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Alpine Space

X-RISK-CC

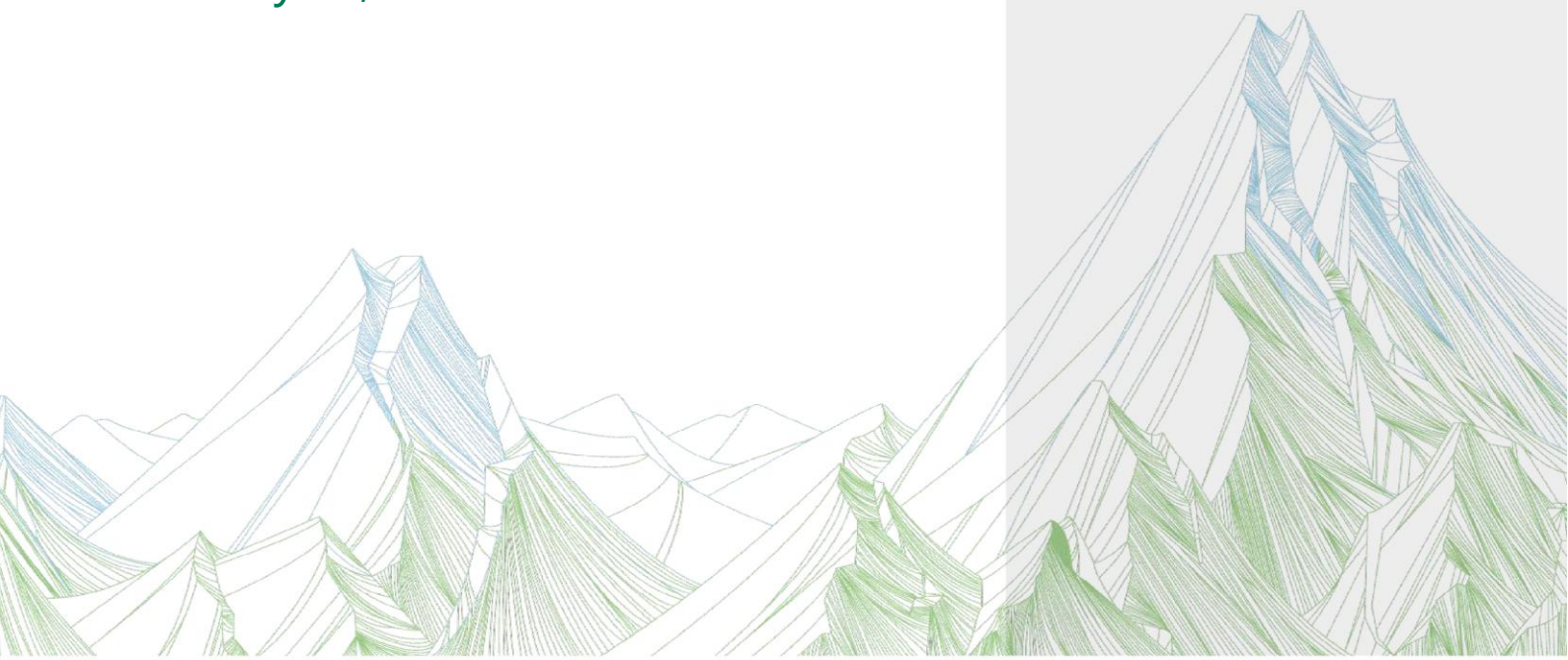
TAILORED ACTION PLAN
FOR RISK MANAGEMENT IMPROVEMENT

Interreg Alpine Space X-RISK-CC project – 2023/2025

PILOT AREA:

Stubai Valley

In Tyrol, Austria



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Technische Universität München

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PROJECT: **X-RISK-CC**

How to adapt to changing weather eXtremes and associated compound RISKs in the context of Climate Change

IMPRESSUM:

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X-RISK-CC - Alpine Space Programme

INTRODUCTION TO THE X-RISK-CC PROJECT

Project Background and Objectives

The X-RISK-CC project addresses the increasing challenges posed by climate-related extreme weather events across the Alpine Space. Recent years have demonstrated that compound and cascading extremes—such as storms combined with heavy precipitation, or heatwaves followed by drought and flooding—can challenge current risk management capacities. The unexpected magnitude and intensity of these extremes can cause compound impacts and domino effects that turn into complex, long-lasting, or even irreversible consequences. While scientific evidence links climate change to the increasing intensity and frequency of such events, knowledge and management of their cascading impacts and risks remain insufficient. The X-RISK-CC project aims to improve risk management of such extreme events in the context of climate change. By considering selected pilot areas across the Alpine Space, co-designed, context-specific interventions are elaborated based on a comprehensive assessment of past extreme events, future climate projections, and systematic evaluation of existing risk management capabilities and gaps. This document presents the Tailored Action Plan developed for one of the project pilot areas.

The Pilot Area of Reference

In the Stubai Valley, approximately 30 debris-flow events have been documented since 1970 by the Torrent and Avalanche Control Tyrol in five analysed catchments: Mutterbergbach, Grawanockbach, Oberbergbach, Margaretenbach, and Mühltalbach. Since 2010, both the frequency of events and the volume of mobilized material per event have increased significantly, with a peak in 2020–2024. One of the most severe recent events occurred on 22 July 2022, when intense rainfall exceeding 100 mm in a single day triggered multiple debris flows across the valley, causing temporary blockage of streams, localized flooding of roads and alpine infrastructure, and highlighting the heightened vulnerability of steep valley slopes.

For further details on the pilot area, the natural hazards that occurred and the activities that led to the co-creation of the tailored action plan, refer to the document “PILOT DOSSIER: STUBAI VALLEY, IN TYROL” available at the project website under “Outcomes”.

Outcomes:
X-RISK-CC - Alpine Space Programme
https://www.alpine-space.eu/project/x-risk-cc/

X-RISK-CC – Web GIS:
Information on intensity and frequency of weather extremes in the entire Alpine Space
https://cct.eurac.edu/x-risk-cc

THIS DOCUMENT

Based on the results of participatory workshops with local stakeholders, this document presents the Tailored Action Plan (TAP) which outlines the priority actions to strengthen the region's capacity across all phases of the risk management cycle. The TAP addresses key gaps in early warning systems, data integration, coordination mechanisms, infrastructure resilience, legal frameworks, and public awareness. The actions are designed to be implementable, measurable, and aligned with both regional and transnational objectives of the Alpine Space for disaster risk reduction and climate change adaptation.

Purpose and Concept

While this document provides the overall structure and documentation, the TAP itself is conceived as a living set of implementation-oriented actions, forming a dynamic and evolving database of priority measures. The actions can be continuously updated and adapted over time and serve as a practical reference for identifying next steps, tracking ongoing initiatives, and maintaining a clear overview of progress in strengthening regional resilience. This flexible approach acknowledges that effective risk management in the context of climate change requires ongoing learning, adaptation, and coordination among stakeholders.

Methodology

The methodology employed to develop the TAP for each pilot area of the project follows a **Community-Based Approach** engaging stakeholders across all phases of the risk management cycle (prevention, preparedness, response, recovery). **Participatory workshops with local stakeholders** were conducted **between 2023 and 2025** in each pilot area.

Participants in the workshops of the pilot area of Stubai Valley, in Tyrol:

- Mayors of the 3 municipalities (Mieders, Fulpmes and Neustift)
- Fire brigade captains of Mieders, Fulpmes and Neustift
- Regional police officers
- Deputy manager of Provincial department for civil protection
- Weather-forecasters from GeoSphere Austria
- Representative of district administration Innsbruck
- Representatives of Provincial Forestry department
- Torrent Rangers of Mieders, Fulpmes and Neustift
- Local Torrent and Avalanche control area construction management office
- Hydraulic Engineering Department Tyrol
- Austrian Research Centre for Forests
- Stubai Glacier Resort (as road managers)
- Representative of Provincial Agricultural department

Prioritization Strategy

Prioritization was carried out separately for each pilot area in the project and is therefore not uniform across pilot regions, reflecting different risk contexts, institutional settings, and capacities.

The TAP developed for the Stubai Valley pilot area is based on field surveys, workshops and discussions with key decision-makers from local authorities, regional planning agencies, the Forest Engineering Service in Torrent and Avalanche Control (WLV), forest authorities, emergency services, weather data providers, and other relevant stakeholders. The results from these discussions and workshops provide the conceptual framework for the TAP outlined below, as well as for establishing priorities for each individual action. The prioritization ranges from 1 to 5 as described below. Only actions assigned to priority level 3 or higher are included in the TAP, since those with lower priority were considered irrelevant.

1 – very low priority:
No relevance for the pilot area.
2 – low priority:
No relevance for the pilot area.
3 – medium priority:
This priority level indicates a substantial gap that should be addressed.
4 – high priority:
The action is recognized of high importance and must be initiated.
5 – very high priority:
The action is essential to address gaps of major importance.

STRUCTURE AND CONTENT OF THE TAILORED ACTION PLAN

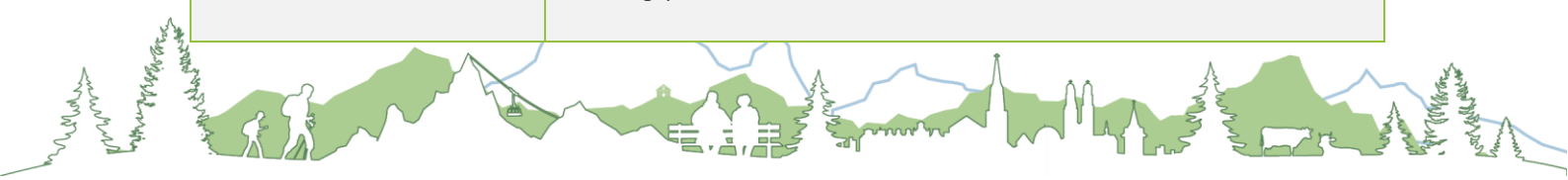
Each action in this document includes:

- **IDENTIFICATION:** Unique code, title, and 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, and potential challenges
- **VALIDATION:** Indicators and parameters for monitoring progress and success
- **FEASIBILITY:** Timeline, funding status, responsibilities, and implementation pathway

Action Plan Fields Explained

ID Number	Unique identifier assigned to each action. This allows for easy reference, tracking of connections between actions, and integration with other planning documents. The initial letter (A to D) indicates the phase of risk management cycle the action refers to.
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 (Very Low Priority) to 5 (Very High Priority) based on the prioritization methodology described above. Priority reflects urgency, impact potential, feasibility, and stakeholder consensus. Only actions assigned to priority level 3 (Medium) or higher are included in the TAP.
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: e.g., 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.

