[4]; modified)*

The **DISASTER RISK MANAGEMENT (DRM) CYCLE** is a well-established, tried and tested tool for systematic planning, organisation, coordination, and continuous improvement of disaster risk management. It provides a structured and iterative process framework directed at avoiding and reducing risks and enhancing resilience. As illustrated by ***FIGURE 2***, this established process involves a continuous cycle of interconnected actions, which are traditionally organised in the following main phases:



These main phases of the DRM cycle overlap, with the transitions between phases (interphases) requiring particular attention to avoid coordination deficits and gaps in risk management.

Activities and measures taken in advance to anticipate, respond and recover from the impacts of a hazardous event. Preparedness aims to build the capacities for ensuring rapid and effective response and for efficiently managing emergencies before a disaster strikes.

Preparedness measures include forecasting and early warning systems, emergency and evacuation planning, standard operating procedures, training and field exercises, resource pre-positioning, public awareness campaigns, and establishment of coordination mechanisms.

Actions taken directly before, during and immediately after an emergency to save lives, reduce impacts, ensure public safety, meet basic subsistence needs and quickly repair the most needed infrastructure. Effective and timely response and disaster relief require the coordinated intervention of all civil protection actors, individuals, and communities.

Response measures include effective coordination, emergency protocols, relief operations, search and rescue, evacuation, emergency communications, and immediate humanitarian assistance.

Measures and activities to avoid or mitigate existing and new disaster risks. Prevention aims to completely avoid the potential adverse impacts of hazardous events, to reduce the chances of a risk incident occurring, and/or to reduce the extent of damage if a disaster occurs. Prevention supports acceptable levels of risk society is willing to live with.

Structural measures include technical protection infrastructure (e.g., dams, embankments), nature-based solutions (e.g., floodplains), retention basins, and property-level asset protection measures.

Non-structural measures include hazard and risk assessments, hazard zone maps, land-use regulations, preventive spatial planning, education, and communication.

Actions taken after a disaster to cope with its effects, restore livelihoods and health, and rebuild resilient critical infrastructures, services, housing, and facilities, aligned with 'build back better' principles to enhance future resilience. Sustainable recovery integrates post-event learning, adaptive management and long-term thinking.

Recovery measures include sustainable restoration of infrastructure and services, damage compensation and reconstruction financing, psychosocial support, participatory reconstruction planning, post-event learning mechanisms, and re-adjustment of risk management frameworks.

FIGURE 2: *The Disaster Risk Management (DRM) Cycle*

In Climate Change Adaptation (CCA), the **ADAPTATION CYCLE** is the established and most widely acknowledged process framework for adaptation policy-making and planning, used by the European Union and all European countries. It is coherent with the UAE Framework for Global Climate Resilience[5], which was adopted by the UNFCCC as a central instrument for operationalising its Global Goal on Adaptation. Like the DRM cycle, the adaptation cycle describes an iterative process, whose steps are in practice not always strictly sequential and may tend to overlap or intermit. ***FIGURE 3*** shows the adaptation policy cycle, as conceptualised and used by the Climate-ADAPT Adaptation Support Tool.

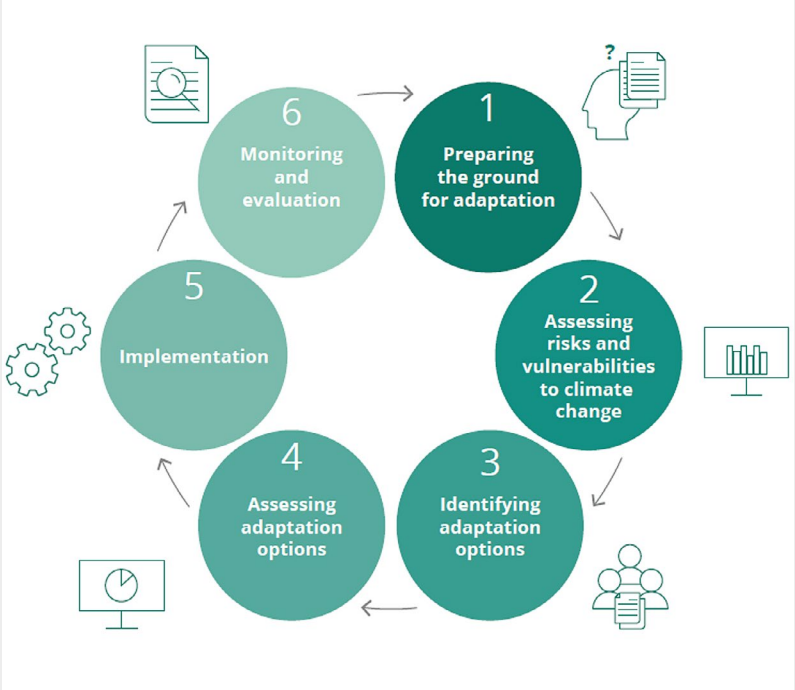


FIGURE 3: *Adaptation Cycle, based on the Climate-ADAPT Adaptation Support Tool (source: EEA, 2022: p. 9)*[6]

In line with their intention to align DRM and CCA, the present Guidelines for regional CRM combine the concepts of the DRM cycle and the CCA cycle. The process framework of the Guidelines is mostly based on the CCA cycle, while all modules and steps require consideration of all phases of the DRM cycle.

DRM and CCA are, up to date, largely different policy fields with different methodologies, traditions, and communities of practice. Both share common goals and many similarities, but they also differ with regard to a range of characteristics (→ ***TABLE 1***). Increasing coherence between both fields by aligning them towards Climate Risk Management allows capitalising on the strengths of both areas, exploiting synergies, and delivering more effective and efficient risk reduction.

Disaster Risk Management (DRM)	Climate Change Adaptation (CCA)
Common objective: *Prevention and reduction of disaster risks by reducing vulnerability and increasing resilience*	
Short- to mid-term management of climate- and non-climate-related risks	Long-term adjustment to actual or expected climate change and its effects on extreme events and slow on-set processes
Focus on present and addressing existing risks, based on previous experience and knowledge of the past, not systematically considering climate change as a driver of risk	Focus mainly on future and addressing new risks of current and future climate change, including their uncertainty
Addressing all hazard types, including geophysical, hydro-meteorological, biological, and technological hazards	Addressing mainly weather- and climate-related hazards, including their impacts on natural hazard processes (e.g., floods, landslides)
Mainly actors in civil protection, security and emergency management administrations and agencies	Mainly actors in environmental administrations and agencies
Mainly done within the existing frame of processes and structures within a system	Learning and adjustment or fundamental changes of system components, processes or structures
Climate Risk Management: *Moderate or avoid harm linked to impacts of climate-related extremes and climate change*	

TABLE 1: *Characteristics and main differences between climate change adaptation and disaster risk management (based on: EEA, 2017; Zebisch et al., 2023)*[7]

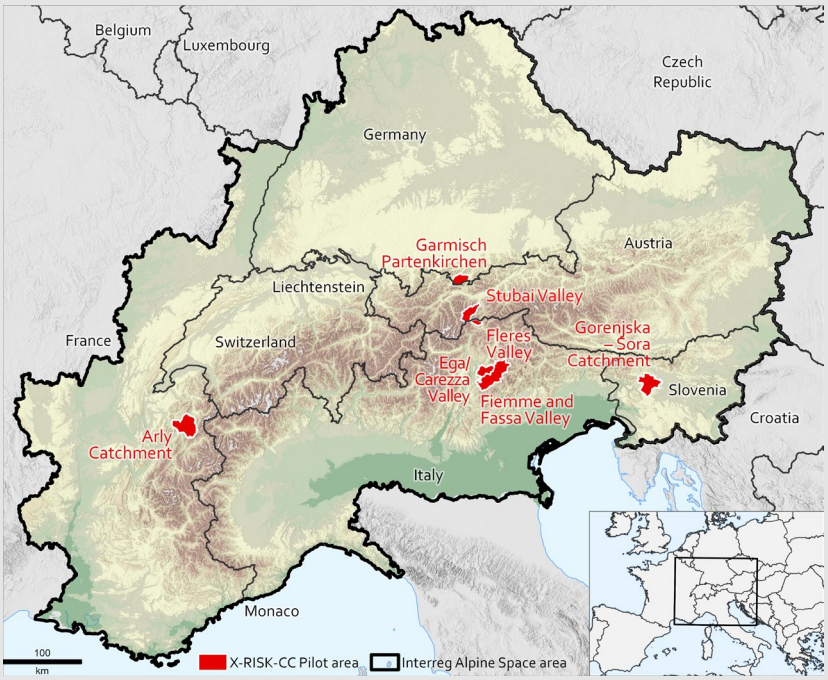


FIGURE 4: *Location of the X-RISK-CC pilot areas across the Alps*

1.6 ABOUT X-RISK-CC

The X-RISK-CC project supports risk managers and policy makers in addressing the risks of climatic extremes by developing new and harmonised Alpine-wide data and knowledge on past and future extremes, local risk management actions and transnational guidelines and action proposals. The X-RISK-CC partnership includes regional risk managers, national authorities, scientists and members of EUSALP AG8, PLANALP and the Alpine Climate Board (ACB). The project results explicitly address the need for shared knowledge, actions and solutions to manage weather extremes in the context of climate change.

Actions to upgrading of current risk management and climate adaptation actions have been co-designed with risk managers in real-world pilot areas across the Alpine Space, including cross-border regions. Representing a distinct geographical, socio-economic, and climatic context in different Alpine countries and focussing on different prioritised risks, each pilot area has conducted an assessment of current and future weather extremes, climate-related hazards and risks, analysed risk management gaps, and developed tailored action plans for enhancing future risk management. The map in ***FIGURE 4*** shows the location of the pilot areas within the Alpine region.

Full documentation of all project outcomes is available at the project website of the Alpine Space Programme and included in a dedicated module at CAPA – Climate Adaptation Platform for the Alps. Both sources give access to all outputs listed in ***BOX 1***.

BOX 1: Further reading: Overview of project outcomes

Transnational outputs

- Action Proposals for Managing Climate Risks of Weather Extremes in the Alps. Synthesis of outcomes and transnational policy recommendations of the X-RISK-CC project.
- Transnational Guidelines for Managing Current and Future Climate Risks Related to Weather Extremes in Alpine regions
- Risk Manual. Assessing Compound and Cascading Risks of Weather Extremes in the Alpine Space under current and future climate
- X-RISK-CC WebGIS of Alpine-Wide Climate Extremes (with Digital Library)

Pilot area outputs

- Reports on past and future weather extremes in pilot areas
- Report on past and future (compound) hazards in the pilot areas
- Report on past and future risk pathways in the pilot areas
- Pilot Dossiers
- Tailored Action Plans for Risk Management Improvement

2. MODULES AND STEPS: PLANNING FOR CLIMATE RISK MANAGEMENT

The following diagram gives an overview of the workflow towards a regional climate risk management action plan, structured in modules and steps, and building on a preceding assessment of regional climate-related risks (→ X-RISK-CC Risk Manual).

INPUT: **Regional climate risk assessment**

MODULE 1: **Prepare the ground for climate risk management and identify main concerns**

Step 1: Pre-planning and preparing the process

Step 2: Collating and translating the findings of the risk assessment, prioritising key risks and identifying strategic adaptation priorities

Outcome:
- Implementation plan for developing CRM action plan
- Key climate risks requiring action
- Adaptation priorities and strategic directions for CCA + CRM planning

MODULE 2: **Identify, analyse and prioritise gaps, action needs and entry points in risk management and policy frameworks**

Step 1: Bottom-up gap analysis (local risk management gaps)

Step 2: Top-down gap analysis (policy frameworks)

Step 3: Cross-analysing and prioritising gaps

Outcome:
- Critical gaps and needs in climate risk management at different governance levels
- Prioritised key risk management gaps with urgency to act, incl. policy context

MODULE 3: **Derive adaptation and risk management options**

Step 1: Identify potential CRM actions

Step 2: Assess, prioritise and select CRM actions

Outcome:
- Catalogue of suitable CCA and CRM options
- Agreed portfolio of preferred CCA and CRM actions

MODULE 4: **Prepare an action plan and initiate implementation**

Step 1: Design action plan and secure political approval

Step 2: Initiate implementation and establish mechanisms for monitoring, evaluation and learning

Outcome:
- Adopted climate risk management action plan
- Short-term implementation roadmap and framework for iterative climate risk management

RESULT:

Action plan for managing regional climate risks with ongoing implementation process, embedded in framework for iterative climate risk management

FIGURE 5: *Workflow for developing a regional action plan for climate risk management and initiating its implementation*

2.1 MODULE 1

Prepare the ground for climate risk management and identify main adaptation concerns

Purpose of this module

To prepare the foundation for the planning process towards an action plan for regional climate risk management in terms of objectives, scope, capacities, framework conditions, process organisation and identification of adaptation priorities. Furthermore, users will collate the results of a preceding risk assessment to make them usable for planning and decision-making, resulting in identification of climate-related key risks that require further action.

The following two steps guide the user through the pre-planning phase and the risk evaluation phase, both preparing the ground for developing a climate risk management action plan. The scoping phase includes assembling the planning team, structuring the process, planning stakeholder engagement, and collecting relevant information (→ ***MODULE 1: STEP 1***). Identifying the climate-related key risks is needed to inform the setting of strategic priorities for adaptation and climate risk management. It is based on evaluation of risk severity and the risk tolerance of stakeholders, building on expert judgments and community-based prioritisation (→ ***MODULE 1: STEP 2***). The desired outcome is a road map with climate risk management priorities, including a mandate to develop an action plan, clear roles and responsibilities, and the necessary resources.

Guiding questions

Step 1

- → What is the main objective of the risk management planning process?
- → What is the spatial and temporal scope?
- → Who is the process owner? Who mandates the planning process?
- → What resources (staff, budget, time, expertise) are required and available?
- → Which regional experts and practitioners should collaborate, and how to organize the collaboration process?
- → Who are the key actors and stakeholders, what are their roles and interests, and how to involve them in the planning process?
- → Do relevant risks and/or potential risk management actions have transboundary dimensions?
- → Which risk management and adaptation measures are already in place or planned? What are relevant policies, regulations and plans?

Step 2

- → How can the results of a preceding regional risk assessment be translated for decision-making and risk management planning?
- → How severe are the identified climate-related risks?
- → Which risks are acceptable, and which intolerable to affected stakeholders?
- → What are the severe climate-related key risks requiring action?
- → Which priorities and objectives can be derived for adaptation and risk management?

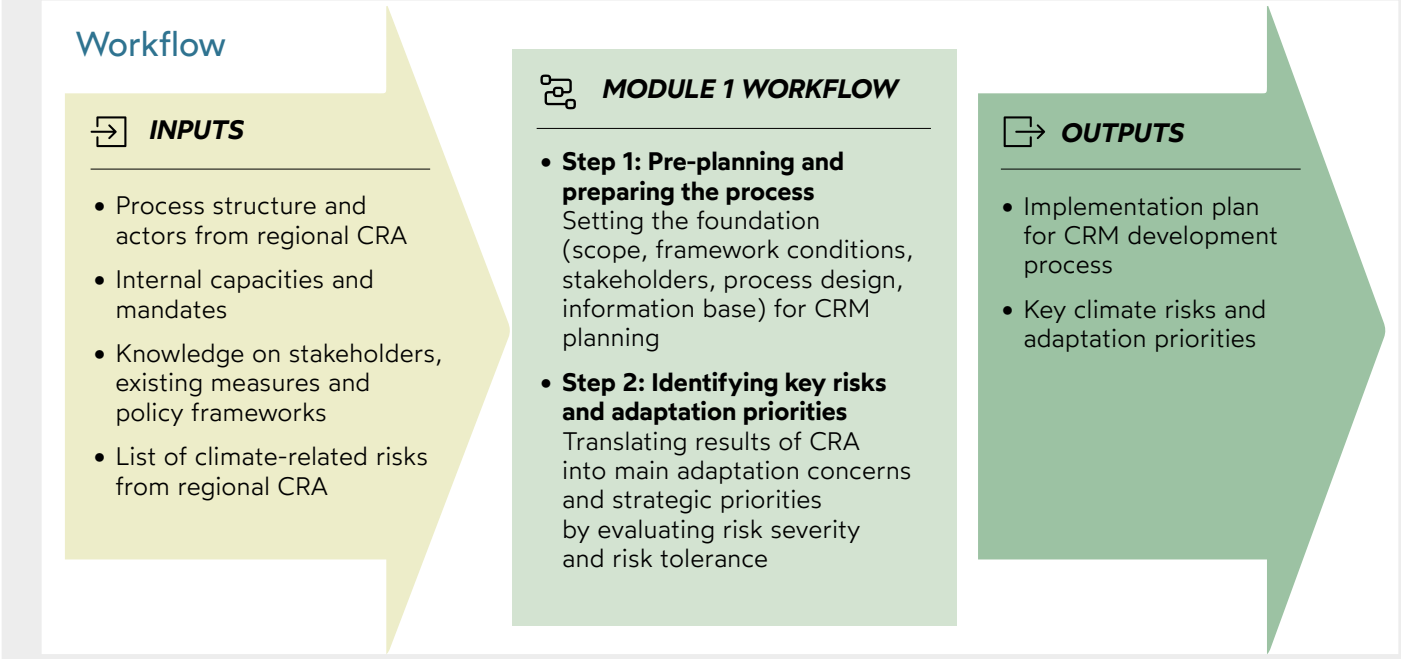


FIGURE 6: *Overview of workflow for Module 1*

Expected outcome

- Implementation concept and operational framework for developing a climate risk management plan, including:
  - objectives, scope, mandate, resources, and timeline
  - structured process design with team members and responsibilities, participating stakeholders and roles
  - stakeholder engagement and communication plan
  - processed information on existing measures and relevant policy contexts
- List and description of climate-related key risks requiring action
- Priorities, strategic directions and objectives for CCA and CRM planning

STEP 1: PRE-PLANNING AND PREPARING THE PROCESS

Purpose of this step: To set up the process for developing a climate risk management action plan by determining its scope, securing the (political) mandate and the required resources, planning a structured process with clear roles and responsibilities, identifying stakeholders and preparing their engagement, and collecting information on existing measures and the policy context.

Pre-planning involves the activities and arrangements that build the basis for a structured and successful risk management review and planning process. By establishing the necessary framework conditions, capabilities, resources and other means, it prepares the involved actors to conduct the steps required for formulating a climate risk management plan and initiating its implementation. This step is also be referred to as scoping.

Which inputs are needed?

- *If you have already conducted a regional climate risk assessment, e.g. based on the X-RISK-CC Risk Manual*: Operational framework (scope, project team, stakeholder network, etc.) established for the preceding risk assessment (→ Risk Manual: Scoping phase) as starting point
- Internal capacities and mandates
- Overview of relevant stakeholders
- Knowledge of regional status quo of risk management and adaptation
- Existing strategies, plans and regulations
- Good practices from other regions

What does this step involve?

Framing the climate risk management process: This preparatory activity serves to gain a clear understanding of the *purpose*, *context* and *boundaries* of the planning process. It involves determining the concrete objectives, delimiting the project scope in terms of spatial boundaries (e.g., a regional political-administrative unit, a cross-border region, a geographical area or a specific eco-functional spatial system, such as a catchment area) and temporal planning horizons (short-term, mid-term, long-term) as well as identifying the policy context (e.g., affected policy fields, division of competences across levels, legislative and institutional frameworks). If based on a preceding regional climate risk assessment (→ X-RISK-CC Risk Manual), the framing may already consider relevant hazards and risks, impacted sectors, exposed assets at risk, and vulnerable social groups. The framing should result in an agreement on the objectives of the risk management planning process and the approaches to be used.

Obtaining political or administrative commitment and securing support: Political will and commitment of responsible decision makers, e.g. a regional or local government or a competent public authority (e.g., regional civil protection authority) are best expressed in a *robust mandate* to engage in a risk planning process. Long-term political commitment safeguards continuity of the planning process beyond the legislative period. Higher-level support provides motivation to participating actors, strengthens their legitimation within their own organisations, and contributes to reducing local resistance and building acceptance.

Estimating and mobilising the required resources: Development of a risk management plan requires sufficient resources in terms of *staff capacities, budget, committed individuals, expertise, access to data, and work time*. Inversely, the scope of the process has to be adjusted to the amount of available resources. The political or institutional mandate for starting such a process needs to go hand in hand with reliable allocation of sufficient resources.

Establishing a planning team and setting up the process in a structured way: Structured process planning involves assigning overall *process ownership* to an (institutional) *lead actor* and appointing a *core team* with decision-making capacities that acts as a steering group. You may also consider assembling a *facilitation team* that manages, supports and enables the process throughout its different stages. The precise responsibilities and roles of core team and facilitation team may be context-dependent but should be clearly defined and agreed upon in a first meeting of the planning team. The same applies to the internal rules of decision-making, collaboration and communication. Composition of the core team and the entire planning team should be based on the competences and expertise required by the planning process, ensuring adequate and representative coverage of institutions, policy fields, sectors, and technical disciplines that are affected by, and needed for, the preparation of risk management measures (e.g. from natural hazard management, civil protection, emergency response, spatial planning, climate adaptation, forest management, providers of critical infrastructure and services). It is particularly recommended to embed cooperation between DRR and CCA communities of practice in the planning team. In the case of more complex processes with broad issues and diverse team members, it may be appropriate to set up *thematic working groups*.

Organising stakeholder engagement and external collaboration: Managing climate-related risks is a complex and cross-cutting process that affects a potentially *diverse range of stakeholders* from various policy fields, administrative areas, and sectors, encompassing political decision-makers, public authorities, risk management practitioners, specialized technical service institutions, sector representatives, infrastructure providers, private businesses, NGOs, citizens, neighbouring regions and municipalities as well as representatives of higher governance levels. ***EXAMPLE 1*** shows the stakeholder institutions represented in the participatory process in one of the pilot areas of the X-RISK-CC project and illustrates their distribution across different levels of governance. Engaging a diverse group of stakeholders is recommended to adequately *account for compound and cascading risks*, which can materialise in unexpected locations and affect exposed sectors, assets and interests in unexpected ways. Continuing collaboration with the same stakeholders as in the regional risk assessment phase (→ Risk Manual) is beneficial, but working on risk management solutions may require also inclusion of actors that are closer to policy-making and operational management. To facilitate systemic perspectives on risk management and pave the way for integrated solutions, it is important

to involve practitioners that are active and have experience in all phases of the DRM cycle, from prevention to recovery. Involvement of interested and affected parties is needed and beneficial throughout the different steps of the planning process. Stakeholder participation is crucial for accessing and integrating local knowledge and expertise, improving quality and usability of decision-making and results, strengthening legitimacy and acceptance of outcomes, and improving ownership and commitment to implementation. It can also fulfil important coordination and capacity-building functions, and networks, relations and trust built during the process can greatly facilitate subsequent implementation, paving the way for smooth cooperation beyond the planning process. When working towards a climate risk management plan, stakeholders may be involved in elicitation of key climate-related risks (→ ***MODULE 1: STEP 2***), bottom-up analysis of risk management gaps (→ ***MODULE 2: STEP 1***), prioritisation of key gaps (→ ***MODULE 2: STEP 3***), development and selection of risk management options (→ ***MODULE 3: STEP 1*** and ***STEP 2***), and allocation of risk ownership for implementation of measures (→ ***MODULE 4: STEP 1***). To fulfil these functions, stakeholder engagement should start early on and happen in a timely, regular, well-planned and professional manner. Organising stakeholder participation builds on *mapping, analysis and selection of relevant actors* and requires sound planning of their engagement and transparent communication. Engagement should be prioritised based on influence and interest. Mapping stakeholder roles early on improves coordination and management of expectations. Special care should be given to involving vulnerable and otherwise underrepresented social groups, such as representatives of elderly or health-impaired people, non-native speaking residents, or second homeowners.

EXAMPLE 2 visualises the generic workflow of the structured stakeholder participation processes in the X-RISK-CC pilot areas, comprising three main phases, which were addressed through dedicated workshops and expert consultations in each pilot area to co-develop customized local action plans. In addition, local dissemination events were conducted to communicate the outcomes to the general public.

EXAMPLE 1:

Stakeholders involved in the risk assessment and risk management planning process in Sora Catchment (Slovenia)

Stakeholders participating in workshops in the Sora Catchment pilot area (all three workshops):

- Administration for Civil Protection and Disaster Relief
- Center for Sustainable Rural Development Kranj
- Chamber of Agriculture and Forestry of Slovenia (Regional Unit Kranj)
- Civil protection and firefighter unit
- Development Agency Sora
- Development Centre of the Heart of Slovenia
- Environmental Agency Slovenia (ARSO)
- Komunala Škofja Loka d.o.o. (public utility company)
- Local Energy Agency of Gorenjska
- Local fishing associations
- Municipality of Škofja Loka
- Municipality of Železniki
- Municipality of Gorenja vas-Poljane
- Municipality of Žiri
- Radio SORA
- Slovenia Forest Service, Regional Unit Kranj
- Slovenian Water Agency

Distribution of participants across governance levels in the Sora Catchment pilot area (2nd workshop):

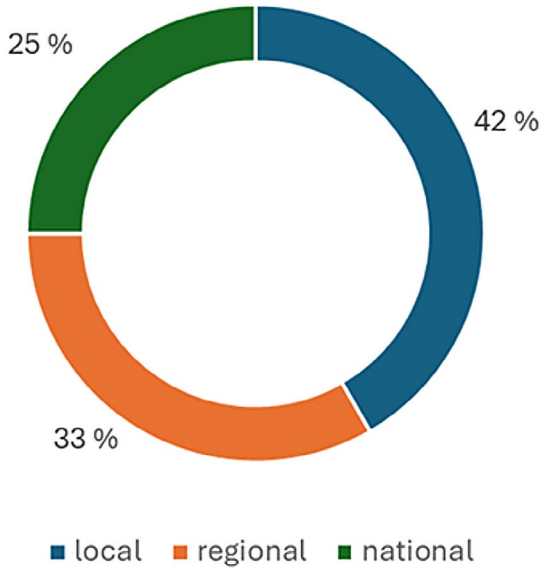


FIGURE 7: *Participants to the 2nd workshop in the Sora Catchment Valley pilot area (Slovenia) according to their affiliation to governance levels (© X-RISK-CC, 2025)*

EXAMPLE 2:

Overview of stakeholder engagement processes in the X-RISK-CC pilot areas

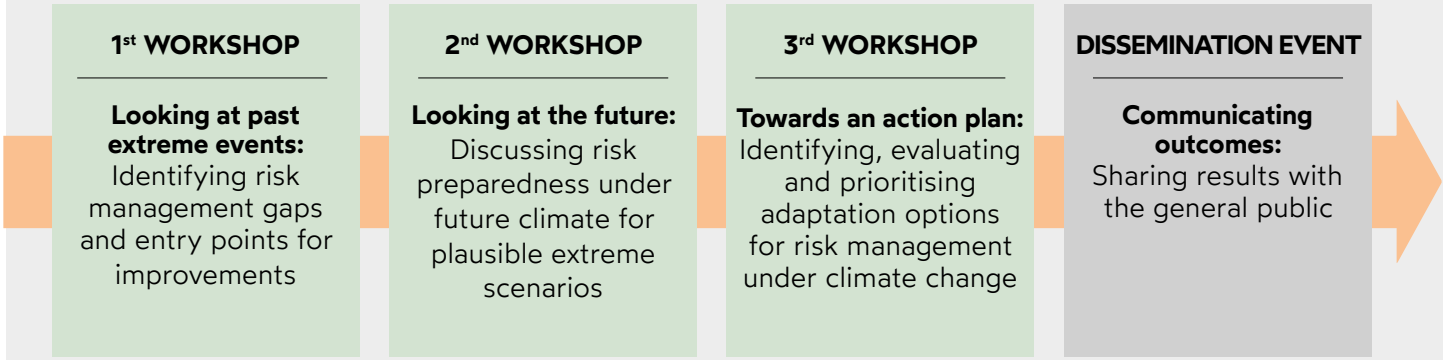


FIGURE 8: *Common workflow of the stakeholder engagement process in the X-RISK-CC pilot areas for reviewing existing risk management practices and developing actions for upgrading future risk management in the context of climate change (© X-RISK-CC, 2025)*

Considering the need for transboundary cooperation: Climate change impacts and climate-related hazards do not stop at borders, risks can cascade across national boundaries, and adaptation measures can affect areas on both sides of borders differently (e.g., upstream and downstream of river systems). If your region is situated in a cross-border setting, features transboundary hazard hot spots, and there is a need to manage border-crossing resources and exposed assets (such as shared catchment areas or transport infrastructure), the required risk management measures, such as interoperability protocols for early warning systems or shared response measures, will benefit from coordination and cooperation across national jurisdictions. In such situations, it is thus important to involve stakeholders from neighbouring regions in a transboundary approach.

Collecting and reviewing relevant information and considering the policy context: Collecting, reviewing and processing available information and data aims at establishing a robust information base to support development of the climate risk management plan. This involves getting an overview of existing risk management and adaptation measures, ongoing implementation initiatives or planning processes, and policies and plans relevant to climate risk management in your region. This information will be needed in later steps of the process (→ ***MODULE 2***; → ***MODULE 3***; → ***MODULE 4***). It also helps ensuring that no duplication of activities occurs, potential synergies and conflicts are identified, interdependencies and coordination needs across levels, sectors and neighbouring territories are considered, and your risk management planning is consistent and coherent with other internal or external policies. Consultations with stakeholders and experts involved in the project can be used to identify information sources. Collating relevant information may include:

- existing adaptation and risk management measures in your region;
- good practices and catalogues of adaptation and risk management options from other regions;
- climate adaptation and disaster risk management strategies and plans at higher-ranking (e.g. subnational, national or transnational) levels;
- adaptation and risk management activities and plans of relevant sectors (e.g., forest management, water management, spatial planning) and actors in your own region and in neighbouring and cross-border regions;
- legal requirements, standards, and norms.

Which methods are applicable?

- **Scoping:** It clarifies purpose, context and system boundaries of risk management planning and sets up a structured process.
- **Stakeholder mapping** and **stakeholder analysis:** It identifies relevant stakeholders, their roles and interests and allows planning of stakeholder engagement.

BOX 2: Stakeholder mapping

Stakeholder mapping is a method for identifying, analysing and categorizing actors that are impacted by potential adverse consequences of climate-related risks, are needed to design and implement robust adaptation and risk management measures, and/or are affected by these measures. Stakeholders can be analysed according to criteria such as their affiliation to sectors or spheres of societal organisation (public, private), their state of knowledge, or their influence, agency and interest. The goal is to identify key actors dependent on the context of the project, achieve representative participation, understand their interests and influence, and build collaborative strategies for climate risk management. The stakeholder mapping informs the choice of strategies and formats for participation in the planning process.

- **Desktop research** and **consultations with experts and stakeholders:** To identify, gather and process information, data and policy documents relevant to planning regional climate risk management.
- **Basic project management**

Which tools are available?

- **Annex 1**: Lessons learnt from implementing stakeholder engagement processes in practice
- **Further reading**: Recommended external resources about good practices, tools and formats for planning and implementing stakeholder interactions in climate adaptation and risk management processes:
  - **Actor selection and analysis for adaptation planning.** In: Methods and Tools for Adaptation to Climate Change. A Handbook for Provinces, Regions and Cities. Part 2 – Methods and Tools: D1 (p. 103 – 107)
  - German Environment Agency (2019): **Adapting to Climate Change: Good Participation Practice in the Alpine Region**. Deliverable of the Alpine Space project GoApply.
  - **10 Steps for Stakeholder Engagement in Climate Risk**. Councilfire.
  - **Formats for stakeholder interaction.** In: Methods and Tools for Adaptation to Climate Change. A Handbook for Provinces, Regions and Cities. Part 2 – Methods and Tools: D3 and D4 (p. 109 – 115)

Which outputs can be expected?

- **Implementation plan,** equipped with **mandate** and **resources,** and **operational framework** for developing a climate risk management plan in a participatory approach

STEP 2: COLLATING AND TRANSLATING THE FINDINGS OF THE RISK ASSESSMENT, PRIORITISING KEY RISKS AND IDENTIFYING STRATEGIC ADAPTATION PRIORITIES

Purpose of this step: Preparing and translating results of the risk assessment for the needs of decision-making, risk management planning, and the involved experts and stakeholders. This involves evaluating the severity of climate-related risks and selecting key risks where action is needed, thus guiding the setting of strategic priorities for adaptation and climate risk management.

This step assumes that some kind of regional climate risk assessment is already available for your region. It intends to link the technical, science-based assessment of climate-related risks to management and planning in a policy context. If you have conducted a risk assessment following the workflow of the X-RISK-CC Risk Manual, you have already identified a list of relevant risks and conducted a detailed analysis of prioritised risks. In that case, it is possible to start

working directly with the outcome of the preceding risk assessment by moving to ***MODULE 2***, where you will work on gaps and entry points for managing the identified key risks. However, it is recommended to revisit the results of the risk assessment and to re-evaluate the identified risks in terms of their severity and the risk tolerance of affected stakeholders. If, otherwise, the range of risks identified should still be too broad and information about severity too unspecific and incomplete to allow priority-setting for risk management planning, then this step will provide guidance on how to evaluate risks, select key risks, and identify main concerns for adaptation and risk management.

Which inputs are needed?

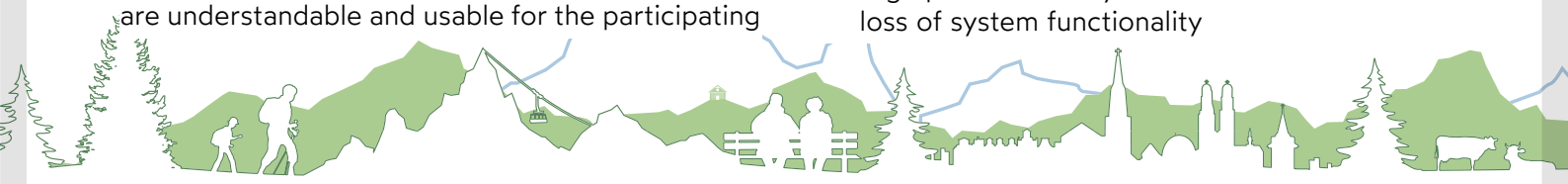
- → Outcome of regional climate risk assessment (→ X-RISK-CC Risk Manual): Risk report with
  - List of identified relevant climate-related risks
  - Risk factsheets for each specific climate-related risk, with summarized information on the main factors and drivers influencing current and future risk (hazards, exposure, vulnerability, risk management capacity, underlying risk drivers, systemic interactions) and, if available, a qualitative rating of their importance for the overall risk (e.g., high, moderate, low)
- → Expertise provided by risk experts
- → Expert-based inputs to community-based stakeholder workshops
- → Perspectives, local contextual knowledge, and risk preferences of stakeholders

What does this step involve?

Collating, preparing and communicating the results of the regional risk assessment for the risk management planning process: It is of vital importance that all experts active in the planning team and all stakeholders involved in the planning process understand the outcomes of the preceding risk assessment. As developing a regional risk management plan requires active participation of decision makers and practitioners, it is assumed that not all actors involved in developing the regional risk management plan will have taken part in the risk assessment or will be familiar with its more technical aspects. The knowledge about the relevant climate-related risks identified in the risk assessment report thus needs to be prepared, translated and communicated in ways that are understandable and usable for the participating risk management experts and stakeholders. In order to prepare the ground for identifying main adaptation concerns and setting strategic directions, conducting a focused analysis of risk management and policy gaps (→ ***MODULE 2***), deriving adaptation options and selecting risk management actions (→ ***MODULE 3***), it is necessary that all participants in the planning process acquire a solid understanding of the severity of specific risks, how hazards, exposure, vulnerability, adaptive capacity, and underlying risk drivers contribute to generating that risk, and what sectors, areas, and assets are potentially affected by adverse consequences.

Evaluating the severity of risks by applying risk criteria: Risk evaluation means estimating the severity of risk based on criteria and drawing conclusions from the risk assessment with respect to risk tolerance as well as the demand and urgency for risk reduction measures. Its goal is to *identify key climate-related risks* that need to be managed, i.e. avoided or mitigated. Identification of key risks thus sets the strategic directions for the further risk management planning process, enabling development of measures that focus on reducing the most severe risks with the highest urgency to act. Key risks are defined as risks that have potentially severe consequences for humans and social-ecological systems resulting from the interaction of climate-related hazards with vulnerabilities of societies and exposed systems. If risk evaluation has not already been done as part of the regional risk assessment, the following, widely acknowledged *criteria for 'key risks'*[8] (→ ***BOX 3***) can be used to assess the severity of risks and prioritise key risks in an objective and traceable way. While magnitude and likelihood have ideally already been assessed in the risk analysis phase of the regional risk assessment (→ X-RISK-CC Risk Manual), the other criteria are an integral part of risk evaluation:

- → High magnitude of potential adverse consequences
- → High likelihood of severe consequences
- → Importance of the system at risk
- → Temporal characteristics of the risk
- → Irreversibility of consequences
- → Low ability for risk reduction
- → High potential for cascading effects across system boundaries
- → High potential for systemic effects with loss of system functionality



Risk evaluation matrices can be used to assess each of the abovementioned criteria and to rate the level of severity by means of qualitative, colour-coded scales (e.g., ranging from very high or catastrophic to low or negligible severity). Assessment of the severity of consequences is based on quantitative data, where available from the risk assessment, and on qualitative information. As typically quantitative data availability is limited in regional or local risk assessment settings, data-driven and indicator-based approaches will often not be possible. Applying the risk criteria will thus often need to rely on *qualitative expert judgments*, e.g. based on literature review and experience-based expertise, and on *stakeholder involvement* in the frame of bottom-up, participatory evaluation exercises. Risk matrices also allow combining severity ratings for different criteria, such as magnitude and likelihood of consequences. ***FIGURE 9*** shows an example of a risk matrix that supports an aggregate risk severity evaluation, based on the criteria listed above and described in more detail in ***BOX 3***. Further risk matrices facilitating structured and transparent evaluation are available in ***ANNEX 2***, including an application example in ***ANNEX 3***.