TAILORED ACTION PLAN

Table of actions

Table 1 provides a comprehensive overview of all identified actions. Each action is coded according to the system described in the previous section and can be filtered by its position in the risk cycle, type, priority level, or progress status. **Detailed descriptions of each action are provided in the Annex**, including the rationale, the gap or need addressed, its position within the risk management cycle, institutional ownership and involved actors, target groups, and current implementation status. Together, these descriptions contextualize the actions, support prioritisation and monitoring, and provide a transparent basis for coordination, decision-making, and future updates of the action plan.

ID Number	Title of the Action	Gap(s) it refers to	Risk Cycle position	Type	Level	Ownership	Actors	Target Groups	Priority	Finalize by (timewise)	Progress Status	Connection to other actions (ID)	Comments/ Details/Observations
A: Prevention													
A 1	Spatial measures	Insufficient adaption to changing event frequency and magnitude, only hazard maps no risk maps	Prevention	Legislation	Local/provincial/regional	Federal and provincial legislation, WLV	WLV, spatial planning	Municipalities, stakeholders, citizens	4		Ongoing	A2, A4, B2, B3, D1, D3	Continuous process
A 2	Specific protective measures	Inadequately dimensioned protection measures, instability of forests (protection function)	Prevention	Technical measures, implementation proposal	Provincial/regional (land use management) – local (technical measurements)	Forest owners, municipalities, WLV	Landowner, forest district inspections, WLV	landowners, municipalities	4		Ongoing	A1, B2, C1, D1	Continuous measures and adaptions
A 3	Competencies, training and communication	Lack of institutionalised communication structures	Prevention	Communication	Local – provincial/regional	Municipalities, Crisis and Disaster Protection Centre, emergency services	Municipalities, WLV, emergency services, Crisis and Disaster Protection Centre	Municipalities, stakeholders, members of the crisis management team, emergency services	4	2025		A4, B1, B2, B3, C2, D1	Permanent municipal operations management team
A 4	Awareness and risk perception of the population	Local population, providers of tourist services and guests are insufficiently prepared for damage events	Prevention	Communication	Local, partly regional	Municipalities, WLV, emergency services, e.g. fire brigades, regional authorities	Municipalities, Crisis and Disaster Protection Centre, WLV, school	Municipalities, population	3	3 Workshops 2024/25 held	Ongoing	A3, B1, B3, C2, D2	Workshops in the frame of X-RISK-CC, permanent efforts necessary
B: Preparedness													
B 1	Early warning / weather forecasts	Insufficient weather warnings and warnings about natural hazards	Preparedness	Data and Knowledge	Local/supra-regional	Geosphere Austria, Austro-Control, Crisis and Disaster Protection Centre	Municipalities, emergency services	Municipalities, emergency response organisations, managers of tourism businesses, citizens	4		Ongoing	A3, B2, B3	Permanent improvement of weather forecast
B 2	Hazard hotspots / Critical areas	Comprehensive identification of risk-hotspots is often insufficient	Preparedness	Data and Knowledge	Provincial/regional	WLV, Crisis and Disaster Protection Centre, municipalities, fire brigades	WLV, municipalities, fire brigades	Municipalities, companies, citizens	4	Partly (hazard maps)		B1, B3	Only hazard - no risk maps, only around settlements (infrastructure often missing/inhomogeneous)
B 3	Emergency and disaster management plans	Missing or incomplete emergency and disaster management plans	Preparedness	Data and Knowledge	Local	Province of Tyrol, municipalities, transport and construction companies, road authorities, emergency services	Municipalities, transport and construction companies, WLV	Municipalities, emergency services, transport and construction companies, WLV, citizens	5	Partly	ongoing	A3, B1, B2	Legal obligation (Disaster Relief Act) but varling/incomplete implementation (no consequences)
C: Response													
C 1	Road closures	Resporisibilities depend on types of roads, rarely standard procedures available, inadequate information on hot spots	Response	Data and Knowledge	Local	Municipalities, road authorities, emergency services	Municipalities, emergency services, police	Citizens	3		No activity	B1, B2, B3	
C 2	Communication during the event	Lack of institutionalised communication structures	Response	Communication	Local	Emergency services, crisis and disaster protection centre	Municipalities, emergency services, Crisis and Disaster Protection Centre	Citizens, emergency services	3	Largely implemented		A3, A4, B3	
D : Recovery													
D 1	Review and documentation of damaging events	Inhomogeneous review and incomplete event-documentation	Recovery	Data and Knowledge	Local	Entire crisis management team	Entire Crisis management team, WLV	Entire crisis management team, citizens	3		ongoing	A1, A2, A3, B2, C2	Continuously update processes and data
D 2	Restoration costs / financial resources for immediate measures	Unflexible financing instruments, "funding jungle"	Recovery	Legislation	Local, provincial	Various funding institutions	Funding institutions, municipalities, Tyrol	Affected persons and institutions	3	2027	preparation	A1, A2, A3, B1, B3, D1, D3	Solidarity Fund
D 3	Disposal areas	Legal problems, only sporadic forward-looking identification of disposal sites	Recovery	Legislation	Local	Landowner, municipalities	Landowner, municipalities	Landowners	4		sproadic activities	A1, B3, D2	Limited space as a fundamental problem in Stubai Valley

TABLE 1: *Complete inventory of the Tailored Action Plan for the Stubai Valley pilot area in Tyrol.*

The table is visible by zooming in

CONCLUSIONS AND NEXT STEPS

This document represents a living framework for improving risk management in the X-RISK-CC pilot area of the Stubai Valley in response to climate-related extreme events. The actions identified through participatory workshops with local stakeholders address critical gaps across all phases of the risk management cycle.

Key Outcomes:

- Comprehensive inventory of 12 tailored actions co-designed with local stakeholders
- Systematic coding system enabling efficient tracking, monitoring and coordination
- Clear prioritization framework to guide implementation
- Integration of scientific climate projections with local knowledge and practical experience

Implementation Approach

The implementation of the proposed measures does not follow a single, predefined approach. Instead, measures are implemented step by step, depending on institutional responsibilities, available resources and emerging needs. Several measures have already been implemented, while others are planned to be implemented as appropriate.

ANNEX

In the following, each action listed in Table 1 is described individually.

Action A1 – Spatial measures

GAP THE ACTION ADDRESSES

- The impact of climate change on the Alpine Space is a major challenge for hazard zone planning. Hazard zones previously delineated based on historical correlations between event frequency and magnitude may no longer be reliable due to altered environmental conditions, such as changes in land use and the increased occurrence of extreme precipitation events.
- In the pilot area, damaging events originally classified as having a 150-year recurrence interval at the time of planning will probably occur with a 50-year recurrence in 2050. Thus, infrequently observed events, exacerbated by the impact of climate change, necessitate a reassessment of their risk.

FRAME THE ACTION

- **Phase of the risk cycle:** Prevention – enhanced mapping of hazard zones
- **Type of action:** Legislation (general framework) as well as data and knowledge (implementation)
- **Relevant levels of action:** local (municipalities) – provincial/regional
- **Ownership:** Federal and provincial legislation, WLV
- **Target groups:** Municipalities, stakeholders, citizens
- **Priority:** 4 – high priority – partially already happening
- **Connection to other actions:** A2, A4, B2, B3, D1, D3

DESCRIPTION OF THE ACTION

In Austria, existing hazard zone plans are approved and widely accepted tools, specified in federal laws (hazard maps), which become binding via provincial laws (spatial planning). However, they require systematic revision, as they are static and cannot reflect dynamic environmental developments. In consideration of the accelerating environmental changes - particularly those driven by climate change - the intervals between necessary updates have shortened. Beyond the delineation of restricted or conditionally permitted construction zones, planning frameworks should also explicitly define “permitted zones” in the future. These areas should be clearly integrated into hazard zoning maps to support forward-looking spatial development. Following Switzerland’s example, hazard zone planning should evolve from a hazard-based to a risk-based approach, enabling economically optimized, transparent development of protection measures according to the accepted risk. Furthermore, potential future developments and changes need to be considered in planning.

Thus, we developed and introduced a method based on existing hazard maps and available spatial information, providing (internal) risk-relevant information on the current status as well as for scenarios of changes in climate, protection measures, and land use.

The proposed method can be applied without legislative changes, but for uniform comparable and traceable implementation, the amendment of the federal law after a test phase would be necessary.

POSITIVE OUTCOMES

Mitigation of casualties and property damages through improved spatial assessment, including:

- **Redefinition of design events and hazard zones:** Presentation of updated design events, revised return periods, and adapted hazard maps based on current and projected climate data.
- **Integration of climate change scenarios and compound events in spatial planning** driven by climatic and environmental changes such as shifts in precipitation patterns, reduced protective effects of forests due to abiotic (e.g., wildfire) and biotic (e.g., beetle calamities) disturbances, permafrost and glacier degradation etc.
- **Consideration of economic parameters** due to the traceable consideration of hazard-exposition and vulnerability (elements at risk) depending on magnitude and frequency of events and resulting differentiation of land use suitability.
- **Enhanced preparedness for emerging risks:** Identification of risk hotspots and residual risks supporting targeted risk communication and planning.
- **Identification of areas with low or non-existent exposure to natural hazards:** Determining “safe areas” based on current and projected hazard scenarios to support targeted control of infrastructure development.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **Assessment of climatic and environmental changes as a basis for forestry measures:** Systematic evaluation of shifts in precipitation patterns, forest health and stability, wildfire risk, windthrow susceptibility, heatwaves, and drought conditions.
- **Capacity building and knowledge transfer:** Structured dissemination of findings and methodologies to municipal authorities, enabling more effective crisis response and long-term adaptation planning.
- **Development of a revised nomenclature for hazard mapping:** Potential refinement of hazard zone terminology - based on the effects of the damaging event - enhancing clarity and relevance of risk communication. This approach must be tailored to the specific local context to ensure both scientific robustness and improved public comprehension.
- **Promotion of resilient construction practices:** The consideration of vulnerability in the risk assessment may promote adapted building practices through individual responsibility, regulatory restrictions, and targeted financial incentives (e.g., subsidies for risk-reducing construction measures).
- **Recognising the need for comprehensive and timely documentation of damage events:** The systematic, accurate, and timely recording of past damage events is gaining increasing importance for evidence-based risk assessment and adaptive planning.

Such documentation provides a critical empirical basis for understanding evolving hazard dynamics under changing climatic conditions.

VALIDATION/ INDICATORS – ANALYSIS

Changes in the definition and classification of hazard zones have significant implications for property owners, particularly regarding property values, and for communities, due to impacts on their development potential. For responsible institutions, this requires clearly defined and legally binding boundaries. However, the complexity of natural systems makes it difficult to define these precisely in the natural environment, especially since they are subject to changes. This complicates the transition from traditional, static hazard zone maps to dynamic, risk-based maps that also reflect changing climatic conditions. The introduction of such planning tools requires methodological innovations and corresponding adjustments to the legal and regulatory framework for hazard mapping, spatial planning and land use.
However, at least for economic reasons, risk assessment (as already implemented in Switzerland) is useful since the extent of damages primarily depends on the values situated in the affected areas. Therefore, we developed and introduced a method for building existing hazard maps, providing (internal) risk-relevant information.

FEASIBILITY AND TIMELINE

In Austria, the introduction, acceptance, and implementation of hazard maps in spatial planning legislation required decades. Since it is now a proven, generally accepted tool, the will for change is limited. Legislative adaptations and measures to achieve the necessary acceptance of this recommendation are required.
However, Austria's hazard zone regulation was adapted in 2021 and introduced the possibility to designate residual risk or HQ300 areas (low hazard probability, white zones) in the hazard zone maps. This feature is currently implemented in the GIS-tool of torrent and avalanche control and is increasingly used in practice. This regulatory update reflects an increased awareness of the potential impacts of climate change and acknowledges the necessity to adapt planning frameworks accordingly.

Action A2 – Specific protective measures

GAP THE ACTION ADDRESSES

- In Austria, mitigation measures are dimensioned according to predefined design events (for torrent scenarios an occurrence probability of 150 years). However, shifting environmental conditions resulting from climate change may lead to more frequent and intense natural hazard events, causing protective structures to become inadequate and/or their maintenance more costly. The overload case and the resulting residual risk need to be presented and communicated more consistently.
- Healthy, well-managed forests mitigate natural hazards, especially in mountainous regions. However, these ecosystems are increasingly vulnerable to the impacts of climate change. Climate change may cause a higher frequency of windthrow events and forest fires. Prolonged periods of drought and heat stress reduce the forest resilience against biotic disturbances such as bark beetle calamities in Picea abies stands, increasingly also at higher elevations. Efforts to adapt forest ecosystems, such as modifying stand structure and promoting climate-resilient tree species, are constrained by long rotation periods. Thus, adaptive strategies can only be realized over the long-term.

FRAME THE ACTION

- **Phase of the risk cycle:** Prevention – ensuring the implementation and functionality of technical and biological measures and procedures (e.g., climate-adapted forests)
- **Type of action:** Technical measures/implementation proposal
- **Relevant levels of action:** Provincial/regional (land use management) – local (technical measures)
- **Ownership:** Forest owners, municipalities, WLV
- **Target groups:** Forest owners, municipalities, WLV, BFI (Forest District Inspections)
- **Priority:** 4 – high priority – recognised as common practice
- **Connection to other actions:** A1, B2, C1, D1

DESCRIPTION OF THE ACTION

The effects of climate change must be addressed through a range of adaptive strategies: The annual torrent inspections required of municipalities are becoming increasingly important, and the "construction register" hosted by the WLV must be regularly updated to reflect current conditions, identify protection gaps and determine necessary interventions. To achieve this, the professional qualifications of the personnel conducting these inspections must be assured through standardized training and certification. In Tyrol, since 2019 several “maintenance associations” have been established. Their aim is to support municipalities in fulfilling their inspection, supervision, and maintenance obligations for protective structures against avalanches, rockfall, and slope movements, and to ensure standardized, guideline-compliant inspections. Torrent control structures are already inspected as part of annual torrent inspections. Forest rangers receive specialized training for this purpose, and municipalities are supported through a torrent management system jointly operated by WLV and the Province of Tyrol, thereby also ensuring standardized, expert inspection and maintenance.

As climate-related disturbances increase, higher maintenance costs of protective structures and shorter intervals for sediment retention basin clearance are anticipated creating financial burden. The latter requires increasing landfill capacities, forward-looking planning and precautionary measures to ensure the continued functionality and resilience of protective infrastructure especially for municipal authorities.

Due to the increasing intensities of damage events, a thorough understanding of potential overload scenarios is essential. Such knowledge enhances the strategic coordination and operational efficiency of emergency response units during critical incidents.

To ensure that forests can fulfil their protective functions adequately, the establishment and maintenance of appropriate infrastructure is essential, facilitating silvicultural interventions such as the timely removal of damaged timber, or reforestation after disturbance events. Well known measures to keep forests healthy and provide adequate reforestation, such as the spatial separation of forest and pasture areas and the regulation of game densities, must be implemented consistently.

POSITIVE OUTCOMES

Mitigation of casualties and property damages by:

- **Enhanced structural safety:** Quality-assured torrent inspections enable early identification of technical deficiencies and provide a reliable overview of existing protective infrastructure and its condition.
- **Sustainable technical protection:** Timely and continuous maintenance and adaptation of protection structures (e.g., for Grawanockbach). Continuous clearance of sediment retention basins to reduce emergency interventions and ensure functionality.
- **Behaviour of protection structures in the overload case:** Can existing structures still mitigate damage? Are they stable and what are the consequences for spatial planning and risk management?
- **Preservation of forest protective functions:** Forest management should ensure the continued maintenance of protective capacities for the future. Effective reforestation adapted to future framework conditions after disturbance events (compare project FORSITE – suitability of tree species under changing climate conditions).
- **Improved operational accessibility:** Well-developed forest roads enable rapid response to climate-related disturbances and support effective forest management.
- **Structural and ecological forest stability:** Clear separation of forest and pasture areas, enforcement of reforestation obligations, and site-adapted regulation of game densities contribute to resilient forest ecosystems.
- **Increased organisational responsiveness:** Prompt availability of financial resources enables timely and coordinated actions.
- **Optimised emergency coordination:** Scenario-based preparedness for overload situations enhances strategic planning and operational efficiency during extreme events.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **Expertise distribution:** Forest rangers, the torrent management system and “maintenance associations” ensure consistent inspection quality and support smaller municipalities.

- **Ecological biodiversity:** Site-adapted forests promote species diversity.
- **Long-term economic efficiency:** Preventive forest management and stable ecosystems enhance stability, lowering the need for expensive emergency actions.
- **Strengthened municipal resilience:** The integration of technical infrastructure, organisational capacity, and ecological adaptation enhances the ability of municipalities to respond effectively to climate-related challenges**.**
- **Attractive living space** in the Stubai Valley due to higher (objective and subjective) perception of safety, countering urbanisation.

VALIDATION/ INDICATORS – ANALYSIS

The technical protective measures implemented by the WLV have demonstrated long-term effectiveness over several decades. In addition to the improvement strategies outlined in action A1, current approaches increasingly account for the influence of changing climatic conditions, particularly through the integration of overload scenario assessments.

These scenarios were systematically discussed with municipal authorities and emergency services and are incorporated into strategic planning for damage prevention and post-event response.

In Austria, legislation assigns the responsibility for conducting annual torrent inspections to the respective municipalities. While municipalities frequently affected by natural hazards tend to have greater practical experience in fulfilling this mandate, the quality of implementation is inherently dependent on the expertise of the involved personnel. To standardize torrent inspections, the specialized training for the forest rangers is crucial. To also ensure adequate inspection of non-torrent control structures, in the near future it is planned to establish a “maintenance association” in the Stubai Valley as well.

Healthy protective forests are the most economic and ecologic protective measure below the treeline. In collaboration with district forestry inspectorates, forest owners are already engaged in a wide range of activities, assisted by targeted financial support. However, the long timeframes required for the practical implementation and ecological effectiveness of these measures - particularly in the context of establishing “climate-resilient forests” - represents a key factor.

FEASIBILITY AND TIMELINE

The Stubai Valley is generally well equipped with technical protective measures. While improvements in maintenance are feasible, they are strongly constrained by available financial and human resources. Parallel efforts are in progress to enhance forest cover and maintain the protective function of forests. However, the protective function is limited by the high altitude of the pilot area. Long-term horizons are required for current measures to achieve practical effectiveness.

Action A3 – Competencies, training and communication

GAP THE ACTION ADDRESSES

- The management of natural hazards in Tyrol is characterised by a multi-level governance structure, with responsibilities distributed according to the type of hazard, the extent of the affected area, and the specific risk scenario. Throughout all phases of the risk management cycle - from prevention and preparedness to response and recovery - municipal authorities, particularly mayors, are the primary contact at the local level. Their responsibilities include the development and implementation of protection and emergency response plans, initiating alarms and coordinating local emergency measures. Municipalities are supported by the district administrative authorities and the Tyrolean government, which facilitate the coordination of supra-local interventions and provide assistance during large-scale incidents. Further institutions such as the WLV, the water engineering administration and infrastructure operators such as the Austrian Federal Railways (ÖBB) and ASFINAG, the national motorway operator, are involved in the hazard and risk management. Scientific and technical experts - including meteorological services, geologists, and hydrologists - assist with risk assessment and support decision-makers. Emergency services such as the fire brigade, the Austrian Red Cross, the police, and the Austrian Armed Forces, are essential actors in operational response and disaster relief.
- The cooperation and communication among these actors work effectively in Tyrol, particularly if actors are familiar with one another through prior collaboration. This familiarity, however, tends to develop primarily in regions where hazard events occur frequently. Inter-agency cooperation is currently often event-driven and lacks institutionalised structures for systematic joint preparedness. There is no standardised protocol or formalised framework that governs collaborative planning and operational coordination during crises or joint training for crisis scenarios. Arrangements are often based on ad-hoc agreements. Written agreements or predefined procedures are either absent or insufficient. Scenarios considering climate change effects are usually not included.