BOX 3: Criteria for evaluating risk severity

- **Magnitude of consequences:** Magnitude characterises the degree to which a system is affected should a specific risk materialise. An assessment of magnitude can include aspects such as: the degree of adverse consequences (i.e. the level of damage and loss); the size or extent of a system (e.g., the extent of an area affected); the pervasiveness of the consequences across the system (e.g., geographically or in terms of affected population); potential for exceeding impact thresholds or local tipping points. Ideally, magnitude is assessed as part of a preceding risk assessment.
- **Likelihood of consequences:** A higher likelihood, especially of serious consequences, a priori represents a greater risk. The probability of consequences is usually described or classified at least in qualitative terms (e.g., frequent, occasional). Risks related to certain hazardous events (e.g., heavy rain, flood) are characterised in terms of frequencies (e.g., likely to occur every 0 – 25 years), whereas impacts of slow-onset events (e.g., biodiversity loss) can be described with probability of occurrence within a specified time frame, e.g., the next ten years (e.g., very likely by 90% - 100% to occur in the next ten years). An estimation of likelihood must always refer to a specific level of magnitude of consequences and a reference time (e.g., current situation, near future, long-term future) or global warming level (e.g., +3°C). Based on quantitative information from modelling or with the help of knowledgeable experts, assessments of magnitude and likelihood can be combined in a risk matrix, resulting in qualitative ratings of risk severity. When blending magnitude and likelihood, it is important to appropriately take into account low probability-high impact risks, i.e. from large one-off extreme events, including cases of overload or failure of structural protection measures, that by definition are unlikely, but have the potential to cause exceptionally high damage and loss when they do occur ('fat tail risks').
- **Importance of the system at risk:** Essential systems and functions, such as human health, food security, critical infrastructure with long life spans, or

sectors that have significant importance to the national economy may be perceived as more important than certain other economic sectors or assets of rather local importance, such as tourism or secondary roads. The importance of a system may also relate to features that are key to the resilience of other sectors that depend on the specific system. For instance, ecosystem functioning or water availability are the basis for many other systems and functions.

- **Temporal characteristics of the risk:** Some risks have a more critical timing than others. Risks that are already faced today, are expected to occur sooner, or will increase more rapidly due to climate change or other non-climatic drivers present greater challenges to climate risk management. Also, risks that are persistent due to constantly growing hazard, exposure or vulnerability (e.g., long-term demographic aging of a population) pose a higher threat than risks that may increase due to short-term changes in vulnerability levels (e.g., temporary repair works on damaged hazard protection structures).
- **Irreversibility of consequences:** Risk events that can cause irreversible damage, e.g. due to the crossing of tipping points, thereby altering an affected system's structure and functioning forever, are more severe than risks whose consequences allow full recovery and reconstruction.
- **Low ability for risk reduction:** Risks are more severe if capacities of affected communities for risk management are limited, e.g. because resources for adaptation measures are lacking or risk reduction solutions missing. Lacking capacities for risk reduction may occur in the prevention, preparedness, response or recovery phase of disaster risk management. Ideally, you have already gathered insights into gaps and constraints of risk management capacities, as a factor contributing to vulnerability, during the preceding risk assessment. With progressing climate change, a range of exposed systems or areas may also face limits to adaptation, thus restricting opportunities to avoid, mitigate or respond to increasing risks.
- **High potential for cascading effects across system boundaries:** Events and impacts that cascade from one region, sector or system to others can cause unexpected, widespread and significantly severe consequences that may result in natural or socio-economic disruption, whereby the resulting aggregate impact is significantly larger than the initial impact. Risks with cross-border dimensions may be considered as a priori more severe, because fragmented risk management systems across national jurisdictions regularly imply lower levels of risk preparedness. Even if a climate-related hazardous event occurs only in the territory of one country, it can trigger a cascade of consequences proliferating from one country to another.
- **High potential for systemic effects:** Climate risks can become systemic risks when they exceed a certain threshold and threaten core functions of a system or society that the society and the economy can no longer cope with (e.g. threatening food security of a whole country, overstraining disaster financing capacities of national economies, or leading to the collapse of critical societal functions).

	Class	Criteria: potential for consequences with the following magnitude/severity
Severe	4 Very high	Frequent, very likely and major losses and damages within important systems. Loss of system functionality, irreversibility of consequences, large extent, very high pervasiveness, high potential for impact thresholds or local tipping points, cascading effects beyond system boundaries, systemic risk. Low ability to respond or adapt to the risk.
	3 High	Likely significant losses and damages, disturbance of system functionality, long-term effects, large extent and high pervasiveness, potential for impact thresholds or local tipping points, cascading effects beyond system boundaries and systemic risk. Moderate ability to respond or adapt.
	2 Moderate	Likely moderate losses and damages, moderate disturbance of system functionality, effects are temporary or unfolding slowly with a moderate extent/pervasiveness. Moderate to high ability to respond or adapt.
	1 Low	No to low losses and damages. No or rare disturbance of functionality, high ability to respond or adapt.

FIGURE 9: *Categories for evaluating overall risk severity, based on the criteria explained in Box 3 (source: Zebisch et al., 2023: p. 129)*

Expert-based and community-based risk evaluation: As application of the risk severity criteria requires joint expert judgments, knowledgeable risk experts should be involved in elicitations (e.g. questionnaire surveys, expert workshops). This can be done by including risk experts in your planning team or by setting up an advisory board or technical council. Complementary to *expert consultations*, it is strongly recommended to engage with stakeholders in a *participatory, community-based prioritisation of key risks,* aided by risk criteria and rating scales (→ ***EXAMPLE 3***). Besides integrating local knowledge on aspects such as capacities for risk reduction, involvement of stakeholders is relevant to account for different risk perceptions and risk tolerances, which are driven by subjective values, interests, and perspectives on the importance of systems at risk. Group-based stakeholder judgments allow correcting expert biases and layering of climate-related risks along a spectrum of acceptable, tolerable and intolerable risks. While acceptable risks are seen by affected stakeholders as not needing additional risk management measures, intolerable risks imply that urgent additional measures are needed, even in the face of high costs or other constraints.[9]

Benchmarks for risk severity evaluation: To counteract subjectivity of severity assessments and facilitate comparison of key risks, it is possible to introduce *quantitative thresholds* for the different severity categories. For slow-onset hazards and relatively frequent extreme events, such benchmarks can be expressed in annualised impacts, such as absolute costs of damage, numbers of fatalities or people affected, or area size of land damaged per year, or in relative terms as damage in percentage of gross domestic product. Consequences of more infrequent, large extreme events can, e.g., be categorized according to the likelihood of occurrence within a specified time period (e.g., more than 50% likelihood during a 5-year period)[10].

EXAMPLE 3:

Community-based identification of climate-related key risks in the X-RISK-CC pilot areas

Evaluation of climate-related key risks in the X-RISK-CC pilot areas was embedded in a *community-based process* for assessing relevant risks and co-developing risk management solutions. Based on gathering and review of existing data and information, expert consultations, and stakeholder interviews, prioritisation of risks was informed, firstly, by past and current climatic extremes that have already triggered serious hazards and caused severe damage and loss *(magnitude)* to important sectors and valued assets *(importance of systems at risk)* in recent years, indicating *persistent risks*. Secondly, analysis of climate projections and expected development of vulnerability and exposure revealed risks with *increasing likelihood and/or severity* under future climate change *(critical timing of risk)*. Thirdly, *expert-based assessments* of past and future weather extremes, hazards, vulnerabilities, impacts and risk pathways were prepared by expert institutions among project partners and, fourthly, shared and discussed with stakeholders in the frame of workshops. Focussing on recent extreme events in the first workshop and on potential extreme events in a plausible future climate and socio-economic context in the following workshop, stakeholders reviewed their *risk management capacities* and identified *gaps and constraints*. In all steps, particular attention was given to *compound* and *cascading events*. In conjunction, this participatory process allowed *identifying climate-related key risks* and focussing the development of tailored action plans for each pilot area in the third workshop on the most severe risks with the most urgent need for action, vis-à-vis feasibility considerations.

Translating key risks into main adaptation concerns and strategic priorities: At the end of this step, you will have identified the climate-related key risks, which severely affect important sectors, systems, assets or hot-spot areas, and for which more risk management action is needed and urgent, in contrast to less severe risks where current action can be sustained. In addition, you may have identified key risks where further in-depth investigation is needed. The key risks should be described and visualised in ways that support the following planning process (→ ***ANNEX 3***). This allows you to bridge the more technical, science-based phase of risk assessment towards the policy- and action-oriented phase of planning for risk management. The prioritised climate-related key risks constitute the *main adaptation concerns* and allow *setting adaptation priorities* and defining goals and objectives for climate risk management.

Which methods are applicable?

- **Desk-top research, literature review:** For information-gathering to support risk evaluation.
- **Expert elicitations:** Consultations, questionnaires or workshop formats for expert-based risk evaluation.
- **Stakeholder engagement:** Stakeholder interaction formats for community-based risk evaluation and assessment of risk tolerance.
- **Qualitative severity ratings:** With the help of criteria, rating scales, and benchmarks.

Which tools are available?

- **Risk criteria:** as described above (→ ***BOX 3***)
- **Annex 2:** Risk evaluation matrices
- **Annex 3:** Presentation of risk evaluation results (example)
- **Benchmarks for risk severity:** as described above
- **Community-based risk evaluation**: as described above and illustrated in ***EXAMPLE 3***.

Which outputs can be expected?

- List and description of **climate-related key risks** requiring action
- **Priorities**, **strategic directions** and **objectives** for CCA and CRM planning

2.2 MODULE 2

Identify, analyse and prioritise gaps, action needs, and entry points in risk management and policy frameworks

Purpose of this module

To detect, define and describe the critical risk management gaps related to climate-related key risks and corresponding adaptation priorities. In order to build a robust basis for developing effective adaptation and climate risk management options, significant gaps and needs are analysed across the DRM cycle, under current and future climatic conditions, and at different levels of governance. This module results in prioritised gaps with high urgency to act, including entry points in policy frameworks and governance linkages across levels.

Before effective options for managing climate risks and adapting risk management to climate change can be formulated, it is necessary to identify the most salient gaps and most promising entry points in existing risk management systems and risk-related policy frameworks. Gaps result from weaknesses, constraints and deficiencies in existing practices, the absence of adequate policies and measures, or their lacking fitness for purpose. They constitute need for action and inherently indicate possible solution pathways. This module gives guidance on how to identify concrete local gaps by evaluating the adequacy of existing and planned measures across the DRM cycle in a community-based approach (→ ***MODULE 2: STEP 1***), how to tap pre-existing knowledge in literature and documents and to map strategic gaps and entry points in generic policy frameworks (→ ***MODULE 2: STEP 2***), and how to integrate bottom-up and top-down knowledge to avoid 'blind spots' and take account of the policy context (→ ***MODULE 2: STEP 3***). The steps put particular emphasis on the involvement of stakeholders and experts to access local knowledge, validate desktop-based analysis, evaluate urgency, and eventually prioritise the key gaps with urgent need for solutions.

Guiding questions

Step 1

- → How adequate are current risk management practices in the region for avoiding and mitigating impacts from recent extreme events and expected future weather extremes?
- → What critical gaps and improvement needs exist across the DRM cycle for effectively reducing climate-related risks under current and future climate conditions?
- → What are the entry points and improvement levers for adapting regional risk management to climate change?

Step 2

- → Which strategic policy gaps and action needs can be identified in existing risk-related policy frameworks? Which relevant policy gaps are already known and can be derived from literature and policy documents?
- → Which suitable entry points for local risk management solutions exist in higher-ranking or sectoral policy frameworks? How can local risk management needs be aligned with a supportive multi-level governance framework?
- → How prepared are the policies in place to respond to regional key risks and local risk management gaps?

Step 3

- → How can knowledge about generic policy gaps inform and inspire development of local risk management solutions? Are there hidden risks or overlooked issues in the local analysis of risk management gaps? What is the broader policy context of local risk management gaps and needs?
- → How can local risk management gaps be prioritised? What are the local key gaps with the most urgent need for action?

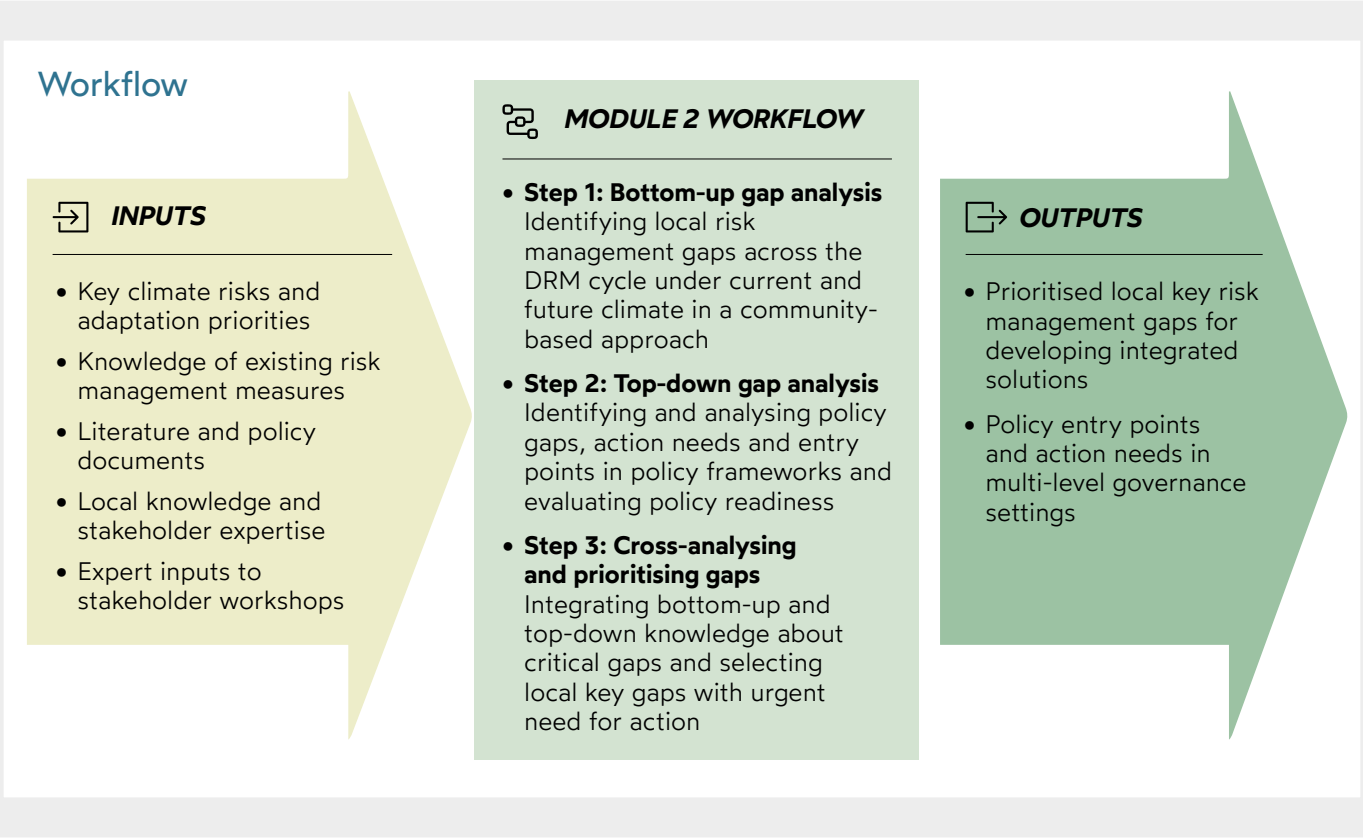


FIGURE 10: *Overview of workflow for Module 2*

Expected outcome

- In-depth knowledge about critical gaps and needs in climate risk management at different governance levels
- Prioritised regional key risk management gaps with urgency to act, validated by pre-existing knowledge, experts and/or stakeholders, including their policy context and multi-level governance linkages
- Solid basis for developing effective CRM options for mitigating severe risks where policy readiness is insufficient

STEP 1: BOTTOM-UP GAP ANALYSIS (LOCAL RISK MANAGEMENT GAPS)

Purpose of this step: To identify concrete local gaps in risk management practices under current and future climate conditions by evaluating the adequacy of existing and planned measures across the DRM cycle, focussing on the key climate-related risks of the region. This step builds on stakeholder engagement and benefits from local knowledge.

The bottom-up analysis of gaps and improvement needs examines risk management performance during past and projected future events. It is conducted in a community-based approach by means of stakeholder workshops, based on expert inputs and dedicated methods. The results provide the basis for prioritising key gaps and developing actions for climate risk management.

Which inputs are needed?

- List of climate-related key risks and corresponding adaptation priorities in your region
- Expert inputs (climate risk information, scenario of future extreme event) to stakeholder workshops
- Status quo information about risk management measures and tools (in place, planned or under development) in your region

What does this step involve?

Community-based identification of risk management gaps: Involvement of relevant experts and stakeholders is key to evaluating risk preparedness, disclosing critical gaps and diagnosing needs for action to better manage current and future climate risks. Stakeholder engagement addresses local needs, builds on local knowledge, and eventually gains legitimacy for the people who will later on roll out the CRM solutions in their daily professional practice. It facilitates out-of-the-silo thinking and the development of feasible solutions that are tailored to the specific local context. A successful bottom-up gap analysis takes stock of structural and non-structural risk mitigation measures that are in place, planned or under development (information collected in ***MODULE 1: STEP 1***), examines whether available measures and tools are fit for purpose, and evaluates if roles, responsibilities, procedures, and coordination mechanisms are clearly defined and effective. It is crucial to provide stakeholders with up-to-date climate risk information, to learn from experiences with recent extreme events under current climatic conditions, to explicitly consider future climate risks, and to reflect on risk management performance under compound and cascading risk scenarios (→ ***EXAMPLE 4***). As gaps can occur in all risk management phases, from prevention to recovery, it is necessary to always systematically consider the role of gaps along the entire DRM cycle, including the often overlooked transitions between consecutive phases ('inter-phases').

Rapid Risk Management Appraisal (RRMA) for identifying the gaps: The Rapid Risk Management Appraisal (RRMA) is a participatory, workshop-based method designed to evaluate the adequacy of existing and planned risk management measures in the context of both current and future climate-related risks. The RRMA uses indicators, transposed into questions, and scoring of risk management performance along the phases and categories of the risk management cycle (→ ***BOX 4***). It is applied in the frame of structured group discussion, involving local and regional stakeholders - including public authorities, civil protection services, planners, infrastructure operators, and sectoral experts. The goal and intended outcome of RRMA-based stakeholder workshops is to identify strengths and weaknesses, critical gaps and entry points for improvement of local or regional risk management performance.

EXAMPLE 4:
Overview of stakeholder engagement processes in the X-RISK-CC pilot areas

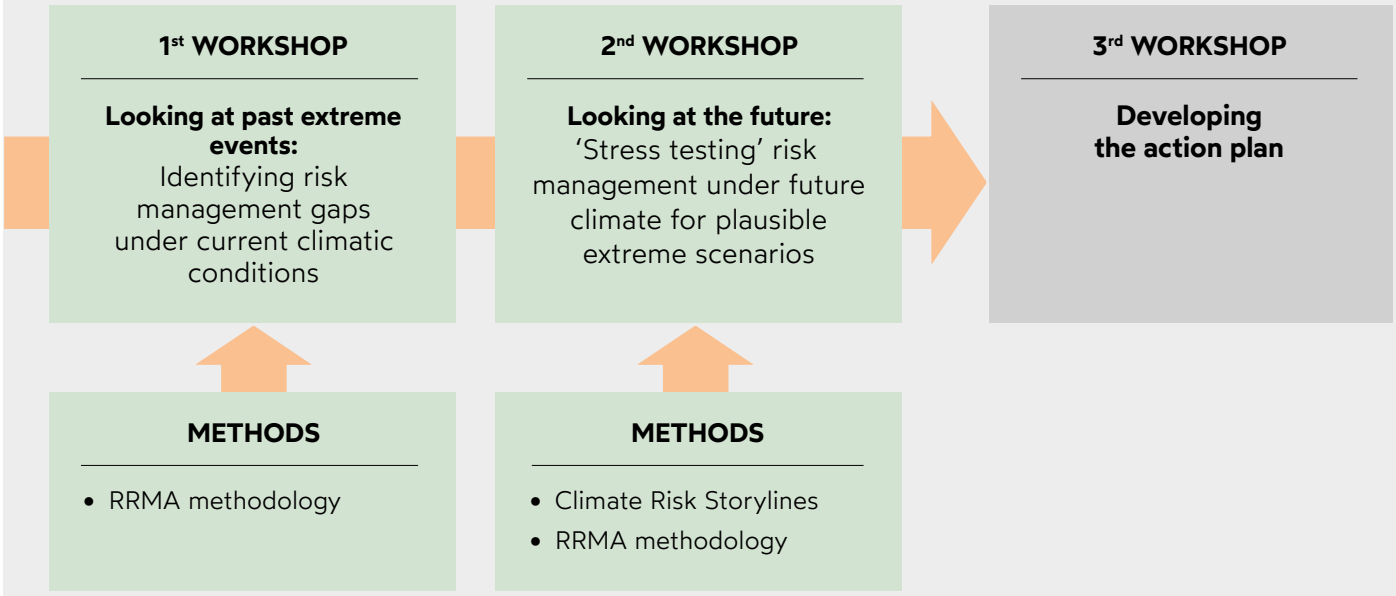


FIGURE 11: *Workflow of participatory local gap analysis and applied methods in the pilot areas (© X-RISK-CC, 2025)*

Key questions for discussion and indicator-based evaluation include:

- Are current measures effective in reducing the impacts of past and future hazards?
- How well would these measures perform under future scenarios involving compound or more extreme events?
- Did the risk management plan achieve its intended objectives, and are those objectives still relevant given projected climate change?
- Were the resources allocated efficiently and used effectively, and will they remain sufficient under future risk conditions?
- Were response and recovery plans adequate in past events, and how might they need to adapt to future hazard patterns and cascading impacts?
- Which risks, particularly emerging climate-related risks, remain unaddressed or insufficiently considered?
- Are there missing policies, procedures, or resources that could limit preparedness for future conditions?
- Are there gaps in communication, monitoring or coordination that may become critical under future scenarios?
- Are any current assumptions, frameworks or planned strategies no longer valid in a changing climate?

The goal and intended outcome of RRMA-based stakeholder workshops is to identify strengths and weaknesses, critical gaps and entry points for improvement of risk management performance across all stages of the DRM cycle. The results can be displayed visually by means of radar diagrams and quantitatively by calculating the range and mean values of individual ratings per indicator (→ ***EXAMPLE 5***). In that regard, in order to produce results that allow meaningful interpretation it is strongly recommended that workshop participants agree in the discussion on one common score per indicator; that way, it is avoided that disparate levels of expertise of participants cause too broad dispersion of individual ratings for the same question. While the scores for each indicator can give a good picture of the levels of risk management performance in different DRM phases, the significant added value of the RRMA approach lies, however, in its potential to generate in-depth qualitative insights, by revealing concrete good practices, gaps, and needs for improvement. More detailed information on the RRMA methodology can be found in ***ANNEX 4***.

BOX 4: Overview of the RRMA methodology

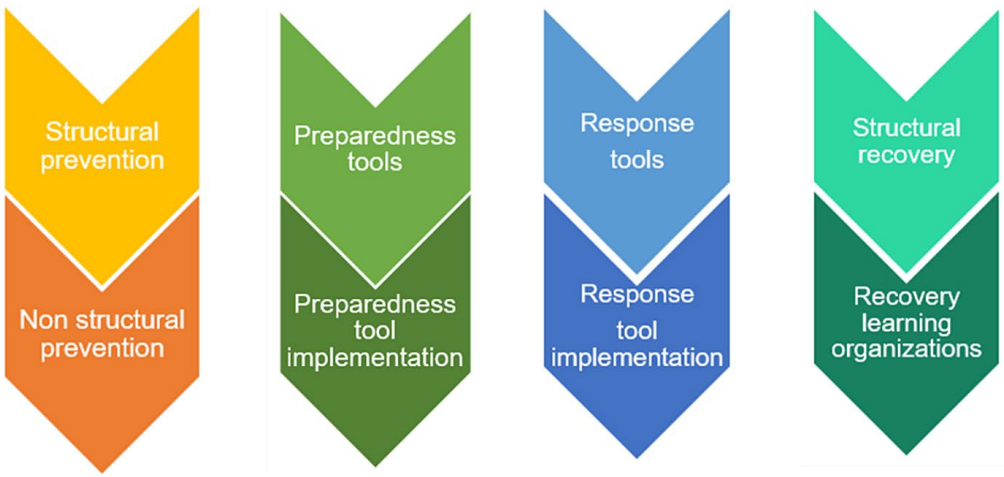


FIGURE 12: *Phases and categories of the DRM cycle analysed by the RRMA method*

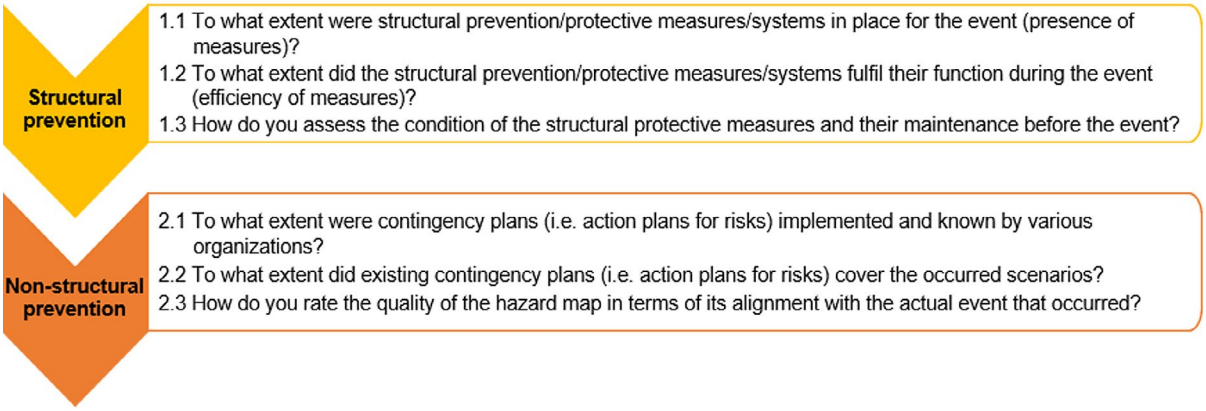
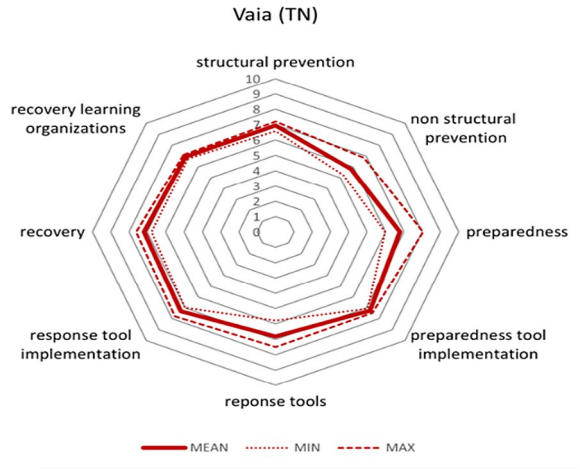


FIGURE 13: *Examples of indicators, formulated as questions, for the categories of the prevention phase*

EXAMPLE 5:

Results evaluation of RRMA stakeholder workshop in Fiemme and Vassa Valleys (Trentino, Italy)

During the first stakeholder workshop in Fiemme and Vassa Valleys, the RRMA method was applied to evaluate the risk management performance during the past Vaia storm event. 32 participants took part in the workshop, contributing to the analysis of local risk management gaps. As the boxplots in ***FIGURE 15*** indicate, the range of scores for some indicators was rather broad, partly spanning from negative (below 5) to positive (above 5) values. A lesson learnt from the first round of pilot area workshops in X-RISK-CC is thus that participants should be facilitated to agree on one common, group-based score per indicator.



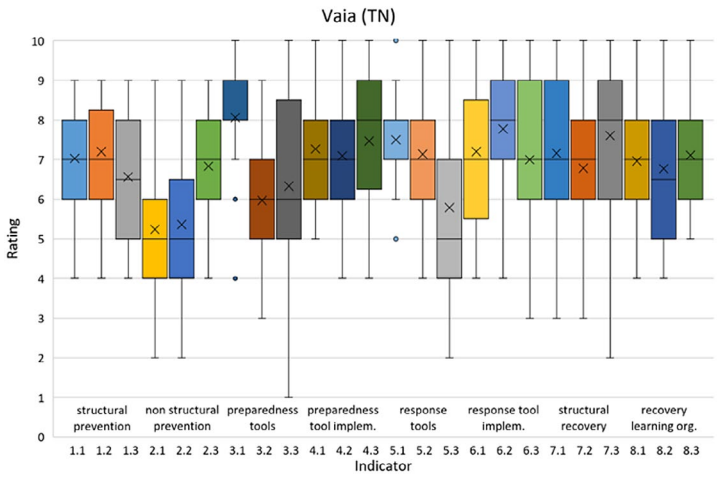


FIGURE 14: *Radar diagram visualising overall RRMA rating results along the DRM cycle (© X-RISK-CC, 2024)*

FIGURE 15: *Boxplot diagram displaying the average value and the range of individual scores for all indicators (© X-RISK-CC, 2024)*

Climate Risk Storylines: Climate risk storylines are narrative scenarios illustrating plausible, high-impact future hazard events and their compound and cascading impacts. They help local stakeholders to understand how a combination of factors - such as extreme weather events, societal vulnerabilities, and response failures - can interact to create significant risks. These storylines are used to 'stress test' current systems and identify critical gaps in a tangible and engaging format. Key features of climate risk storylines include:

- **Impact-focused**: Illustrating high-impact events with cascading or compound impacts (e.g., heavy rainfall combined with windstorms, or a multi-week drought triggering wildfires and infrastructure failures).
- **Narrative and qualitative**: Combining climate projections with local knowledge to explore how hazards and vulnerabilities may evolve.
- **Plausibility over probability**: Describing plausible future scenarios, based on observed trends, climate model outputs and expert/ local knowledge, is more important than precise likelihoods.
- **Context-specific**: Storylines tailored to the geographical, social, and institutional realities of the area under consideration.
- **System stress-testing**: Scenarios could be set for around 2040, assuming events with return periods of between 100 and 300 years, in order to test the limits of risk management capacity.

In X-RISK-CC, storylines were used as input to a 'Rapid Risk Management Appraisal' (RRMA) (→ ***EXAMPLE 6***). Two examples of a climate risk storyline are available in ***ANNEX 5*** and ***ANNEX 6***.

Documenting the identified gaps per DRM cycle phase: The gaps identified for past events and for the projections of the future through the participatory workshop process should be accurately described and documented for each phase of the risk management cycle. As often different actors are responsible for managing different phases, coordination problems may occur in particular in the transition from one phase to another; it is thus recommended to take a closer look at these inter-phases. By the example of the prevention phase and the consecutive inter-phase towards preparedness, ***EXAMPLE 7*** lists the most important gaps detected in one of the project pilot areas. The complete risk management gaps identified in each pilot area are reported in the project's pilot dossiers.

EXAMPLE 6:

Application of climate risk storylines in X-RISK-CC pilot areas

Climate risk storylines were applied in the frame of local stakeholder workshops dedicated to future climate risks to assess in a 'stress test' setting the strengths, weaknesses, critical gaps and potentials for improvement in current risk management systems. Customised storylines designed for each pilot area were developed in advance and adapted by risk managers to reflect local conditions and past experiences. These storylines were presented during workshops as a narrative report using maps and visual materials to facilitate structured discussions and scoring by applying the RRMA methodology.

Divided into groups according to their expertise, participants then discussed and evaluated how current risk management practices perform in the prevention, preparedness, response and recovery phases, based on re-adjusted RRMA indicators. In a second step, groups with mixed expertise examined what could go wrong and should be improved in the transition between consecutive phases of the DRM cycle ('inter-phases'). The use of climate risk storylines in RRMA-based stakeholder workshops proved effective in identifying both, critical gaps and opportunities for enhancement.

EXAMPLE 7:

Local risk management gaps identified for the prevention phase and the inter-phase from prevention to preparedness in Fleres Valley (Italy)

Prevention
In South Tyrol, hazard maps are usually developed for single hazards without considering how events can combine. A landslide could block a river and cause a flood, creating risks where we don't expect them. To be prepared, we need tools that reflect these complex connections.
The hazard mapping should not stop at confluence points of rivers but continue along larger watercourses where risks may still be significant.
Non-structural prevention measures can be strengthened to help keep communities safe by ensuring people know the risks, what to do, and how to communicate in emergencies. This awareness building is often undervalued when compared to the building of physical defences. Strengthening it improves prevention and cooperation, making communities more prepared when disasters strike.
Some areas, like Kogbach and Allrissbach, may be at risk of more frequent or intense debris flow and flood events than originally planned for and need protective measures for these cases. In Kogbach, for example, there is no retention basin to manage floods. Protective infrastructure was mainly built based on past rainfall record, but in recent years, we need a push to strengthen it to handle more intense weather conditions due to climate change.
Part of prevention is to make sure the citizens and people present in the region know what each alarm (sirene) means and to know how to act according to each one. Practice drills are needed and the importance of being prepared for emergencies should be understood by administrations and civil society alike, so that everyone can react quickly and safely.
Improving coordination between emergency services - such as fire brigades, police, and municipal staff - is a key prevention measure to ensure smoother response during events. Even with well-structured plans, real-time cooperation can falter without preparation. Regular joint exercises to help clarify roles, build trust, and speed up decision-making are needed.
Interphase Prevention → Preparedness
Slow shift from risk insight to preparedness action: Despite knowing where risks exist, lengthy procedures often delay translating this knowledge into timely, concrete preparedness steps.
Protective structures and climate change adaptation: While protective structures are well-defined with calculated design volumes, they are not designed with future climate change projections in mind, and methods for parametrizing these changes remain unclear.
Preparedness gaps for overload scenarios: Planning rarely accounts for situations where protective systems are exceeded, leaving critical gaps in emergency logistics and readiness.
Unclear roles and actions during warnings: Though roles are legally defined, public and administrative awareness of how to interpret warnings and respond appropriately have to be improved.

TABLE 2: *Example of local risk management gaps for the prevention phase and the consecutive inter-phase towards preparedness, as identified in Fleres Valley (Italy) (© X-RISK-CC, 2026)*

Which methods are applicable?

- **Participatory stakeholder workshops:** Customized workshop designs and facilitation techniques for community-based gap analysis.
- **Rapid Risk Management Appraisal (RRMA)**: as described above.
- **Climate Risk Storylines**: as described above.

Which tools are available?

- **Annex 4:** RRMA methodology
- **Annex 5:** Example of climate risk storyline – Floods
- **Annex 6:** Example of climate risk storyline – Drought
- **Pilot Dossiers**: Description of stakeholder involvement approaches and compilations of risk management gaps per phase for all pilot areas

Which outputs can be expected?

- List and description of **concrete local risk management gaps** (per phase and inter-phase)
- **Entry points** for improvement

STEP 2: TOP-DOWN GAP ANALYSIS (POLICY FRAMEWORKS)

Purpose of this step: To identify and analyse policy gaps and action needs related to the management of regional key climate risks and adaptation priorities in generic policy frameworks. This involves a review of state-of-the art literature, up-to-date policy documents, and existing policy instruments to identify strategic gaps that have already been recognized, to check the adequacy of policies in place to respond to risk management gaps detected at local level, and to reveal needs for improving higher-level support and multi-level governance.

A generic top-down analysis of strategic climate risk management gaps and needs in existing policy frameworks for CCA and DRM can fulfil several important, interrelated functions in the risk management planning process:

- *Firstly*, it allows regional risk managers to *detect and learn from policy gaps and action needs that have already been identified by others* and that are at least partly known. These *a priori gaps*, or 'known unknowns', relate to issues that have already been recognized as constraints or challenges requiring action or further investigation, but are still unsolved or not adequately addressed by existing instruments and measures. Identifying such generic gaps in relevant literature and policy documents helps regional risk managers to look beyond their own horizon, to discover critical gaps and potential solution pathways that were not yet revealed during the local bottom-up gap analysis, and to consider challenges related to still 'silent', but emerging climate risks (e.g., drought, forest fires) and unexpected climate-driven events. A top-down policy gap analysis can be conducted in parallel, and complementary to, the bottom-up analysis of local gaps (→ ***MODULE 2: STEP 1***).