FRAME THE ACTION

- **Phase of the risk cycle:** Prevention – strengthening cooperation
- **Type of action:** Legislation (general framework) and communication
- **Relevant levels of action:** Local (municipalities) – provincial/regional
- **Ownership:** Municipalities, Crisis and Disaster Protection Centre
- **Target groups:** Municipalities, stakeholders, members of the crisis management team, emergency services
- **Priority:** 4 – high priority – partially effective
- **Connection to other actions:** A4, B1, B2, B3, C2, D1

DESCRIPTION OF THE ACTION

Municipalities are legally required to be kept their disaster protection plans up to date. These plans should also include climate change scenarios and risk assessments to be prepared for future challenges. However, adequate protection plans require well-founded expert knowledge

and are associated with costs. Currently, there are no sanctions for omissions when the plans are not always up to date. Thus, the municipalities, which are responsible for the development and implementation of the disaster protection plans, need to be supported in technical and financial matters.

In the field of natural hazard risk management, responsibilities are sometimes not clearly defined. For example, in the aftermath of landslides (which can trigger debris flows by blocking a torrent or may develop into debris flows), various institutions such as the WLV, the geological services, or the fire brigades are involved, and responsibilities overlap or show gaps. Even in cases where responsibilities are clearly regulated, problems regarding the delineation of competence repeatedly arise, for instance between hydraulic engineering and WLV. The cooperation between different actors can be enhanced within the framework of specific projects, for example in the context of combined hazard scenarios or the financing of protective measures. However, periodic joint exercises and training help to avoid misunderstandings and close gaps.

In Tyrol, the Tyrolean Crisis and Disaster Management Act (TKKMG) was amended with effect from January 2025. The amendment considers analyses and insights from the damage events of 2022 in the Stubai Valley. In practice, the law brings advantages through an improved regulation of responsibilities between the municipality and the state regarding risk management.
The workshops held within the framework of the X-RISK-CC project enhanced the understanding of the different participating actors and their specific requirements and perspectives. Further periodic workshops could strengthen and enlarge these effects.

POSITIVE OUTCOMES

Mitigation of casualties and property damages by the:

- **Establishment of a Crisis and Disaster Protection Centre:** Consolidation of the cooperation and communication between the State Warning Centre, Avalanche Warning Service, and Provincial Geology.
- **Daily situation reports integrating weather models, natural hazard data and infrastructure status:** Faster and enhanced adequate activities to respond to potential hazards and risks.
- **Mandatory information sharing from critical infrastructure operators (e.g., hospitals, roads, power grid):** Enlarged data basis for the situational assessment and improved early warning systems allow timely targeted response to natural hazard events.
- **Legally mandated training for operations staff:** Standardised courses, practical modules, and specialised sessions (e.g., digital radio) optimise the effectiveness of rescue forces and resources in the case of events.
- **Integration of the Avalanche Commission Act into TKKMG**: Harmonized regulations.
- **Clear definitions of different disaster events**: Clarified responsibilities result in enhanced legal certainty.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **Potential future introduction of Natural Hazard Commissions:** As a further development of the Avalanche Commissions (see above) to consider all geogenic natural hazards.
- **Consideration of demographic changes:** Adaption of information accessibility and emergency aid provision due to the increasing number of seniors and non-German speaking tourists; supporting the targeted management of rescue operations.
- **Systematic knowledge transfer and integration of early warning systems**: More timely and partly automated countermeasures support actors in the case of disaster events.

VALIDATION/ INDICATORS – ANALYSIS

The amendment of the TKKMG is an important step that is supposed to show positive effects in all phases of the risk cycle, depending however on its concrete implementation. Municipalities, where knowledge of natural hazards is already strong will be the main beneficiaries.

The establishment of a permanent municipal operation management team is crucial and support mayors in difficult situations. Local knowledge should be documented, regularly updated through training, and incorporated into disaster protection plans. These trainings are important to establish standard procedures for municipal operation management. Furthermore, they offer the opportunity to share cross-institutional knowledge, for example, by involving the WLV in training emergency personnel on torrent processes.

FEASIBILITY AND TIMELINE

It is important to ensure that training programs remain manageable for municipalities, avoiding excessive demands in terms of time, scope or cost. Subsidies for protective measures or funding for renovations could be linked to participation in such training sessions. Following the first X-RISK-CC-workshop, all municipalities in the pilot area established municipal crisis management teams. In addition, the provincial department for civil protection now offers expanded training opportunities and emergency exercises for municipalities and local staff. In the future, torrent and avalanche control authorities will also be involved in these exercises.

Above all, securing personnel and financial resources for the emergency services is essential. The role model of voluntary fire brigades in Austria must be preserved and strengthened.

In the case of the implementation of natural hazard commissions, appropriate legal and technical foundations as well as experts from geology, WLV, hydraulic engineering, meteorology, forestry and other relevant fields are required. Even though the establishment of such commissions, similar to avalanche commissions, is challenging, implementation seems to be an interesting vision, even if it is time-consuming.

Action A4 – Awareness and risk perception of the population

GAP THE ACTION ADDRESSES

- In a world of overflowing with information, it is challenging to gain attention – thus actions involving the (local) population to preserve and increase risk awareness are necessary, strengthening self-responsibility, adequate behaviour in the case of events, and support through event documentation. It is challenging to involve people that have no history of dealing with local natural hazard risks, e.g., tourists, in risk-mitigation measures in a way which does not hinder relaxing holidays. In this context, the local population and local decision-makers need to be aware of the residual risk, which will always remain despite all safety measures. This needs to be communicated in a traceable way, considering that people do not calculate probability in their daily lives.
- There are few predefined activities, these usually depend on the commitment of the local stakeholders (e.g., mayors) and the frequency of events. However, information on advanced warning and the appropriate behaviour to minimise damage and casualties need to be refreshed and updated regularly.
- Nowadays, an increasing number of spectators can often hinder the emergency services. Road closures are sometimes ignored, despite the risk of casualties. To counteract this development, information to increase personal responsibility and personal resources during and after natural hazard events, should be planned to manage this challenge.
- The presence of emergency managers (e.g., mayors) on site is psychologically advantageous, as it can convey the feeling that someone is taking care of those affected by events.

FRAME THE ACTION

- **Phase of the risk cycle:** Prevention
- **Type of action:** Communication, strengthening of self-responsibility
- **Relevant levels of action:** Local (municipalities), partly regional
- **Ownership:** Municipalities, WLV, emergency services as e.g. fire brigades, regional authorities **Target groups:** Municipalities, population
- **Priority:** 3 – Medium priority – partially already implemented
- **Connection to other actions:** A3, B1, B3, C2, D2

DESCRIPTION OF THE ACTION

In tourist areas such as the Stubay Valley, communication should address the local population, providers of tourist services and tourists individually. Providers of accommodations, infrastructure and (touristic) activities are usually responsible for the safety of people in their care (personnel, guests). Thus, they should be well informed on where to get early warning information and guidance on adequate behavior of personnel and guests. Personal invitations to expert-led information and training events are recommended for this target group, as well as for local decision-makers.

Touristic infrastructure providers must ensure the accessibility of guests for instructions in the case of early warnings of impending events. Rudimentary security measures, for example the documentation of planned mountain tours – including destinations, routes and expected departure and arrival times – should be in place for both tourists and the local population. Furthermore, public events with tailored content and instructions for measures of property protection (including risk checks) should be offered for local residents and presented in an easy-to-understand way.

As a part of school education, the understanding of risks and management of natural hazards, adapted to the region, should be taught. For associations (e.g., mountain clubs) or institutions (e.g., volunteer fire brigades), specific information and support should be offered.

Social media channels should be created and/or adapted, offering easy-to-understand information on protective measures and behavior before, during and after a natural hazard event.

POSITIVE OUTCOMES

- **Well-informed active providers of touristic infrastructure and local decision makers** reduce the efforts for rescue and number of victims in the case of events.
- **Enhanced self-responsibility** decreases damages due to adequate behaviour and timely implementation of protective measures.
- **Understanding of risks and residual risks in large sections of the local population** supports the acceptance of risk management measures.
- **Attendance of well-educated emergency managers (e.g., mayors) on-site during and shortly after events** ensures the best possible use of resources.
- **Comprehension of risk management** hopefully reduces the number of spectators.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **The attendance of emergency managers on-site during and shortly after events** supports rescue teams and affected people.
- **The knowledge of risks and residual risks** supports adequate spatial land use and less vulnerable building designs.
- **Knowledge of existing risks, their probability and adequate behaviour** enhances the “feel good – feeling”, psychological health and the attractiveness of the living space (during and after the event as well as support-options in the case of damages).
- **Enhanced understanding of risk management efforts** encourages event documentation by locals.

VALIDATION/ INDICATORS – ANALYSIS

Adequate communication adapted to the different requirements of actors, stakeholders and affected people has positive effects in all phases of the risk cycle. Success strongly depends on the consistent announcement, promotion, and delivery of appropriate events for different groups of stakeholders and their acceptance. Municipalities with in-depth knowledge of natural hazard events can be the main beneficiaries, supported by the WLV and regional authorities.

The reinforced integration of associations and institutions, especially of local volunteer fire brigades, ensures a low-threshold knowledge transfer.

Specific school education, adapted to the local situation, supports a basic understanding of natural hazard risks and a better acceptance of necessary risk management measures. However, this probably requires the adaptation of the lesson plans on a federal and/or national level, which allows the adaption of the local conditions.

Several media and online platforms already provide information on risks in mountainous areas. However, the challenge is to get the attention of the target groups.