- *Secondly*, by reviewing adopted legislation, published policy documents, and existing measures vis-à-vis the identified regional key risks, adaptation priorities (→ from ***MODULE 1: STEP 2***) and local risk management gaps (from ***MODULE 2: STEP 1***), it can be determined whether, and to what extent, the respective action needs are already being recognized and managed by higher-ranking or sectoral policies. This is important because often local actors cannot successfully tackle climate-related risks and risk management gaps on their own, but need 'support from above', e.g. in the form of policy or regulatory action at higher-ranking levels, supporting multi-level governance frameworks, and enabling framework conditions, such as provisioning of resources, capacity-building, or data infrastructure. Checking the *adequacy of existing policy frameworks* to effectively support management of regional key risks and to respond to local gaps sheds light on the *level of policy readiness* and can reveal policy gaps at higher levels of risk ownership, indicating a need to upgrade the policies in place.

- *Thirdly*, a gap analysis at generic policy level allows the identification of *entry points for local actions* in higher-level or broader policy frameworks, supporting policy alignment of local solutions and their embedding in *multi-level and cross-sectoral governance settings and policy mixes.*

Which inputs are needed?

- List of **climate-related key risks** and corresponding **adaptation priorities** in your region
- Relevant **literature** and **policy documents** (higher-level policy frameworks for risk management)

What does this step involve?

Review of state-of-the art literature, up-to-date policy documents, and existing policy instruments: Detecting strategic risk management gaps, action needs and entry points for interventions in existing policy frameworks requires identifying and reviewing relevant literature and documents. The goal is to screen these sources for relevant policy gaps that have already been identified in previous studies, assessment reports or expert recommendations, observed and documented in event analyses of past extreme events, and addressed as challenge, objective or action demand in recent policy documents, such as strategies and plans for climate adaptation and disaster risk reduction. The general focus of the review is on current and future risks with potentially severe consequences caused by extreme weather events and the hazards, compound impacts and cascading effects triggered by these climatic extremes. More specifically, it should focus on the current and future climate-related key risks with potential for severe consequences in your region, as identified in ***MODULE 1: STEP 2***, and cover all phases of the risk management cycle. Relevant gaps can be caused by limitations, deficiencies, weaknesses or absence of adequate policies, regulations, instruments, governance mechanisms, procedures, resources, or data for managing severe risks from weather extremes. The presence of gaps indicates insufficient levels of preparedness for increasing climate-related risks, reveals needs for action, and will guide the development of adaptation options (→ ***MODULE 3***). Policy readiness can be lacking because risk issues are not recognized or not addressed, existing policies are not fit-for-purpose, or actions exist largely on paper only, i.e. implementation on the ground is widely lacking or insufficient. The scope of literature and policy documents selected for review should include but go significantly beyond policies and available studies within your own regional jurisdiction. Building on the information gathered already in ***MODULE 1: STEP 1***, relevant sources may comprise:

- Science-based assessments, technical reports, expert opinion reports, and similar knowledge resources at national and transnational level and about other regions with similar challenges;
- Policy documents and regulations at higher hierarchical (sub-national, national, transnational) levels that steer (climate) risk management in your own region and provide the framework conditions for regional risk management practices, in particular climate adaptation and disaster risk management strategies, plans and instruments;
- Policies of sectors that are relevant to disaster risk reduction and climate adaptation because they influence hazards, exposure or vulnerability, such as spatial planning and territorial development, forest management, water and drought management;
- Relevant strategies, plans and instruments in neighbouring jurisdictions, including in cross-border settings.

The X-RISK-CC project has conducted a comprehensive top-down analysis of generic policy gaps for the climate risk management of weather extremes for the Alpine region. Yielding repositories of in total almost 480 distinct policy gaps in several policy fields, the complete results are available at the CAPA portal and can serve as knowledge base, work aid and inspiration for further exploration and refinement through the lenses of specific Alpine regions (→ ***EXAMPLE 8***; → ***ANNEX 8***). In addition, the project has developed a searchable online tool that provides interactive access to all results, facilitating interactive exploration and analysis of policy gaps in a user-friendly way.

EXAMPLE 8:

Top-down policy gap analysis in X-RISK-CC

The X-RISK-CC project has carried out a comprehensive review of relevant literature (available transnational studies, scientific assessment reports, policy studies, expert opinion reports, expert-based policy recommendations) and recent higher-level policy documents of Alpine countries (strategies and plans for climate adaptation and disaster risk management, sectoral policy documents), covering more than 50 studies published and policy documents adopted up to mid-2025. Overall, almost 480 distinct policy gaps for the management of risks from weather extremes, which are in principle relevant across Alpine countries and regions, have been mapped and compiled in structured policy gap repositories. The gap analysis focused on the following key policy fields with central roles in reduction of climate-related risks: natural hazard management, civil protection and disaster risk management, spatial planning, (protection) forest management, and forest fire risk management. ***TABLE 3*** provides an overview of the number of cluster topics and specific gaps that have been mapped per policy field.

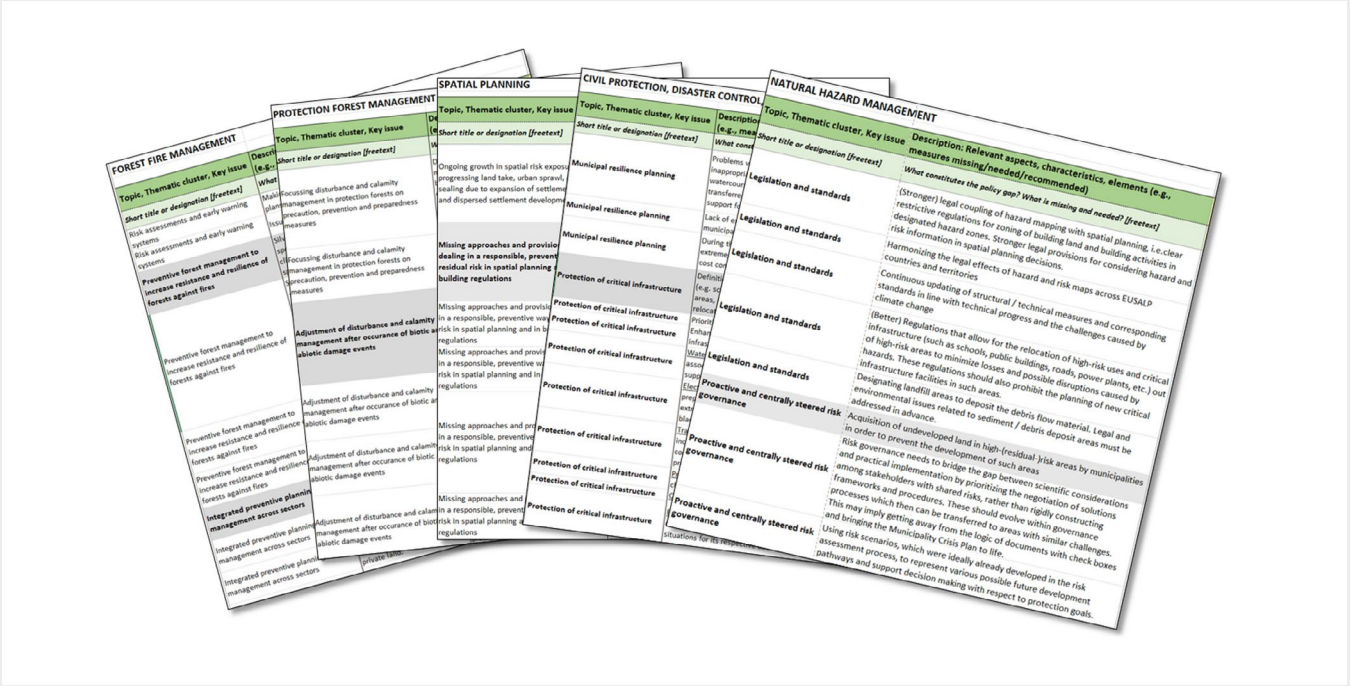


FIGURE 16: *Generic policy gap catalogues (excerpts) for five sector-related policy fields compiled in the X-RISK-CC project (© EAA, 2025)*

Policy fields	Gap cluster topics	Specific gaps
Natural hazard management: structural & non-structural measures	10	154
Civil protection, disaster control, emergency management	14	151
Spatial planing	11	45
Forest fire management	13	61
Protection forest management	14	67
TOTAL	**62**	**478**

TABLE 3: *Quantitative overview of identified specific gap issues and thematic clusters per policy field (© EAA, 2025)*

Mapping and structured documentation of policy gaps and action demands: For documenting the stocktaking of policy gaps in a systematic way that facilitates further analysis and prioritisation, the gap inventory should be structured and organised according to the needs of the further process. In the X-RISK-CC project, compiling gap catalogues that organise the identified gaps in thematic clusters per policy field, using sortable and filterable table format (MS Excel), proved a highly practicable approach (→ ***EXAMPLE 9***).

Categorisation of policy gaps: Categorizing the compiled policy gaps according to analytical criteria facilitates further analysis and exploration of the gap catalogues and supports all following steps, in particular the cross-linking of top-down with bottom-up gap analysis (→ ***MODULE 2: STEP 3***), prioritising key gaps (→ ***MODULE 2: STEP 3***), developing adaptation and risk management options (→ ***MODULE 3***), and elaborating an action plan (→ ***MODULE 4***). Useful criteria from a policy-oriented perspective include (see also ***EXAMPLE 10***):

- affected policy fields,
- position in the DRM cycle,
- types of policy gaps,
- relevant types of climate risks
- relevant natural hazards,
- types of measures needed to respond to the gap,
- risk ownership (levels, main actors).

EXAMPLE 9:
Structuring and organising of policy gap repositories in X-RISK-CC

NATURAL HAZARD MANAGEMENT

Topic, Thematic cluster, Key issue	Description: Relevant aspects, characteristics, elements (e.g., measures missing/needed/recommended)
Short title or designation	*What constitutes the policy gap? What is missing and needed?*
Early warning, forecasting and alert systems	Target groups / the population lack knowledge of and compliance with existing warnings and alerts. This causes insufficient response of citizens to warnings and inadequate use of preventive measures advocated by local institutions. Need for measures to incrase behaviourial compliance.
Early warning, forecasting and alert systems	Lacking capacity (of risk managers and target groups) to communicate and act on the information from early warning systems. Even if reasonably accurate early warning systems are in place, the lack of capacity to translate forecasting data into adequate action constrains the effectiveness of forecasting and early warning. It needs to be safeguarded that available and advanced tools and data are actually used in an active way to take preventive actions, which includes defining what action should follow after warnings.
Financing and insurance	Involvement of local communities and beneficiary parties in financing construction and maintenance of protection measures in order to strengthen commitment and awareness of local actors
Financing and insurance	Taxation and fiscal policies to counteract the development of hazard-prone areas as well as incentives for reducing land-use intensities in hazard-prone areas. Revenues from these fiscal policies can be redirected to support emergency management services.
Financing and insurance	Need for reforms of risk transfer mechanisms, particularly with regard to private properties. Missing mandatory building insurance is a key driver of economic vulnerability. E.g. in Austria, damages caused by natural hazards such as flooding or debris flows are only partially covered by insurance, and relevant information is usually not available. Compulsory, uniform flood and natural hazard insurance models (as in Switzerland) that are rooted in solidarity principles, i.e. mandatory insurance of the respective owners against natural hazards, has potential to overcome constraints of private voluntary insurance systems and maladaptive, pervert incentives of public disaster relief funds models. Together with short-term liquidity options like Kontokorrent loans, this could reduce financial vulnerability. Compulsory insurance also can have supportive effects in the context of increased personal precautions.
Financing and insurance	Insurance systems, in particular such based on the private insurance market, are increasingly under pressure due to rising flood risk. According to projections, several European regions could face an adaptation tipping point in the long run beyond which the uptake of flood insurance will be too low for a viable system. Limits to the viability of (market-based) insurance systems can result from constraints to premium ratings and from constraints on maximizing coverage:

FIGURE 17: *Section showing the structure of the policy gap repositories compiled in the X-RISK-CC project (© EAA, 2025)*

By the example of the policy field 'natural hazard management', the section of a policy gap catalogue presented in ***FIGURE 17*** shows how a policy gap catalogue can be structured to facilitate navigation and further use. In this two-level hierarchy, gaps have been clustered according to common topics in the first column, while the second column provides more detailed descriptions of what constitutes the concrete gap. More columns can be added to categorise each gap according to specific characteristics (see further below). ***FIGURE 18*** below lists all topics defined to organise the catalogue of 154 policy gaps identified for 'natural hazard management'.

Natural Hazard Management: Example for thematic clustering of policy gaps

- Early warning, forecasting and alert systems
- Financing and insurance
- Research, knowledge, information management and learning
- Legislation and standards
- Proactive and centrally steered risk governance
- Participative (residual) risk governance
- Lack of hazard and risk information for risk-based spatial planning and land use planning
- Lack of integrated risk assessments considering multi-hazards, cascading events, and climate change influences
- Risk communication, awareness raising and building a (residual) risk culture
- Structural protection measures

FIGURE 18: *Topics used for thematic clustering of the policy gap repository for the policy field of natural hazard management (© EAA, 2025)*

EXAMPLE 10:

Criteria and categories for analysing policy gaps

All sectoral policy gap catalogues in the X-RISK-CC project have been comprehensively tagged for five analytical criteria with categorisation schemes: position in the DRM cycle (according to the scheme of the RRMA methodology), types of policy gaps, types of climate risks (hazard-based), levels of risk ownership, and local validation. The criterion of 'local validation' denotes whether manifestations of generic gaps have been identified also empirically at local scale in the project pilot areas, thereby confirming, complementing, or concretising findings of the top-down analysis. ***FIGURE 19*** shows how the Excel-based policy gap repositories have been used to categorise all identified gaps, allowing filtering and sorting operations to facilitate further analysis. ***TABLE 4*** below lists the categories applied to characterise the criterion 'types of policy gaps' according to the policy dimensions causing the gap. The complete categorisation schemes for all criteria, including the descriptions of categories, are provided in ***ANNEX 9***.

Types of policy gaps

What are the prevailing root causes of the gap? To what domains do these main causes and action needs predominantly belong?

- → Knowledge, data & evidence
- → Awareness & recognition
- → Policy design & planning
- → Governance: organisational & procedural
- → Legislative & regulatory
- → Resources, capacity & implementation
- → Compliance & enforcement
- → Effectiveness & efficiency
- → Local risk preparedness & community-driven adaptive capacities
- → Other

TABLE 4: *Categories applied in X-RISK-CC for the criterion 'types of policy gaps' (© EAA, 2025)*

CIVIL PROTECTION, DISASTER CONTROL, EMERGENCY MANAGEMENT

Topic, Thematic cluster, Key issue	Description: Relevant aspects, characteristics, elements (e.g., measures missing/needed/recommended)	Risk management cycle (RRMA)	Types of gaps	Climate risks (hazard-based): risks related to	Risk ownership (levels)	Validated locally
Short title or designation	*What constitutes the policy gap? What is missing and needed?*	*What phases and categories of the risk management cycle, according to the RRMA scheme, does the gap issue mostly relate to?*	*What are the prevailing root causes of the gap? To what domains do these main causes and action needs on predominantly belong?*	*What type of natural hazard process or climate impact causes the risk addressed by the gap?*	*At what levels (government, political-administrative system, governance, society) do the crucial decisions or actions need to be taken in order to overcome the policy gap?*	*Has the gap been identified or confirmed at local pilot area level?*
Insurances	A uniform natural hazard insurance (as in Switzerland) and short-term liquidity options like Kontokorrent loans could reduce the financial vulnerability of municipal authorities. Early investment in risk cycle measures saves recovery costs.	Preparedness: tools Recovery: structural	Policy design & planning Legislative & regulatory Resources, capacity & implementation	Multi-hazard, multi-risk	National & subnational	x
Insurances	In Austria, damages caused by natural hazards such as flooding or debris flows are only partially covered by insurance, and relevant information is usually not available.	Preparedness: tools Recovery: structural	Policy design & planning Resources, capacity & implementation	Floods: fluvial; Flooding: pluvia	National & subnational	x
Participative risk governance	A Comprehensive Risk Management approach with broad stakeholder involvement is needed to overcome knowledge and language disparities. In practice, non-participatory approaches have displayed a problem. The involvement of citizens should therfore be expanded and structured.	Preparedness: tool implementation Prevention: non-structural	Governance: organisational & procedural Effectiveness & efficiency Local risk preparedness & community-driven adaptive capacities	Multi-hazard, multi-risk	Multi-level, cross-level, co-owned	x
Participative risk governance	'Local reasons for concern' need to be included into national policy making to make risk reduction solutions more target-oriented and ambitious.	Prevention: structural Prevention: non-structural Preparedness: tool implementation	Governance: organisational & procedural Local risk preparedness & community-driven adaptive capacities	Multi-hazard, multi-risk	National & subnational	
Participative risk governance	Community resilience projects should serve as a role model for stakeholder engagement across different scales and sectors.	Preparedness: tool implementation Prevention: non-structural	Governance: organisational & procedural Local risk preparedness & community-driven adaptive capacities	Multi-hazard, multi-risk	Multi-level, cross-level, co-owned	
Participative risk governance	An active involvement of civil society actors (e.g. in the conception of emergency plans) is needed to strengthen private risk precaution. This measure could prevent inadequate use of preventive measures advocated by local institutions.	Prevention: non-structural Preparedness: tool implementation	Governance: organisational & procedural Local risk preparedness & community-driven adaptive capacities Compliance & enforcement	Multi-hazard, multi-risk	Local & regional	x

FIGURE 19: *Section of policy gap repository (sector 'civil protection') with categorisation according to five criteria (© EAA, 2025)*

Evaluating policy readiness: The top-down policy gap analysis can also fulfil the function of evaluating policy readiness, i.e. the adequacy of existing policies to manage the climate-related key risks by overcoming a generic gap or responding to identified local gaps. Combined with the severity of a specific risk (→ from ***MODULE 1: STEP 2***), the level of policy preparedness is an important indicator of the urgency to act, which informs the prioritisation of key gaps (→ ***MODULE 2: STEP 3***) and the selection of CRM options (→ ***MODULE 3***). In general, the presence of significant gaps for the mitigation of key climate risks in certain policies indicates a low level of policy preparedness, and vice versa. ***BOX 5*** shows a possible categorisation of different levels of policy readiness[11], which can be added as an additional dimension of analysis to the structured policy gap repositories.

BOX 5: Levels of policy readiness

None	Gap not recognized and/or not addressed; no policies in place to reduce the risk
Low	Gap identified, action discussed or recommended, agenda-setting in progress; few policies in place that address the risk, but objectives are vague and existing policies not fit-for-purpose
Medium	Gap partly addressed by policies, plans, strategies, instruments; but actions exist largely on paper only, implementation widely lacking or insufficient
Advanced	Gap addressed adequately or to a high degree; policies with clear objectives and actions to reduce the risk in place; implementation on the ground happening

FIGURE 20: *Possible evaluation scheme for qualitative rating of policy readiness (© EAA, 2025)*

Which methods are applicable?

- **Literature and document review:** to identify and extract generic 'a priori' policy gaps (as described above).
- **Mapping of policy gaps:** stocktaking and systematic documentation of gaps by means of structured matrices (as described above).
- **Criteria-based categorisation of policy gaps:** to facilitate exploration, further analysis and prioritisation (as described above).
- **Policy analysis and qualitative evaluation of policy readiness:** as described above.

Which tools are available?

- **Annex 7:** List of literature and documents reviewed for the top-down policy gap analysis in X-RISK-CC
- **Annex 8:** Example of policy gap catalogue for sector 'spatial planning'
- **Annex 9:** Criteria and categories applied to analyse the policy gap catalogues in X-RISK-CC
- **X-RISK-CC Policy Gap Explorer Tool**: Interactive web application for exploring the identified policy gaps of transnational relevance

Which outputs can be expected?

- Repositories of **gaps and action needs in policy frameworks** for managing the regional climate-related key risks
- **Policy entry points** for local risk management actions with **multi-level governance linkages** and **coordination needs**
- **Levels of policy readiness** to manage regional key risks and overcome local risk management gaps

STEP 3: CROSS-ANALYSING AND PRIORITISING GAPS

Purpose of this step: Integrating bottom-up and top-down knowledge about critical gaps in management of climate-related risks by detecting 'blind spots', adding multi-level governance requirements and coordination needs, and consolidating the definition and description of regional risk management gaps. Prioritising key gaps with urgent need for action by involving experts and stakeholders.

This step involves the cross-analysis of local risk management gaps (→ ***MODULE 2: STEP 1***) and higher-level policy gaps (→ ***MODULE 2: STEP 2***) and the prioritisation of key gaps, based on an evaluation of the urgency to act. Looking at gaps and potentials of regional risk management from two complementary angles prevents silo-thinking and the ignorance of multi-level governance needs in settings of shared risk ownership. The outcome of this step establishes a solid foundation for developing integrated climate risk management options that align with broader policy frameworks (→ ***MODULE 3***).

Which inputs are needed?

- List and description of concrete local risk management gaps (per phase and inter-phase) in your region (outcome of → ***MODULE 2: STEP 1***)
- Repositories of gaps and action needs in policy frameworks for managing the regional climate-related key risks (outcome of → ***MODULE 2: STEP 2***)
- Stakeholder and/or expert ratings of priority (key gaps)

What does this step involve?

Cross-analysing and integrating local management gaps and higher-level policy gaps: The cross-analysis is a process that joins bottom-up (→ ***MODULE 2: STEP 1***) and top-down (→ ***MODULE 2: STEP 2***) knowledge about critical gaps in climate risk management. Aligning the generic policy gaps with the empirically grounded, community-based local gaps can help avoid 'blind spots', complement, enrich and deepen the practice-oriented gap analysis from a top-down angle, and put it into a broader policy and multi-level governance context. The junction where climate-related key risks (→ ***MODULE 1: STEP 2***) meet upon insufficient local risk management capacities and converge with strategic policy gaps indicates high urgency to act. Systematic integration of local management gaps and higher-level policy gaps thus supports prioritisation of key gaps and creates a knowledge base for developing integrated risk management solutions, which adequately consider the roles of different levels of risk ownership. The X-RISK-CC Policy Gap Explorer Tool, which gives online access to the policy gap repositories compiled by the project, can be used to support the cross-analysis (→ ***EXAMPLE 11***).

- *Covering 'blind spots' in regional risk management:* The policy-oriented top-down gap repositories can support and inspire the development of local solutions by helping to detect 'blind spots' in the bottom-up gap analysis, addressing hidden and emerging, but still 'silent' climate-related risks, and avoiding biases that might otherwise have gone unnoticed, thereby benefitting from available knowledge about limitations and needs in climate risk management.
- *Considering multi-level governance requirements and coordination needs:* Blending the results of bottom-up and top-down gap analysis informs risk managers about the broader context of regional risk management, by adding information about the concerned policy levels and actors, required governance arrangements, and the needs for coordination, cooperation and communication. This indicates policy entry points at different levels of risk ownership and supports alignment of local actions with higher-level support and enabling framework conditions.
- *Consolidating the regional gap catalogues:* Results of the cross-analysis need to be incorporated into the definition and description of regional risk management gaps, resulting in a consolidated regional gap inventory that reflects the multi-level architecture of climate risk governance with its often shared risk ownership.

EXAMPLE 11:

X-RISK-CC Policy Gap Explorer Tool

The X-RISK-CC Online Policy Gap Explorer allows filtering a collection of almost 480 climate risk management policy gaps relevant for the Alpine region. Possible filters are the policy sectors, the DRM cycle phases, the gap types, the risk ownership level, the type of climate risks, and whether gaps were locally validated by X-RISK-CC case study regions. The results can be rated and exported in an Excel-file.

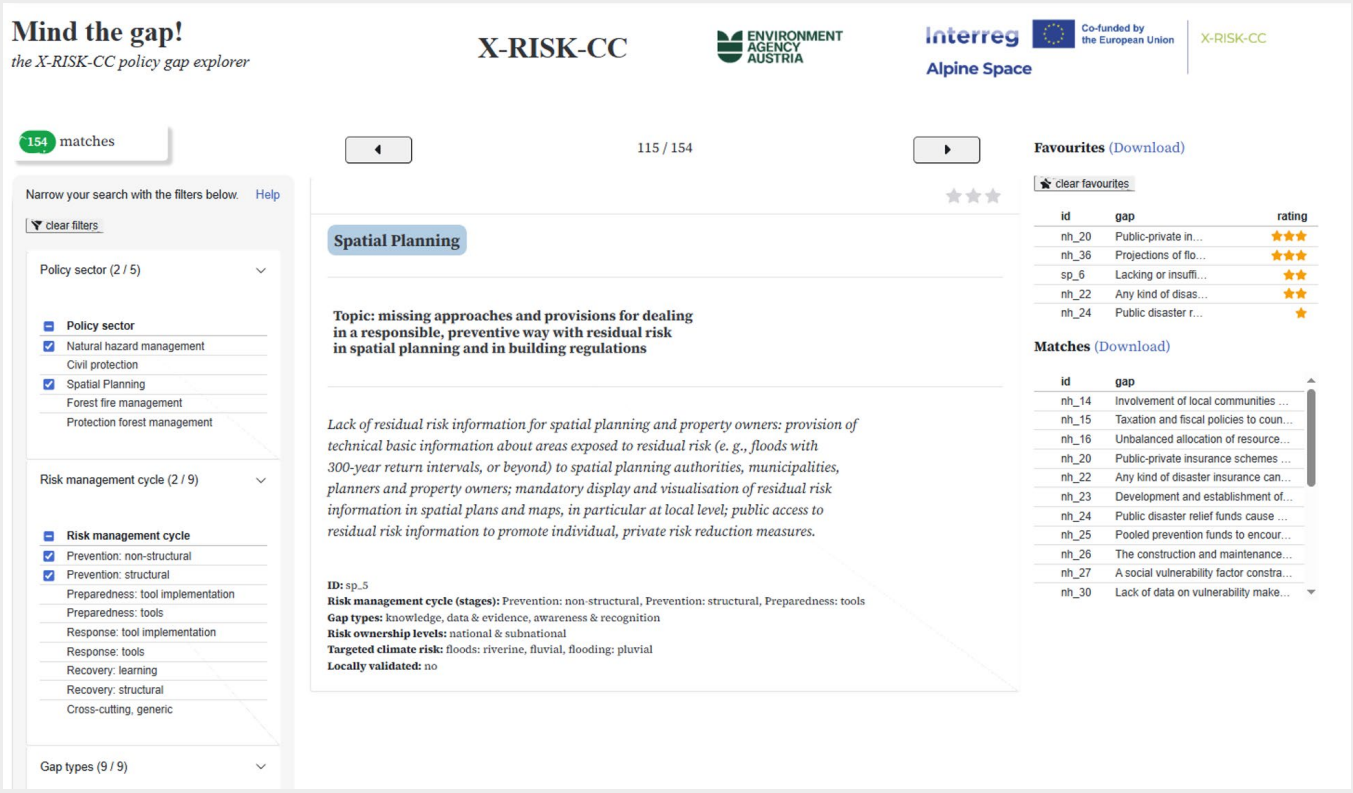


FIGURE 21: *Screenshot of the online gap explorer tool in action (© EAA, 2026)*

Prioritising key gaps with urgent need for action: By systematically joining the results of the bottom-up and the top-down gap analysis, you may have implicitly already arrived at the key gaps, i.e. the gaps related to the most severe regional climate risks where policy readiness is insufficient. Low policy readiness may result primarily from lacking regional risk preparedness or from its combination with inadequate policies at higher levels of risk ownership. If the resulting list of key gaps requiring action should still be too comprehensive, you might want to narrow it down to a more workable list. This requires prioritisation, which should be based on an evaluation of the urgency to act upon a gap. Urgency to act is usually determined by combining risk severity (from → ***MODULE 1: STEP 2***) with policy readiness, whereby urgency increases with higher risk severity and lower policy preparedness. In practice, prioritisation based on urgency evaluation is best done by means of expert elicitation and/or stakeholder involvement (→ ***EXAMPLE 12***). Such expert- or stakeholder-based urgency ratings are useful in any case for validating your selection of key gaps, which may include re-evaluation and re-ranking. Participatory prioritisation exercises can be aided by formalised urgency evaluation matrices (→ ***ANNEX 10***) with qualitative scales (→ ***BOX 6***).

EXAMPLE 12:

Prioritising transnational policy gaps in X-RISK-CC expert workshops

To prepare development of the Transnational Action Proposals of the X-RISK-CC project, the comprehensive compilations of transalpine policy gaps were first clustered and compacted and then prioritised in interactive expert workshops with project partners, the Alpine Climate Board of the Alpine Convention, and EUSALP Action Group 8. Prioritisation was based on the criterion of urgency (considering also other criteria such as climate change relevance and transnational relevance) and done by means of group-based rating and scoring of points. The cumulated scores of all three interaction formats resulted in a priority-ranked list of 29 key gaps (→ ***ANNEX 11***).

FIGURE 22: *Project partners working on prioritisation of transalpine policy gaps during partner meeting (© EAA, 2025)*

FIGURE 23: *Members of the Alpine Climate Board prioritising policy gaps at joint transnational expert workshop (© EAA, 2025)*

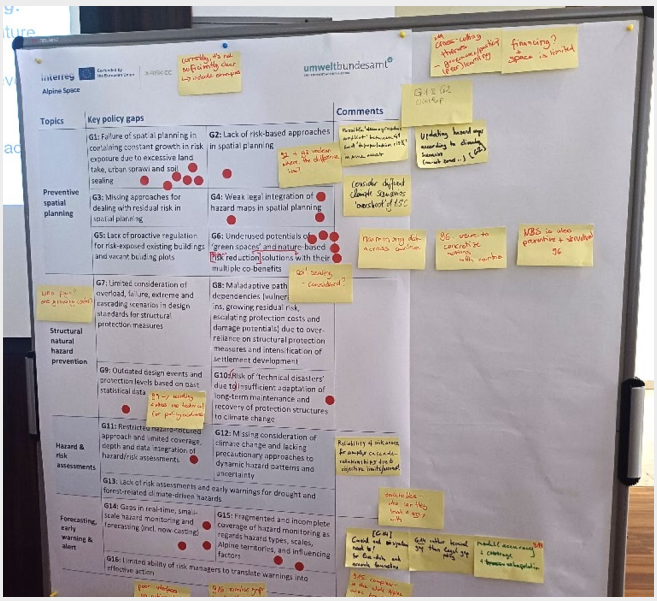


FIGURE 24: *Prioritisation and review of transalpine policy gaps at joint expert workshop with the Alpine Climate Board (© EAA, 2025)*

BOX 6: Example of categories for urgency evaluation

Urgency to act	Description
Urgent action needed	The combination of catastrophic risks and insufficient policy readiness calls for urgent new, stronger or different action in the coming years to reduce climate risks. Such actions include policymaking, implementation, capacity building or enabling the environment for adaptation, over and above those already planned.
More action needed	The severity of risk and the limited level of policy readiness calls for more action to be implemented. It is crucial to initiate processes that strengthen adaptation action to avoid critical impacts of climate change.
Further investigation	The available knowledge is insufficient to call for specific new action. Priority should be given to gathering additional evidence regarding the severity of the risk as well as policy readiness, e.g. through dedicated research, monitoring or policy evaluation.
Sustain current action	Current or planned levels of activity are appropriate, but continued implementation of these policies or plans is needed to ensure that the risk continues to be managed in future. A monitoring and evaluation process should be in place to evaluate policy effectiveness, with a view to continuous improvement.
Watching brief	The evidence in these areas should be kept under review, with continuous monitoring of risk levels, so that further action can be taken if necessary.

FIGURE 25: *Description of urgency categories as used in the European Climate Risk Assessment (EUCRA) (source: EEA, 2024: p. 393)*

Which methods are applicable?

- **Desktop research:** For cross-analysing bottom-up and top-down gaps, including by a 'blind spot' analysis to uncover overlooked issues at regional level and by using the X-RISK-CC Policy Gap Explorer Tool (as described above).
- **Urgency evaluation:** Evaluating urgency to act upon gaps by combining risk severity and policy readiness with the help of evaluation matrices (as described above).
- **Expert elicitation and stakeholder interactions:** For rating urgency and prioritising gaps with urgent need for action (as described above).

Which tools are available?

- **X-RISK-CC Policy Gap Explorer Tool**: Interactive web application for exploring the policy gaps of transnational relevance compiled by the project
- **Annex 10:** Matrix for evaluating urgency to act
- **Annex 11:** List of prioritised transalpine key policy gaps with ranking
- **Action Proposals for Managing Climate Risks from Weather Extremes in the Alps**: The X-RISK-CC transnational policy recommendations include a summary of trans-Alpine key policy gaps and descriptions of their context and relevance.

Which outputs can be expected?

- **Prioritised key risk management gaps** with urgency to act, validated by experts and/or stakeholders, including policy context and multi-level governance linkages
- Solid **foundation for developing** actionable, targeted and effective **CRM options**

2.3 MODULE 3

Derive adaptation and risk management options

Purpose of this module

To identify and compile suitable CCA and CRM options that address the climate-related key risks, risk management gaps and action needs, and to assess, prioritise and select the preferred climate risk management options. The outcome of this module leads towards the preparation of an action plan.

After having determined the climate-related key risks (outcome of → ***MODULE 1***), gaps and action needs (outcome of → ***MODULE 2***), it is now possible to derive suitable climate risk management options. This is done firstly by identifying and characterising potential actions (→ ***MODULE 3: STEP 1***) that meet the defined adaptation priorities and objectives, and secondly by evaluating, prioritizing and selecting relevant options (→ ***MODULE 3: STEP 2***), based on the greatest gain or the prevention of biggest loss. Both steps are guided by criteria and informed by stakeholder involvement. The expected outcome is an agreed portfolio of preferred adaptation and risk management measures that constitutes the basis for a climate risk management action plan (***MODULE 4***).

Guiding questions

Step 1

→ Which climate risk management options are at hand to adequately and effectively respond to the identified risks, gaps and demands resulting from Modules 1 and 2?

- Which measures and good practice examples are available to inspire development of actions?
- How to design broad action catalogues with a diverse range of measures that address the different risk drivers and phases of the DRM cycle?
- How to involve stakeholders and experts to co-develop possible actions that are tailored to the specific regional context?
- How to align CCA and CRM options with the broader policy context?

Step 2

→ How to narrow down the compilation of available options to a workable, coordinated portfolio of prioritized measures for a CRM action plan?

- How to assess and compare alternative options?
- How to prioritise and select preferred CCA and CRM actions?

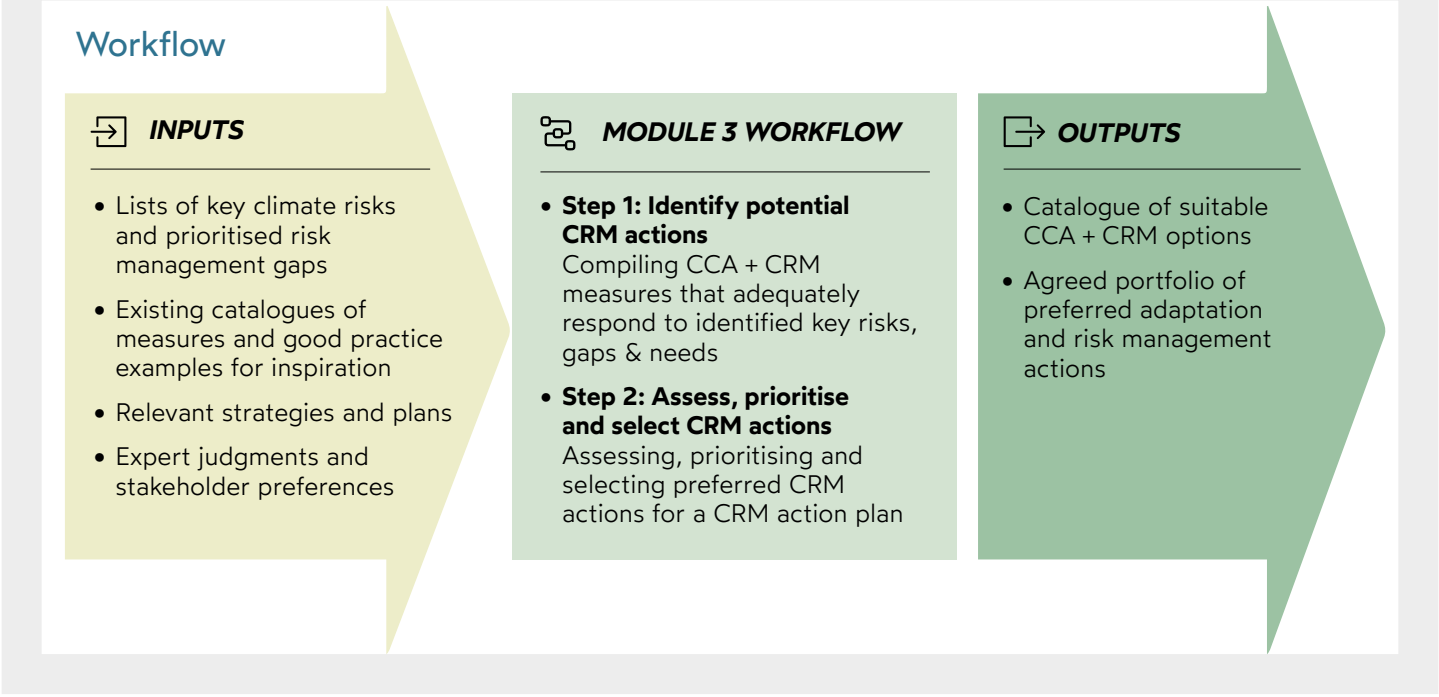


FIGURE 26: *Overview of workflow for Module 3*

Expected outcomes

- → Catalogue of suitable CCA and CRM option (presented in factsheet format)
- → Agreed portfolio of preferred CCA and CRM actions (as basis for action plan)

STEP 1: IDENTIFY POTENTIAL CRM ACTIONS

Purpose of this step: To identify the climate risk management options at hand, i.e. to develop potential adaptation and risk management measures that adequately and effectively address the climate-related key risks, align with the adaptation priorities, and respond to the identified gaps and demands. This involves exploring a wide range of diverse options and bundling them to mixed action portfolios, building on existing catalogues and good practice examples of measures, co-development with stakeholders, and considering the policy context.

Now that key climate risks have been identified, risk management gaps prioritised and needs for action derived, it is time to compile CCA and CRM options that address the respective challenges. This step guides users through the exploration of potential actions, directs to information sources, gives advise on how to design effective portfolios of measures, and recommends stakeholder involvement in a community-based approach. At the end of this step, users will have developed a catalogue of suitable CCA and CRM options, described for prioritisation and decision-making in ***MODULE 3: STEP 2*** in factsheet format.

Which inputs are needed?

- → Climate-related key risks and corresponding adaptation priorities (outcome of → ***MODULE 1***)
- → List of prioritized gaps and action needs (outcome of → ***MODULE 2***)
- → Existing catalogues and good practice examples of measures for climate risk management
- → Existing strategies and plans relevant for adaptation and risk management in your region
- → Proposals for actions by stakeholders

What does this step involve?

Exploring a wide range of diverse options and building action portfolios: To identify suitable climate risk management options, a *broad range of potential measures across the entire solution space* should be explored and reviewed. Relevant options need to adequately address the identified climate-related key risks, corresponding adaptation priorities, and the prioritised gaps and needs, having the potential to significantly reduce the risk of adverse consequences. Adaptation options can range from actions that build adaptive capacity (e.g. knowledge creation, information sharing, creating supportive institutional frameworks, learning from disaster events) or establish early warning systems and frameworks for preventive land use management (e.g. risk-based spatial planning) to risk transfer mechanisms (e.g., insurance schemes) and adaptation actions implemented on the ground (e.g. upgrading of structural protection measures or nature-based risk reduction solutions). When compiling portfolios of options, you should pay attention to the following:

- Consider measures that address the *different dimensions of climate-related risk*, i.e. that avoid or contain *exposure*, protect or increase resilience against *hazards*, reduce *vulnerabilities*, mitigate or avoid *impacts*, increase *adaptive capacities* and/or tackle *underlying (non-climatic) risk drivers*. Because climate risk management transcends sectoral and administrative borders and needs to confront a variety of risk factors and drivers, it is essential to develop a *systemic approach* when it comes to potential CRM actions. Developing a systemic understanding of risk and the intended effects of measures in this step facilitates the prioritizing and selection of CRM options in the following step (→ ***MODULE 3: STEP 2***).
- Taking a systemic approach also means to collect potential measures that intervene in *different steps of the risk management cycle*, i.e. that cover the phases of *prevention, preparedness, response* and *recovery*, including the often overlooked *interphases* that link transition from one step to another.
- Cover a wide spectrum of *types of adaptation options*, including technological, informational, organisational, behavioural, ecosystem-based, social, and socio-economic options at all levels, within sectors, and across sectors. This is needed to prepare the ground for a *well-mixed portfolio of effective measures* that tackle different sources and drivers of risk by different means. *Categorising* identified measures is important for not overlooking critical gaps and utilizing the entire solution space. E.g., focussing on legislative measures alone is often not sufficient, as it disregards implementation barriers that may stem from a lack of data, knowledge or awareness. Vice versa, a CRM action plan focussing mostly on measures to increase risk communication and awareness might lack the institutional setup required for the implementation of measures. Categorising measures is also helpful for prioritisation, and, eventually, for developing an effective CRM action plan. Different approaches to categorising climate risk management options exist.

  At a generic level, *green* measures (nature-based adaptation solutions, ecosystem-based risk reduction), *soft* measures (building adaptive capacity, e.g. knowledge generation, governance, communication, awareness raising), *grey* measures (structural, technical, e.g. flood protection infrastructure) and *hybrid* measures (combinations of aforementioned categories, e.g. urban rainwater management systems combining green and grey options) are often distinguished.

  EXAMPLE 13 shows the classification of action types used in the tailored action plans for improving risk management in the X-RISK-CC pilot areas. More fine-grained approaches can be found in ***ANNEX 12***.

EXAMPLE 13:

Classification of actions applied in the tailored action plans for each X-RISK-CC pilot area

- **Knowledge & Data:** Actions focused on improving information, understanding, monitoring, or data systems
- **Communication:** Actions aimed at improving information flow, awareness, warnings, or coordination
- **Legislative:** Actions requiring changes to laws, regulations, standards, or formal procedures
- **Technical:** Actions involving physical infrastructure, technology deployment, or engineering solutions
- **Capacity Building:** Actions focused on training, institutional strengthening, or resource development

- Design action portfolios that *combine incremental and transformative steps*. *Incremental measures* are usually adjustments of business-as-usual practices, predominantly pragmatic, small-scale, localized, single-sector and single-risk, and characterized by good feasibility. As adaptation does not always require completely new action, incremental options have their place in adaptation portfolios and can generate 'quick wins', but their speed and effectiveness may be insufficient over the long term. In comparison, *transformative measures* are substantial, more radical in addressing root causes of vulnerability, involve shifts away from existing practices, reflect deep structural or system-wide change, affect wider geographical areas, address multiple risks, and include multiple sectors and levels of governance. At the same time, they are also less feasible, politically more contested, and thus more difficult to implement. Examples of transformative actions are a regulatory shift towards risk-based spatial planning, structural reforms of insurance systems or damage compensation mechanisms, or managed retreat and relocation in high risk areas with predictable transgression of technical protection limits. Single measures alone are rarely transformative. Transformative adaptation requires goal-oriented, coordinated bundles of measures that balance feasibility and effectiveness, and a broadening of conventional policy mixes beyond, e.g., soft informational measures, incentives, or structural protection systems.

Reviewing existing catalogues of measures: In recent years, a wealth of materials on options for adaptation and climate-related risk management has become available. To avoid 're-inventing the wheel' and gather inspiration, existing catalogues of adaptation options can be retrieved from literature review, policy documents (such as national and regional strategies and plans for climate adaptation and disaster risk reduction), and databases, such as the European Climate-ADAPT portal, CAPA – The Climate Adaptation Platform for the Alps, national adaptation platforms, and a plethora of project-based web resources (→ ***BOX 7***).

Collecting and capitalising on existing examples of good practices: To learn from forerunners in other regions, the landscape of existing examples of implemented measures should be screened for transferable good practices. This can lower implementation barriers by overcoming possible scepticism among key stakeholders, and it can open the horizon of possible implementation pathways, building on lessons learnt by other regions. Although a large number of potentially applicable adaptation options can be excessed through desktop research, often little is known about their performance, acceptance, and issues linked to implementing them. Therefore, it is important to identify adaptation options and practices that others have already put into practise and to learn from their experience. Seeing adaptation options already successfully implemented and delivering results elsewhere gives them additional credibility. When developing a climate risk management plan, successfully implemented adaptation measures should be repurposed and prioritised. Compilations of case studies and good practice examples are often accessible through the same web portals as mentioned above (→ ***BOX 7***).

BOX 7: Web-based databases of adaptation options and practice examples

- **Climate-ADAPT: Adaptation options**
  The Climate-ADAPT database of adaptation options is searchable by categories such as adaptation sector, climate impact or Key Type Measure. For the sector 'Disaster Risk Reduction' alone, 30 different adaptation options are available.
- **Climate-ADAPT: Case Studies**
  Accessible through the case study explorer or the resource catalogue, the case studies showcase adaptation measures that have been implemented in European countries. They serve as inspiration on how known adaptation options can be implemented in practice under a range of different conditions. Currently, more than 60 case studies on disaster risk reduction are available, of which many are located in Austria, France, Italy, Germany, Slovenia, and Switzerland.
- **CAPA – Climate Adaptation Platform for the Alps**
  CAPA puts a special focus on knowledge resources linking climate adaptation and disaster risk reduction. The inventory currently hosts about 180 knowledge items addressing the sector 'natural hazard management', of which more than 60 resources contain adaptation options and almost 50 include adaptation measures implemented in practice. Also available is a thematic collection on the topic of risk governance.
- **Alpine Convention**
  The website of the Alpine Convention offers a range of publications and other resources on various climate change issues, with natural hazard management being one of the Convention's thematic working fields. The Alpine Climate Board regularly updates a stocktaking report on climate-relevant activities, including many on natural hazard management in an adaptation context.
- **National adaptation portals**
  The national climate adaptation portals of many Alpine countries include databases of good adaptation examples implemented in practice. Climate-ADAPT has a web directory linking to such good practice compilations at national level, including in Austria, France, Germany, and Italy.

Co-developing potential actions with stakeholders and experts: Local expert knowledge and close collaboration with stakeholders is key to identifying climate risk management options that are implementable and tailored to the specific regional context. Collecting ideas for actions builds on the preceding participation process leading up to the common prioritisation of key gaps (→ ***MODULE 2: STEP 3***). As risk management gaps and needs inherently point the way to solution pathways, and the analysis of risk management gaps has already revealed entry points for improvements, the step towards co-developing potential actions can be taken organically as part of the community-based process, be it in a dedicated workshop or embedded in preceding workshops. Stakeholder involvement also increases the legitimation of regional actors and the chances of successful implementation of the CRM action plan.

EXAMPLE 14:

Community-based development of measures in the X-RISK-CC pilot areas

In the project's pilot areas, development of measures for upgrading regional risk management in the context of climate change was based on the results of participatory workshops with local stakeholders. Building on two previous workshops for analysing the gaps under current and future climate conditions, an additional dedicated workshop for identifying, discussing and prioritising risk management options was conducted in each pilot area, eventually leading up to tailored action plans for each case study region.

FIGURE 27: *Workflow of stakeholder engagement process in the X-RISK-CC pilot areas with dedicated workshop for developing risk management improvement options (© X-RISK-CC, 2026)*

Alignment with other policies and initiatives: It is important to consider the policy and planning context of CCA and CRM options. This involves reviewing relevant strategies, plans, legal frameworks and standards in place that may affect risk management planning in your region, building on the information already gathered as part of the pre-planning phase (→ ***MODULE 1: STEP 1***). Recognizing interdependencies and connectivity with existing policy frameworks ensures coherence across levels and sectors, avoids maladaptation, allows exploiting synergies, and reduces the need for new actions. If your regional options align with the goals of overarching policies, such as (sub)national adaptation and DRR plans, and respective entry points are identified, this will support implementation of your regional action plan. Being aware of plans and strategies of neighbouring jurisdictions, including across country borders, is a prerequisite for transboundary coordination of risk management measures.

Describe options in factsheets: Describing the identified actions in concise factsheets supports stakeholder discussions, comparison of options, and subsequent decision-making. This will also provide an important basis for elaborating the action plan and for its implementation. As far as feasible, information may be provided for the items listed in ***BOX 8***[12].

BOX 8: Possible items for characterising CRM options in factsheets

- Overarching objective, specific aim
- Significance: climate risks and gaps addressed
- Description of the action
- DRM cycle position
- Spatial or territorial scope
- Responsible actors (risk ownership) and supportive actors for implementation
- Beneficiaries (who benefits from implementing the action)
- Type(s) of action
- Transboundary aspects, if any
- Connection to existing instruments or measures
- Stage of planning or implementation (if already ongoing)
- Financial and/or other resources required
- Timescales for planning, implementing, and gaining full effectiveness
- Potential conflicts/maladaptation issues
- Preliminary indicators for monitoring & evaluation

Which methods are applicable?

- **Desktop research and expert consultations:** To identify options in catalogues and databases, and to review existing policy documents.
- **Stakeholder engagement:** Workshop for co-developing options.
- **Entry points for adaptation in impact chains**: See ***EXAMPLE 15*** and ***ANNEX 13***.
- **Desktop refinement of suitable options:** describing options in fact sheets.

Which tools are available?

- **Annex 13:** Schemes for categorising CCA and CRM options
- **Annex 14:** Example of how to use impact chains for identifying adaptation options

Which outputs can be expected?

- **Catalogue** of **potential CCA and CRM actions** (e.g. described in factsheets)

EXAMPLE 15:

Entry points for adaptation in impact chains for flash floods in Gorenjska / Sora Catchment (Slovenia)

During the regional risk assessment you may have already worked with *sequential impact chains* (→ X-RISK-CC Risk Manual) to understand and visualize how climate-related events unfold and interact to produce risk. When working on identification of suitable adaptation options, it is recommended to revisit the impact chains developed as part of the risk identification and risk analysis phase. Impact chains can serve as a valuable tool to identify entry points for adaptation interventions, meaning places in the impact chain where a targeted adaptation option can 'break' or minimize the creation of risk, thus indicating entry points for adaptation measures. This can be vulnerability factors, like weaknesses and gaps in existing risk management systems, which limit adaptive capacity and thus increase the resulting risk. ***FIGURE 28*** shows an example of pre-impact vulnerability factors, as identified in the impact chains of the X-RISK-CC project. ***ANNEX 13*** illustrates how impact chains can be used to identify entry points for adaptation by addressing hazards, impacts, and/or vulnerabilities.

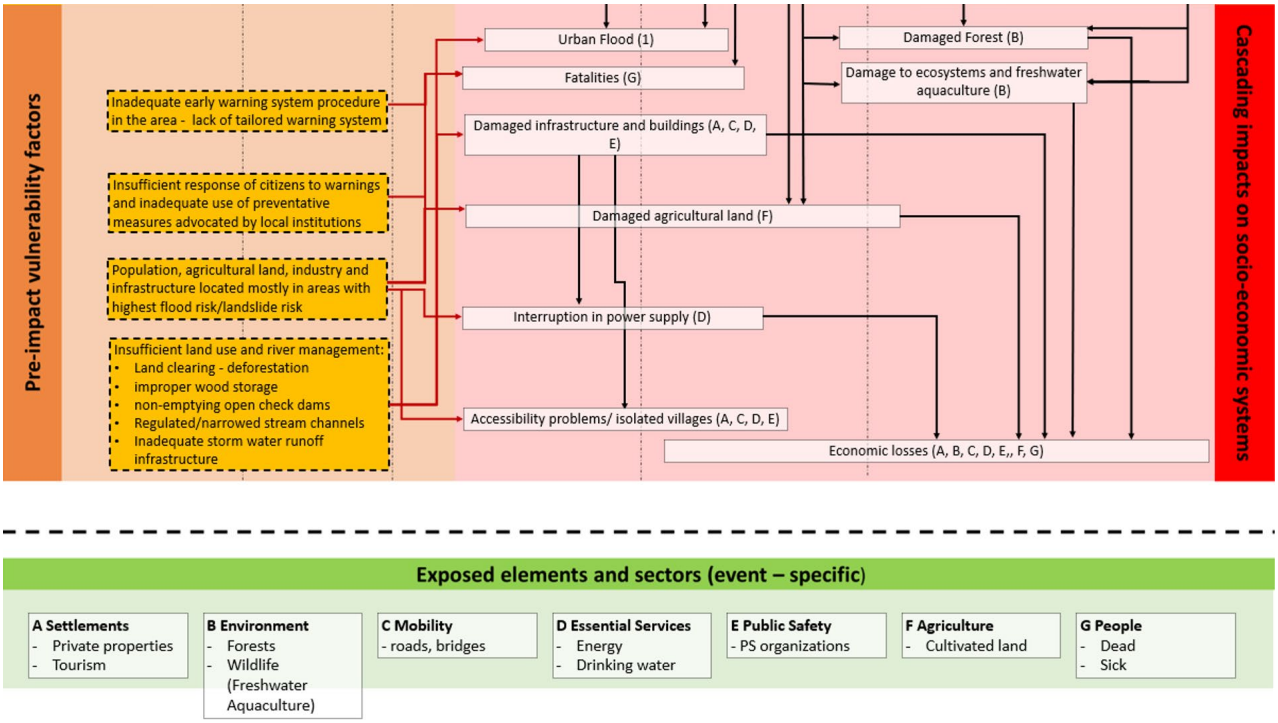


FIGURE 28: *Vulnerability factors (orange text boxes) contributing to risk from flash floods and offering entry points for adaptation (© X-RISK-CC, 2024)*

STEP 2: ASSESS, PRIORITISE AND SELECT CRM ACTIONS

Purpose of this step: To narrow down the compilation of available options to a prioritised list of agreed key CRM actions that will be the basis for preparing a CRM action plan. This includes establishing a decision-making framework, based on criteria, dedicated methods and stakeholder involvement, for identifying, evaluating and prioritising suitable options and selecting the preferred actions.

Once possible adaptation and risk management measures have been identified, compiled and described (→ ***MODULE 3: STEP 1***), you should now set up a decision-making framework for assessing, comparing and selecting the most suitable and preferred actions, which will then be the main input for a climate risk management action plan (→ ***MODULE 4***). This framework includes criteria and assessment methods and builds on stakeholder participation. Apart from effectiveness- and feasibility-oriented criteria, users will consider aspects such as broader sustainability objectives, just resilience, and implementation costs. The resulting portfolio of actions that are most adequate to respond to the key climate risks and to overcome the related risk management gaps should be agreed upon with the participating stakeholders and other key actors needed for implementation.

Which inputs are needed?

- → Catalogue and description of potential CCA and CRM actions (from → ***MODULE 3: STEP 1***)
- → Expert judgments and stakeholder preferences

What does this step involve?

Criteria for evaluating CCA and CRM options: A transparent, legitimate and credible prioritisation of the options identified in the previous step (→ ***MODULE 3: STEP 1***) is best done against robust evaluation criteria. A criteria-based assessment ensures that the selected options are both feasible and effective in addressing your adaptation priorities and in reducing climate-related key risks, while considering social,

environmental and economic impacts. A set of assessment criteria should be agreed within the planning team and with affected stakeholders and applied to each option in the compiled catalogue, plus for entire packages of measures, in order to consider their interactions. Ideally, the factsheets created about each option contain the information needed to conduct the assessment. A broad range of criteria is available for assessing the suitability of possible CCA and CRM options. ***BOX 9*** lists criteria that are recommended by authoritative institutions and widely used by adaptation policy making communities[13]. Selected methods for applying some of the criteria are described in this step further below.

Prioritising and selecting CCA and CRM options: Decision-making on the most suitable actions is based on the assessments of options, allowing ranking, prioritising and selecting the preferred measures, and bundling them into well-mixed, mutually supportive and coherent portfolios. A multi-criteria analysis (MCA) is a useful method for ranking and selecting options; an MCA may also involve different weightings of criteria. Deciding on preferred actions should consider that the management of future climate-related risks always faces inherent uncertainties, including related to projections of future climatic development and climate-driven extreme events, development of non-climatic risk drivers (e.g., exposure and vulnerability) under different scenarios of socio-economic development, or predictions of the effectiveness of measures. CCA and CRM options that are likely to work well and to deliver substantial benefits under a range of plausible future developments should thus be prioritised. ***BOX 10*** presents several tried-and-tested criteria that facilitate such decision-making in the face of uncertainty[14].

Participation of stakeholders in selection of preferred CCA and CRM options: In any case, the list of preferred actions should be agreed with regional stakeholders that have already been involved in the risk management planning process and will be needed to implement the resulting action plan. This will also help in building acceptance, strengthening political and financial support for implementation, and thus increasing feasibility. Stakeholder engagement allows including different values and interests and is beneficial during different steps of the prioritisation process, including the choice of assessment and prioritisation criteria, selection of decision-making methods, application of criteria, setting of criteria weights, and the tailoring of selected measures to specific regional contexts. The prioritisation and selection strategies applied in the X-RISK-CC project are described for the trans-Alpine policy level in ***EXAMPLE 16*** and for one of the pilot areas in ***EXAMPLE 17***.

BOX 9: Criteria for assessing CCA and CRM options

Effectiveness	Level of risk reduction (specific or multiple climate-related risks); level of increasing resilience; degree of avoiding severe damage and loss or irreversible consequences; degree of mitigating and preparing for compound impacts and cascading effects; extent of achieving adaptation priorities and objectives; probability, broadness, and duration of successful outcome.
Urgency	Time-related criticalities, e.g. urgency of mitigating a climate-related key risk; short-term need to prevent damages occurring already under current climate; need to mitigate high-impact future risks; timeframes needed for planning and implementing the measure; lead times until measure becomes effective
Costs	Implementation costs of the measure, considering entire life span (initial investment, operating, maintenance, and transaction costs).

Efficiency, cost-effectiveness	Ratio between costs and benefits; degree to which the benefits outweigh the costs.
Avoidance of maladaptation	Level of risk that the measure has unintended adverse (side-)effects, including increasing or shifting vulnerability, increased GHG emissions, conflicts or trade-offs with sustainability goals, more inequitable outcomes, or diminished welfare.
Incremental vs transformative	Location of measure along the continuum between i) step-wise, small-scale adjustments of business-as-usual practices and ii) deep structural or system-wide changes; transformative potential
Policy coherence	Degree of alignment and consistency with policies relevant to climate risk management at other levels (e.g., national or subnational CCA and DRR strategies, plans and programs); consistency with policies for sustainable development.
Interactions with other policy objectives	Trade-offs / conflicts and co-benefits / synergies with other environmental, social and economic sustainability objectives; additional (co-)benefits for other sectors and policies; co-benefits for mitigation of climate change.
Social justice, just resilience	Impacts on social equity and justice; distribution of benefits and costs across different social groups; impacts on vulnerable and marginalized groups.
Acceptance, feasibility	Acceptability of the measure within the political and socio-cultural context; implementation barriers and enablers; political feasibility.

BOX 10: Prioritisation criteria for decision-making under conditions of uncertainty

- **'No-regret' options:** Robust actions that are cost-effective under current climate conditions and are worthwhile, or do not bring disadvantages, whatever the extent of future climate change might be (e.g., avoiding building in high-risk areas).
- **'Low-regret' options:** Actions for which the associated costs are relatively low and for which the benefits, although primarily realised under predicted future climate change, may be relatively high.
- **'Win-Win' options:** Actions that deliver the desired result in terms of minimising the climate risks or exploiting potential opportunities but also contribute significantly to other social, environmental or economic goals; options that deliver benefits independent of climate change and its future extent.
- **'Flexible or adaptive management'** options: Implementation pathways that are easily adjustable or reversible, at low cost, if actual (climatic) development diverges from initial projections.
- **'Multiple-benefit' options:** Actions that provide synergies across several or all phases of the DRM cycle and with other goals such as mitigation of climate change, biodiversity conservation, environmental management or sustainability (e.g., well-designed Nature-based Solutions, by definition, provide such multiple benefits).

EXAMPLE 16:

Expert workshop for evaluating and prioritising transnational action proposals of X-RISK-CC

For developing the **Transnational Action Proposals for Managing Climate Risks of Weather Extremes in the Alps**, the project conducted an online transnational expert workshop (with members of EUSALP AG8 and PLANALP) that applied participatory, expert-based scoring and ranking to prioritize emerging Alpine-wide policy options. First, participants were asked to give scores to the draft action proposals, based on the following criteria: relevance for reducing risks and overcoming related gaps under future climate change, urgency, effectiveness, and feasibility. In a second step, the top-ranked action proposals were evaluated against two core criteria: *effectiveness/impact* (positive change that implementing the action could bring and the strength of the contribution to solving the problem) and *effort/feasibility* (amount of time, resources and coordination required and the difficulties that need to be overcome for implementation). Requiring a consensual group-based expert judgment, each action then was positioned in a two-dimensional evaluation matrix according to its effectiveness (vertical axis) and effort (horizontal axis), eventually displaying all actions on a grid marked by the four corner points *'quick wins'*, *'major projects'*, *'fill-ins'*, and *'thankless tasks'*. The outcome was used as a major input for selecting the twelve X-RISK-CC transnational action proposals.

FIGURE 29: *Prioritisation of policy options by means of scoring (votes per participant)*

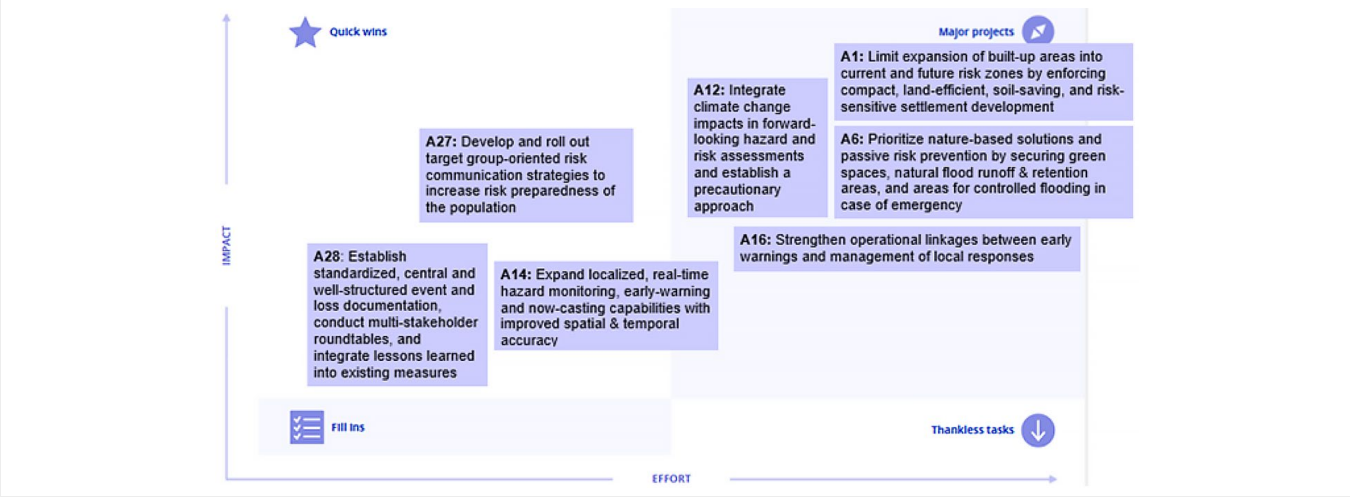


FIGURE 30: *Prioritisation of policy options by evaluating effectiveness (impact) and effort (feasibility)*

EXAMPLE 17:

Prioritisation strategy in Fiemme and Fassa Valleys (Italy)

In general, a five-level prioritization method (1 = Highest Priority, 5 = Lowest Priority) was applied within each pilot area of the X-RISK-CC project. Prioritization was carried out separately for each pilot region and is therefore not uniform across pilots, reflecting different risk contexts, institutional settings, and capacities. For the South Tyrolean pilot area, all actions proposed during the participatory workshops in each pilot region were first collected and clustered by topic to address overlaps. The project team then identified, for each action, the institution with primary responsibility and agency for implementation. Based on this, targeted exchanges were held with the relevant offices and authorities to discuss feasibility, existing or planned activities, resource availability, and possible implementation pathways. The prioritization was derived qualitatively from these discussions and reflects the assessment of the responsible institutions in the pilot area. Priority levels consider urgency, feasibility, and the timeline for implementation (immediate versus stepwise or long-term), as well as expected impact, co-benefits, climate change relevance, and institutional readiness. The assigned priority therefore indicates the readiness and urgency for action within the specific pilot context.

Which methods are applicable?

- **Sets of assessment and prioritisation criteria:** as described above.
- **Analytical methods:** for applying the criteria (as described below).
- **Stakeholder participation and expert elicitation:** for applying criteria and methods, and for agreeing on preferred action portfolio.

Which tools are available?

- **Cost-benefit analysis (CBA):** A form of economic analysis that assigns a monetary value to the benefits of a measure. It assists decision-makers in working out the best strategy for using scarce economic resources for the most effective adaptation approach and help prioritize and time investments. The analysis can help to predict whether the benefits of a measure outweigh its costs, including in comparison to other alternatives.

  Further reading:
  - EEA Briefing: 'Assessing the costs and benefits of climate change adaptation'
  - Climate-ADAPT database

- **Cost-effectiveness analysis (CEA):** A form of economic analysis that compares the relative costs and outcomes (effects) of different courses of action.

  Further reading:
  - Climate-ADAPT: Economic tools

- **Multi-criteria analysis (MCA):** It describes any structured approach used to determine overall preferences among alternative options, where the options accomplish several objectives. In MCA, desirable objectives are specified, and corresponding attributes or indicators are identified. The actual measurement of indicators need not be in monetary terms, but are often based on the quantitative analysis (through scoring, ranking and weighting) of a wide range of qualitative impact categories and criteria.

  Further reading:
  - UNDP: Multi-Criteria Analysis

- **Real options analysis:** It derives from the financial markets, where it has been used to assess the valuation of financial options and risk transfer. The same insights are also useful when there is risk or uncertainty involved with investment in physical assets, hence 'real' options. Real Options Analysis quantifies the investment risk associated with uncertain future outcomes. It accounts for uncertainty and flexibility rather than assuming a deterministic future required for traditional CBA, and most commonly uses Monte Carlo analysis and decision trees to calculate the value of real options.

  Further reading:
  - MEDIATION project: Policy Briefing

- **Planning scenarios:** They help to understand how climate-related events and their associated risks and opportunities may impact a business model, a strategy or financial performance over time. Scenario analysis can be complex and can range from narrative descriptions to quantitative information using detailed models.

- **Adaptation pathways and threshold analysis:** A decision-making approach that works with thresholds, decision points, and sequences of measures towards a pre-defined goal, allowing adjustment of responses over time. It uses different flexible adaptation scenarios that can be explored and implemented depending on how the climate and its impacts evolve. The approach is characterised by a focus on the adaptive decision-making process rather than its outcomes.

  Further reading:
  - Pathways2Resilience: Methodologies for adaptation pathways formulation

- **SWOT analysis:** SWOT stands for an analysis that considers Strengths, Weaknesses, Opportunities, and Threats. In context of climate change, a SWOT analysis determines the exposure of a business/municipality/region to climate strengths, weaknesses, opportunities, and threats, or those brought about by climate change.

Which outputs can be expected?

- **Agreed portfolio** of preferred adaptation and risk management **measures**

2.4 MODULE 4

Prepare an action plan and initiate implementation

Purpose of this module

To arrive at a climate risk management (CRM) action plan and to prepare and initiate its successful implementation, this module aims at converting the selected options into actionable measures, drafting a detailed and structured roadmap for their delivery, and obtaining political approval and administrative support. Moving from planning to sustained implementation in practice involves preparation of a short-term implementation roadmap and laying the foundations for iterative climate risk management.

Proceeding from the prioritised CRM options (→ ***MODULE 3***), this module guides users through the design of a coherent, implementable and politically supported action plan and the kicking off of its delivery. This involves establishing cornerstones of iterative climate risk management, including clear governance structures, mechanisms for regular monitoring, reporting, evaluation and learning (MREL), and regular update cycles of the action plan and the regional CRA.

Guiding questions

Step 1

- → How can the prioritised CRM options be translated into a coherent, structured action plan that is aligned with existing policies, plans and institutional procedures?
- → How should a CRM action plan be designed to serve as a roadmap for implementation? What are minimum requirements and quality criteria for its contents and structure?
- → Which actors are responsible for implementation, in what roles, with what resources, and along which timeline?

Step 2

- → How is implementation steered and coordinated across levels, sectors and borders?
- → How will progress on implementation and effectiveness be monitored, reported and evaluated?
- → What is needed to embed the CRM action plan into a framework for iterative climate risk management?

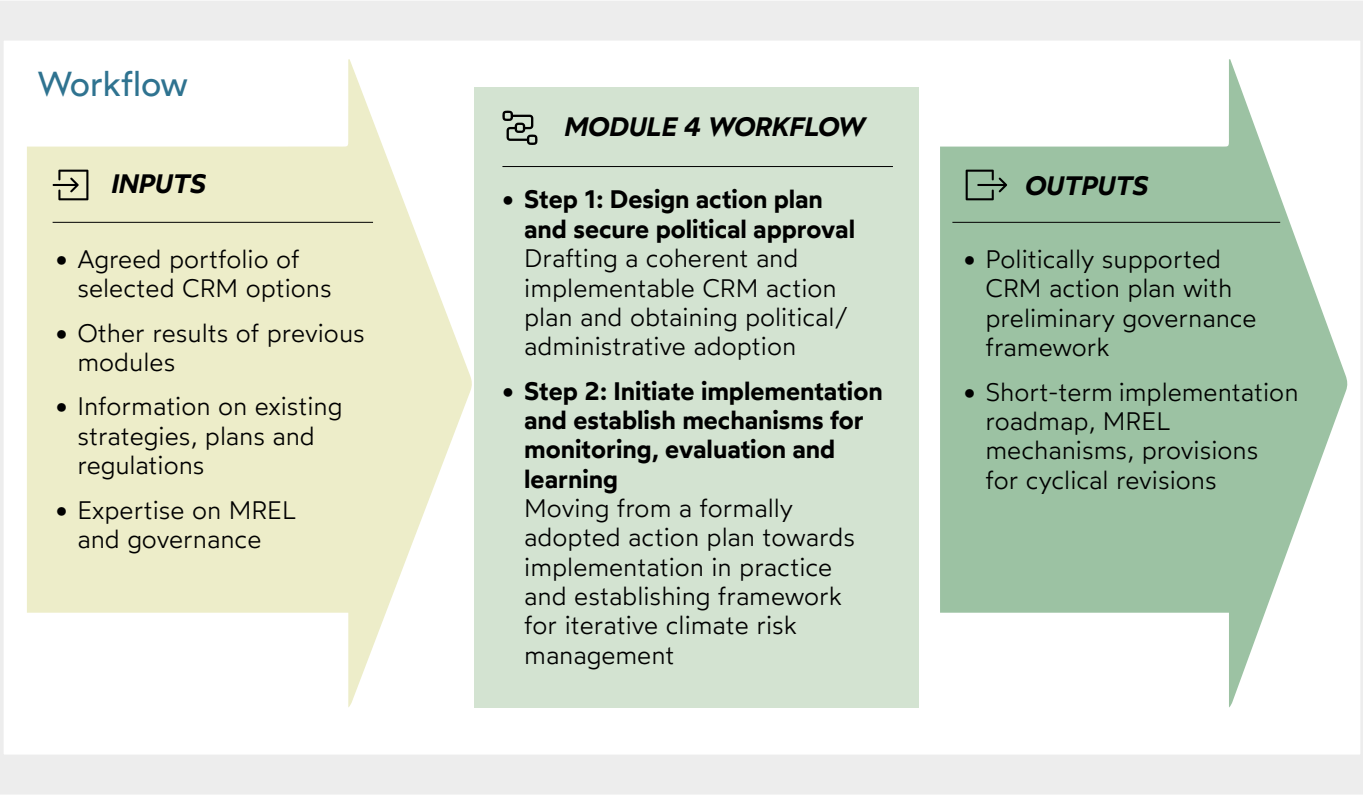


FIGURE 31: *Overview of workflow for Module 4*

Expected outcomes

- → Adopted climate risk management action plan
- → Short-term implementation roadmap, ongoing implementation process, and framework for iterative climate risk management

STEP 1: DESIGN ACTION PLAN AND SECURE POLITICAL APPROVAL

Purpose of this step: To draft a coherent and implementable action plan for regional climate risk management and secure its political or administrative adoption. This involves defining the mission and scope of the action plan, translating preferred options into actionable measures, aligning them with existing policy frameworks, allocating responsibilities and clarifying governance structures, and outlining mechanisms for monitoring and evaluation.

Once the preferred CCA and CRM options have been selected, the agreed actions for adapting prevention, preparedness, response and recovery activities to the challenges of current and future climate change need to be documented and developed into a structured and agreed plan. The regional action plan for climate risk management is the central policy instrument for putting adaptation and risk management options into effect, i.e. to translate options into implementable actions and to put them into practice. It converts the outcomes of the regional climate risk assessment, the results of the gap analysis, the strategic adaptation priorities, and the list of prioritised options into concrete targets and operational measures by specifying what needs to be done by whom and when, and by addressing allocation of resources and how to monitor and evaluate progress. The main purpose of an action plan is to formulate the measures, guide the implementation process by providing a detailed roadmap for their delivery, and to set a framework for reviewing and updating the plan in regular intervals. As such, an action plan is also a means of giving accountability to the roles of competent authorities and risk managers.