FEASIBILITY AND TIMELINE

Information events must be recognised by target groups and attractive enough to gain their interest and participation. This is a challenge in a world with an over-supply of information. Integrated efforts of risk-, product- and/or advertisement-experts with strong support of "local influencers" and actors will help in being successful. This is valid also for specific information-services via various social media platforms.

Besides, offering events and information services adapted to specific groups of stakeholders is time and resource consuming. Thus, a strategy considering both the costs and the benefits of such events should be developed to implement these measures in an efficient manner.

To integrate associations and institutions, as a first step, the identification of interested members might be helpful. They can support communication to the respective organisation by advising on specific requirements, promoting events and engaging further interested participants.

It is very difficult to assess clearly to which extent the teaching of adapted risk relevant issues is possible within the current curriculum. So far, it seems not to be required and is left to the teacher's initiative. Thus, the curricula should be changed, which is challenging knowing the Austrian education system and due to the needed regional to local flexible teaching contents. A more straightforward method is to educate children about natural hazards, risk and safety through school projects. To raise public awareness more broadly and strengthen societal resilience, a joint participatory information event involving all relevant authorities is planned to take place in the Stubai Valley in spring/early summer 2026.

Generally, the success of the proposed communication measures depends on the support of the local decision-makers and responsible individuals and their willingness to provide support and activities.

Action B1 – Early warning / weather forecasts

GAP THE ACTION ADDRESSES

- Short-term heavy rainfall is the primary trigger for debris flows. Due to climate change, the frequency and intensity of such events are increasing. In Austria, the combination of radar data from Austro-Control and calibration with ground-based precipitation measurement stations provides a broadly robust weather monitoring system with significant potential for further improvement. Additionally, the analyses and forecasts from Geosphere Austria enable a well-established weather warning system. While general weather warnings are available, accurately assessing debris flow risks is still challenging, as predicting the exact locations of thunderstorm cells and small-scale precipitation intensities remains extremely difficult or sometimes even impossible.
- There is a clear demand from stakeholders that weather warnings should be translated into concrete natural hazard alerts. What is needed is timely, highly localised warnings, as well as detailed information on the movement or stationary nature of heavy rainfall cells. However, conventional forecasting methods struggle to predict the precise timing, duration, and location of such storms. As a result, the current warning system does not include a real-time integration of thunderstorm alerts. At present, authorities, decision-makers, and the public only receive limited information regarding local natural hazards, which limits their ability to take effective precautionary measures. In this respect, it becomes obvious how high the need is for a Natural Hazard Commission (see Action A3) to support decision makers.

FRAME THE ACTION

- **Phase of the risk cycle:** Preparedness - improved, small-scale weather forecasts for more accurate early warnings
- **Type of action:** Data and knowledge (forecasts) as well as communication (warning system)
- **Relevant levels of action:** local/supra-regional
- **Ownership:** Geosphere Austria, Austro-Control, Crisis and Disaster Protection Centre
- **Target groups:** Municipalities, emergency response organisations, managers of tourism businesses, citizens
- **Priority:** 4 – high priority (ongoing process)
- **Connection to other actions:** A3, B2, B3

DESCRIPTION OF THE ACTION

The weather radar for Austria provides updated information every five minutes regarding areas of precipitation and their trajectories. It indicates both the location and intensity of rainfall and offers a forecast for the subsequent two hours. Precipitation intensity is shown using a six-level colour scale, ranging from light rainfall to severe storms. By densifying the weather radar network and increasing the number of levels in the scale (e.g., through the addition of the weather station at Valluga), it is anticipated that even more accurate forecasts will become feasible in the future.

The weather data portal “Wetterbox Tirol” supplies decision-makers at state, provincial, municipal, local and specialist levels with a central, evidence-based foundation for crisis management and road maintenance. In collaboration with Geosphere Austria, the province of Tyrol provides comprehensive meteorological data. The TKKMG works together with Geosphere Austria to evaluate and improve these data. They are continuously working on making the data more impact-oriented and comprehensible for users.

Interdisciplinary meetings, such as those conducted within the framework of the X-RISK-CC project, constitute an important factor in exchanging perspectives and requirements concerning weather forecasting among various organisations and stakeholders. Only through such exchanges, can the access to and use of meteorological data at the local level generate the corresponding added value. Furthermore, it is only through regular utilisation and application of weather data that appropriate inferences can be drawn in the event of a warning.

POSITIVE OUTCOMES

- **Provision of precise weather data and forecasts:** Enhanced safety through faster and more accurate warnings.
- **Direct access to data for authorities, municipalities, and emergency services via the “Wetterbox Tirol”**: Improved risk awareness among decision-makers.
- **Specialized warning systems, such as warning SMS notifications for road maintenance and mountain hut keepers:** Optimising decision-making processes, enabling cost savings, and facilitating automated protective measures (e.g., road closures).
- **Mutual data exchange between province of Tyrol and Geosphere Austria:** Improved data analysis and increased forecast accuracy.
- **Strengthening the safety and decision-making capabilities of stakeholders**: Improved emergency response and more efficient use of resources.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **Improved familiarity among the various stakeholders**, even during "peace times", leads to enhanced cooperation in crisis situations.
- **False alarms:** Overly cautious warnings may reduce trust in the system.
- **Missed events:** Certain heavy rainfall occurrences can be underestimated in their intensity, or their direction and speed of movement may be incorrectly assessed.
- **Data dependency:** The system relies on high-quality weather data, which may not always be available.
- **Technological dependency:** Authorities and citizens might become excessively reliant on automatic warnings, potentially neglecting other precautionary measures.
- **Cost and maintenance:** The maintenance and further development of weather data and analysis models require ongoing investments.

VALIDATION/ INDICATORS – ANALYSIS

The implementation of a weather forecasting system as an alert system capable of producing precise, localised predictions remains particularly challenging, especially regarding small-scale heavy precipitation events. Currently, there is no standardised procedure detailing how

to respond to specific weather warnings. This represents a significant challenge, given the highly complex framework conditions that must be considered when assessing the concrete impacts of precipitation events.

Even when weather warnings provide accurate forecasts, continuous engagement with this information and skilled interpretation of the potential consequences are essential, particularly at the local administrative level. This necessitates not only personnel who are well trained in these matters but also adequate staffing resources to ensure prompt and correct responses. Effective collaboration between regional and local stakeholders is therefore a crucial factor for success. The introduction of Natural Hazard Commissions would certainly help to narrow this gap.

FEASIBILITY AND TIMELINE

Continuous efforts are being made to enhance the collection of meteorological data. The development of models capable of generating reliable weather forecasts from these data also remains an ongoing process. The application of Artificial Intelligence in this context can contribute to further improvements. At the same time, it is essential to ensure effective collaboration between authorities and other stakeholders, thereby granting all relevant actors access to forecasts and warnings wherever possible.

Action B2 – Hazard hotspots / critical areas

GAP THE ACTION ADDRESSES

- Due to climate change, scenarios for damaging events are shifting. Areas that were previously considered safe may now become critical hazard points. Therefore, possessing knowledge about such hazard hotspots is essential for effective preparedness.
- In settlement areas, hazard hotspots are generally well identified and known through hazard zone maps. However, such hotspots can also be located outside settlement areas (e.g., along transport routes). Assessing these points is just as important as proactively designating so-called "safe" zones, which can subsequently be used for the accommodation of evacuated individuals.
- Critical locations that are particularly vulnerable during damage events could be represented even more clearly in the hazard zone maps of the WLV. Improvements could include residual risk mapping and more detailed information, such as areas prone to blockage (e.g., due to debris flows).

FRAME THE ACTION

- **Phase of the risk cycle:** Preparedness - local knowledge of dangerous spots and safe locations
- **Type of action:** Data and knowledge
- **Relevant levels of action:** Provincial/regional
- **Ownership:** WLV, Crisis and Disaster Protection Centre, municipalities, fire brigades
- **Target groups:** Municipalities, companies, citizens
- **Priority:** 4 – high priority (ongoing process)
- **Connection to other actions:** B1, B3

DESCRIPTION OF THE ACTION

Effective communication between subject matter experts (e.g., WLV), stakeholders within municipalities and emergency services is essential to prevent the miscalculation of critical locations. Such communication also enables the derivation of appropriate measures, such as the monitoring of these critical points in the context of preventive checks. This proactive surveillance should be intensified following weather warnings, particularly upon the occurrence of precipitation events. The effectiveness of this approach is greatly enhanced if, in advance, it has been clearly defined which organisation is responsible, which methods are to be employed, and at what temporal resolution (continuously or at specific intervals) the practical implementation will occur. Possible actions include the fire brigade patrolling critical points, the installation of automated sensors, or the deployment of observation posts.

The communication process among stakeholders - specifically, to whom observations are relayed and which subsequent measures should be taken - constitutes a crucial aspect that must be established during non-crisis periods. This allows for potential countermeasures, such as evacuations, to be rehearsed and preventively planned. For specific hotspots (e.g., "forest playgrounds") located near hazard areas, dedicated safety concepts must be developed.

POSITIVE OUTCOMES

- **Precise identification of critical hotspots:** Classification of threat potentials and enhanced risk assessment.
- **Establishment of monitoring routines:** Early detection of hazardous situations and timely response through intervention strategies.
- **Designation of safe locations in disaster protection plans**: Sites for evacuation measures (accessibility and logistical support).
- **Definition of assembly points for crisis management teams.**
- **Considering communication capabilities and accessibility:** Effective coordination during the damaging event.
- **Designation of alternative safe locations:** Flexible response during damaging events and increased overall system resilience.
- **Provision of alternative infrastructure (e.g., power supply):** Redundant infrastructure to ensure operational capability.
- **Clear allocation of responsibilities and communication channels:** Structured and effective crisis management.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **Regular interdisciplinary exchange:** Definition of areas of responsibility and allocation of duties.
- **Early establishment of structured communication processes**: Better collaboration between experts and decision-makers already during “peace time”.

VALIDATION/ INDICATORS – ANALYSIS

The identification, assessment, and monitoring of critical hazard points are of particular significance in the context of climate change. Accurate localisation and classification of hazard sites provide the foundation for enhanced risk assessment. The implementation of monitoring routines and structured communication processes between experts and decision-makers contributes to reducing response times. This facilitates efficient coordination during emergency operations, enabling evacuations and other countermeasures to be executed swiftly. The proactive designation of safe areas and the integration of redundancies within infrastructure serve to increase overall resilience to extreme events.