As the action plan document represents the policy output of the planning process, it should be firmly based on the outcomes of all preceding steps and

establish clear linkages between the actions and the key climate risks, key gaps, and strategic priorities. This step gives guidance on the contents and structure of an action plan for regional climate risk management, so that it can serve as reference document for implementation, building on a clear political mandate given by the competent authority. As a planning document, the action plan constitutes a cornerstone in the risk management planning process, but it is also embedded in an iterative policy cycle. It should thus include provisions on the governance of its implementation and on its monitoring, evaluation and revision in the future. Drawing on ISO standards, other guidance documents and existing national action plans, this step outlines minimum requirements and good practice criteria for designing an action plan.

Which inputs are needed?

- Portfolio of agreed adaptation and risk management measures (from → ***MODULE 3: STEP 2***)
- Policy entry points, multi-level governance linkages and coordination needs of local actions (from → ***MODULE 2: STEP 2***)
- Other results of previous modules (for summarising climate-related risks, key gaps, and adaptation priorities)
- Information on existing strategies, plans and regulations related to risk management and adaptation at local, regional, national and (where relevant) transnational levels (from → ***MODULE 1: STEP 1*** and ***MODULE 2: STEP 2***)
- Overview of relevant risk owners and implementing actors (responsible institutions, sectors, levels)

What does this step involve?

Strategic context, purpose and scope of the action plan: The action plan document represents the policy output of the preceding stages of the planning process. It should thus be firmly based on the outcomes of all previous modules and steps and should document and summarize them in a transparent and accessible way. The first part of the document should establish the strategic framework by clarifying the role of the CRM action plan in the regional policy landscape, stating its rationales and mission, and defining overarching objectives. Building on outcomes of previous steps in these guidelines, useful elements may include:

- *Objectives and desired outcome:* What are the overarching objectives and strategic directions the plan aims to achieve? What will be the benefits if the actions are implemented?
- *Scope and system boundaries*: Which area (e.g., administrative, geographic), sectors, and beneficiaries does the plan cover? What is the time horizon of actions? What implementing actors are addressed?
- *Current and expected climate change*: Why is adaptation and climate risk management needed? Which impacts have already been observed? Which are expected or possible in the future? What uncertainties exist, and how are they dealt with?
- *Summarized outcome of regional climate risk assessment and risk evaluation*: Which climate-related key risks and corresponding adaptation priorities does the plan address? Which risk narratives can be derived?
- *Summarized outcome of gap analysis:* Which key gaps in risk management and risk-related policy frameworks are addressed?
- *Policy context:* How does the plan relate to existing strategies, plans and instruments relevant to CCA and CRM - within the region, at higher-ranking levels, and of relevant sectors?
- *Development approach:* How was the action plan developed and how were decisions taken? Who was main responsible, and who was involved?
- *Formal characteristics:* In how far has the plan binding character, and for which actors? What is the period of validity?

Structuring and designing the portfolio of CRM options: The portfolio of selected CRM actions should be structured into a coherent set of measures.

This may include:

- Grouping actions by key risk, sector, thematic field or DRM cycle phase
- Identifying cross-cutting or generic actions
- Identifying actions that require coordination across borders, sectors or levels of government, including reference to relevant governance processes and instruments
- Checking for interactions, i.e. synergies and conflicts, between actions, flagging relevant issues, and, if necessary, adjusting or sequencing measures accordingly

Describing each action in a standardised, well-structured format: The formulation and presentation of the CRM actions is at the core of an action plan. Each action should be described according to a common structure (e.g. in factsheet format) by providing the information needed to enable their implementation. It is important to present clear linkages of actions with key risks, adaptation priorities, and key gaps. For filling the contents of the suggested structure, the information provided in the description of potential options (→ ***MODULE 3: STEP 1***) can be capitalised on. The structure of action factsheets may use the following content items[15]:

- Specific goals or targets (if possible, in a verifiable or measurable form)
- Relevance and rationales of actions (with clear linkages between action, key risks, adaptation priorities, and key gaps)
- Description of action: Implementation steps and/or pathways (if possible, in chronological sequence)
- Position in DRM cycle
- Links to existing policies and instruments offering entry points for mainstreaming and implementation
- Responsibilities and roles of implementing actors (risk ownership)
- Cooperation partners and coordination needs (across sectors and levels)
- Timeline for implementation (at least: short term, medium term, long term)
- Estimated resource needs and sources for funding and financing
- Potential conflicts and synergies (between actions, with other policies and interests)
- Vulnerable groups and equity aspects, including how measures might affect different social groups and territories
- Potential indicators for monitoring progress and outcome
- Potential inhibitors and enabling factors to overcome them
- Information and research needs

EXAMPLE 18:

Tailored Action Plans for improving risk management in the X-RISK-CC pilot areas

Based on comprehensive assessment of past extreme events, future climate projections, and a systematic evaluation of existing risk management capabilities and gaps, each project pilot area has co-developed a context-specific Tailored Action Plan for enhancing the risk management of climate-driven extreme events. Each action in the Tailored Action Plans is presented in factsheet format and described according to the following items, which can be grouped in content categories:

- **IDENTIFICATION:** Unique code, title, summary
- **GAP ADDRESSED:** Specific weakness or need in current risk management
- **FRAMING:** Position in risk cycle, action type, governance level, ownership, target groups
- **DESCRIPTION:** Detailed explanation of the action, preliminary steps, expected benefits, potential challenges
- **VALIDATION:** Indicators and parameters for monitoring progress and success
- **FEASIBILITY:** Timeline, funding status, responsibilities, implementation pathway

The complete structure of the action factsheets with descriptions of each field, is available in ***ANNEX 15***. In ***ANNEX 16***, two fully elaborated examples of actions from one of the Tailored Action Plans demonstrate application of the content structure.

Setting up governance framework for implementation: The action plan also needs to outline the governance structures, mechanisms and arrangements for steering, coordinating, and monitoring implementation, including for evaluation and revision of the plan. Key elements to be determined include:

- Political responsibility (policy owner)
- Lead institution or actor (process owner) responsible for overall coordination
- Steering group with shared coordination roles, composed of key implementing actors (e.g. civil protection, spatial planning, water management, forestry, climate adaptation, critical infrastructure providers)
- Arrangements for coordinating with higher-level actors
- Roles and responsibilities for implementation of each measure, including lead and supporting actors
- Reporting requirements: who reports about what to whom and when?
- Mechanisms for cross-border cooperation
- Engagement of stakeholders and interested parties in implementation, evaluation and revision

Outlining approaches to monitoring, reporting, evaluation and learning (MREL): Already at the stage of designing the action plan, it is highly recommended to outline how implementation will be monitored and periodically reviewed. This includes:

- Formulating the goals of each action in a clear, verifiable way that supports measurement
- Suggesting preliminary indicators or qualitative descriptors for monitoring implementation progress and effectiveness of measures
- Outlining a reporting system with responsibilities, procedures and cyclical intervals
- Aligning indicators and reporting procedures, where possible, with existing reporting requirements (e.g. at national or EU level) to reduce administrative burden
- Describing how monitoring results will be compiled, evaluated and used for learning (e.g. regular implementation reports, stakeholder meetings, integration into existing reporting systems)
- Establishing regular monitoring and revision cycles (e.g. every five years) for reviewing and updating the action plan
- Describing how learning from implementation, new evidence and updated climate risk assessments will inform future revisions of the action plan

Securing political or administrative approval: For an action plan to be effective, it is essential to obtain political approval. Formal recognition is a key step for ensuring mandate, legitimation, ownership, and sustainability of implementation in the long term. This typically involves:

- Consulting with relevant authorities and political decision makers (e.g. municipal council, regional government) during the drafting phase and integrating their feedback
- Preparing a concise summary (e.g. policy brief or presentation) highlighting the rationales, key measures, resource implications and expected benefits
- Organising formal adoption according to existing procedures (e.g. council resolution, decision by regional government, administrative approval)

Which methods are applicable?

- **Stakeholder engagement workshop:** It can be used to co-develop or present a draft action plan, validate the structure and content, agree on responsibilities and timelines, and identify gaps or inconsistencies. Building on the workshop formats described in the preceding modules, such a workshop can also be helpful in strengthening commitment to implementation.
- **Consultations with policy makers and decision makers:** Personal interaction formats during the drafting process and/or a written consultation procedure on the draft action plan fosters political buy-in and commitment.

- **Quality criteria and minimum requirements**: The checklists presented above, based on ISO standards, available guidance documents, and existing action plans, can be used by the planning team to guide drafting, conduct quality reviews and document that all important key elements have been considered.

Which tools are available?

- **Annex 15:** Structure and contents of action factsheets in X-RISK-CC
- **Annex 16:** Examples of actions in Tailored Action Plans of X-RISK-CC pilot areas
- **Tailored Action Plans** of X-RISK-CC pilot areas

Which outputs can be expected?

- Adopted **climate risk management action plan** with mandate for implementation, including:
  - Purpose, scope, context, and linkages to key risks, adaptation priorities and key gaps
  - Structured portfolio of CRM actions with responsibilities, timelines and indicative resources
  - Governance arrangements and coordination mechanisms for steering implementation
  - Preliminary MREL concept (indicators, reporting and review procedures, revision cycles)

STEP 2: INITIATE IMPLEMENTATION AND ESTABLISH MECHANISMS FOR MONITORING, EVALUATION AND LEARNING

Purpose of this step: To move from a formally adopted action plan towards implementation in practice and to path the way for iterative climate risk management. This includes organising governance of implementation, preparing a short term implementation roadmap, determining basic mechanisms for monitoring, reporting, evaluation and learning (MREL), and agreeing on cyclical renewal of the CRA and regular revision of the CRM action plan.

This step marks the transition from planning for climate risk management to putting the action plan into effect by delivering implementation of its measures. Implementation means transforming the climate risk management plan into ongoing actions, closing the loop to subsequent stages of the adaptation and risk management cycle, and iterating its main steps. While implementation will be beyond the immediate mandate of the planning team, it is advisable to harness the momentum of the planning process to initiate early implementation steps, to activate governance mechanisms, and to work towards establishing a framework for monitoring, reporting, evaluation, and learning (MREL). This helps to ensure that the action plan remains a living document that is regularly updated based on new information, experiences and evolving climate risks.

However, giving detailed guidance on the implementation process and MERL is beyond the scope of the present guidelines document. The following recommendations thus just outline in an indicative way main elements that should be considered for kicking off implementation and setting up a framework for iterative, cyclical climate risk management.

What does this step involve?

Organizing governance and steering of implementation across sectors and levels: Successful implementation of the action plan requires adequate institutional set-ups and governance frameworks to ensure effective, coherent and continued implementation. This includes leadership and commitment, mechanisms for horizontal (cross-sectoral) and vertical (multi-level) coordination, sufficient coordination capacities, supportive and enabling conditions provided by higher-ranking levels (e.g., capacity-building, knowledge provision, financing and funding), formats for continued stakeholder involvement and external communication, and transboundary cooperation arrangements.

Preparing a short-term implementation plan: To move from planning to action, it is useful to prepare a roadmap that sequences measures for the first implementation period (e.g., 2 – 3 years). Such a short-term plan may focus on the most urgent actions, prioritise 'quick win' measures that can be started

immediately with existing resources, schedule preparatory work (e.g., further in-depth investigations, feasibility studies, funding proposals, amendment of legislation) for more complex actions that require lead times, or align measures with existing budget and planning cycles at relevant government levels.

Establishing monitoring, reporting, evaluation and learning (MREL): A lean, but robust MREL framework should be agreed to track progress and support learning and policy revision. This may include a set of indicators to monitor implementation of key measures and, where feasible, changes in levels of risk, vulnerability or preparedness, data sources for applying indicators, straight-forward procedures for assessing whether measures are on track, delayed or need adjustment, and formats for joint reflection and learning (e.g., annual steering group meetings or stakeholder fora). Also, the format and frequency of reporting should be agreed upon, integrated in existing reporting procedures, wherever possible.

Planning cyclical renewal of the regional climate risk assessment (CRA) and revision of the action plan: Risk management and adaptation are organised in iterative cycles, allowing learning and adaptive management. This requires regular review and revision of the action plan, which is based on both, the results of MREL and an updated CRA. As climate-related risks, vulnerability and exposure patterns evolve over time and new knowledge becomes available, the regional CRA needs to be periodically reviewed and updated. In conjunction with the learnings derived from MREL, this renewed evidence informs revision of the action plan, which may include adjustments of goals and priorities, modifications of actions and their sequencing, and formulation of additional measures. If designed properly, CRA and MREL can be mutually supportive, e.g. when evaluation uses CRA results as baseline to measure effectiveness of actions in terms of risk reduction, or when monitoring provides evidence on changing risk levels. In any case, actors should agree on a regular cycle for updating the CRA (e.g., every 5 – 7 years) and on rules and timelines for revising the action plan in light of new information on climate risks and implementation success.

Which outputs can be expected?

- → **Implementation** of key CRM actions started and ongoing, including a **workable governance framework** and a **short-term implementation roadmap**
- → **Basic MREL framework** for the CRM action plan determined and in place
- → **Cyclical renewal** of the **regional CRA** and **regular revision** of the **CRM action plan** agreed and periodicity determined

2.5 RESULT

Managing climate risks and delivering risk reduction

The **key output** of the planning process is an **action plan for managing regional climate risks**, which is guiding an **ongoing implementation process** and embedded in a **framework for iterative climate risk management**. The cornerstones of this framework are regular progress, monitoring and evaluation reports and periodical updates of the regional CRA, which are both feeding into regular revisions of the action plan.

In terms of **outcome**, successful climate risk management will **effectively reduce current and future climate-related risks, keep them at tolerable levels,** and **increase adaptive capacities and resilience**.

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4. ANNEX

Interreg Co-funded by the European Union

Alpine Space

X-RISK-CC

X-RISK-CC TRANSNATIONAL GUIDELINES

ANNEX: COMPENDIUM OF TOOLS, METHODS, MATERIALS AND EXAMPLES

LEAD PARTNER

PROJECT PARTNERS

eurac research

Wildbach- und Lawinenverbauung Forsttechnischer Dienst

umweltbundesamt

GeoSphere Austria

Technische Universität München

Auvergne Rhône-Alpes Energie Environnement

Republic of Slovenia Ministry of the Environment, Climate and Energy Slovenian Environment Agency

Razvojna agencija Sora d.o.o.

ANNEX 1: GLOSSARY

Adaptation (Climate Change Adaptation, CCA): In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; in some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2022, World Bank, 2026).

Adaptive capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities or to respond to consequences (MA, 2005; IPCC, 2022).

Cascading events: A sequence of interconnected events where one initial event triggers subsequent events, often amplifying impacts as they progress. Cascading events are particularly relevant in *risk management* and disaster studies, as they can result in unexpected and widespread consequences (e.g. heavy rainfall causes a river to overflow, triggering floods that damage homes, disrupt transportation, contaminate water supplies, and lead to economic and social crises) (IPCC, 2019).

Cascading hazards: Cascading *hazards* occur when one hazard triggers another, creating a chain reaction of events. Any natural hazard might trigger zero, one or more secondary natural hazards. The secondary natural hazard might be identical or different from the primary hazard (Tilloy et al., 2019). An example in the Alpine context might be a landslide caused by intense rainfall that subsequently blocks a river, leading to flooding (X-RISK-CC, 2025).

Cascading impacts: Cascading impacts from *weather extremes* (extreme weather/climate events) occur when an extreme *hazard* generates a sequence of secondary events in natural and human systems that result in physical, natural, social or economic disruption, whereby the resulting impact is significantly larger than the initial impact. Cascading impacts are complex and multi-dimensional, and are associated more with the magnitude of *vulnerability* than with that of the *hazard* (IPCC, 2022). Interconnected, and escalating effects triggered by a climate-related hazard that impact multiple sectors or systems, amplifying *risks* (X-RISK-CC, 2025).

Climate risk (climate-related risk): Potential for adverse consequences from climate variability, climate change or climate-related extreme events for human or ecological systems and their functions. Climate risk results from the dynamic interaction of *hazards* with the *exposure*, *vulnerability* and *adaptive capacity* of the affected system. It describes how, to what extent, and why climate change and weather extremes could cause harm to people, assets, sectors, or systems and, if possible, how likely adverse consequences are today or could become in the near or far future. It is often represented as the probability that a hazardous event or trend occurs multiplied by the expected impact. Relevant adverse consequences include those on lives, livelihoods, health and wellbeing, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species (World Bank, 2026; IPCC, 2021a; Zebisch et al., 2023).

Climate Risk Assessment (CRA): Umbrella term for the diverse forms of systematic evidence-gathering activities that seek to assess and understand climate *hazards*, impacts, *vulnerabilities* and/or *risks*. CRAs are a fundamental element of the adaptation policy cycle, providing the essential knowledge base about current and future *climate-related risks* for informing evidence-based *adaptation* planning and implementation processes (EEA 2018, 2022).

Climate Risk Management: Climate Risk Management includes all mechanisms and measures (such as plans, actions, strategies or policies) to reduce current and future *climate risks*. The management of current risk to climate extremes is typically covered by the existing *Disaster Risk Reduction (DRR)* mechanisms. *Climate Change Adaptation (CCA)* involves the process of adapting current *risk management* practices to the actual or anticipated impacts of climate change in order to limit damage or take advantage of positive opportunities. This includes adapting to the increasing intensity and frequency of climate extremes, as well as slow-onset processes (such as sea-level rise) and emerging *climate risks*. Today, CCA and DRR are seen as integral constituent parts of successful Climate Risk Management (Zebisch et al., 2023).

Compound events: The combination of multiple drivers and/or *hazards* that contributes to societal or environmental *risk*. In the framework of weather phenomena, compound events involve two or more individual meteorological processes that occur simultaneously or within a short timeframe (e.g., a heatwave coinciding with a drought) (IPCC, 2021b).

Compound hazards: Different *hazards* resulting of the same triggering event. In this case there is not a primary and a secondary hazard as the different hazards occur simultaneously or sequentially within a reasonably short timeframe, often interacting to amplify overall impacts. For example, a prolonged drought followed by an intense rainfall event can lead to flash flooding and soil erosion (Tilloy et al., 2019; X-RISK-CC, 2025).

Compound risks: They arise from the interaction of *hazards*, which may be characterised by single extreme events or multiple coincident or sequential events that interact with exposed systems or sectors (IPCC, 2022). Compound risks emerge when multiple climate hazards occur together or in succession, interacting with exposed and vulnerable systems to amplify impacts (X-RISK-CC, 2025).

Disaster Risk Management (DRM): Processes for designing, implementing and evaluating strategies, policies and measures to improve the understanding of current and future disaster *risk*, foster *disaster risk reduction* and *transfer*, and promote continuous improvement in disaster *preparedness*, *prevention* and protection, *response* and *recovery* practices, with the explicit purpose of increasing human security, well-being, quality of life and sustainable development (IPCC, 2022). Disaster risk management is the application of *disaster risk reduction* policies and strategies to prevent new disaster risk, reduce existing disaster risk and manage residual risk, contributing to the strengthening of *resilience* and reduction of disaster losses (UNDRR, 2017).

Disaster Risk Reduction (DRR): Disaster risk reduction is aimed at preventing new and reducing existing disaster risk and managing *residual risk*, all of which contribute to strengthening *resilience* and therefore to the achievement of sustainable development. DRR denotes both a policy goal or objective, and the strategic and instrumental measures employed for anticipating future disaster *risk*, reducing existing *exposure*, *hazard*, or *vulnerability*, and improving *resilience* (UNDRR, 2017; IPCC, 2022).

Disaster: Serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of *exposure*, *vulnerability* and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts. The effect of the disaster can be immediate and localized, but is often widespread and could last for a long period of time. The effect may test or exceed the capacity of a community or society to cope using its own resources, and therefore may require assistance from external sources, which could include neighbouring jurisdictions, or those at the national or international levels (MA, 2005; UNDRR, 2017).

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2022). The situation of people, infrastructure, housing, production capacities and other tangible human assets located in hazard-prone areas. Measures of exposure can include the number of people or types of assets in an area. These can be combined with the specific *vulnerability* and capacity of the exposed elements to any particular hazard to estimate the quantitative *risks* associated with a *hazard* in the area of interest (UNDRR, 2017).

Green and blue infrastructure: A strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, green infrastructure is present in rural and urban settings. Green Infrastructure is based on the principle that protecting and enhancing nature and natural processes, and the many benefits human society gets from nature, are consciously integrated into spatial planning and territorial development. Compared to single-purpose, grey infrastructure, green and blue infrastructure has many benefits. It is not a constraint on territorial development but promotes natural solutions if they are the best option. It can sometimes offer an alternative, or be complementary, to standard grey solutions (EC, 2013).

Hazard: A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. Natural hazards are predominantly associated with natural processes and phenomena. Hazards may be single, sequential or combined in their origin and effects. Each hazard is characterized by its location, intensity or magnitude, frequency and probability (UNDRR, 2017).

Hazard map (hazard mapping): Geographic map that identifies and shows areas potentially affected by a specific natural *hazard*. It visually represents where hazards are likely to occur, how severe they may be, and sometimes how frequently they happen. They are typically created for hydrometeorological and geophysical hazards, such as riverine floods, torrential floods, debris flows, rockfall, or avalanches. In simple terms, hazard mapping answers the question: 'what can happen, and where?'. Hazard maps are essential tools for *disaster risk management* and spatial planning, as they help guide land use decisions, infrastructure development, and emergency *preparedness*.

Hazard zone planning: *Hazard maps* that use zonation to categorize the likelihood and intensity of a *hazard* occurring in specific locations. For example, hazard zones may relate to flood events with statistical return intervals of every 30 or every 100 years, or they may represent areas with different degrees of susceptibility to landslides. Usually, colour coding is used to represent different hazard zones, such as red zones to delineate areas where a potential hazard is so severe or frequent that permanent settlement activities are considered ineligible, and yellow zones where building permissions can only be granted if certain protection requirements are complied with.

Impact-based forecasting: Impact-based hazard or event forecasting is an approach to forecasting that goes beyond predicting the physical characteristics of a *hazard* (such as rainfall amount, or wind speed) to instead forecast the likely impacts and consequences of that hazard on people, infrastructure, services, and the environment. The goal is to communicate forecasts in terms of what the event will do, rather than only what the event will be. Impact-based forecasting supports better *preparedness* and early *response* action by making forecasts more relevant and actionable for emergency managers, authorities, and the public.

Maladaptation (maladaptive action): Actions that may lead to increased risk of adverse climate-related outcomes, including via increased greenhouse gas (GHG) emissions, increased or

shifted *vulnerability* to climate change, more inequitable outcomes, or diminished welfare, now or in the future. Most often, maladaptation is an unintended consequence (IPCC, 2022).

Monitoring, reporting, evaluation and learning (MREL): Mechanisms put in place to monitor and evaluate efforts to adapt to the impacts of climate change with the aim of systematically identifying, characterising and assessing progress over time. MREL activities are essential for *climate change adaptation*, as they provide a framework for tracking progress towards adaptation goals, support effective adaptation planning, and identify areas for improvement. They also facilitate learning and accountability by ensuring adaptation efforts are responsive to changing circumstances (IPCC, 2022; EEA, 2020).

Multi-hazard: The specific contexts where hazardous events may occur simultaneously, cascadingly or cumulatively over time, and taking into account the potential interrelated effects (UNDRR, 2017).

Nature-based Solutions (NbS): Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively. Therefore, they provide human wellbeing and biodiversity benefits (IUCN, 2016). Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build *resilience*. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions Nature-based solutions must benefit biodiversity and support the delivery of a range of ecosystem services (EC, 2015).

Non-structural measures: Measures not involving physical construction which use knowledge, practice or agreement to reduce disaster *risks* and impacts, in particular through policies and laws, public awareness raising, training and education. Common non-structural measures include building codes, land-use planning laws and their enforcement, research and assessment, information resources and public awareness programmes (UNDRR, 2017).

Nowcasting: Weather forecasting on a very short term mesoscale period of up to 2 hours, according to the World Meteorological Organization. This forecast is an extrapolation in time of known weather parameters, including those obtained by means of remote sensing, using techniques that take into account a possible evolution of the air mass. This type of forecast therefore includes details that cannot be solved by numerical weather prediction models running over longer forecast periods. The strength of nowcasting lies in the fact that it provides location-specific forecasts of storm initiation, growth, movement and dissipation, which allows for specific preparation for a certain weather event by people in a specific location.

Path dependency: In generic terms, path dependency is the concept that decisions, actions, or developments made in the past constrain or shape the options available in the present and future, even when alternative choices might now be more efficient or desirable. It describes the situation where decisions, events, or outcomes at one point in time constrain *adaptation*, mitigation or other actions or options at a later point in time, because earlier choices create self-reinforcing effects—such as established infrastructure, regulations, investments, habits, technologies, or social norms—that are difficult or costly to change. Risk of adverse path dependencies is a characteristic of *maladaptation*, i.e. adaptation measures that, simultaneously with high future uncertainty, are irreversible or inflexible, and thus are impossible or difficult to correct, re-direct, or retract. Detrimental path dependencies can cause *vulnerability lock-ins*, reduce *adaptive capacities* and solution space over time, inhibit transformative change, and result in high and unavoidable damage and loss, if adaptation limits are reached (EPA IG CCA, 2025).

Pluvial flooding: Pluvial floods occur when extreme rainfall creates flooding independent of overflowing water bodies. They can happen in urban or rural areas, even without nearby bodies of water. Surface water floods occur when the ground's ability to absorb water or the capacity of urban drainage systems is overwhelmed, while flash floods are characterized by intense, high-velocity water torrents triggered by torrential rain or sudden water releases from upstream levees or dams.

Preparedness: Activities and measures taken in advance to anticipate, respond and recover from the impacts of a hazardous event. Preparedness aims to build the capacities for ensuring rapid and effective *response* and for efficiently managing emergencies before a *disaster* strikes (based on: UNDRR, 2017). Preparedness measures include forecasting and early warning systems, emergency and evacuation planning, standard operating procedures, training and field exercises, resource pre-positioning, public awareness campaigns, and establishment of coordination mechanisms.

Prevention: Measures and activities to avoid or mitigate existing and new disaster *risks*. Prevention aims to completely avoid the potential adverse impacts of hazardous events, to reduce the chances of a risk incident occurring, and/or to reduce the extent of damage if a disaster occurs. Prevention supports acceptable levels of risk society is willing to live with (based on: UNDRR, 2017). Prevention involves *structural* and *non-structural measures*.

Protection-development spiral: Denotes the phenomenon that implementation of *structural* hazard protection measures regularly triggers development intensification with new construction activities, expansion of settlement areas and in-migration of residents in former hazard zones and on now supposedly 'protected' land. In conjunction with increasing *hazards* due to climate change, such development pathways can increase *exposure* to (growing) *residual risk*, damage potentials and severity of consequences in case of overload or technical failure. Especially if spatial planning policies encourage withdrawing of *hazard zone maps* and associated restrictions for the zoning of building land after protective infrastructure has been erected, this can create irreversible vulnerability lock-ins and inevitable damage and loss when technical protection limits are exceeded by escalating climate change. The resulting *maladaptive path dependency* is also called 'safe development paradox' or 'building land-revision dilemma' (EPA IG CCA, 2025).

Real-time monitoring: Refers to the continuous and immediate observation, measurement, and analysis of data, events, or processes as they occur in real time. Real-time hazard monitoring uses continuous data collection and AI to instantly detect, analyse, and alert about potential dangers, e.g. from *extreme weather events* and natural *hazards*. It allows real-time alerts and rapid *response* actions to prevent and minimize damage, including by interfering in chains of evens before they escalate.

Recovery: Actions taken after a *disaster* to cope with its effects, restore livelihoods and health, and rebuild resilient critical infrastructures, services, housing, and facilities, aligned with 'build back better' principles to enhance future *resilience*. Sustainable recovery integrates post-event learning, adaptive management and long-term thinking (based on: UNDRR, 2017). Recovery measures include sustainable restoration of infrastructure and services, damage compensation and reconstruction financing, psychosocial support, participatory reconstruction planning, post-event learning mechanisms, and re-adjustment of *risk management* frameworks.

Residual risk: The risk related to climate change impacts that remains following *adaptation* and mitigation efforts (IPCC, 2022). The disaster *risk* that remains even when effective *disaster risk reduction* measures are in place, and for which emergency response and recovery capacities must be maintained. The presence of residual risk implies a continuing need to develop and support effective capacities for emergency services, *preparedness*, *response* and *recovery*, together with socioeconomic policies such as safety nets and *risk transfer* mechanisms, as part of a holistic approach (UNDRR, 2017). The concept of residual risk is closely related to the determination of protection goals. Protection goals denote the level of security that responsible risk management actors aim to achieve, and the threshold of risk that protection measures in place are designed to protect against (controlled, i.e. intolerable risk), e.g. a 100-year event. In that context, the risk related to events that exceed the protection goals (accepted, uncontrolled risk), e.g. due to cases of overload or failure, constitutes a crucial part of residual risk. Residual risk comprises also those risks that are related to unawareness and/or ignorance, an incorrect assessment of risks or inappropriate measures to control them (Schneiderbauer et al., 2018).

Resilience: The ability of a system, community or society exposed to *hazards* to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazardous event, trend or disturbance in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through *risk management* The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance (UNDRR, 2017; IPCC, 2022).

Response: Actions taken directly before, during and immediately after an emergency to save lives, reduce impacts, ensure public safety, meet basic subsistence needs and quickly repair the most needed infrastructure. Effective and timely *response* and disaster relief require the coordinated intervention of all civil protection actors, individuals, and communities (based on: UNDRR, 2017). Response measures include effective coordination, emergency protocols, relief operations, search and rescue, evacuation, emergency communications, and immediate humanitarian assistance.

Return period: Also known as the recurrence interval, it is the estimated average time between events of a given magnitude. It is expressed in years and derived from statistical analysis. For example, a 100-year return period for a flood means there is a 1/100 (or 1 %) chance of such a flood being exceeded in any given year (X-RISK-CC, 2026).

Risk (disaster risk): The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. (Disaster) risk is determined probabilistically as a function of *hazard*, *exposure*, *vulnerability*, and *capacity*. Relevant adverse consequences include those on lives, livelihoods, health and well-being, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species (IPCC, 2021a). In the context of climate change impacts, risks result from dynamic interactions between climate-related *hazards* with the *exposure* and *vulnerability* of the affected human or ecological system to the hazards. Hazards, exposure and vulnerability may each be subject to uncertainty in terms of magnitude and likelihood of occurrence, and each may change over time and space due to socioeconomic changes and human decision-making (IPCC, 2022).

Risk drivers: Processes or conditions, often development-related, that influence the level of *disaster risk* by increasing levels of *exposure* and *vulnerability* or reducing *capacity*. Underlying disaster risk drivers — also referred to as underlying disaster risk factors — include poverty and inequality, climate change and variability, unplanned and rapid urbanization and the lack of *disaster risk* considerations in land management and environmental and natural resource management, as well as compounding factors such as demographic change, non-disaster risk-informed policies, the lack of regulations and incentives for private disaster risk reduction investment, complex supply chains, the limited availability of technology, unsustainable uses of natural resources, declining ecosystems, pandemics and epidemics (UNDRR, 2017).

Risk exposure: The extent to which an entity is subject to potential loss or harm from a specific *risk*.

Risk management capacity: The combination of all the strengths, attributes and resources available within an organization, community or society to manage and reduce disaster risks and strengthen *resilience*. Capacity may include infrastructure, institutions, human knowledge and skills, and collective attributes such as social relationships, leadership and management (UNDRR, 2020)

Risk management: Plans, actions, strategies or policies to reduce the likelihood and/or magnitude of adverse potential consequences, based on assessed or perceived *risks* (IPCC, 2022).

Risk map (risk mapping): Geographic map that shows not only where a hazardous event may occur and its characteristics

(intensity, likelihood, extent) but combines the *hazard* with information on *exposure* and *vulnerability*. It shows the potential consequences of a hazard on people, buildings, infrastructure, and the environment, accounting for factors that determine potential damage and loss, such as population density, building quality, land use, and coping capacity. In simple terms, risk mapping answers the question: 'what can happen, who or what will be affected, and how severe could the impacts be?' More widespread and systematic application of risk mapping can crucially support risk-based decision making on land use and building design, enabling differentiated allocation of different forms and intensities of land use according to their risk levels.

Risk owner: Risk owners are persons, institutions or other entities responsible for managing *hazards*, *exposure*, *vulnerabilities* and resulting *risk*.

Risk transfer: The process of formally or informally shifting the financial consequences of particular risks from one party to another, whereby a household, community, enterprise or state authority will obtain resources from the other party after a disaster occurs, in exchange for ongoing or compensatory social or financial benefits provided to that other party. Insurance is a well-known form of risk transfer, where coverage of a risk is obtained from an insurer in exchange for ongoing premiums paid to the insurer. Risk transfer can occur informally within family and community networks where there are reciprocal expectations of mutual aid by means of gifts or credit, as well as formally, wherein governments, insurers, multilateral banks and other large risk-bearing entities establish mechanisms to help cope with losses in major events. Such mechanisms include insurance and reinsurance contracts, catastrophe bonds, contingent credit facilities and reserve funds, where the costs are covered by premiums, investor contributions, interest rates and past savings, respectively (UNDRR, 2017; IPCC, 2022).

Structural measures: Any physical construction to reduce or avoid possible impacts of *hazards*, or the application of engineering techniques or technology to achieve hazard resistance and *resilience* in structures or systems (UNDRR, 2017). Common structural measures for disaster risk reduction include dams, flood levies, retention basins, property-level asset protection measure, or evacuation shelters.

Vulnerability: The propensity or predisposition to be adversely affected. The conditions are determined by physical, social, economic or environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of *hazards*. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt (IPCC, 2022; UNDRR, 2017).

Vulnerability lock-in: Refers to a situation in which people, communities, systems, or places become trapped in patterns of *vulnerability* due to past decisions, structures, or practices that are difficult to change, even when those vulnerabilities are well understood. It occurs when *path-dependent* choices—such as settlement patterns, infrastructure investments, institutional arrangements, or livelihood strategies—create self-reinforcing conditions that continue to *expose* actors to hazards and limit their *capacity* to adapt or reduce risk.

Weather extreme (climate extreme, extreme weather or climate event): The occurrence of a value of a weather or climate variable above (or below) a threshold value near the upper (or lower) ends of the range of observed values of the variable. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. When a pattern of extreme weather persists for some time, such as a season, it may be classified as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., high temperature, drought or heavy rainfall over a season). For simplicity, both extreme weather events and extreme climate events are referred to collectively as climate extremes (IPCC, 2022, 2021a).

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ANNEX 2: LESSONS LEARNED FROM IMPLEMENTING STAKEHOLDER ENGAGEMENT PROCESSES IN PRACTICE

The successful implementation of any stakeholder engagement process requires sound planning and depends on the integration of all interests. Any dissatisfaction of participants with the content or form of a participatory process can have a negative impact on the substantive outcomes of the collaboration. Thus, the following list, building on Prutsch et al. (2014) and Schinko and Bednar-Friedl (2022), summarises important points in preparing, implementing and postprocessing a successful stakeholder engagement process.

Important considerations when preparing a stakeholder engagement process

- The objectives of the participatory engagement, identified against the backdrop of the key contextual conditions, determine who will be involved and to what extent.
- All interests that are to be integrated and considered in a certain decision context should be represented by stakeholders. To this end, comprehensive stakeholder analysis and mapping should be conducted, including stakeholder identification, stakeholder differentiation and categorisation, and identification of relationships between stakeholders.
- The key participatory process features (e.g. open dialogue and deliberation, power delegation; participation of citizens vs. organised stakeholders) have to be defined.
- The method for stakeholder engagement (e.g. workshop, focus group, role play, serious games) should be selected based on the objectives of the participatory process and tailored to the number of participants. Methods can also be combined.
- Existing participatory methods can only serve as a starting point for similar case specific stakeholder engagement processes and have to be adjusted according to the respective local needs as well as environmental, socio-economic and governance framework conditions. Existing participatory methods can only serve as a starting point for similar case specific stakeholder engagement processes and have to be adjusted according to the respective local needs as well as environmental, socio-economic and governance framework conditions.
- The resources available for the participatory process (time, money, experienced personnel) must be determined in advance.
- The time resources required from participating stakeholders need to be considered, and the integration process has to be explained in detail from the very beginning (number of events, schedule, expected results, etc.).
- Guard against high expectations on the part of the stakeholders by communicating their power from the start: Will the stakeholders only be informed about the process, will they be consulted, or will they have a say in decisions?
- The roles of stakeholders in the participatory process must be clear. Of course, roles may change over the course of the process; for example, certain stakeholders may be information providers at the beginning, but active supporters in the later implementation of the project.
- The roles of scientists, experts, and process leaders must also be clearly communicated.
- From the start, explain what will happen with the results of the process.

SOURCE: *Zebisch, M. et al. (2023).*

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ANNEX 3: RISK EVALUATION MATRICES

MAGNITUDE OF CONSEQUENCES

	Class	Criteria: potential for consequences with the following magnitude/severity
Severe	4 Catastrophic/ very high	Major losses and damages, loss of system functionality, irreversibility of consequences, large extent, very high pervasiveness, high potential for impact thresholds or local tipping points, cascading effects beyond system boundaries, systemic risk.
	3 Critical/high	Significant losses and damages, disturbance of system functionality, long-term effects, large extent and high pervasiveness, potential for impact thresholds or local tipping points, cascading effects beyond system boundaries and systemic risk.
	2 Moderate	Moderate losses and damages, moderate disturbance of system functionality, effects are temporary or unfolding slowly with a moderate extent/pervasive-ness.
	1 Negligible/low	No to low losses and damages. No disturbance of functionality.

FIGURE: *Classes to describe the magnitude of consequences by applying risk criteria of the IPCC (2022) (source: Zebisch et al., 2023: p. 126)*

LIKELIHOOD OF CONSEQUENCES

	Hazardous event		Slow-onset process	
4	Frequent	Likely to occur often in a lifetime (every 0 – 10 years)	Very likely	Very likely (90%–100%) to occur in the next ten years
3	Probable	Likely to occur several times in a lifetime (every 0 – 25 years)	Likely	Likely (66% – 100%) to occur in the next 10 years
2	Occasional	Likely to occur sometime in a lifetime (every 0 – 50 years)	As likely as not	As likely as not (33% to 60%) to occur in the next 10 years
1	Remote	Unlikely but still possible to occur in a lifetime (0 – 100 years)	Unlikely	Unlikely (0% – 33%) to occur in the next 10 years

FIGURE: *Proposal of likelihood classes of consequences for one-off hazardous events and slow-onset processes (source: Zebisch et al., 2023: p. 127)*

RISK MATRIX COMBINING MAGNITUDE AND LIKELIHOOD

Frequency/ likelyhood of consequences		Remote/ unlikely	Occasional/ as likely as not	Probably/ likely	Frequent/ very likely
Magnitude of consequences	Catastrophic				
	Critical				
	Moderate				
	Negligible				

Key for the risk: very high | high | moderate | low

FIGURE: *Example of a risk matrix combining magnitude and likelihood of consequences (source: Zebisch et al., 2023: p. 127)*

SEVERITY OF RISK

	Class	Criteria: potential for consequences with the following magnitude/severity
Severe	4 Very high	Frequent, very likely and major losses and damages within important systems. Loss of system functionality, irreversibility of consequences, large extent, very high pervasiveness, high potential for impact thresholds or local tipping points, cascading effects beyond system boundaries, systemic risk. Low ability to respond or adapt to the risk.
	3 High	Likely significant losses and damages, disturbance of system functionality, long-term effects, large extent and high pervasiveness, potential for impact thresholds or local tipping points, cascading effects beyond system boundaries and systemic risk. Moderate ability to respond or adapt.
	2 Moderate	Likely moderate losses and damages, moderate disturbance of system functionality, effects are temporary or unfolding slowly with a moderate extent/pervasiveness. Moderate to high ability to respond or adapt.
	1 Low	No to low losses and damages. No or rare disturbance of functionality, high ability to respond or adapt.

FIGURE: *Classes to describe the severity of risk by applying the risk criteria of the IPCC (2022) (source: Zebisch et al., 2023: p. 129)*

References

Zebisch, M. et al. (2023). Climate Risk Sourcebook. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Bonn. https://civil-protection-knowledge-network.europa.eu/media/climate-risk-sourcebook

IPCC (2022): Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.

ANNEX 4: PRESENTATION OF RISK EVALUATION RESULTS

EXAMPLE FOR PRESENTING RESULTS OF A RISK EVALUATION PROCESS

From Risk Analysis	Key risk 1 – risk to farmers due to drought – lowlands		
	Current (2001 – 2020)	**Near-term (2021 – 2040)** Intermediate emissions –> +1.5°C BAU = Business-as-usual Asp. = Aspiration	**Mid-term 2041 – 2060** High emissions –> + 2.4 °C Moderate emissions –> +2°C
Potential for severe consequences	Moderate: only occasional critical consequences	High: the critical consequences may become likely (BAU)	Very high: under high warming levels (BAU)
		Moderate: if exposure and vulnerability lowered through CCA (Asp.)	High: potential for severe consequences (Asp.)
Critical constellations or locations	High: small-scale farmers in remote areas in the north are highly vulnerable towards climate change	High: the situation in vulnerable regions for vulnerable groups might aggravate	Very high: in highly vulnerable regions and for highly vulnerable groups if no CCA measures are taken
Temporal characteristics of the risk	High: droughts are already posing a risk under current conditions, but persistence is low. Persistent droughts (over several years) might become more frequent already in near future, which requires urgent action.		
Ability to respond to the risk	The ability to respond to current droughts is high. Land degradation can be stopped, and irrigation systems can be made efficient and water saving	High: low ability to respond, if CCA is not started now (BAU)	Very high: Very low ability to respond in high emissions scenario. For some farms, limits of CCA may be reached (BAU)
		Moderate: if CCA has been started today and land is managed in a sustainable manner (Asp.)	Low to moderate: ability to respond even in a moderate emissions scenario; it is important to start CCA now and practice in order to move towards sustainable land-management(Asp.)
Importance of the system at risk	Very high importance of agriculture for food security and as the main source of income		
Severity of risk	Moderate	High (BAU)	Very high (BAU)
		Moderate (Asp.)	High (Asp.)
Confidence and uncertainty of the assessment	High, good data on current drought impacts as well as on the economic situation and farmland distribution	Moderate, climate model data available, but no model on future drought impacts. Aspiration scenarios are highly uncertain	High uncertainty, particularly on exposure, vulnerability and underlying risk drivers

FIGURE: *Example of results of a risk evaluation for selected key climate risks (source: Zebisch et al., 2023: p. 92)*

References

Zebisch, M. et al. (2023). Climate Risk Sourcebook. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Bonn. https://civil-protection-knowledge-network.europa.eu/media/climate-risk-sourcebook

ANNEX 5: RRMA METHODOLOGY

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RRMA Categories and indicators

Structural prevention

- **1.1 To what extent were structural prevention/protective measures/systems in place for the event (presence of measures)?**
- **1.2 To what extent did the structural prevention/protective measures/systems fulfil their function during the event (efficiency of measures)?**
- **1.3 How do you assess the condition of the structural protective measures and their maintenance before the event?**

Non structural prevention

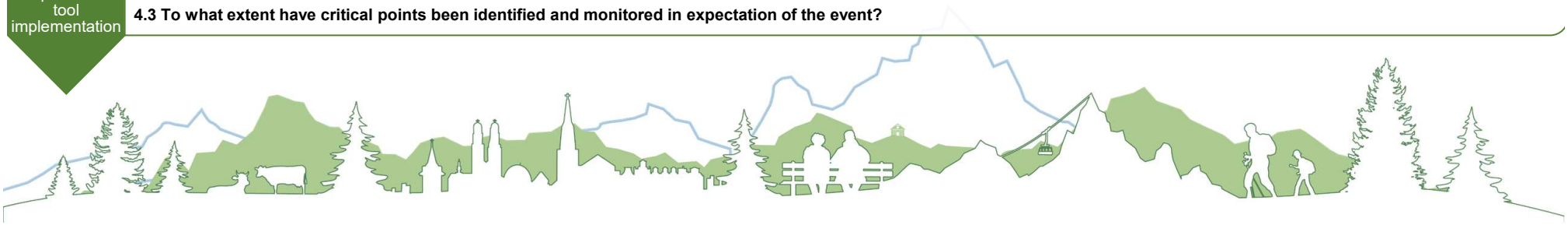
- **2.1 To what extent were contingency plans (i.e. action plans for risks) implemented and known by various organizations?**
- **2.2 To what extent did existing contingency plans (i.e. action plans for risks) cover the occurred scenarios?**
- **2.3 How do you rate the quality of the hazard map in terms of its alignment with the actual event that occurred?**

Preparedness tools

- **3.1 How well were the phenomena of the event forecasted?**
- **3.2 To what degree have the predicted phenomena been assessed with respect to possible impacts and risks for warning purposes prior to the event?**
- **3.3 To what extent was a warning system in place to inform the target groups of the possible impacts and risks?**

Preparedness tool implementation

- **4.1 To what degree were the standard procedures for authorities and civil protection organizations accessible and implemented in response to the warning?**
- **4.2 How do you evaluate the effectiveness of the short-term prevention measures implemented in anticipation of the event?**
- **4.3 To what extent have critical points been identified and monitored in expectation of the event?**



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RRMA Categories and indicators

Response tools

- **5.1 To what extent was an organizational structure established, outlining key roles, responsibilities, communication channels and key players?**
- **5.2 How do you rate the quality/procedure of information shared by the involved authorities during the response phase?**
- **5.3 To what extent were decision support tools available for managing the situation?**

Response tool implementation

- **6.1 To what extent were the exiting protocols followed by managing authorities and other involved target groups?**
- **6.2 How effective was the organizational structure in adapting to the event and handling unexpected situations?**
- **6.3 How do you evaluate the adequacy of the administrative procedures to implement the measures?**

Structural recovery

- **7.1 To what degree were recovery measures planned and prioritized according to the established planning?**
- **7.2 To what degree did the implementation of recovery match the planned time and costs?**
- **7.3 To what degree was the funding for structural recovery adequate?**

Recovery learning organizations

- **8.1 To what extent has the management of the event been debriefed and documented?**
- **8.2 To what degree was the information collected in the debriefing evaluated to identify possible improvements for the future?**
- **8.3 To what extent were „lessons learned“ implemented in concrete strategies for future improvement?**

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Structural prevention

1.1 To what extent were structural prevention/protective measures/systems in place for the event (presence of measures)? (e.g. check dams for debris flow, bridges etc.)

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Structural protective measures were in place for **all processes** that occured	• Structural protective measures were in place for **most processes** that occured	• Structural protective measures were in place for **few processes** that occured	• **No structural protective measures** in place

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Structural prevention

1.2 To what extent did the structural prevention/protective measures/systems fulfil their function during the event (efficiency of measures)?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Structural protective measures have **fully fulfilled** their protective function for the processes that have occured • Structural protective measures have reacted in a good-natured manner to the overload of the system (e.g. no collapse-like failure)	• Structural protective measures have **mostly fulfilled** their protective function for the processes that have occured • Structural protective measures have reacted in a good-natured manner to the overload of the system (e.g. no collapse-like failure)	• Structural protective measures have **only partially** protected against the processes that have occured • Some structural protective measures have failed	• Structural protective measures have **not fulfilled** their protective function at all • Collapse of structural protective measures made situation even worse (no good-natured manner)

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Structural prevention

1.3 How do you assess the condition of the structural protective measures and their maintenance before the event?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Structural protective measures were in **excellent condition** • Condition of structural protective measures was **checked regularly** • necessary maintenance measures were **implemented promptly**	• Structural protective measures were in **excellent condition but not regularly inspected** • Structural protective measures were in **good condition and regularly inspected** • Necessary maintenance measures were **carried out with delay**	• Structural protective measures were in **poor condition** • Structural protective measures were **only rarely inspected** • Necessary maintenance measures were **not implemented**	• Structural protective measures were in **very poor condition** • Condition of structural protective measures was **never checked** • **No maintenance**

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Non structural prevention

2.1 To what extent were contingency plans (i.e. action plans for risks) implemented and known/practised by various organizations?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Contingency plans were **up to date** and **in force** • Plans known on all levels • The **complex scenario** of the event was practised	• Contingency plans **in force** but **not up to date** • **Most of the scenarios** that occured were practised	• Contingency plans **in elaboration** • Plans only known by decision makers • **Only few specific scenarios** of the contingency plans are practised	• **No** existing **contingency plans** • No practice of contingency plans

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Non structural prevention

2.2 To what extent did existing contingency plans (i.e. action plans for risks) cover the occurred situations?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• **All situations** that occured were considered in the scenarios included in the contingency plans	• The **most important situations** that occured were considered in the scenarios included in the contingency plans	• **Only few situations** that occured were considered in the scenarios included in the contingency plans	• **None of the situations** that occured were considered in the scenarios included in the contingency plans

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Non structural prevention

2.3 How do you rate the quality of the hazard map in terms of ist alignment with the actual event that occurred?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Event occured **as „mapped"** in the hazard map	• Most of the affected areas shown in the hazard map, **only few deviations**	• **Large deviation** between hazard map and areas affected by the event	• Hazard map and event **completely different** • Hazard map not existing

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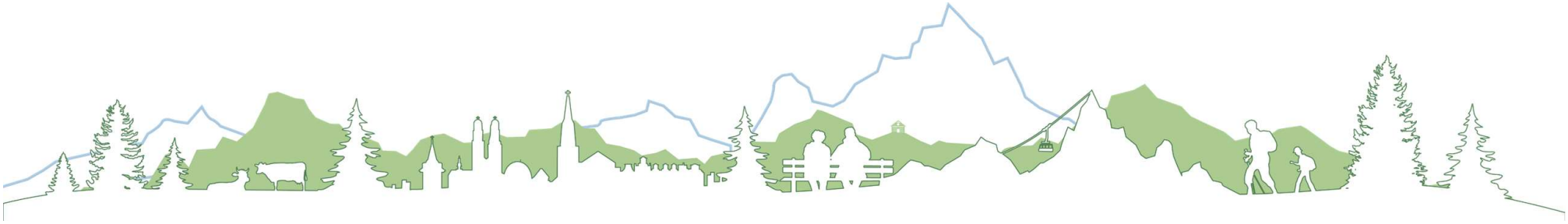

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Preparedness tools

3.1 How well were the weather- and hazard phenomena of the event forecasted?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• **All weather- and hazard phenomena** were forecasted in the intensity they have occured	• **All weather- and hazard phenomena** were forecasted but **not with the intensity** they have occured	• **Not all weather- and hazard phenomena** that occured were forecasted and **not with the intensity** they have occured	• **Not all weather- and hazard phenomena** that occured were forecasted and their **intensity was highly underestimated**

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Preparedness tools

3.2 To what degree have the forecasted phenomena been assessed with respect to possible impacts and risks for warning purposes prior to the event?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Forecasted phenomena **have been assessed** with respect to possible impacts and risks • Impacts and risks were predicted **in the magnitude that occured** at the event	• Forecasted phenomena **have been assessed** with respect to possible impacts and risks • Impacts and risks were **underestimated** compared to the magnitude that occured at the event	• **Some** forecasted phenomena have been assessed with respect to possible impacts and risks • Impacts and risks were **underestimated** compared to the magnitude that occured at the event	• Forecasted phenomena have **not been assessed** with respect to possible impacts and risks

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Preparedness tools

3.3 To what extent was a warning system in place to inform the population of the possible impacts and risks?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Warning system **in place** • **Big part of population** received warnings of possible impacts and risks including tips to avoid risks	• Warning system **in place** • **Some people** received warnings of possible impacts and risks	• Warning system **partially in place / in trial** • Population didn't receive information	• **No warning system** in place

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Preparedness tool implementation

4.1 To what degree were the standard procedures for authorities and civil protection organizations accessible and implemented in response to the warning?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Standard procedures exist **for all** involved authorities and civil protection organizations • Standard procedures were adopted by **all** involved authorities and civil protection organizations	• Standard procedures exist **for most** involved authorities and civil protection organizations • Existing standard procedures were adopted by **most** involved authorities and civil protection organizations	• Standard procedures exist **for few** involved authorities and civil protection organizations • Existing standard procedures were **not adopted** by involved authorities and civil protection organizations	• **No** existing standard procedures

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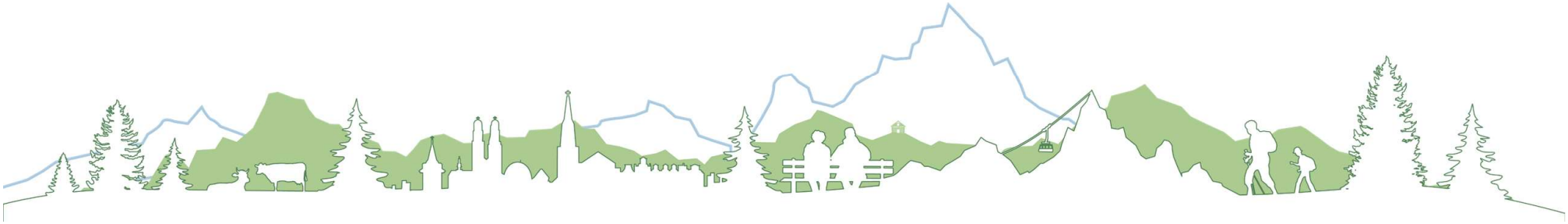

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Preparedness tool implementation

4.2 How do you evaluate the effectiveness of the short-term prevention measures implemented in anticipation of the event?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• **All necessary** short-term prevention measures were taken • Short-term prevention measures taken were **fully appropriate** to the given warning	• **Some** short-term prevention measures were taken • Short-term prevention measures taken were **mostly appropriate** to the given warning	• **Some** short-term prevention measures were taken • Short-term prevention measures taken were **not appropriate** to the given warning	• **No** short-term prevention measures were taken

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Preparedness tool implementation

4.3 To what extent have critical aspects/points been identified and monitored in expectation of the event? (e.g. critical bridges)

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• **All** Critical points were identified and monitored	• **Most** critical points were identified and monitored	• **Some** critical points were identified and monitored	• Critical points were **not** identified

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Response tools

5.1 To what extent was an organizational structure established, outlining key roles, responsibilities, communication channels and key players?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Organizational structure put in place **already in phase of „preparedness"** • responsibilities and communications chains were **totally clear** • **All** necessary key players / experts available when the event happened	• Organizational structure put in place **right after start of the event** • Responsibilites and communication chains were **mostly clear** • **Most** key players/ experts available when the event happened	• Organizational structure **evolved during the phase of response** to the event • Responsibilities and communication chains were **mostly unclear** • **Some** key players/ experts not available when the event happened	• **No** organizational structure in place • Responsibilities and communication chains were **not clear at all**

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Response tools

5.2 How do you rate the quality/procedure of information shared by the involved authorities during the response phase?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Information was shared **promptly / in time** • Information was shared **directly** • Sharing of information was **unbureaucratic**	• Information was **mostly shared in time** • Information was shared **mostly directly** • Sharing of information was **mostly unbureaucratic**	• Information was **shared with delay** • Information was shared via **complicated procedures** • Sharing of information was **bureaucratic**	• Information was **not shared** at all

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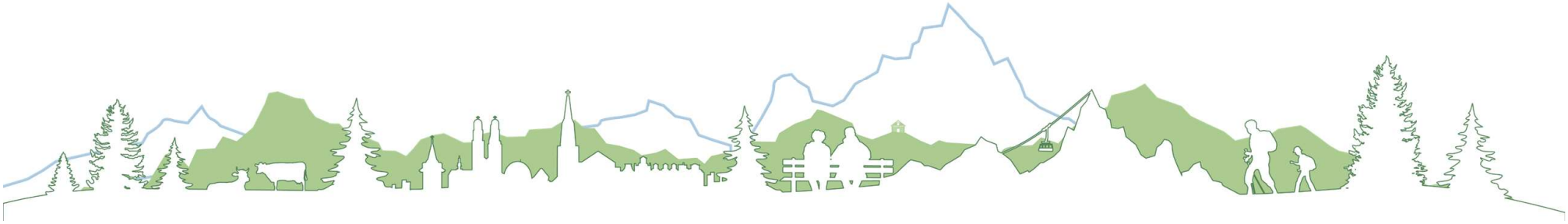
Response tools

5.3 To what extent were decision support tools available for managing the situation? (e.g. GIS applications , digital map of situation, platforms for information sharing, checklists)

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Instruments for decision support were available • **Existing tools** for the assessment of damage/ loss on a economical/ social/ environmental level	• Instruments for decision support were available • **No existing tools** for the assessment of damage/loss on a economical/ social/ environmental level	• **Few instruments** for decision support available	• **No instruments** for decision support available



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Response Tool implementation

6.1 To what extent were the existing protocols followed by managing authorities and other involved target groups?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Protocols existed and were followed for **all scenarios** of the event • Protocols were **available for all** involved target groups	• Protocols existed and were followed only for **some scenarios** of the event • Protocols were **available only for some** target groups	• Protocols existed, but were **not followed** • Protocols existed, but were **not available** to the target groups	• **No protocols** existed

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Response Tool implementation

6.2 How effective was the organizational structure in adapting to the event and handling unexpected situations?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• The organizational structure adapted **proactively** to the event and unexpected scenarios	• The organizational structure adapted **well** to the event and unexpected scenarios	• The organizational structure adapted well to the event • **Unexpected scenarios** were **not handled** well by the organizational structure	• The event and unexpected scenarios were **not handled at all**

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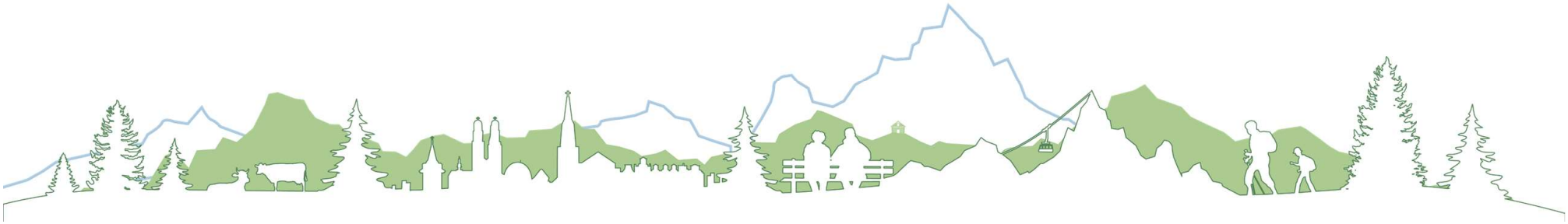

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Response Tool implementation

6.3 How do you evaluate the adequacy of the administrative procedures to implement the measures?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Administrative procedures to take measures were **fast, simple** and could be done **efficiently**	• Administrative procedures to take measures were **mostly fast, simple** and could **mostly** be done **efficiently**	• Administrative procedures to take measures were mostly **slow, complicated** and took mostly a **lot of effort**	• Administrative procedures to take measures were **too slow, complicated** and took a **lot of effort**

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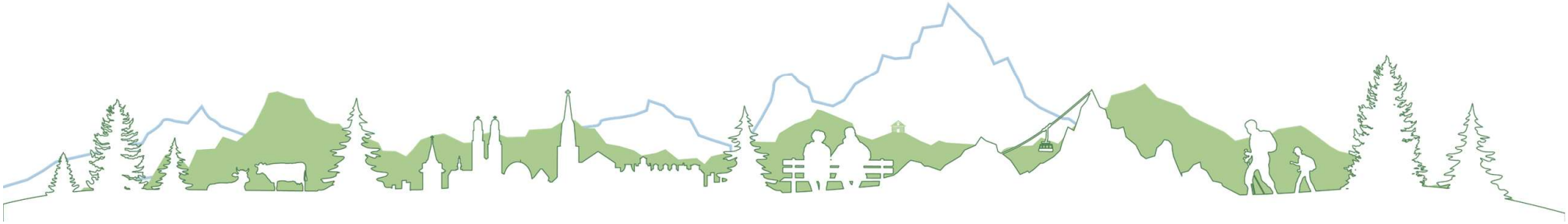

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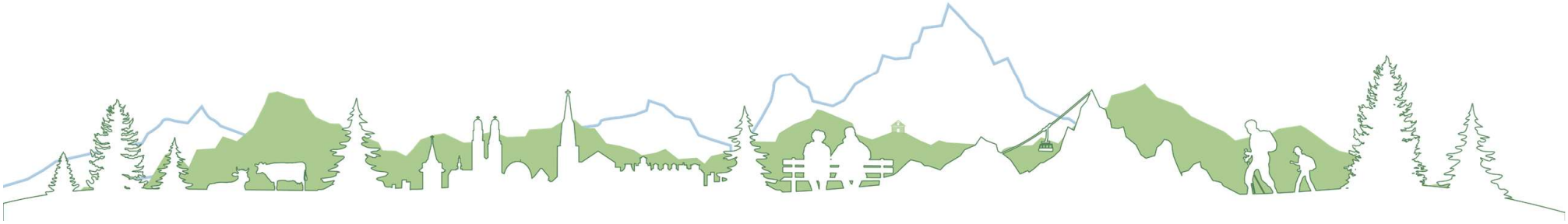
Structural recovery

7.1 To what degree were recovery measures planned and prioritized according to the established planning?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Recovery plan was was **multi-sectorial** and **well integrated** • Recovery plan was used to **prioritize** measures	• Recovery plan elaborated for **most sectors** • Recovery plan was **mostly well integrated** • Recovery plan was used to **prioritize** measures	• Recovery plan elaborated for **few sectors** • Recovery plan **not well integrated** • Recovery plan was **not** used to **prioritize** measures	• **No recovery plan** was elaborated



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Structural recovery

7.2 To what degree did the implementation of recovery measures match the planned timeline and costs?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Implementation of recovery matched planned time and costs **very well** • recovery measures and response measures with synergies	• Correspondance of time and costs for implementation of recovery with planned time and costs was **satisfactory**	• Implementation of recovery did **not match** planned time or cost frame	• **No frame** for time and costs was given

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Structural recovery

7.3 To what degree was the funding for structural recovery adequate?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Funding was **absolutely adequate**	• Funding was **quite adequate**	• Funding was **satisfactory**	• Funding was **not satisfactory** at all

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Recovery learning organisations

8.1 To what extent has the management of the event been debriefed and documented?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Management of event documented by **all target groups**, **all** useful information available • Debriefing of the event with **all** target groups involved	• Management of event documented by **most target groups**, **some** useful information missing • Debriefing of the event with **some** target groups involved	• Management of event documented by **few target groups**, **sparse** information in documentation • **No debriefing** of the event	• **No documentation** of management of event • **No debriefing** of event

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Recovery learning organisations

8.2 To what degree was the information collected in the debriefing evaluated to identify possible improvements for the future?

Good practice	"Satisfactory" Improvements possible	"Partly satisfactory" Improvements desirable	"Not considered" Improvements needed
• Information of debriefing was evaluated to identify possible improvements for the future • Implementation of identified improvements **strategically planned** and **continuously followed up**	• Information of debriefing was evaluated to identify possible improvements for the future • Implementation of identified improvements **only partially followed up**	• Information of debriefing was **partially evaluated** to identify possible improvements for the future	• Information of debriefing was **not further used** • Debriefing did **not take place**

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Recovery learning organisations

8.3 To what extent were „lessons learned“ implemented in concrete strategies for future improvement?

Good practice	“Satisfactory” Improvements possible	“Partly satisfactory” Improvements desirable	“Not considered” Improvements needed
• Communication of „lessons learned“ to **all** relevant decision makers and responsibles • **All** „lessons learned“ implemented in concrete strategies	• Communication of „lessons learned“ to **most** decision makers and responsibles • **Some** „lessons learned“ implemented in concrete strategies	• Communication of „lessons learned“ to **some** decision makers and responsibles • **No** implementation in concrete strategies	• **No** communication or implementation of „lessons learned“ in concrete strategies

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ANNEX 6: X-RISK-CC CLIMATE RISK STORYLINE – GORENJSKA / SORA CATCHMENT (SLOVENIA) - FLOODS

IN THE YEAR 2040...

Scope	Geographical setting: Sora river catchment in Gorenjska (municipalities of Škofja Loka, Gorenja vas-Poljane, Žiri and Železniki) Temporal setting: August 2040 Intended purpose: Stress testing and appraisal of risk management for extreme flooding events and compound impacts.
General climate situation (normal conditions in year 2040)	Gorenjska is in a warmer climate with an average temperature increase of 1 °C compared to the early 21st century. New temperature records of up to 40 °C have been recorded in lowland areas. Mountain regions are still relatively cool, even though winter and summer temperatures are higher than in the past. Winters are getting mild and wet throughout the region with more rain and less snow. Precipitation regime is highly variable with dry periods up to several months interrupted by intense precipitation events. Extreme precipitation events in the region are more intense and frequent than in the past, especially in spring and winter with accumulated daily amounts exceeding 220 mm/day. Precipitation in summer shows a greater variability with dry periods, often in combination with heatwave conditions, interrupted by intense short-duration precipitation events. Precipitation in late summer and autumn can be occasionally very intense and persist for several days, mainly driven by warm and moist southerly flows. During these events, 3-day precipitation totals can locally exceed 300 mm in Gorenjska.
General effects of climate change	Shorter but more intense rainfall periods cause more frequent flooding (particularly flash floods), erosion, and landslides. Stronger winds lead to more frequent windthrow events, exacerbating erosion on slopes where forest protection functions are already weakened by other factors. Climate change reduces snow cover and overall precipitation, worsening aquifer recharge and river and lake flows, threatening drinking water supplies. Prolonged drought and heatwaves accelerate soil erosion and degradation, destabilizing ecosystems, especially in arid areas. Forests are particularly vulnerable to heat, drought, and pests, increasing the risk of erosion, landslides, and wildfires. Changes in temperature and precipitation disrupt ecosystem balance, causing species extinctions, the spread of invasive species (e.g., bark beetles), and negatively affecting agriculture and health.

General non-climatic situation / non-climatic risk drivers	The population in the region has not significantly increased in the last 15 years, but the demographic structure in higher-altitude villages has shifted. Most residents there are aged 80 or older, making evacuation challenging due to reduced mobility. There are fewer active volunteers in Civil Protection and firefighting organizations. Škofja Loka has seen the most significant population growth. By 2040, it has become more urbanized, serving as an important centre for the Sora River catchment area with higher number of educational institutions and services. A larger urban area has more impermeable surfaces than before, increasing the water runoff and the potential for urban flooding. Some drainage systems are outdated and poorly maintained. Tourism is one of the main economic activities in the Sora River catchment area, especially in higher-altitudes. Winter tourism has declined due to lack of snow, while other tourism offerings in other seasons have expanded. Some of the new touristic infrastructure has been built in the landslide-prone areas. The number of farms has not decreased significantly, and the agricultural area has remained stable. However, the total area of agricultural and forestry land affected by extreme weather and hydrological events has increased, which has led to greater economic damage. Škofja Loka has a railway station on the Ljubljana-Kranj route. The railway connects Škofja Loka also to Jože Pučnik Airport, which is of great economic importance for the area. Flood protection in Železniki, built against 100-year floods (including the "Pod Sušo" reservoir, sediment retention measures, and regional bypass road improvements), is now about 15 years old. **Event of 2038** In November 2038, the region experienced an extreme 2-day rainfall event (270 mm/day), concentrated in the northern Sora River catchment (Železniki). Flood protection measures effectively mitigated the impact of flash floods. Some damage occurred to houses and roads upstream of Železniki due to landslides around Zali Log and Davča. Sediment retention structures prevented sediments from being transported downstream, but not all retention structures had been cleared by August 2040. Infrastructure damaged in the 2038 floods, such as roads between Zali Log, Davča, and Železniki, has been only partially repaired by 2040.
Meteorological event	After a dry and unusually warm June, July, and most of August, marked by multiple heatwaves and brief but intense rainfall events, Gorenjska was hit by a multi-day extreme rainfall event on August 27, 2040. Synoptic situation: A low-pressure system with a weather front developed over Central Europe. Warm, moist air from the heated Mediterranean flowed into the region from the south, and due to unstable air masses and orography triggered intense convective rainfall over the Alpine-Dinaric barrier. In the Poljanska Sora catchment, near Gorenja Vas, 250 mm of rain fell in the first 24 hours, starting in the early afternoon. The following day, the heaviest rain shifted to the northern basin, over the Selška Sora. Less intense rainfall continued evenly across the Sora Basin for a third day. Over three days, local precipitation totals reached 370 mm.

Event – Hazards	Due to intense rainfall, and critical underlying conditions (extremely dry soil, unemptied sediment retention structures, forest debris, urban impermeable surfaces in Škofja Loka, and landslides from 2038, which haven't been remediated), the rainfall triggers flash floods and sediment erosion. Poor infiltration leads to most rainwater immediately running off into river channels. Woody debris from forests and other floating materials jam river channels, causing flooding. First-day flash floods in Poljanska Sora deposit large amount of debris on the main road between Škofja Loka and Gorenja Vas, limiting access to some villages. Landslides require the evacuation of residents and because of many elderly residents with health issues, the process is delayed into the night. As rain moves northward, further evacuations are needed, including foreign tourists who are unfamiliar with local warnings. Second-day rain triggers more landslides, notably unremediated ones around Davča and Zali Log. The flood protection measures in Železniki significantly limit damage downstream of the Pod Sušo retention reservoir. However, rivers overflowed at certain sediment retention structures and dams that had not been maintained since the floods two years prior (e.g., in Češnjica). The main road between Železniki and Škofja Loka remains undamaged but requires monitoring over the next 48 hours. On the second day in Škofja Loka, flooding occurs also at the confluence of the two Sora rivers, near the Fishermen's Club in Puštal. After three days of rainfall, the overwhelmed drainage channels cause runoff water to flood the basements of buildings on Sorška Cesta, as well as facilities at the Škofja Loka Secondary School Center and High School, as well as the Poden Sports Hall.
Event – impacts	Tourists and local residents have to be evacuated from Dolenje and Gorenje Brdo, Davča, and the surrounding areas. Houses were damaged by floods and landslides. Access to drinking water is limited. A two-day power outage affects a large area around Gorenja Vas and Žiri, causing consequent problems for cooking, access to houses with "smart" doors, gates, roller blinds, cooling for food in supermarkets etc. Businesses, including shops, hotels, and restaurants, are unable to operate. Mobile networks are unstable, and emergency lines are overloaded on the first and second day of the event.
Post-event (post emergency)	The effects of this event last for months or years, requiring extensive repair of buildings, roads, and bridges throughout the Sora River catchment. Landslides cause severe erosion on already affected slopes, further destabilizing them and destroying areas of protective forests. Sediments accumulated at critical points increase the risk of future flood events. The population becomes deeply concerned about the future. The tourism sector is heavily impacted, suffering significant economic losses due to direct damage to infrastructure and the inability to resume activities until recovery. The agricultural sector is also faced with substantial damage, having already been weakened by prior droughts.

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X-RISK-CC: Risk Questionnaire. Sora Catchment – Flood. (Multi-) Hazard Analysis. Prepared by Primož Banovec Ph. D. SI University of Ljubljana, Faculty of Civil and Geodetic Engineering (as subcontractor of University of Ljubljana, Faculty of Natural Science and Engineering; ordered by ARSO) , 2024. 41 p.

X-RISK-CC: WP1 Pilot Report: Drought and Heatwaves in Gorenjska – Sora Catchment. Slovenia. ARSO, 2024. 27 p.

ANNEX 7: X-RISK-CC CLIMATE RISK STORYLINE – GORENJSKA / SORA CATCHMENT (SLOVENIA) - DROUGHT

IN THE YEAR 2040...

Scope	Geographical setting: Sora river catchment in Gorenjska (municipalities of Škofja Loka, Gorenja vas – Poljane, Žiri, Železniki) Temporal setting: summer 2040 Intended purpose: Preparation for the worst/most extreme possible scenario of weather/ hydrological events and their compounded consequences, considering current risk management practices and climate projections for the future ("stress testing").
General climate situation (normal conditions in year 2040)	Gorenjska is in a warmer climate, with average temperatures now 1°C higher compared to the early 21st century. In lowland areas, new temperature records of up to 40°C have been recorded. Mountainous and hilly areas remain relatively cool, although temperatures there have also increased in all seasons compared to the past. Winters are becoming mild and wet across the region, with more rain and less snow. The precipitation regime is highly variable, marked by drought periods that can last for several months, interrupted by intense rainfall events. Drought conditions occur in all seasons, including spring and autumn, and are frequently accompanied by heatwaves during the summer. Overall, droughts and heatwaves are becoming more frequent and intense, as is the combination of both events. There has been a notable increase in the number of dry months during the growing season, when plants have an elevated demand for water.
General effects of climate change	Climate change impacts the reduction of snow cover and precipitation, leading to a decline in aquifer recharge and river and lake flow rates, which threatens the supply of drinking water. Prolonged droughts and heatwaves accelerate soil erosion and degradation, destabilizing ecosystems, particularly in arid regions. Forests are especially vulnerable to heat, drought, and pests, increasing the risk of erosion, landslides, and wildfires. Changes in temperature and precipitation disrupt ecosystem balance, causing species extinction, the spread of invasive species (such as bark beetles), and negatively affecting agriculture and human health. Shorter but more intense rainfall periods result in more frequent floods, especially flash floods, erosion, and landslides. Stronger winds lead to more frequent windthrows, which further exacerbate erosion on slopes where the protective function of forests is weakened by other factors.