FEASIBILITY AND TIMELINE

The WLV is already responding to the challenges of climate change and the depiction of hazard zones, for example, by adapting how design events are illustrated (see Action A1). However, the measures outlined in Action B2 can only be implemented through close cooperation among all stakeholders. Achieving the most accurate possible identification of critical hazard points is feasible only by combining all existing planning foundations, local knowledge regarding previous damage events, and the use of modern technology. In this context, the continual updating of data is a particularly critical factor.

Action B3 – Emergency and disaster management plans

GAP THE ACTION ADDRESSES

- In Austria, the federal Civil Protection Act assigns the responsibility for the development of emergency and disaster management plans to the municipalities. The province of Tyrol supplements this legislation through the Disaster Relief Act and guidelines, which provide municipalities with templates for disaster protection plans – including risk analyses, alerting procedures, and resource lists. In this context, municipalities must consider a wide range of risks, such as pandemics, chemical accidents, blackouts, and traffic accidents. Natural hazards, therefore, represent only one subset within the broader scope of crisis preparedness.
- The multitude of potential hazards necessitates the involvement of various stakeholders and ongoing updates to the plans. For instance, road operators or larger enterprises (such as chemical plants, energy suppliers, industrial facilities), as well as organisations classified as "critical infrastructure" (such as hospitals, telecommunications, and food supply companies), are also obliged to implement disaster preparedness measures.
- In practice, these plans are tailored very individually by each municipality. Standardised processes and checklists - such as those provided in the form of an 'emergency kit', are therefore frequently missing. For certain scenarios, such as thunderstorm warnings and debris flows, there are often only specific procedures in place established by the fire brigades, which are based primarily on expert knowledge for dealing with such events.

FRAME THE ACTION

- **Phase of the risk cycle:** Preparedness
- **Type of action:** Data and knowledge
- **Relevant levels of action:** Local
- **Ownership:** Province of Tyrol, municipalities, transport and construction companies, road authorities, emergency services
- **Target groups:** Municipalities, emergency services, transport and construction companies, WLV, citizens
- **Priority:** 5 – very high priority (ongoing process)
- **Connection to other actions:** A3, B1, B2

DESCRIPTION OF THE ACTION

Well-designed emergency and disaster management plans are crucial not only for effective crisis response. Even during the process of designing these plans, knowledge concerning natural hazards is systematically consolidated, thereby establishing a foundation that enables the implementation of preventive measures. The expertise of representatives from the Crisis and Disaster Protection Centre, local authorities, fire brigade, police, forestry services, WLV, water management, and geology is essential for the effective development of these plans. Ensuring the availability of heavy equipment (such as excavators) is a key consideration. However, it is not sufficient merely to establish contractual agreements; it must also be guaranteed that such equipment can be deployed at critical hotspots even if roads become

impassable. An inter-municipal approach (for example, regarding the equipment of fire brigades in different municipalities) is required in this context. The prioritisation of fuel distribution must ensure the operational readiness of vehicles and equipment over extended periods.

POSITIVE OUTCOMES

- **Precise development and updating of emergency and disaster management plans:** Proactive risk identification serves as the foundation for preventive measures.
- **Involvement of various experts and organisations:** Establishing robust planning foundations through interdisciplinary input.
- **Defining clear responsibilities and roles within the plan:** Preparing for a coordinated approach.
- **Inter-municipal approach:** Using synergies and ensuring optimal resource utilisation.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **Financial advantages for companies:** The provision of heavy machinery (withdrawn from construction sites) initially results in a loss of revenue; however, this can be compensated for or even exceeded through their deployment in damage recovery operations.
- **Enhanced networking and collaboration:** Intensive cooperation among various stakeholders promotes the exchange of knowledge and resources, which may also contribute to the development of a stronger sense of community.
- **Inter-municipal approaches:** Increase of operational resilience which also may heighten dependency on external resources and support.

VALIDATION/ INDICATORS – ANALYSIS

Well-developed emergency and disaster management plans sustainably enhance risk management at the municipal level, both in preventive measures and in effective crisis response. The involvement of various stakeholders in the development of these plans leads to a comprehensive risk assessment. This process is further promoted through inter-municipal cooperation, such as the workshops conducted within the framework of the X-RISK-CC project. The emergency plans must also ensure the availability of heavy equipment and prioritise the distribution of fuel to maintain operational readiness, particularly in the event of large-scale incidents. An inter-municipal approach fosters synergies, optimises resource utilisation, and increases resilience during emergency situations.

FEASIBILITY AND TIMELINE

In the municipalities of the Stubai Valley, emergency and disaster management plans are in place. However, these plans require regular updates. The effective implementation of such measures necessitates close coordination among the municipalities, emergency services, and other local stakeholders, as well as a willingness to review and, if necessary, adapt existing structures. By establishing clear responsibilities, conducting regular training, and maintaining open channels of communication, the practical applicability of emergency and disaster management plans can be further enhanced.

Action C1 – Road closures

GAP THE ACTION ADDRESSES

- Road closures represent a highly effective measure for primarily preventing personal injury in areas affected by natural hazard events. In Tyrol, however, responsibility for road closures during debris flow incidents depends on which road is affected and who is accountable for its maintenance. For instance, district construction offices are responsible for provincial roads, whereas municipalities are in charge of municipal roads. In cases of acute danger, the police may also order immediate closure. As a rule, the closure of a road depends on a precise local assessment of the situation. Only in very rare and exceptional cases, a clear standard procedure exists.
- The timing at which the closure is enforced is of crucial importance. This factor also limits the effectiveness of early warning systems, as it determines the time available to implement the necessary measures following a warning. Furthermore, the duration of the closure and the conditions under which it may be cancelled are complex issues that require careful consideration.
- Similar to the process described for hotspot identification (Action B2), precise knowledge of critical points within transport networks is essential. The criteria outlined for the determination of hotspots are equally applicable to road closures. Rapid and effective communication with the public is important.

FRAME THE ACTION

- **Phase of the risk cycle:** Response
- **Type of action:** Data and knowledge and communication
- **Relevant levels of action:** Local
- **Ownership:** Municipalities, road authorities, emergency services
- **Target groups:** Citizens
- **Priority:** 3 – medium priority (partially effective system)
- **Connection to other actions:** B1, B2, B3

DESCRIPTION OF THE ACTION

Although ultimately, a single organisational unit holds the legal responsibility for the closure of a road, such closures are typically carried out in cooperation with several authorities and organisations. The process always begins with a hazard report, which may originate from meteorological services, road maintenance authorities, fire brigades, or even from the public. Subsequently, the responsible parties conduct a local assessment of the hazardous situation. For this purpose, relevant experts - such as geological services, fire brigades, or the WLV - are generally consulted. In addition to implementing physical closure (using barriers, signs, or guidance systems), coordination with emergency services is particularly focused on potential evacuations or the organisation of detours. If a technical inspection and/or the implementation of safety measures makes it feasible to do so, the road is reopened. In this context, temporary safety measures may be employed, which are often followed by more extensive, long-term

reconstruction. Where appropriate, temporary road use may also be facilitated using traffic light systems.

On roads with clearly defined critical points, early warning systems can be deployed. Such systems are currently under development (e.g., geophones in conjunction with INCA data/precipitation sensors as part of the Interreg Project INADEF (INnovative eArly warning system for DEbris Flow events based on nowcasting and phenomenology) in the pilot area Gröbentalbach). Automated road closures remain a significant exception at present.

POSITIVE OUTCOMES

- **Effective coordination and collaboration between organisations** enable rapid risk assessment and efficient implementation of measures.
- **Protection of human life:** Immediate impact achieved by keeping hazardous areas clear, thereby safeguarding individuals from imminent danger.
- **Minimization of material damage** provides emergency services with the necessary space to carry out preventive actions and protect property.
- **Signalling effect** raises awareness of potential hazards and discourages risky behaviour.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **False alarms or "unnecessary" road closures** reduce the acceptance of this measure.
- **Potential traffic jam:** Vehicles may be stationary at other hazardous locations.
- **Disadvantages in the daily life of the population:** Certain road connections are simply essential.
- **Impairment of tourism:** Absence of tourists / guests resulting in potential economic repercussions.
- **Development of tourism emergency management plans**, including the provision of maps, detour routes, and guest information.
- **Disruptions to regular goods traffic:** Possible bottlenecks may arise, and alternative routes may become overloaded.
- **Construction of emergency routes and rehabilitation concepts required**, which may lead to financial burdens.
- **Approval of exemptions:** Difficulties may occur in externally justifying the reasoning behind such decisions.

VALIDATION/ INDICATORS – ANALYSIS

Road closures are regarded as a central measure in risk management for natural hazard events, particularly in Alpine regions. They prevent individuals from entering danger zones and enable emergency services to carry out preventive measures without hindrance. However, their effectiveness is largely dependent on timely implementation, accurate situational assessment, and local conditions.

The signalling effect on the population is generally positive. Nevertheless, the acceptance of such measures is strongly influenced by transparent and, if possible, early communication.

Side effects such as acceptance issues, traffic disruptions, and economic losses necessitate careful consideration and continuous optimisation of these measures.

The applicability of automated road barriers depends on the type of road category and the availability of alternative routes. Companies offering such systems argue that, for instance, with geophones and traffic light systems, other protective measures may become redundant, thus reducing costs. To date, however, such solutions have only been implemented in a few isolated cases. Standardised decision-making criteria, flexible early warning systems, and participatory information strategies can contribute to achieving a better balance between protective interests and societal needs.

FEASIBILITY AND TIMELINE

For the practical implementation of road closures as an effective risk management measure, it is essential that they are integrated into the existing operational and emergency plans of municipalities and emergency organisations. At present, the development and deployment of automated systems remain very limited. Provided that a clear systematic approach based on early warning systems is feasible (with the use of new technologies likely to contribute to this), there is a need to further develop such systems.

Action C2 – Communication during the event

GAP THE ACTION ADDRESSES

- In Tyrol, communication among the institutionalised organisations involved in the management of natural hazard events is generally effective, due to the frequent occurrence of such events. However, communication still lacks in terms of institutionalised structures. A notable advantage is that many actors are often familiar with each other through prior collaboration. Technical requirements such as radio devices and standardisation of radio frequencies have been largely established.
- At the local level, conditions differ among the municipal authorities, depending on their experience with natural hazards. Generally, municipalities have disaster prevention plans that facilitate effective communication by providing contact information for relevant institutions and emergency managers. Overall, communication within the local community action management is crucial. Communities that are sporadically affected by natural hazard events, often lack complete and regularly updated lists. Moreover, insufficient expertise on how to use the specific equipment hinders communication.
- Establishing effective communication with the local population and guests is challenging, although there already exist several sources of information, such as AT-alerts or various social media platforms, since there is an overwhelming abundance of information. Many individuals are often not familiar with such events and the associated risks, and do not know how to behave best and where to obtain reliable information. Spectators increasingly hinder the emergency services or endanger themselves. Tourists are dispersed across the region, and their movements, intentions, and precise locations are often unclear or unknown. The management of this challenge needs to be developed and implemented.
- Local authorities, particularly mayors, have a crucial role during events. They are the primary contact on-site and have the best information on local conditions, characteristics and contacts to the locals. The effectiveness of these individuals is influenced by several factors, including the frequency with which such events occur, their experience, the level of trust the locals have in these actors and personal attributes such as openness to the relevant tasks and their capacity to manage stressful situations.

FRAME THE ACTION

- **Phase of the risk cycle:** Response
- **Type of action:** Communication
- **Relevant levels of action:** Local
- **Ownership:** Emergency services, Crisis and Disaster Protection Centre
- **Target groups:** Citizens, emergency services
- **Priority:** 3
- **Connection to other actions:** A3, A4, B3

DESCRIPTION OF THE ACTION

The institutionalisation of communication structures by completing lists of institutions, contact numbers, responsible persons and deputies (to account for absences such as holidays), can significantly improve communication during an event, especially if those involved have limited experience in natural hazard and risk-management. One of the involved institutions (e.g., the crisis and disaster protection centre) should be responsible for keeping such lists up-to-date and ensuring their availability to all stakeholders, ideally prior to, but at the latest at the time of the damaging event.

Local actors, such as volunteers, must be provided with appropriate communication tools if lacking, including necessary facilities such as energy supply and instructions on how to handle these tools to ensure adequate and efficient communication and leadership.

Nowadays, due to various social media channels, large quantities of - sometimes misleading – information are available. Thus, a responsible institution/person must validate these data in a timely manner to ensure proper information across different channels for different actors and the affected population, as well as for the press. During the event, it is also necessary to contact providers of accommodations and touristic infrastructure to instruct both their staff and guests regarding the current situation and potentially required actions. At the same time, they can support the risk manager and/or rescue forces to identify and localise people (guests) who are around in the endangered area.

At event hot spots, emergency managers (e.g., the mayors) should be present on-site. This facilitates or enables the implementation of necessary ad-hoc measures. Additionally, it can give affected people and rescue teams the feeling that someone is taking care of them.

POSITIVE OUTCOMES

- **Effective coordination and collaboration between actors** enable rapid reaction though targeted lead of emergency forces and measures.
- **Effective measures due to targeted, proper information:** During a damaging event, information on the situation (e.g., passable roads) enhances the effectiveness of measures.
- **Effective communication mitigates victims and damages:** The knowledge of the location and behaviour of potentially endangered people support targeted measures to save them and optimises the lead of limited emergency forces to minimise damages.
- **Presence of emergency managers on site**: Ad-hoc measures in the case of unexpected problems can be facilitated and give people a sense of being supported and cared.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **Rising interest on correct behaviour:** Proper communication can raise the awareness of local people regarding potential hazards and whom to ask for the best behaviour in the case of future events and/or whom to inform about the local situation.
- **Updated contact lists and communication tools:** Insight to keep emergency plans, contact lists and communication equipment up-to-date.

- **Experience and enhancement:** Events are the best possibility to identify communication problems and to improve it among the different institutions, local actors, volunteers, population and press for further natural hazard events.

VALIDATION/ INDICATORS – ANALYSIS

Proper communication between the actors during damaging events is crucial for the efficient management of limited emergency resources. It must work despite failing communication infrastructure such as mobile networks, which require their own independent energy supply. Thus, a dedicated backup communication system is necessary and already widely established at the institutional actors. However, deficiencies persist among providers of accommodation, touristic infrastructure and locals in sporadically affected areas. They need to be "reminded" that existing equipment must be regularly serviced. Its use should be trained from time to time. Generally, the risk-awareness, acceptance and self-responsibility need to be increased. The most effective means of achieving this is through targeted dissemination of information during or immediately following emergency events.

It is very important to develop a centralised information platform to collect incoming data and information, assess and verify it, and disseminate it according to the requirements and requests of various actors and stakeholders providing an overview of the situation and enabling effective leadership of the often-limited emergency forces efficiently.
Preparation to establish such platforms and to ensure that people know where to send and where to receive information is necessary. The implementation of the new Tyrolean Crisis and Disaster Management Act includes permanent updated information according to critical infrastructure as hospitals and retirement homes, is an essential step in this manner.

Experience shows that the presence of responsible persons on site, capable of making ad-hoc decisions, provides support to emergency services and has positive psychological effects, particularly when they are locally accepted, well-informed, communicate clearly and are able to manage stressful situations well.

FEASIBILITY AND TIMELINE

Due to the increasing number of damaging events and the learned lessons, the communication between different institutions involved in event response has become well-established in Tyrol. Enhancing communication with volunteers, the general population, tourists and press representatives during damaging events is still challenging, preparations must be made prior to such events. However, contacting persons who are expected to be affected or are already affected by torrential processes and ensuring that they are informed about optimal response strategies can reduce the number of victims, the amount of property damage and support other affected persons. The presence of well-prepared responsible staff on-site is limited by personal resources and the extent of the hazard event.

The involvement of affected people, rescue services, and risk managers can facilitate the identification of disaster event hotspots.

Effective communication is essential for increasing risk-awareness and proper behaviour (e.g., less spectators) of the population during damaging events. Anyhow, the best chance to achieve success in this manner is a clear targeted communication during or shortly after events.

Action D1 – Review and documentation of damaging events

GAP THE ACTION ADDRESSES

- In practice, individual experiences of persons are often the only available information, while systematically written documentation of natural hazard damage events is frequently lacking. However, improvements in risk management require the establishment of concrete and standardised written records of such damage events. Emphasis should be placed on the detailed documentation of the impacts of these incidents, so that this information can also be systematically relayed to organisations responsible for issuing warnings, thereby enabling a structured learning process.
- At present, no standard exists for this purpose; the current processing of events generally takes place only within individual organisations and is highly inconsistent. There is therefore an urgent need for an institutionalised and scientific approach to the documentation and evaluation of damage events.

FRAME THE ACTION

- **Phase of the risk cycle:** Recovery
- **Type of action:** Data and knowledge and communication
- **Relevant levels of action:** Local
- **Ownership:** Entire crisis management team
- **Target groups:** Entire crisis management team, citizens
- **Priority:** 3 – medium priority
- **Connection to other actions:** A1, A2, A3, B2, C2

DESCRIPTION OF THE ACTION

Within the framework of effective natural hazard management, it is essential that responsible stakeholders maintain regular coordination to continuously update existing processes and data. Emphasis should be placed on the integration of external perspectives to benefit from diverse experiences and expertise. Proactive engagement with individuals in identified hotspots can contribute to this.

Learning from damage events not only serves the stakeholders, directly affected on site, but should be utilised for the calibration, testing, and further development of numerical simulation models, as well as for statistical analyses.

A structured “lessons learned” process, including debriefings, post-event discussions, and comprehensive documentation, is important. The aim is to integrate the principles of “build back better” - that is, the improved and more resilient reconstruction - into the standard process. Adapted reconstructions are an essential measure of prevention.

Psychological aftercare should be established as an integral part of standard procedures to adequately address the psychological burdens experienced by individuals and emergency

staff. It is important to create low-threshold support options or to offer existing support services in a more targeted manner.

POSITIVE OUTCOMES

- **Effective knowledge transfer and systematic learning:** Individual experiential knowledge is transferred into an institutionalised knowledge base.
- **Enhanced early warning systems through the structured feedback of incident impacts to organisations responsible for issuing alerts:** Improvement of warning mechanisms based on insights gained from past events.
- **More efficient response strategies through a structured "lessons learned" process:** Optimisation of response measures as well as the identification of sources of error.
- **Strengthening of reconstruction efforts ("build back better"):** Reconstruction measures should not aim to restore the original state but are designed to be more sustainable and resilient.
- **Mental health and aftercare:** The integration of psychological aftercare is established to reduce long-term consequences.
- **Methodological advancement and scientific rigor:** Development and validation of new methodologies enabled by the comprehensive documentation of damage events.
- **Strengthening collaboration:** Leveraging synergies to facilitate mutual learning.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **Documentation efficiency:** Without standardized documentation and clear responsibility, higher personnel and resource effort yields limited usable data.
- **Resistance to changes:** Particularly pronounced when established practices are subject to (critical) review.

VALIDATION/ INDICATORS – ANALYSIS

So far, the thorough analysis and documentation of damage events are underestimated. By transferring individual experiential knowledge into a standardised review system, the quality of decision-making is enhanced. Structured "lessons learned" processes reduce misjudgements and strengthen cross-organisational resilience. The integration of feedback from damage events into early warning systems allows improved calibration.

Structured debriefings and post-event reviews enable the identification of sources of error and increase the effectiveness of response measures during subsequent incidents. The approach of not merely restoring the original state during reconstruction but instead building in a more sustainable and resilient manner, causes, in the long term, lower consequential damages.

FEASIBILITY AND TIMELINE

The requirement to document damage events promptly and systematically is not new. While there is a general desire for more precise information regarding past incidents, no institution truly considers itself responsible for this task, particularly in terms of providing the necessary resources. Nevertheless, the insights gained through such documentation could offer valuable feedback that would lead to significant improvements in early warning systems. Therefore, it is

essential to clearly communicate the added value of thorough analyses and damage documentation, thereby creating the potential to secure the resources required for their implementation.