General non-climatic situation / non-climatic risk drivers	The population has remained at a similar level to that of 2025, with a slight increase and a pronounced aging trend. People continue to move from smaller settlements to larger ones and from higher to lower altitudes. In higher-altitude settlements, the population is predominantly older. The number of agricultural holdings in the area has slightly declined, but efforts are being made to maintain their numbers through various strategies. The area of agricultural land has remained roughly the same, but extreme weather events now cause greater economic damage than two decades ago. In livestock farming, some holdings are still oriented towards grazing, but they face challenges such as water shortages for livestock. A portion of the population still relies on drinking water from smaller water sources, which are more vulnerable to drought, particularly in higher-altitude areas. As a result, interruptions in water supply have become more frequent, requiring more water deliveries, especially to higher-altitude settlements. Drought periods can also lead to poorer drinking water quality, potentially affecting the health of both people and animals. Water scarcity could become a severe issue in the event of wildfires. Drought and high temperatures increase the risk of spreading plant and animal diseases, greater pest presence, and the proliferation of invasive species. Tourism has also undergone changes. In lower areas, the impact is negative during summer due to higher temperatures and drought, while in higher-altitude areas, cooler temperatures have a positive effect. Nevertheless, water saving remains a challenge, as many tourists are unaware of the seriousness of the situation. Tourism is mainly focused on hiking, cycling, and spending time along riverbanks. Due to reduced snow levels and higher temperatures, the ski resorts of Soriška Planina and Stari Vrh no longer operate in winter, as they cannot maintain conditions for winter activities. This has significantly affected winter tourism, which has had to adapt by developing alternative activities. Heatwaves can also damage infrastructure, including roads, railways, bridges, and energy networks.
Meteorological event	During the winter of 2039/2040, there was less snowfall, which impacted groundwater recharge. Spring precipitation could not fully compensate for the prior water deficit, resulting in moderately to severely dry conditions in groundwater aquifers as early as spring. Due to lower precipitation levels at the start of spring, moderately dry conditions were also observed in the surface soil layer. From May to July, large parts of Europe experienced high mid-tropospheric air pressure anomalies, particularly in western, southern, and central Europe. These relatively stationary atmospheric circulation patterns are typically associated with summer heatwaves and droughts in Europe, as they block or redirect traveling cyclones that usually bring cool and moist air. Prolonged high-pressure conditions persisted from late spring to late summer, exacerbating the already existing drought, as precipitation deficits had been apparent since the winter of 2039/2040. The first heatwave occurred at the end of May, followed by three more heatwaves by the end of July. Temperatures in lowland areas exceeded 40°C, and multiple tropical nights were recorded, as the heat showed no respite. Dry conditions intensified from mid-June onward. Between June 15 and July 31, 2040, only 10% of the usual precipitation fell (compared to the 1990–2020 reference period), while daily evaporation exceeded 6 liters of water per square meter. The water balance deficit in the surface soil layer grew, river water levels dropped, and groundwater levels fell to critical thresholds. Occasional summer storms occurred but did not significantly improve soil moisture due to rapid water runoff and the reduced infiltration capacity of the dry soil. By the end of July, extreme drought conditions were evident across all components of the water cycle.

Event – Hazards	The lack of snow in the mountains, prolonged drought, high temperatures, and heat-waves contribute to reduced river flows and groundwater recharge, posing a risk to drinking water supply. Multi-month droughts combined with heat lead to extremely high fire risk and the potential for large-scale forest fires, especially in areas where water resources are smaller and more vulnerable to drought. With reduced availability of drinking water resources, there is a risk of water shortages for firefighting. Large-scale fires degrade air quality due to particulate matter in the air, posing health risks to people. Drought and heat reduce plants' resistance to various diseases. In areas with a significant proportion of spruce trees, there is a high risk of rapid bark beetle infestations, which can devastate large, forested areas. This leaves slopes more susceptible to erosion, particularly during intense rainfall, which was more frequent in 2040 (increasing the risk of landslides). Sudden downpours following drought periods exacerbate flooding risks, as dry and compacted soil absorbs water less effectively, leading to greater consequences from floods. Dried-out soils, loss of vegetation, and weakened or damaged forests—whether due to snow, windthrow, or forest fires—result in increased erosion and sediment transport, which burden river systems and heighten flood risks. Additionally, drought weakens tree root systems, making trees more prone to falling during windstorms or heavy rainfall. Bark beetle infestations further contribute to forest degradation. Drought and heat lead to reduced agricultural yields, limit the use of drinking water, and cause water shortages, impacting the health of humans and animals while disrupting ecosystem balance. In terms of water supply, the impact of drought is most strongly felt in higher-altitude areas, where residents rely on smaller local water sources. Following prolonged drought, the potential for multi-day heavy rains poses a significant risk, as they can lead to floods and landslides. The consequences of such events can be catastrophic due to the factors mentioned above.
Event – impacts	**Water Supply Challenges:** Smaller local water sources in higher-altitude areas do not provide enough water for the population's supply. As a result, numerous additional water deliveries are needed, particularly for residents in higher-altitude settlements (e.g., in July and August, there were 41 water deliveries to Breznica pri Žireh and 25 to Žirovski vrh). Reduced water quantities in aquifers also affect drinking water quality, and in several settlements, water must be boiled before consumption. Instructions for water conservation are becoming increasingly common for all water users in all four municipalities. There is a ban on washing cars and filling swimming pools. **Agriculture:** The effects of drought are evident in reduced crop yields, threatening food security and economic activities. Crops most affected include corn, vegetables, and grasslands. In areas without irrigation, signs of drought stress have appeared, especially on shallow and gravelly soils. This drought stress is compounded by severe heat stress. High air temperatures have caused scorching, most noticeable in low grass cuts. The heatwave has also increased risks for livestock on pastures, which are facing water shortages, leading to reduced milk production. Heat and drought stress have affected both cultivated and wild plants, manifesting in plant wilting, disrupted growth and development, yellowing and leaf loss, premature ripening, scorching, shortened growth phases, or even plant death. Air temperatures above 35°C are expected to result in a poorer wheat harvest, as late wheat varieties have undergone forced ripening. Drought conditions in some affected areas have significantly reduced corn yields (corn growth has stalled, with less foliage and smaller, lighter corncobs). Grass cuts were lower than in previous years, forcing some farmers to reduce livestock numbers. Water shortages and high temperatures have also impacted vineyards. Farmers who planted permanent crops this year and lack irrigation have found themselves in a difficult position, with young trees drying out in some areas. The increased need for irrigation due to drought in agriculture has created conflicts over water usage, as restrictions on drinking water supply remain in place.

	Forests: The consequences of drought in forests are reflected in reduced tree growth. A lack of rainfall is also evident in forest trees, causing premature yellowing and leaf death. Weak forests are more susceptible to pests, such as bark beetles, which have spread in the Polhov Gradec Hills. Due to dried vegetation in forests, the fire risk is high. A large forest fire broke out in the Žirovski Vrh area. Water restrictions during this time created challenges in delivering water for firefighting. Difficult-to-access terrain further complicated firefighting efforts. **Tourism:** Water shortages are also felt in tourism, where additional restrictions on water use are in place. Tourism activity decreases during heatwaves, with high temperatures leading to canceled bookings in Škofja Loka. Despite the low water levels, swimmers seek relief in the Sora River. Increasingly, visitors prefer easily accessible higher-altitude areas due to slightly cooler temperatures. **Health Impacts:** High air temperatures negatively impact the health of both humans and animals. High temperatures cause overheating and dehydration in people. Health centers report an increase in emergency transports due to heatstroke. Vulnerable groups, including the elderly, pregnant women, children, and those with chronic illnesses, are most affected.
Post-event (post emergency)	The long-term effects of drought are reflected in reduced annual forest growth. Biodiversity and the protective functions of forests diminish, potentially leading to increased erosion. High temperatures have caused damage to infrastructure, particularly roads, railways, and bridges. In the economy, the impacts are seen in reduced agricultural production, higher costs of water and energy supply, and a decline in tourism activity in affected areas. Agricultural product prices increase. Additionally, long-term soil degradation due to erosion and water scarcity reduces soil fertility, which has lasting/long-term implications for food security. After a drought period, it takes time for natural conditions to return to their previous state. Temperatures decrease, and rainfall increases gradually, allowing for water replenishment. Often, there are no comprehensive plans to improve existing systems, leading to the restoration of outdated, inefficient solutions instead of implementing long-term measures to enhance resilience to future droughts. Water shortages can cause conflicts among various water users, such as drinking water supply, agricultural irrigation, industrial use, and the needs of firefighters during drought periods. These challenges highlight the need for sustainable planning and inclusive policies for recovery.

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X-RISK-CC: Risk Questionnaire. Sora Catchment – Drought. (Multi-) Hazard Analysis. Prepared by Slovenian Environment Agency (ARSO) with the support of Mihael Brenčič Ph. D. and Nives Vidmar (University of Ljubljana, Faculty of Natural Science and Engineering, Department of Geology), 2024. 23 p.

X-RISK-CC: WP1 Pilot Report: Drought and Heatwaves in Gorenjska – Sora Catchment. Slovenia. ARSO, 2024. 27 p.

ANNEX 8: LITERATURE AND DOCUMENTS REVIEWED FOR THE TOP-DOWN ANALYSIS OF GENERIC POLICY GAPS IN X-RISK-CC

No	Title	Author	Year	Type
1	Österreichische Strategie zur Anpassung an den Klimawandel. Teil 2 - Aktionsplan.	BMK	2023	Policy document
2	Zweiter Fortschrittsbericht zur österreichischen Strategie zur Anpassung an den Klimawandel	BMK	2021	Policy document
3	Beitrag zur Österreichischen Sicherheitsstrategie. Fokus auf Klimarisiken.	Umweltbundesamt	2023	Policy document
4	ExtremA 2019: Aktueller Wissensstand zu Extremereignissen alpiner Naturgefahren in Österreich.	Glade, T. et al. (Hrsg.)	2020	Assessment Report
5	ExtremA 2023: Aktueller Wissensstand zu Extremereignissen alpiner Naturgefahren in Österreich. Fachtagung zum Update des ExtremA 2019 Berichts.	BML & Universität Wien (Hrsg.)	2023	Workshop report, presentations
6	Beyond the Expected: Dealing with the Case of Overload and Residual Risk of Natural Hazards in the Alpine Region	EURAC (EUSALP AG8)	2018	Report
7	Natural hazards in the Alpine Region: Dealing with the cases of overload and residual risk. Policy Paper.	EURAC (EUSALP AG8)	2018	Policy Brief
8	Natural Hazard Risk Governance: Status Quo in the EUSALP Region. EUSALP Action Group 8	Schindelegger, A. & Kanonier, A. (EUSALP AG8)	2019	Report
9	Dealing with disasters. The Risk Governance Approach. Policy Brief.	Schindelegger, A. & Kanonier, A. (EUSALP AG8)	2019	Policy Brief
10	Natural Hazard Risk Governance. Report on the State of the Alps. Alpine Convention.	Alpine Convention	2019	Report
11	Forest fires in the Alps – State of knowledge, future challenges and options for an integrated fire management. EUSALP Action Group 8.	Müller M.M., Vilà-Vilardell L., Vacik H. (EUSALP AG8)	2020	White Paper
12	CLISP-ALP: Climate-resilient spatial planning in the Alps. An Analysis of the integration of climate change adaptation and climate resilience in spatial planning systems and practice in the Alpine region. EUSALP Action Group 8.	Schindelegger, A.; Steinbrunner, B.; Ertl, M. (EUSALP AG8)	2022	Report
13	Climate-resilient development: Foster adaptation through spatial planning in the EUSALP area. Policy Brief. EUSALP Action Group 8.	EUSALP AG8	2022	Policy Brief
14	Mainstreaming CCA and DRR in the Alpine macro-region. EUSALP AG8.	Karin Weber, Anna Dopler, Wolfgang Lexer, Doris Damyanov (EUSALP AG8)	2019	Report
15	Contingency Planning. Comparative analysis of challenges, strengths and weaknesses between contingency planning and natural hazard management. Fact sheet.	Alpine Convention (PLANALP)	2021	Fact Sheet

16	Contingency Planning in the Area of Natural Hazards. Comparative analysis of challenges, strengths and weaknesses between contingency planning and natural hazard management. Report.	Alpine Convention (PLANALP)	2021	Report
17	Persistence of Alpine natural hazard protection. Meeting multiple demands by applying systems engineering and life cycle management principles in natural hazard protection systems in the perimeter of the Alpine Convention.	Alpine Convention (PLANALP)	?	Report
18	Nature-based solutions in the context of natural hazards. Policy Brief.	Alpine Convention (PLANALP)	2022	Policy Brief
19	Climate Action Plan 2.0	Alpine Convention (Alpine Climate Board)	2021	Policy document
20	Alpine strategy for adaptation to climate change in the field of natural hazards.	Alpine Convention (PLANALP)	?	Report
21	Facing droughts in the Alpine region. Experiences, approaches and common challenges	Alpine Convention (Water Management Platform)	2018	Expert paper
22	GreenRisk4ALPs - Development of ecosystem-based risk governance concepts with respect to natural hazards and climate impacts – from ecosystem-based solutions to integrated risk assessment.	https://www.alpine-space.eu/project/greenrisk4alps/	2021	Project outputs
23	European Climate Risk Assessment (EUCRA).	European Environment Agency (EEA)	2024	Assessment eport
24	Bodenstrategie für Österreich. ENTWURF.	ÖROK	2023	Policy document (draft)
25	ÖROK-Empfehlung Nr. 57 zum Hochwasserrisikomanagement.	ÖROK	2017	Policy document
26	Stock-taking analysis and outlook of drought policies, planning and management in EU Member States. Final Report.	European Commission	2023	Assessment report
27	Klimakrise - Herausforderungen für die Wasserwirtschaft in Niederösterreich. Bericht des Rechnungshofes.	Rechnungshof Österreich	2024	Expert opinion report
28	Aktionsprogramm Waldbrand. Wahrnehmen - Vermeiden - Bekämpfen	BML - Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft	2022	Policy document
29	Aktionsprogramm Schutzwald	BMLRT - Bundesministerium für Land- und Forstwirtschaft, Regionen und Wasserwirtschaft	2020	Policy document
30	Gestaltung von Anpassungspfaden im Klimarisikomanagement. Leitfaden für Entscheidungstragende.	BOKU IAN, Joanneum Research & IIASA	2022	Report, Guidance
31	IPCC AR6 WGII Report: Europe (Report, Supplementary Material)	Bednar-Friedl, B. et al. (2022): Europe. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the IPCC AR6.	2021	Assessment Report
32	Wasserschatz Österreichs (Bericht, Hintergrunddokument, Zusammenfassung)	BMLRT	2021	Assessment report
33	PLACARD: Bonding CCA and DRR: Recommendations for institutional strengthening	PLACARD project	2019	Policy recommendations

34	Auswirkungen des Klimawandels auf den Bevölkerungsschutz in der Schweiz	EBP Schweiz AG	2022	Report
35	Österreichische Waldstrategie 2020+	BMNT - Bundesministerium für Nachhaltigkeit und Tourismus	2018	Policy document
36	Aktionsprogramm zur Umsetzung der Österreichischen Waldstrategie 2020+	https://bfw.ac.at/ws/strat2020public.main?seite=0	2022	Policy document
37	Die Anpassung von Wäldern und Waldwirtschaft an den Klimawandel. Gutachten des Wissenschaftlichen Beirates für Waldpolitik.	WBW - Wissenschaftlicher Beirat für Waldpolitik	2021	Expert opinion report
38	2nd Assessment Report on Climate Change in Austria (AAR2).	APCC - Austrian Panel on Climate Change	2025	Assessment Report
39	Exploring the limits and gaps of flood adaptation.	Aerts, J.C. et al. (Nature Water, 16 July 2024.)	2024	Journal article
40	Regional inequalities in flood insurance affordability and uptake under climate change. Sustainability 12, 8734 (2020)	Tesselaar, M. et al. (Sustainability 12, 8734 (2020))	2020	Journal article
41	Fehlanpassung im Kontext von privater Anpassung an den Klimawandel. Kriterien, Entwicklung eines Bewertungsrahmens und Anwendungsbeispiele.	Lexer, W.; Ahamer, G.; König, M.	2016	Research Report
42	Supporting successful adaptation and limiting maladaptation to climate change. Technical paper.	EPA IG CCA	2025	Policy Brief
43	Maladaptation. Global Environmental Change - Human and Policy Dimensions 20: 211-214 (editorial).	Barnett, J. & O'Neill, S.	2010	Journal article
44	Reframing strategic, managed retreat for transformative climate adaptation.	Mach, K. J. & Siders, A.R. (Science, 18 Jun 2021 Vol 372, Issue 6548)	2021	Journal article
45	Knowledge gaps and climate adaptation policy: a comparative analysis of six Latin American countries. Clim. Pol., 19 (2019), pp. 1297-1309.	Ryan, D. & Bustos, E.	2019	Journal article
46	Unravelling the capacity-action gap in flood risk adaptation.	Schubert, A.; von Streit, A. & Garschagen, M. (EGU Natural Hazard and Earth System Sciences.)	2024	Journal article
47	Addressing the risk of maladaptation to climate change.	Magnan, A. K., Schipper E.L.F., Burkett M., Bharwani S., Burton I., Eriksen S., Gemenne F., Schaar J., Ziervogel G. (Wiley Interdisciplinary Reviews: Climate Change 2016, Volume 7, Issue 5: 646-665.)	2016	Journal article
48	Key Risks Across Sectors and Regions. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change	O'Neill, B. et al.	2022	Assessment Report
49	Maladaptation: When Adaptation to Climate Change Goes Very Wrong. One Earth, Primer, Volume 3, Issue 4: 409-414.	Schipper, E.L.F. (One Earth, Primer, Volume 3, Issue 4: 409-414.)	2020	Journal article
50	Fallstudienbericht Klimawandelanpassung von Privathaushalten. Bericht im Rahmen des ACRP-Projekts PATCH:ES.	Babcicky, P. & Seebauer, S.	2016	Research report
51	Strategies to adapt to an uncertain climate change. Global Environmental Change 19: 240–247.	Hallegatte, S. (Global Environmental Change 19: 240–247.)	2010	Journal article

ANNEX 9: CATALOGUE OF GENERIC POLICY GAPS FOR SPATIAL PLANNING

Identifying generic (climate) risk management gaps & needs in existing policy frameworks

SPATIAL PLANNING

Topic, Thematic cluster, Key issue	Description: Relevant aspects, characteristics, elements (e.g., measures missing/needed/recommended)	Locally validated	Risk management cycle (RRMA)	Types of gaps	Climate risks (hazard-based): risks related to	Risk ownership (levels)
Ongoing growth in spatial risk exposure through progressing land take, urban sprawl, and soil sealing due to expansion of settlement areas and dispersed settlement development	Ongoing urbanisation continues to drive excessive land take and dispersed settlement patterns in many Alpine regions, thereby continously increasing societal vulnerability and exposure of settlements, infrastructure and humans to floods and other natural hazards. The persistent growth dynamics of settlement areas vis-a-vis intensifying hazard processes and expanding hazard zones due to climate change result in constantly growing climate risks. Substantial reduction of further land consumption, soil sealing and urban sprawl is needed to contain further increase in risk exposure, but so far spatial planning policies and instruments have been limited in effectiveness, due to lack of adequate regulations, enforceability or coherent implementation. Spatial planning systems (legislation, planning instruments, fiscal and subsidy policies, planning processes and practices at all levels) need to be re-directed towards forcing compact, inward-oriented, land-efficient and soil-saving settlement development with adequate (re-)densification of built-up areas ('land sufficiency'), while steering current and future hazard zones free from development and securing green spaces and their nature-based hazard protection and adaptation functions.	X	Prevention: non-structural	Policy design & planning Legislative & regulatory Effectiveness & efficiency Resources, capacity & implementation	Multi-hazard, multi-risk	Multi-level, cross-level, co-owned
Ongoing growth in spatial risk exposure through progressing land take, urban sprawl, and soil sealing due to expansion of settlement areas and dispersed settlement development	Goal-oriented, coordinated, enforcable, and consistently implemented portfolios of spatial planning measures and instruments (existing and new) for avoiding further land take and urban sprawl, e.g.: # Enhancement and more consistent and effective implementation of existing planning instruments to achieve established goals of sustainable spatial development; # binding and restrictive (national, subnational) quantitative goals for reduction of land take and soil sealing, concretized e.g. by allocation of maximum building land quota at regional level; # prioritizing goals related to soil-efficient use of land in spatial planning laws and in the weighing of interests in planning decisions; # concretizing restrictive criteria for the zoning of building land in spatial planning laws, and consistent implementation by strengthened regional planning with binding effects for local planning; # containment of outward-oriented settlement development and stronger protection of green spaces, e.g. by instruments such as settlement boundaries, priority green zones, and mandatory dedication of areas free of building development at municipal planning level; # obligations for compensating land take on formerly undeveloped land, e.g. by re-zoning building land reserves at other locations; # forcing the re-zoning of excessive building land reserves, especially in unfavourable, dispersed locations, at municipal planning level; # intensifying the management and re-use of brownfield sites and vacant buildings, including through inter-municipal cooperation, taxation, and subsidies.		Prevention: non-structural	Policy design & planning Legislative & regulatory Compliance & enforcement Resources, capacity & implementation	multi-hazard, multi-risk	Multi-level, cross-level, co-owned
Ongoing growth in spatial risk exposure through progressing land take, urban sprawl, and soil sealing due to expansion of settlement areas and dispersed settlement development	Adjustment of financial instruments with steering effects on land use and soils: # Incentivicing soil-saving municipal policies by re-designing the fiscal transfer scheme between territorial authorities ('Finanzausgleich'); # Re-adjusting soil-related fees and taxes to support economical, soil-efficient land use (e.g., property tax, infrastructure development fees); # Introducing new fiscal policies with steering effects against urban sprawl and land consumption, e.g. fees for new zoning of building land (compensating for increase in property value), fees for secondary homes and building vacancies, soil sealing fees; # Re-designing subsidies to support soil-saving, e.g. by integrating financial incentives for retrofitting of buildings and brownfield recycling into housing construction subsidy schemes; staggering housing construction subsidies according to building densities, sealing degrees, and centrality of locations; funding for strengthening and revitalizing city centres.		Prevention: non-structural	Policy design & planning Legislative & regulatory Resources, capacity & implementation	Multi-hazard, multi-risk	Multi-level, cross-level, co-owned
Ongoing growth in spatial risk exposure through progressing land take, urban sprawl, and soil sealing due to expansion of settlement areas and dispersed settlement development	Splintered settlement patterns with frayed outer boundaries are more difficult and more costly to protect against natural hazards and forest fires. In particular (future) risk of forest fires and wildfires are up to now hardly considered in settlement planning (local spatial development concept, zoning plan). Shaping compact settlements with clear outer boundaries is beneficial for cost-effective technical protection, and a less interlocked wildland-urban-interface reduces forest fire risk and facilitates forest fire control.		Prevention: non-structural	Policy design & planning Effectiveness & efficiency Awareness & recognition	Forest fire, wildfire	Local & regional

Missing approaches and provisions for dealing in a responsible, preventive way with residual risk in spatial planning and in building regulations	Lack of residual risk information for spatial planning and property owners: Provision of technical basic information about areas exposed to residual risk (e.g. floods with 300-year return intervals, or beyond) to spatial planning authorities, municipalities, planners and property owners; mandatory display and visualisation of residual risk information in spatial plans and maps, in particular at local level; public access to residual risk information to promote individual, private risk reduction measures.		Prevention: non-structural Prevention: structural Preparedness: tools	Knowledge, data & evidence Awareness & recognition	Floods: fluvial; Flooding: pluvial	National & subnational
Missing approaches and provisions for dealing in a responsible, preventive way with residual risk in spatial planning and in building regulations	Lacking or insufficient provisions related to residual risk areas in planning-related legislation: Integration of residual risk in planning laws and building regulations, by anchoring residual risk areas plus associated restrictions for zoning of building land and for construction of buildings in legislation		Prevention: non-structural	Legislative & regulatory Policy design & planning Awareness & recognition	Multi-hazard, multi-risk	National & subnational
Missing approaches and provisions for dealing in a responsible, preventive way with residual risk in spatial planning and in building regulations	Introducing risk-differentiated, staggered restrictions for zoning of building land and building permits in residual risk areas, including zoning prohibitions for hazard-sensitive and intense land uses with substantial damage potential		Prevention: non-structural	Policy design & planning Legislative & regulatory	Multi-hazard, multi-risk	Local & regional
Missing approaches and provisions for dealing in a responsible, preventive way with residual risk in spatial planning and in building regulations	Maladaptive practice of suspending hazard maps and their restrictive effects on zoning of building land after protection structures have been implemented, leading to exponential growth of residual risk exposure due to settlement development in 'former' hazard zones and causing unexpectedly high damage and loss in cases of overload or failure (‘building land revision dilemma’, ‘protection-building-spiral’, ex-post maladaptation): Hazard zone maps and building prohibitions for formerly red hazard zones need to be maintained to avoid irreversible vulnerability lock-ins and inevitably high damage and loss when technical protection limits are exceeded.		Prevention: non-structural	Policy design & planning Legislative & regulatory	Multi-hazard, multi-risk	Local & regional
Missing approaches and provisions for dealing in a responsible, preventive way with residual risk in spatial planning and in building regulations	Developing and implementing legal requirements for flood-/hazard-proof building design in residual risk zones (building development plan, building law)		Prevention: structural	Legislative & regulatory Policy design & planning	Floods: fluvial; Flooding: pluvial	National & subnational
Lack of risk-oriented approaches in spatial planning and land use planning	Moving from hazard-oriented to risk-based spatial planning. Strengthening risk-based approaches in spatial planning requires that i) spatially relevant risk assessments are provided as technical information basis for planning, and ii) that, beyond hazard exposure, different degrees of vulnerability of planned and existing land uses are considered in planning decisions.		Prevention: non-structural	Knowledge, data & evidence Policy design & planning	Multi-hazard, multi-risk	National & subnational
Lack of risk-oriented approaches in spatial planning and land use planning	Adoption of risk reduction and climate change adaptation as goals in spatial planning laws; defining risk as a planning principle in regulations		Prevention: non-structural	Legislative & regulatory	Multi-hazard, multi-risk	National & subnational
Lack of risk-oriented approaches in spatial planning and land use planning	Defining risk-based and risk-differentiated protection goals and safety levels in spatial planning for different forms of land use, according to their different damage potentials, vulnerabilities and exposure to hazards		Prevention: non-structural	Policy design & planning Legislative & regulatory	Multi-hazard, multi-risk	National & subnational
Lack of risk-oriented approaches in spatial planning and land use planning	Developing and applying risk-oriented criteria for zoning decisions and building design (zoning plan, building development plan), e.g. based on risk zones, to allow steering of land use intensities according to damage potential, vulnerability and exposure		Prevention: non-structural	Policy design & planning Legislative & regulatory	Multi-hazard, multi-risk	Local & regional
Regulations for dealing with designated, but undeveloped building land and existing buildings in hazard zones and residual risk zones	Trying to keep overlapping areas of hazard zones and settlements as low as possible is an established guiding principle of spatial planning. However, past planning decisions, the absence of hazard maps in the past, and changing frequencies and magnitudes of hazard events have created situations where considerable amounts of zoned building land, existing buildings and infrastructure are located in areas exposed to risk. Due to climate-driven expansion of many hazard zones, the volume of exposed building land and objects is bound to grow further. The options for spatial planning to intervene with adaptation and risk reduction measures in already existing zonings and building structures are limited, because it would affect valid rights of property owners and property values. Provisions for dealing in a preventive way with risk-exposed stocks of buildings and zoned, but yet undeveloped building land are still largely missing. There is a need for addressing this gap in spatial planning legislation and instruments, in particular as regards building laws, and for providing guidelines for how to mitigate risks to existing settlement areas.	X	Prevention: non-structural	Legislative & regulatory Policy design & planning	Multi-hazard, multi-risk	National & subnational

Regulations for dealing with designated, but undeveloped building land and existing buildings in hazard zones and residual risk zones	Clear zoning regulations that allow re-zoning of building land in hazard zones and residual risk zones, e.g. by: i) re-dimensioning excessive building land reserves in the course of cyclical revisions of zoning plans; ii) stipulating time limits for realisation of designated building uses in planning laws or by means of contractual spatial planning (with automatic re-zoning if time limits are exceeded); iii) applying 'soft' forms of re-zoning, such as temporal building bans or downgrading of building land reserves to future development areas, in order to ensure that property-related technical protection measures are taken before designated uses are realized.		Prevention: non-structural Prevention: structural	Legislative & regulatory Policy design & planning	Multi-hazard, multi-risk	Local & regional
Regulations for dealing with designated, but undeveloped building land and existing buildings in hazard zones and residual risk zones	Strengthening exploitation of risk reduction potentials of building laws and building development plans: i) provisions for land use restrictions on risk-exposed building land; ii) ex-ante and ex-post requirements for hazard-proof building design and object-related protection measures; iii) requirements for organisational preparedness measures at object/household level (e.g., statutory contingency concepts, alarm plans).	X	Prevention: non-structural Prevention: structural Preparedness: tools	Legislative & regulatory Policy design & planning	Multi-hazard, multi-risk	National & subnational
Regulations for dealing with designated, but undeveloped building land and existing buildings in hazard zones and residual risk zones	Supportive, active role of spatial planning in managing retreat and resettlement (in high-risk areas with returning damage events and limited feasibility of technical protection) and for relocation of high-risk uses and critical infrastructure.	X	Prevention: non-structural	Governance: organisational & procedural	Floods: fluvial; Flooding: pluvial; Forest fire, wildfire	Multi-level, cross-level, co-owned
Securing green spaces (within and outside of settlements) and employing their multifunctional ecosystem-based services for hazard prevention and climate adaptation	Giving preference to passive risk prevention and nature-based solutions for reduction of risks from floods, natural hazards and drought, whereever posssible. Avoiding settlement development in - current and future - hazard zones is the most effective and macroeconomically most cost-efficient strategy for risk reduction and climate adaptation. Simultaneously, by steering green and open spaces clear of development, their nature-based adaptation services against natural hazards and drought can be conserved and valorized, including water retention, rainwater infiltration, groundwater renewal, and decentralized rainwater management. Spatial planning needs a shift in perspective from planning the development of the built environment to 'positive planning' of green and open spaces on equal footing. This includes: giving more importance to the multiple functions and co-benefits of undeveloped green spaces for society and environment in the context of climate change; developing differentiated instruments for the planning and development of green spaces; upgrading the weight of nature- and landscape-related aspects in existing spatial planning instruments.		Prevention: non-structural	Policy design & planning Awareness & recognition	Multi-hazard, multi-risk	Local & regional
Securing green spaces (within and outside of settlements) and employing their multifunctional ecosystem-based services for hazard prevention and climate adaptation	Establishing new functional planning categories for green and open spaces with climate adaptation and hazard protection functions, such as priority, precautionary, or reservation areas, and strengthening their designation and implementation in regional and local planning instruments. Defining clear rules and restrictions for zoning, building activities and land use in respectively designated areas and enforcing them in planning practices in order to safeguard the delivery of their nature-based protection and adaptation services.		Prevention: non-structural	Policy design & planning Legislative & regulatory Compliance & enforcement	Multi-hazard, multi-risk	Local & regional
Securing green spaces (within and outside of settlements) and employing their multifunctional ecosystem-based services for hazard prevention and climate adaptation	Utilizing the potentials of local zoning plans, building development plans and building regulations to secure and activate space potentials for green and blue infrastructure on smaller scales within urban areas, including for rainwater and drought management (runoff, retention, infiltration, storage): legally based provisions for enabling and/or stipulating minimum shares of green, unsealed areas for rainwater retention and infiltration (at planning area level or building site level), maximum sealing percentages, requirements for desealing, areas for decentralized rainwater mangement, requirements for greening roofs, buildings and streets, etc.		Prevention: non-structural Prevention: structural	Policy design & planning Legislative & regulatory	Floods: fluvial; Flooding: pluvial; Drought	Local & regional
Securing green spaces (within and outside of settlements) and employing their multifunctional ecosystem-based services for hazard prevention and climate adaptation	In spatial planning decisions, public interests in the preservation of green spaces and their multifunctional co-benefits are regularly defeated by conflicting, more powerful economic use interests. Robust and traceable planning criteria for transparent assessment, weighing and prioritisation of green space functions for hazard prevention and climate adaptation are thus needed.		Prevention: non-structural	Policy design & planning Knowledge, data & evidence	Multi-hazard, multi-risk	National & subnational
Securing (and restoring) flood runoff and flood retention areas	Designating natural flood runoff areas, flood retention areas, areas for controlled flooding in cases of emergency, and other areas with hazard-protective functions and keeping them clear of settlement development at all planning levels. This requires designating such areas as priority, precautionary or reservation zones in regional and inter-municipal plans, and defining clear, strict and legally binding restrictions for zoning, building, and other intense uses that might conflict with their runoff or retention functions at local planning level.		Prevention: non-structural	Policy design & planning Legislative & regulatory Compliance & enforcement	Floods: fluvial; Flooding: pluvial	Multi-level, cross-level, co-owned

Securing (and restoring) flood runoff and flood retention areas	Instruments and models for adapted land management in flood runoff and retention areas in order to safeguard fulfillment of their protective functions		Prevention: non-structural	Governance: organisational & procedural Resources, capacity & implementation	Floods: fluvial; Flooding: pluvial	National & subnational
Securing (and restoring) flood runoff and flood retention areas	Restoration of floodplain ecosystems: utilizing mutual synergies in implementing measures for ecological river enhancement (Water Framework Directive), nature restoration (Restoration Directive), and flood control (Floods Directive).		Prevention: non-structural	Policy design & planning	Floods: fluvial; Flooding: pluvial	Transnational National & subnational
Legal coupling of hazard mapping with spatial planning	Strengthening embedding of hazard maps / hazard zone plans in spatial planning laws and building regulations by defining binding and unambiguous legal effects on local spatial planning (consideration requirement): clear and restrictive rules for the zoning of building land, building permits, and requirements for hazard-proof constructions in designated hazard zones.		Prevention: non-structural	Legislative & regulatory	Multi-hazard, multi-risk	National & subnational
Legal coupling of hazard mapping with spatial planning	Strengthening implementation and enforcement of zoning and use restrictions connected to designated hazard zones, including through intensified checks of local plans by supervisory authorities at higher-ranking level		Prevention: non-structural	Compliance & enforcement Legislative & regulatory	Multi-hazard, multi-risk	National & subnational
Instruments and measures for prevention of risks to settlements from pluvial flooding ('urban flash floods')	Provision of basic technical information about pluvial flood risks (surface water maps, drainage areas, surface runoff pathways, hazard index maps, etc.), especially considering climate change, for spatial planning. Addressing urban drainage and flooding in local climate adaptation plans. Giving public access to such hazard assessments to increase risk awareness and risk preparedness of municipalities, property owners, and citizens.	X	Prevention: non-structural	Knowledge, data & evidence Awareness & recognition Policy design & planning	Flooding: pluvial	National & subnational
Instruments and measures for prevention of risks to settlements from pluvial flooding ('urban flash floods')	Pluvial flood hazards are still a regulatory gap in many planning laws: Planning legislation should allow, or require, restrictions and conditionalities for the zoning of building land and the issuing of building permits in areas exposed to pluvial flood hazards	X	Prevention: non-structural	Legislative & regulatory	Flooding: pluvial	National & subnational
Instruments and measures for prevention of risks to settlements from pluvial flooding ('urban flash floods')	Storm water runoff infrastructure in urban areas is often inadequate to current and predicted rainfall intensities. Statutory requirements for adjusted design of buildings and object-related protection measures in areas exposed to surface runoff are needed and should be addressed by urban adaptation plans.	X	Prevention: non-structural Prevention: structural	Legislative & regulatory Policy design & planning Resources, capacity & implementation	Flooding: pluvial	Local & regional
Instruments and measures for prevention of risks to settlements from pluvial flooding ('urban flash floods')	Intensifying application of measures for prevention of pluvial flood risk in local planning instruments: designation of free spaces for runoff pathways, areas for nature-based rainwater drainage and infiltration, water retention areas, drainage concepts as part of building development plans, etc. Securing in a timely way the urban spaces needed for implementation of such measures is crucial.	X	Prevention: non-structural Prevention: structural	Policy design & planning Resources, capacity & implementation	Flooding: pluvial	Local & regional
Instruments and measures for prevention of risks to settlements from pluvial flooding ('urban flash floods')	High degrees of sealed soils in urban areas cause a significant increase in risk of pluvial flooding (plus in heat stress) and reduce area potentials for natural drainage, infiltration and storage of rainwater. This calls for new regulations and measures to avoid new soil sealing and to promote de-sealing: i) provisions in building development plans for determining maximum sealing degrees, minimum shares of unsealed areas capable of rainwater infiltration, desealing potentials, sealing bans, or desealing commandments; ii) sealing fees or desealing rewards; iii) integrating incentives for desealing in subsidy schemes for housing, restoration and village renewal; iv) upper thresholds for sealed car parking spaces (residential homes, retail centres).	X	Prevention: non-structural	Legislative & regulatory Policy design & planning	Floods: fluvial; Flooding: pluvial	Multi-level, cross-level, co-owned
Inter-municipal and regional cooperation models for risk management and adaptation measures with cross-municipal land demands	Just as climate change impacts and hazards do not stop at administrative borders, many spatially relevant risk management and adaptation measures require space, i.e. land resources, that cut across municipal boundaries or are located in territories of other municipalities, and measures sometimes can affect different municipalities in different ways. Inter-municipal cooperation is thus needed to secure joint areas for flood retention, nature-based hazard prevention, green infrastructure, groundwater renewal, and active structural protection measures. Often, burdens and benefits are distributed asymmetrically between neighbouring municipalities, e.g. when natural flood retention areas need to be preserved in upstream municipalities, whereas downstream municipalities benefit from higher protection levels and new development potentials, which requires inter-municipal negotiations and agreements.		Prevention: non-structural Prevention: structural	Governance: organisational & procedural Policy design & planning	Multi-hazard, multi-risk	Local & regional

Inter-municipal and regional cooperation models for risk management and adaptation measures with cross-municipal land demands	Municipalities are often over-challenged with organising, institutionalising and financing inter-municipal cooperation for measures that affect the territories of two or more municipalities. Spatial planning authorities and higher governance levels should thus provide and strengthen supportive framework conditions for inter-municipal cooperation models. Higher-level support may relate to: i) developing and using cooperative planning instruments and processes for inter-municipal risk management and climate adaptation measures; ii) intensifying use of existing, formal and informal planning instruments to implement inter-municipal agreements, e.g. by designating and securing large-scale, border-crossing precautionary areas for flood and natural hazard protection in regional spatial plans; iii) legal and institutional strengthening of regional cooperation models; iv) providing financial incentives for inter-municipal cooperation; v) organisational support and counselling by higher-level authorities, e.g. by means of facilitating cross-municipal negotiations or providing model cooperation agreements; vi) employment of existing regional governance structures (e.g. LEADER regions, regional managements, regional flood protection associations) to support and embed inter-municipal cooperation; vii) preparing good practice examples of inter-municipal cooperation models.		Prevention: non-structural	Governance: organisational & procedural	Multi-hazard, multi-risk	National & subnational
Inter-municipal and regional cooperation models for risk management and adaptation measures with cross-municipal land demands	Need to develop and establish (financial) compensation models and mechanisms between municipalities for coping with asymmetric distribution of burdens and benefits of land provision for risk prevention in a solidary way (e.g., upstream-downstream problem in flood risk management), e.g. by means of inter-municipal fiscal transfer.		Prevention: non-structural	Governance: organisational & procedural Policy design & planning Resources, capacity & implementation	Floods: fluvial; Flooding: pluvial	National & subnational
Inter-municipal and regional cooperation models for risk management and adaptation measures with cross-municipal land demands	Inter-municipal management of droughts and water scarcity: creation of regional water supply systems to allow risk pooling and compensating for local water supply bottlenecks.		Preparedness: tools Preparedness: tool implementation	Policy design & planning Governance: organisational & procedural	Drought	Local & regional
Clear risk communication and active role in risk governance processes	Clear communication of protection goals, safety levels (intolerable / not accepted risk) and residual risk (accepted / tolerated risk) to foster risk awareness and individual risk precaution of property owners.		Prevention: non-structural	Awareness & recognition Governance: organisational & procedural	Multi-hazard, multi-risk	Local & regional
Clear risk communication and active role in risk governance processes	Active role of spatial planning in risk governance processes to balance safety and development needs and to resolve conflicts between risk mitigation and economic growth potentials by involving all affected actors. Providing support (organisational, financial, expertise, tools) for participatory risk governance processes.	X	Prevention: non-structural	Governance: organisational & procedural	Multi-hazard, multi-risk	National & subnational
Strengthening basic research on climate-induced natural hazards and climate risks in spatial planning	Strengthening basic spatial research as part of regular planning processes (set-up and revision of spatial plans): establishing climate change, climate risks and adaptation / risk prevention as statutory subject of basic spatial research		Prevention: non-structural	Awareness & recognition Knowledge, data & evidence Legislative & regulatory	Multi-hazard, multi-risk	National & subnational
Strengthening basic research on climate-induced natural hazards and climate risks in spatial planning	Developing and providing basic information on changes in hazard processes (probability of occurrence, magnitude) due to climate change, cumulative and compound impacts, cascading effects, taking this information into account in planning processes, and making it available to the public		Prevention: non-structural	Knowledge, data & evidence	Multi-hazard, multi-risk	National & subnational
Strengthening basic research on climate-induced natural hazards and climate risks in spatial planning	Enhancing usability and decision-making relevance of hazard and risk information for spatial planning: Preparing and 'translating' data and information according to the needs of spatial planners		Prevention: non-structural	Knowledge, data & evidence Resources, capacity & implementation	Multi-hazard, multi-risk	Local & regional
Strengthening basic research on climate-induced natural hazards and climate risks in spatial planning	Systematic and process-oriented integration of climate change, adaptation and risk reduction in planning instruments & procedures ('climate-proofing spatial planning systems, mainstreaming)		Prevention: non-structural	Policy design & planning Resources, capacity & implementation	Multi-hazard, multi-risk	Multi-level, cross-level, co-owned
Strengthening capacities and qualification of planners to deal with climate risk issues	Knowledge transfer and capacity-building: Integrating climate risk knowledge in professional education of spatial planners and providing specific training and counselling offers		Prevention: non-structural	Resources, capacity & implementation	Multi-hazard, multi-risk	National & subnational
Strengthening capacities and qualification of planners to deal with climate risk issues	Providing work aids, decision support tools, guidance, and good practice examples on how to deal with (extreme) climate risks to planners, planning authorities (esp. municipalities), and supervisory and approval authorities (in charge of checking and approving spatial plans)		Prevention: non-structural	Resources, capacity & implementation Local risk preparedness & community-driven adaptive capacities	Multi-hazard, multi-risk	National & subnational

Strengthening horizontal, vertical and participatory governance	Spatial planning, climate adaptation, natural hazard / flood risk management, and civil protection are all eminently cross-sectoral and multi-level disciplines, with often complex and fragmented division of competencies between different levels of government (depending on the political-administrative state system). Moreover, the management of extreme weather events and their often interacting consequences requires holistic perspectives and integrated approaches, with well-working cooperation of multiple stakeholders. Overcoming disciplinary policy silos and administrative fragmentation is thus a pressing need, increasing the importance of improving cooperation and coordination of spatial planning with sector policies and sectoral planning (horizontally) as well as between planning levels (vertically). This requires both, good government and good governance, i.e. enforcable and institutionalised rules and mechanisms of coordination as well as strengthened and new informal governance arrangements.		Prevention: non-structural	Governance: organisational & procedural	Multi-hazard, multi-risk	Multi-level, cross-level, co-owned
Strengthening horizontal, vertical and participatory governance	Reinforcing involvement of regional and local actors, stakeholders and citizens by strengthening cooperative and participatory planning processes, giving particular attention to adequately involving vulnerable and marginalized groups. Participatory and inclusive planning contributes to solving conflicts related to land use and risk management, and it has significant potential to enhance legitimacy, quality, feasibility and acceptance of risk management solutions.		Prevention: non-structural	Governance: organisational & procedural Local risk preparedness & community-driven adaptive capacities	Multi-hazard, multi-risk	Local & regional

ANNEX 10: CRITERIA AND CATEGORIES FOR ANALYSING THE POLICY GAP CATALOGUES

RISK MANAGEMENT CYCLE (RRMA SCHEME)	
Phases and sub-categories	**Description**
To what phases, categories and aspects of the risk management cycle, according to the RRMA scheme, does the gap issue mostly relate to?	
Prevention: structural	*Active grey, green and hybrid measures to mitigate or control hazards; structural protection measures, technical protection infrastructure, incl. related protection concepts that are part of protection systems; nature-based, bio-engineered, or hybrid protection measures; object-related structural protection measures at property level (presence, design events, effectiveness, adequacy for magnitude and frequency of current and future hazard events, condition, maintenance)*
Prevention: non-structural	*Measures to reduce exposure and vulnerability; hazard and risk assessments; hazard and risk maps; contingency plans and implementation; passive risk prevention by spatial planning, land use management & ecosystem-based adaptation services; insurance-based incentives for prevention; information & communication*
Preparedness: tools	*Tool-based measures to anticipate and prepare for hazard events; monitoring, forecasting and early warning systems; impact predictions (availability, reliability, accuracy); warning and alert chains; insurance; resource planning; information & communication; organisation*
Preparedness: tool implementation	*Standard procedures (available, known, trained, implemented, sufficient, effective); deployment planning; training; compliance with warnings and procedures*
Response: tools	*Organisation, structures, procedures, protocols for managing enfolding events, mitigating their consequences, and limiting extent of damage (availability, quality, adequacy); information-sharing and communication mechanism; resources*
Response: tool implementation	*Implementation of organisational, procedural, informational & communicative arrangements (adequacy, effectiveness, compliance) for alert, rescue and damage mitigation*
Recovery: structural	*Post-event measures to repair and reconstruct after damage events; repair and compensation of physical damage; funding & financing of reconstruction; building back better; mitigating long-term consequences*
Recovery: learning	*Post-event measures to evaluate and learn from damage events; debriefings; documentation and analysis of events; revision and re-adjustment of risk management frameworks; strengthening risk prevention and future resilience*
All, cross-cutting, generic	*Cross-sectional, generic or overarching; relating to the entire risk management cycle*

TABLE: *Categories with descriptions for allocating policy gaps to phases of the DRM cycle (RRMA scheme) (© X-RISK-CC, 2025).*

POLICY & ACTION GAPS	
Types of gaps	**Description**
What are the prevailing root causes of the gap? To what dimensions do these main causes and needs for action predominantly belong?	
Knowledge, data & evidence	*Lacking or insufficient data, information, evidence and assessments (e.g. related to climate, hazards, risk, management options) prevents more effective risk management policies and actions; uncertainties; monitoring & early warning systems and forecasting tools missing or not fit-for-purpose; complexity of climate-hazard-impact-event-management interactions and of compound and cascading risk; too little knowledge exchange & transfer*
Awareness & recognition	*Issues and (emerging) challenges not recognized or not perceived as urgent enough; problems and solutions have not entered policy agendas yet or have too little priority; lack of political will to act; available knowledge about key risks and management options not known or not acccessible to decision-makers; lacking familiarity with existing plans, rules and procedures*
Policy design & planning	*Policies (strategies, action plans, instruments, procedures) for new, emerging or extreme risks missing; existing policies not fit-for-purpose, e.g. critical issues are blind spots (e.g., emerging risks, cascading risks, compound impacts), or clear objectives and actions to manage key risks missing, lacking or incomplete; planning instruments (e.g. spatial plans, land use plans, flood protection plans, forest management plans) missing or not adequately addressing key risks; restricted or disparate coverage of geograpic areas by policies (e.g., when policies do not apply to the entire territory of interest); certain vulnerable social groups or exposed system elements not covered; too rigid and unflexible policies that do not allow adapting to changing circumstances; lack of coherence and integration between different policy fields, leading to conflicting goals and trade-offs; lack of future-oriented foresight in policies, e.g. no preparedness for future climate change or changes in non-climatic risk drivers*
Governance: organisational & procedural	*Responsibilities (organisations, authorities, actors) missing or unclear; institutional arrangements, cooperation agreements, communication mechanisms, horizontal and vertical governance bodies and mechanisms missing or inadequate; institutional practices and routines, standard operating procedures and protocols missing or not fit-for-purpose; lack of stakeholder involvement; cross-border cooperation inadequate; lack of supportive and enabling governance frameworks for local and regional actors*
Legislative & regulatory	*Absence or lack of updating of necessary legislation and regulatory provisions (laws, subordinated legislation, ordinances, implementing regulations, norms, standards) to address critical issues or emerging challenges; existing legislation or regulations acting as barrier to solutions*
Resources, capacity & implementation	*Policies, instruments and actions exist largely on paper only, implementation widely lacking or insufficient; lack of funding and financial resources; lack of capacities (staff, equipment, expertise, skills, training, infrastructure, technology, coordination capacity) among responsible insitutions and actors to implement action; lacking availability of solutions (tools, instruments, measures)*
Compliance & enforcement	*Existing regulations, plans and procedures not applied or followed; insufficient enforcement and execution of legal or policy provision, incl. supervision and inspection*
Local risk preparedness & community-driven adaptive capacities	*Low local preparedness levels; local prevention and coping capacities not fully exploited; lack of bottom-up or bottom-linked initiatives for review and improvement of risk management practices; disaster events not used as windows of opportunities for reflection and learning (e.g., systematic debriefings and structured event documentation lacking; lessons learnt missed or not implemented in practice); endogenous potentials for increasing resilience underused*
Other	

TABLE: *Categories with descriptions for allocating policy gaps to types of gaps (© X-RISK-CC, 2025).*

CLIMATE RISKS (HAZARD-BASED)	
Risks related to	**Description**
What type of natural hazard process or climate impact causes the risk addressed by the gap?	
Floods: fluvial	*Risks related to flooding at rivers; innundations caused by high streamflow exceeding the flow capacity of a water body*
Flooding: pluvial	*Risks related to innundation independent of water bodies caused by heavy rainfall exceeding the infiltration capacity of the soil and subsequent surface runoff; often also called (urban) flashflood*
Hydrological hazards: other	*Risks related to mudflows, debris flow, hyperconcentrated flow, torrential flooding: transport processes of sediment, water and often driftwood in torrential catchments; landslides of the flow type and torrential process, characterized by high sediment concentration and internal deformation of the material*
Gravitational hazards: mass movements	*Risks related to landslide, earth flow: shallow slides and deep-seated slides of earth and/or debris with a sliding process along a distinct rupture surface or shear zone. Transition into debris flow may often occur.* *Rockfall, rock avalanche, rock slide, rock slope failure: fall process of single blocks; rapid, massive, flow-like motion of fragmented rock from a large rock slide or rock fall, characterised by large runout lengt; sliding of a rock mass along a discrete shear zone/ rupture surface*
(Peri-)Glacial hazards	*Risks related to glacier collapse, ice avalanches, glacial lake outbursts*
Drought	*Risks related to soil mostuire drought, streamflow drought, groundwater drought, flashdrought; may cause agricultural drought, ecological drought, socio-economic drought*
Forest fire, wildfire	*Drought, heat, bark beetle infestations and windthrow are pre-disposing factors for forest fire risk.*
Forest disturbances & loss of protective forest functions	*Risks related to bark beetle infestations, windthrow, water stress, leading to deterioriating quantity, quality and effectiveness of protection forests with increasing downslope hazard potential and cascading impacts across sectors.*
Direct extreme weather impacts	*Direct physical impacts of extreme weather agents (strong winds, hail, lightning, extreme temperature, snow and ice load, lightning) on exposed objects (buildings, infrastructure, humans, agricultural crops, etc.)*
Multi-hazard, multi-risk	*If more than four distinct hazard/risk categories apply. Includes gap topics with explicit and clear reference to compound hazards and cascading risks.*

TABLE: *Categories with descriptions for allocating policy gaps to types of climate-related risks (hazard-based) (© X-RISK-CC, 2025).*

RISK OWNERSHIP	
Level of risk ownership	**Description**
At what levels (government, political-administrative system, governance, society) do the most crucial decisions or actions need to be taken in order to overcome the policy gap? Actors at what levels are primarily responsible and accountable for implementing the related need for action? Select the level that has the key role and is most needed and decisive for effective solutions. If possible, choose only the one option that applies most.	
Transnational	*Gaps & needs that have a clear Alpine-wide or transboundary dimension and can best be tackled by actors (cooperation structures, institutions, networks), instruments and processes at the scale of the Alpine macro-region, the Alpine Convention area, or at cross-border level. Typical examples include EUSALP, the Alpine Convention, the Alpine Space programme, cross-border Interreg programmes, cross-border spatial planning instruments, or cross-border cooperation agreements. The category 'transnational' also applies if the management of transboundary hazards and risks as well as of related transboundary resources (e.g. international river basins) requires cross-border cooperation and coordination between entities of two or more countries.*
National & subnational	*Gaps & needs that depend primarily on top-down or top-linked agency. Responsible actors (government, authorities, public administrations, organisations, institutions, bodies, networks, individuals) are allocated at i) national, country-wide level (countries / NUTS0) and at ii) subnational territorial level (e.g., Länder, federal states, cantons, regions, provinces / NUTS1, NUTS2, NUTS3). This includes in particular higher-ranking levels of: i) the territorial / political-administrative system with own compentence areas, legislative powers, policy-making and financing capacities, ii) the market system with capacity to decide about business policies, and iii) organized civil society (e.g., NGOs, interest groups, chambers, associations).*
Local & regional	*Gaps & needs that depend primarily on bottom-up or bottom-linked agency. Responsible actors (authorities, politicians, public administration, organisations, institutions, agencies, bodies, networks, individuals) are allocated at the level of municipalities, cities, micro-regions, inter-municipal cooperations, municipality mergers, management/planning/development regions (LAU - NUTS3).*
Multi-level, cross-level, co-owned	*Decisions and actions that need to be shaped and taken collectively by actors at (several) different levels and that inevitably require collaboration and coordination across levels. This category applies in particular if overcoming the gap requires to an equal or similar extent the agency and coordinated actions by the national/ subnational level and/or the local/regional level and/or the private/individual level. In cases where the primary main responsibility cannot be clearly allocated to one distinct level alone, this multi-level option should be chosen.*
Private & individual (citizens, households, property owners)	*Gaps & needs that primarily need to be tackled by individual citizens, typically in their roles as households, land or property owners, tenants, insurance customers, etc.*
Non-specific, generic, other	*If none of the above categories apply.*

TABLE: *Categories with descriptions for allocating policy gaps to levels of risk ownership (© X-RISK-CC, 2025).*

ANNEX 11: URGENCY EVALUATION MATRIX

Risk severity	Confidence	Policy readiness		
		Very advanced	Advanced	Medium/low
Catastrophic	High	More action needed	Urgent action needed	Urgent action needed
	Medium	Further investigation	More action needed	Urgent action needed
	Low	Further investigation	Further investigation	More action needed
Critical	High	Sustain current action	More action needed	Urgent action needed
	Medium	Sustain current action	Further investigation	More action needed
	Low	Sustain current action	Further investigation	Further investigation
Substantial	High	Sustain current action	Sustain current action	More action needed
	Medium	Sustain current action	Sustain current action	Further investigation
	Low	Sustain current action	Sustain current action	Further investigation
Limited	High	Sustain current action	Sustain current action	Watching brief
	Medium	Sustain current action	Sustain current action	Watching brief
	Low	Sustain current action	Sustain current action	Watching brief

FIGURE: *Matrix for determining the urgency to act upon risks and risk management gaps, based on risk severity, policy readiness, and confidence levels (source: EEA, 2024: p. 394)*

Reference:

EEA (2024): European Climate Risk Assessment. EEA Report 01/2024.

ANNEX 12: PRIORITISED TRANSALPINE KEY POLICY GAPS FOR DEVELOPING THE X-RISK-CC TRANSNATIONAL ACTION PROPOSALS

Topics	Key policy gaps	Rank
Preventive spatial planning	**G6:** Underused potentials of 'green spaces' and nature-based risk reduction solutions with their multiple co-benefits	1
Preventive spatial planning	**G1**: Failure of spatial planning in containing constant growth in risk exposure due to excessive land take, urban sprawl and soil sealing	2
Forecasting, early warning and alert	**G14:** Gaps in real-time, small-scale hazard monitoring and forecasting (incl. now-casting)	2
Post-event learning and capacity building	**G29:** Lack of behavioural routines, information uptake and regular trainings	3
Preventive spatial planning	**G4:** Weak legal integration of hazard maps in spatial planning	4
Resilience planning & disaster response operations	**G17:** Fragmented governance and missing or unclear responsibilities for disaster risk management	4
Forecasting, early warning and alert	**G16:** Limited ability of risk managers to translate warnings into effective action	5
Hazard and risk assessments	**G11:** Restricted hazard-focused approach and limited coverage, depth and data integration of hazard/risk assessments	6
Hazard and risk assessments	**G12:** Missing consideration of climate change and lacking precautionary approaches to dynamic hazard patterns and uncertainty	6
Insurance, damage compensation, financing	**G20:** Maladaptive effects of public disaster recovery funds by inhibiting private risk reduction measures	6
Risk Governance & Risk Communication	**G27:** Lack of individual risk awareness, knowledge, compliance and self-responsible action among the population	6
Post-event learning and capacity building	**G28:** Lack of systematic post-event documentation, analysis, debriefing and learning	6
Preventive spatial planning	**G2:** Lack of risk-based approaches in spatial planning	7
Structural natural hazard prevention	**G7:** Limited consideration of overload, failure, extreme and cascading scenarios in design standards for structural protection measures	7
Insurance, damage compensation, financing	**G21:** Lack of incentives for pro-active individual protection measures in market-based insurance schemes	7
Risk Governance & Risk Communication	**G24:** Limited public participation in risk planning and decision-making	7

Preventive spatial planning	**G3:** Missing approaches for dealing with residual risk in spatial planning	**8**
Structural natural hazard prevention	**G9:** Outdated design events and protection levels based on past statistical data	**8**
Hazard and risk assessments	**G13:** Lack of risk assessments and early warnings for drought and forest-related climate-driven hazards	**8**
Forecasting, early warning and alert	**G15:** Fragmented and incomplete coverage of hazard monitoring as regards hazard types, scales, Alpine territories, and influencing factors	**8**
Resilience planning & disaster response operations	**G18:** Lacking local disaster preparedness	**8**
Preventive spatial planning	**G5:** Lack of proactive regulation for risk-exposed existing buildings and vacant building plots	**9**
Risk Governance & Risk Communication	**G25:** Ambiguity and lack of knowledge regarding protection goals and residual risk	**9**
Risk Governance & Risk Communication	**G26:** Lack of institutional and legal frameworks for inter-municipal cooperation in risk management	**9**
Insurance, damage compensation, financing	**G22:** Limits to viability of market-based insurance systems resulting from constraints to increasing premium ratings (affordability) and too low market penetration	**10**
Insurance, damage compensation, financing	**G23:** Overstraining of governmental compensation and recovery capacities in case of large-scale disaster losses with severe macro-economic risks	**10**
Structural natural hazard prevention	**G8:** Maladaptive path dependencies (vulnerability lock-ins, growing residual risk, escalating protection costs and damage potentials) due to over-reliance on structural protection measures and intensification of settlement development	**11**
Structural natural hazard prevention	**G10:** Risk of 'technical disasters' due to insufficient adaptation of long-term maintenance and recovery of protection structures to climate change	**11**
Resilience planning & disaster response operations	**G19:** Lack of infrastructure and capacities for prevention and response of forest fires, forest disturbances and calamities	**11**

TABLE: *List of 29 key policy gaps with transalpine relevance and with prioritisation according to cumulated ranking in three transnational expert workshops (X-RISK-CC partner meeting, Alpine Climate Board, EUSALP AG8). Same ranks result from equal number of scores (points) (source: X-RISK-CC, 2025).*

ANNEX 13: SCHEMES FOR CATEGORIZING CCA AND CRM OPTIONS

KEY TYPE MEASURES (KTM)

Key Type Measures (KTM) are a system used to report climate adaptation actions in the EEA member countries, as part of the Energy Union Governance Regulation (EU, 2018). Developed to provide a standardised way of communicating various adaptation measures to better support adaptation policy processes across the EU, the scheme can also be used as inspiration for a tailored categorisation of CCA and CRM options in Alpine regions.

KTM	Sub-KTM	Specifications
A: Governance and Institutional	**A1: Policy instruments**	• Creation / revision of policies • Creation / revision of (implementing) regulations
	A2: Management and planning	• Mainstreaming adaptation into other sectors • Creation / revision of technical rules, codes and standards
	A3: Coordination, cooperation and networks	• Creation / revision of ministerial coordination formats • Creation / revision of stakeholder networks
B: Economic and Finance	**B1: Financing and incentive instruments**	• Creation / revision of incentive mechanisms • Creation / revision of funding schemes
	B2: Insurance and risk sharing instruments	• Creation / revision of insurance schemes and products • Creation / revision of contingency funds for emergencies
C: Physical and Technological	**C1: Grey options**	• New physical infrastructure(s) • Rehabilitation, upgrade and / or replacement of physical infrastructure(s)
	C2: Technological options	• Early warning systems • Hazard / risk mapping • Service / process applications
D: Nature Based Solutions and Ecosystem-based Approaches	**D1: Green options**	• Creation of new / improvement of exiting green infrastructure • Natural and / or semi-natural land-use
	D2: Blue options	• Creation of new / improvement of existing blue infrastructure • Natural and / or semi-natural water and marine areas management
E: Knowledge and Behavioural change	**E1: Information and awareness raising**	• Research and innovation • Communication and dissemination • Decision support tools and databases
	E2: Capacity building, empowering and lifestyle practices	• Identification and sharing of good practices • Training and knowledge transfer • Reporting on lifestyle practices and behaviours

TABLE: *System of Key Type Measures (KTM) for classification of adaptation measures under the Regulation on the Governance of the Energy Union and Climate Action in 2021 (Leitner et al., 2021)*

Reference:

Leitner, M. et al. (2021): Using Key Type Measures to report climate adaptation action in the EEA member countries. ETC/CCA Technical Report 2021/1.

ACTION TYPES USED FOR DEVELOPING THE TRANSNATIONAL ACTION PROPOSALS OF X-RISK-CC

TYPES OF ACTION
• **Data & Knowledge**
• **Legislative & regulatory**
• **Enforcement & compliance**
• **Policy design & policy instruments**
• **Planning & management**
• **Coordination & cooperation**
• **Capacity-building & training**
• **Communication & behavioural change**
• **Funding & financing**
• **Insurance & risk-sharing**
• **Technical & technological**
• **Nature-based solutions**
• **Institutional & organisational**

TABLE: *Types of actions used for developing the Transnational Action Proposals for Climate Risk Management of Weather Extremes (X-RISK-CC, 2026).*

Reference:

Lexer, W.; Deubelli-Hwang, T. & Buschmann, D. (2026): Action Proposals for Managing Climate Risks of Weather Extremes in the Alps. Synthesis of outcomes and transnational policy recommendations. X-RISK-CC project. https://www.capa-eusalp.eu/s/x-risk-cc-sourcebook

ANNEX 14: HOW TO USE IMPACT CHAINS FOR IDENTIFYING ADAPTATION OPTIONS (EXAMPLE)

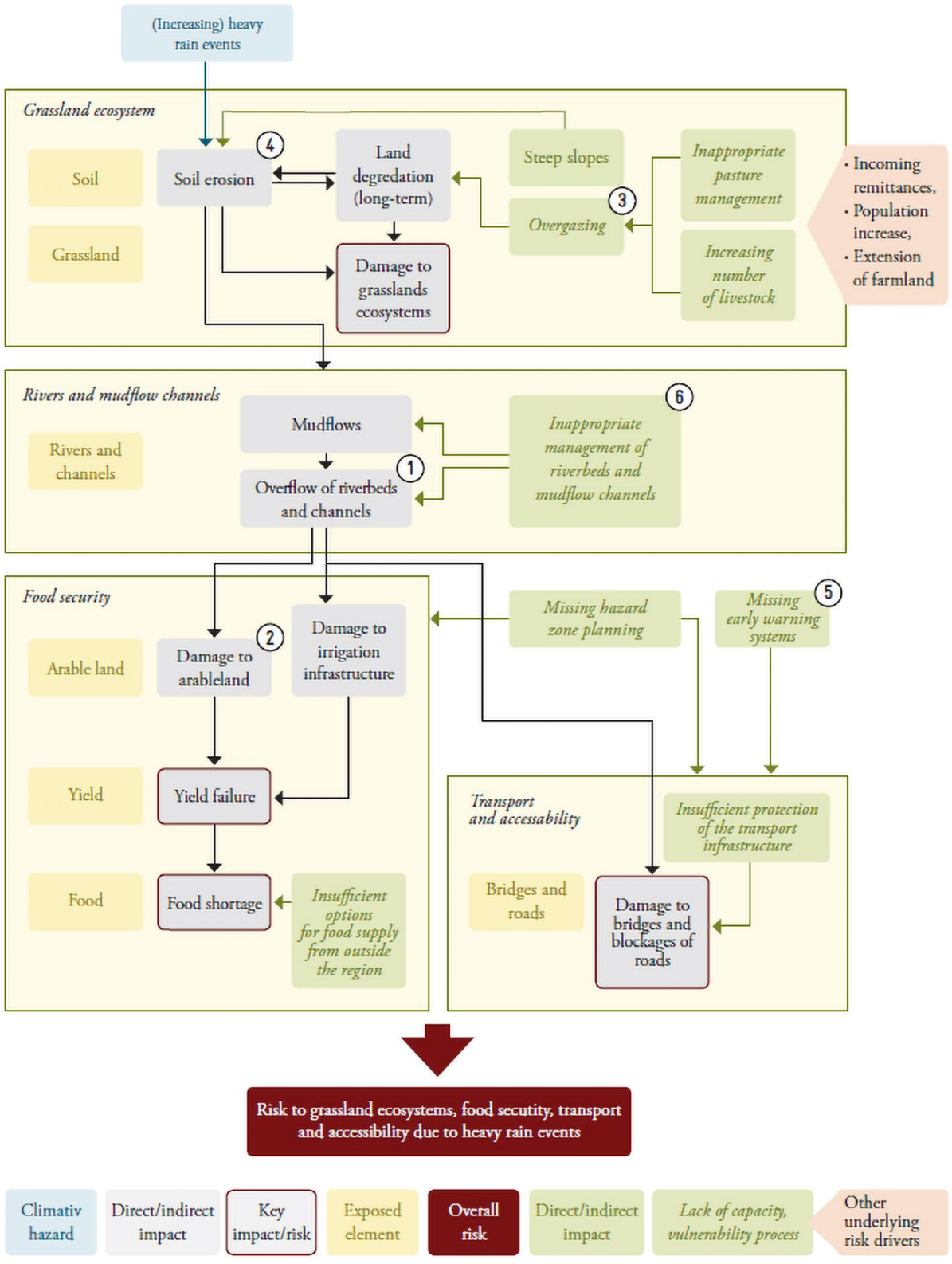

FIGURE: *Using impact chains to identify entry points for adaptation options (Source: Zebisch, M. et al., 2023).*

No.	CCA option	Category
1	Construct dykes along the river channels	Structural
2	Government-funded insurance for damage to arable land	Institutional
3	Farmers diversify grazing patterns & locations for their livestock	Behavioural
4	Afforestation/reforestation on slopes	EbA
5	Developing & implement early warning systems	Early warning systems
6	Seasonal forecasting apps for farmers to improve pasture management	Climate information services

TABLE: *Adaptation options identified in the impact chains in the Figure above (source: Zebisch et al., 2023).*

Reference:

Zebisch, M. et al. (2023): Climate Risk Sourcebook.
Deutsche Gesellschaft für Internationale
Zusammenarbeit (GIZ) GmbH. Bonn.

ANNEX 15: STRUCTURE AND CONTENTS OF ACTION FACTSHEETS FOR TAILORED ACTION PLANS OF X-RISK-CC PILOT AREAS

ID Number	Unique identifier assigned to each action. This allows for easy reference, tracking of connections between actions, and integration with other planning documents.
Title of the Action	Brief, descriptive name that clearly communicates the core focus of the action.
Gap(s) it refers to	Specific deficiencies, weaknesses, or missing elements in current risk management practice that this action aims to address. Gaps may include missing infrastructure, inadequate procedures, lack of coordination, insufficient data, legislative limitations, communication deficiencies, or capacity constraints.
Risk Cycle Position	The phase(s) or interphase(s) of the risk management cycle where this action primarily operates: Prevention, Preparedness, Response, Recovery, or Interphases (e.g., "Preparedness-Response," "Recovery-Prevention").
Type	Classification of the action according to its primary mechanism: • Knowledge and Data: Actions focused on improving information, understanding, monitoring, or data systems • Communication: Actions aimed at improving information flow, awareness, warnings, or coordination • Legislative: Actions requiring changes to laws, regulations, standards, or formal procedures • Technical Measures: Actions involving physical infrastructure, technology deployment, or engineering solutions • Capacity Building: Actions focused on training, institutional strengthening, or resource development
Level	The primary governance or implementation scale: Local (municipal level), Provincial/Regional, National, Cross-border/International, or Multiple levels.
Ownership	The institution(s) or organization(s) with primary responsibility for initiating, implementing, and ensuring completion of the action. Ownership implies decision-making authority and accountability.
Actors	Other institutions, organizations, or groups that play significant roles in implementing the action, providing input, or whose cooperation is essential for success.
Target Groups	The populations, sectors, or constituencies that will directly benefit from or be affected by the action. This may include general population, specific vulnerable groups, professional sectors, municipalities, emergency responders, or infrastructure operators.

Priority	Ranking from 1 (Low Priority) to 5 (Highest Priority) based on the prioritization methodology described in Section 4.4. Priority reflects urgency, impact potential, feasibility, and stakeholder consensus.
Funding	Current or anticipated funding status: Funded (source identified), Partially funded, Funding sought, No external funding required (resourced through existing budgets), or TBD (to be determined).
Finalize by (timewise)	Target date or timeframe for completion of the action: Short-term (within 1-2 years), Medium-term (3-5 years), Long-term (5+ years), Ongoing (continuous improvement without fixed endpoint), or Specific dates where applicable.
Progress Status	Current state of implementation: Concept, Planning, Approved, In Progress, Completed, On Hold, or Continuous
Connection to other actions (ID)	Lists the ID numbers of related actions that must be completed first (prerequisites), should be coordinated with (synergies), address related gaps (thematic connections), or may conflict with (trade-offs to manage).
Comments/Details/ Observations	Additional context, clarifications, challenges identified, lessons learned, or other relevant information that does not fit in structured fields.
Documentation and Links	References to supporting documents, reports, legal texts, technical studies, websites, or other resources relevant to understanding or implementing the action.

TABLE: *Categories for presentation of each action in the Tailored Action Plans of the X-RISK-CC pilot areas (© X-RISK-CC, 2026)*

ANNEX 16: EXAMPLES OF ACTIONS FROM A TAILORED ACTION PLAN: X-RISK-CC PILOT AREA SOUTH TYROL (ITALY)

The following two actions are excerpts from the Tailored Action Plan for Risk Management Improvement in South Tyrol. The complete action plan, as well as the Tailored Action Plans of all pilot areas in the X-RISK-CC project, are available at the project website of the Alpine Space Programme and at a dedicated thematic module of the CAPA platform.

A06 - ESTABLISHMENT OF A WORKING GROUP FOR THE REVISION OF HAZARD ZONE PLANNING AND ORGANIZATIONAL STRUCTURE FOR NATURAL RISKS

Gap the action addresses

It is necessary to introduce regulations that ensure the structured involvement of provincial offices in the revision of hazard zone plans. Currently, revisions are driven solely by municipalities, with no incentives to integrate new models if they exist, or to account for changes following natural events or the construction of protective structures. Furthermore, the plans are based exclusively on simple scenarios, without systematically considering climate change or compound/cascading events, limiting their ability to reflect real-world risk conditions. Revising the regulations would allow tools, scenarios, and procedures to be updated coherently, improving preparedness and the management of natural hazard risks at the provincial and local level.

Frame of the action

- **Phase of the risk cycle:** Prevention, Interphase Recovery - Prevention
- **Type:** Legislation
- **Level:** Province
- **Responsible authority:** Provincial Warning Centre
- **Involved:** Regional government and 16 regional offices, distributed across 4 departments in 4 different assessorates
- **Target groups:** Municipalities, regional offices
- **Priority:** 1
- **Links with other measures in the document:** A12
- **Timeline:** already started, ongoing in 2026

Description of the action

The provincial government tasks the Civil Protection Agency to convene a conference with the competent provincial offices, the municipal consortium, and representatives of individual municipalities to present the current situation, challenges, and needs. A working group consisting of representatives from the Department of Nature, Territory and Landscape, the Civil Protection Agency, the Forestry Service, the Building and Technical Service, and the Municipal Consortium will develop a proposal for a new law on hazard planning, update and simplify related regulations, and propose an organizational structure responsible for natural hazards and risks.

A11 - REAL-TIME THUNDERSTORM NOWCASTING AND EARLY WARNING SYSTEM FOR THE PROVINCE OF BOLZANO

Gap the action addresses

With climate change, thunderstorms are becoming more frequent and intense, while their evolution in time and space remains difficult to predict using traditional forecasting methods. Although a radar-based tracking system exists at provincial level, there is a lack of specialized algorithms for real-time analysis and prediction of thunderstorm development. As a result, the warning system does not yet integrate real-time thunderstorm alerts, and authorities and decision-makers receive limited localized risk information, reducing their capacity for timely preventive action.

Frame of the action

- **Risk cycle phase:** Preparedness
- **Type:** Knowledge and data development, communication and warning systems
- **Level:** provincial, Local (municipalities),
- **Responsibility:** Provincial Warning Centre of the Autonomous Province of Bolzano
- **Target groups:** Municipalities, civil protection operators, citizens (e.g. farmers, cable car operators)
- **Priority:** 1
- **Links to other actions:** To be defined
- **Timing:** step one till end 2027

Description of the action

The action focuses on the development of a real-time thunderstorm nowcasting system for the province, integrating weather radar and measurement networks with AI-based predictive algorithms to estimate storm movement and intensity in the short term.

As a first step, existing short-term warning systems from neighbouring regions and countries are benchmarked. Based on this assessment, a locally adapted concept and implementation plan are developed, including the definition of required measurement networks and forecasting algorithms. The resulting information is distributed to end users through a modular alert system and a dedicated visualization tool, improving risk communication and enabling timely, localized warnings for authorities and the public.

Reference:

Civil Protection Agency, Autonomous Province of Bolzano (2026): Tailored Action Plan for Risk Management Improvement. South Tyrol.