Action D2 – Restoration costs / financial resources for immediate measures

GAP THE ACTION ADDRESSES

- The provision of appropriate financial resources has significance in all phases of the risk cycle. Particularly for the implementation of immediate measures following debris flow events, and especially in the context of damage management, the prompt availability of such financial resources for immediate measures is important and usually secured. It would be advisable to ensure the availability of these funds proactively, during periods of normalcy, in order to guarantee a rapid response when required.
- During reconstruction, several funding agencies can be identified (federal funding programs, rural development funding, damage assessment commissions of the Disaster Relief Fund, ...). Funding is highly heterogeneous and fragmented, depending on whether the applicants are private individuals, businesses, or public entities. Furthermore, certain funding channels require specific decision-making and approval processes, which delay the implementation of necessary measures. This highlights the tension between administrative bodies and those involved in the action on-site. Additionally, there arises the question of the extent to which the increasing costs resulting from damaging events can be covered by insurance companies.
- The increasing frequency and intensity of debris flow events, due to climate change, cause rising costs for additional technical protective measures and the maintenance of existing structures, since the more frequent clearance of sediment retention basins is necessary. Additionally, climate-induced damage to forests is leading to increased expenditure for reforestation and afforestation efforts.

FRAME THE ACTION

- **Phase of the risk cycle:** Recovery
- **Type of action:** Legislation, data and knowledge, communication
- **Relevant levels of action:** Local, provincial
- **Ownership:** Various funding institutions
- **Target groups:** Affected persons and institutions
- **Priority:** 3 – medium priority
- **Connection to other actions:** A1, A2, A3, B1, B3, D1, D3

DESCRIPTION OF THE ACTION

For immediate measures, the timely provision of financial resources is essential. The enhancement of flexible financing instruments, such as the Kontokorrentkredit, is suggested. To bridge liquidity shortages, the municipality can, through agreements with banks, overdraw its account up to a predetermined credit limit. Interest rates are only paid on the amount drawn, and repayment is variable, depending on the revenues of the municipality.

To guide applicants through the “funding jungle”, the establishment of a central, cross-organisational advisory body would be desirable. This body should possess comprehensive knowledge of all relevant funding opportunities and be able to support applicants in a targeted manner. Such a central institution would not only relieve private individuals and businesses, but also local authorities.

The introduction of compulsory insurance for buildings against natural hazards, as is already in place in Switzerland, represents one viable policy option. By contrast, Tyrol pursues its own insurance strategy: as a joint initiative of the State of Tyrol and its municipalities, the “Solidarity Fund” was established. The objective of this fund is to mitigate financial burdens following damaging events, to help in an unbureaucratic manner, and to ensure the continued functionality of flood protection measures. The fund supports immediate actions such as the clearing of watercourses and the repair of banks, dams, and mitigation measures. Starting in 2027, a minimum of approximately three to four million euros is to be paid into the fund annually on a solidarity basis. Federal participation is envisaged.

The guiding principle of "Build Back Better" should be consistently applied not only to structural measures but also at the strategic level, in order to embed technical and organisational improvements on a lasting basis. This principle should also be strengthened through funding policies.

POSITIVE OUTCOMES

- **Rapid provision of financial resources:** Enhanced responsiveness in crisis situations enables timely intervention and mitigates the impact of emergencies.
- **Bridging liquidity bottlenecks through flexible financing instruments (Kontokorrentkredit):** Operational capacity is maintained even under exceptional stress conditions.
- **Reduction of damaging effects and accelerated restoration:** Essential immediate measures can be implemented without delay, thereby expediting recovery processes.
- **Facilitated application procedures:** The establishment of a central advisory office increases the likelihood of successful funding approvals and alleviates administrative burdens for municipalities.
- **Risk distribution through the introduction of a “Solidarity Fund”:** The unbureaucratic provision of resources for protective measures ensures that risks are shared among multiple stakeholders.
- **Sustainable improvement through the "Build Back Better" principle:** Both structural and strategic enhancements minimise future risks and strengthen the resilience of municipalities.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **Financial burden:** The mandatory contributions required from municipalities to the “Solidarity Fund” are an additional financial strain, particularly for those communities that are only infrequently affected by damaging events.

VALIDATION/ INDICATORS – ANALYSIS

The rapid availability of financial resources is required for damage mitigation and recovery, as it enables immediate interventions that minimise consequential losses and ensures the functionality of critical infrastructures. The establishment of a central advisory office enhances both the efficiency and accessibility of funding allocation, offering advantages not only to individual applicants but also providing administrative relief to municipalities.

The principle of the "Solidarity Fund" ensures risk diversification; however, it necessitates a secured financial basis and clear governance structures, due to the anticipated increase in damaging events.

"Build Back Better" strategies promote not only structural, but also organisational and strategic resilience within municipalities and infrastructure. Beyond all financial support measures, the strengthening of self-protection among municipalities and private individuals remains a fundamental component.

FEASIBILITY AND TIMELINE

The contracts between municipalities and banks allow for the bridging of short-term liquidity bottlenecks. The immediate availability of funds enables the prompt initiation of measures such as clearances or repairs without delay. Although the establishment of a central advisory office for grants is frequently requested, there are currently no established implementation models available. The introduction of the "Solidarity Fund" can be realised through provincial coordination and clear contribution regulations. The implementation is planned for 2027.

Action D3 – Disposal areas

GAP THE ACTION ADDRESSES

- During debris flow events, large quantities of sediment have to be removed and designated areas for the disposal of this material become necessary. This is a major challenge for sediment management in Alpine valleys such as the Stubai Valley, where space is limited. Thus, the early identification and allocation of such disposal sites is essential. However, to date, these areas are rarely defined within spatial planning frameworks, which causes coordination problems with landowners during the course of damaging events. Furthermore, the designation of disposal areas is primarily governed by waste management legislation. Therefore, necessary permitting procedures for the deposition of debris material must be addressed proactively and obtained prior to events. Nonetheless, individual municipalities sometimes simply lack the requisite available land for this purpose.
- Another issue is the clearance of sediment retention areas: If such clearance is not carried out immediately following an event, it may necessitate extensive approval procedures, because biotope habitats can develop quickly in basins that have not been cleared promptly. In this case, conservation concerns hinder urgently required regular maintenance, despite this being essential to preserve the protective function of the facility.

FRAME THE ACTION

- **Phase of the risk cycle:** Recovery
- **Type of action:** Legislation and communication
- **Relevant levels of action:** Local
- **Ownership:** Landowners (in some areas the municipalities)
- **Target groups:** Landowners
- **Priority:** 4 – high priority
- **Connection to other actions:** A1, B3, D2

DESCRIPTION OF THE ACTION

According to current estimates by the WLV, there are approximately 7,500,000 cubic metres of retention capacity in basins constructed in Tyrol. Each year, around 200,000 m^3 are removed by the WLV for maintenance measures. Thus, the selection of precautionary areas must be carried out strategically to ensure short transport routes and good accessibility (access roads). In this context, EU funding opportunities could also be utilised.
The proactive designation of disposal areas guarantees the rapid availability of disposal options without time-consuming approval procedures. In practice, this is already partly implemented, as in the case of damaging events actions that would not be permissible during “peace time” are allowed by law.

The issue of sediment deposition should not be addressed by single municipalities but managed from the perspective of sediment management for the entire valley. The legal approach should be integrated into spatial planning.

POSITIVE OUTCOMES

- **Accelerated and improved damage management:** Proactive designation of disposal sites enables rapid and effective response.
- **Enhanced logistics and reduced costs:** Optimal site selection, featuring short transport routes and accessible infrastructure, streamlines logistics and minimises associated costs.
- **Facilitated collaboration and reduced conflicts:** Supra-regional, valley-wide coordination of sediment management prevents isolated solutions by individual municipalities and minimises the potential for landowner disputes.
- **Legal and planning certainty:** Integrating disposal areas into spatial planning frameworks ensures legal compliance and reliable long-term planning.
- **Access to funding opportunities:** Early-stage planning enables eligibility for EU funding programs.
- **Sustainable utilisation:** Regular, legally based clearance of retention areas promotes sustainable use and maintains functional capacity.

POSSIBLE CRITICALITIES/ SIDE EFFECTS

- **Increased land requirements:** The strategic selection of disposal areas hinders alternative long-term uses.
- **Impact on nature and landscape:** The establishment of disposal areas may lead to significant ecological and visual disturbances and limit their availability for other purposes in the short to medium term.
- **Financial burden:** The creation and maintenance of disposal areas, including access roads, cause additional costs.
- **More complex coordination processes:** Valley-wide sediment management demands closer collaboration between municipalities.

VALIDATION/ INDICATORS – ANALYSIS

The efficient management of debris flow events necessitates a strategic selection and early designation of adequate disposal sites. Adequate plannings reduces logistical costs and accelerates damage remediation efforts. Currently, the prevailing focus on waste management legislation hinders the rapid utilisation of areas during emergency situations, as extensive permitting procedures are required. Therefore, timely designation through spatial planning regulations is intended to ensure the availability of disposal sites in the event of an incident and to minimise conflicts with landowners. The sustainable integration of disposal areas into spatial planning can avoid long-term land use conflicts and supports supra-regional coordination.

FEASIBILITY AND TIMELINE

A strategic selection and early designation of disposal areas support efficient sediment management. In addition to increased logistical efficiency and cost savings, legal certainty, sustainability, and inter-municipal cooperation are ensured and the utilisation of EU funding opportunities is facilitated. As a result, the resilience of affected regions and their capacity to

respond to damaging events is strengthened. For the proactive designation of disposal sites, these areas must be systematically integrated into spatial planning.
Therefore, the implementation of these measures in spatial planning legislation and waste management legislation must be adapted accordingly.

The designated areas must be subject to regular inspection, maintenance, and, where necessary, adjustment to guarantee their functionality when a damaging event occurs. This also includes legally secured and timely clearance of retention areas. To minimise conflicts, landowners must be involved at an early stage of the planning process, and fair compensation models need to be developed that are also financially viable.

Forest-technical service for torrent and
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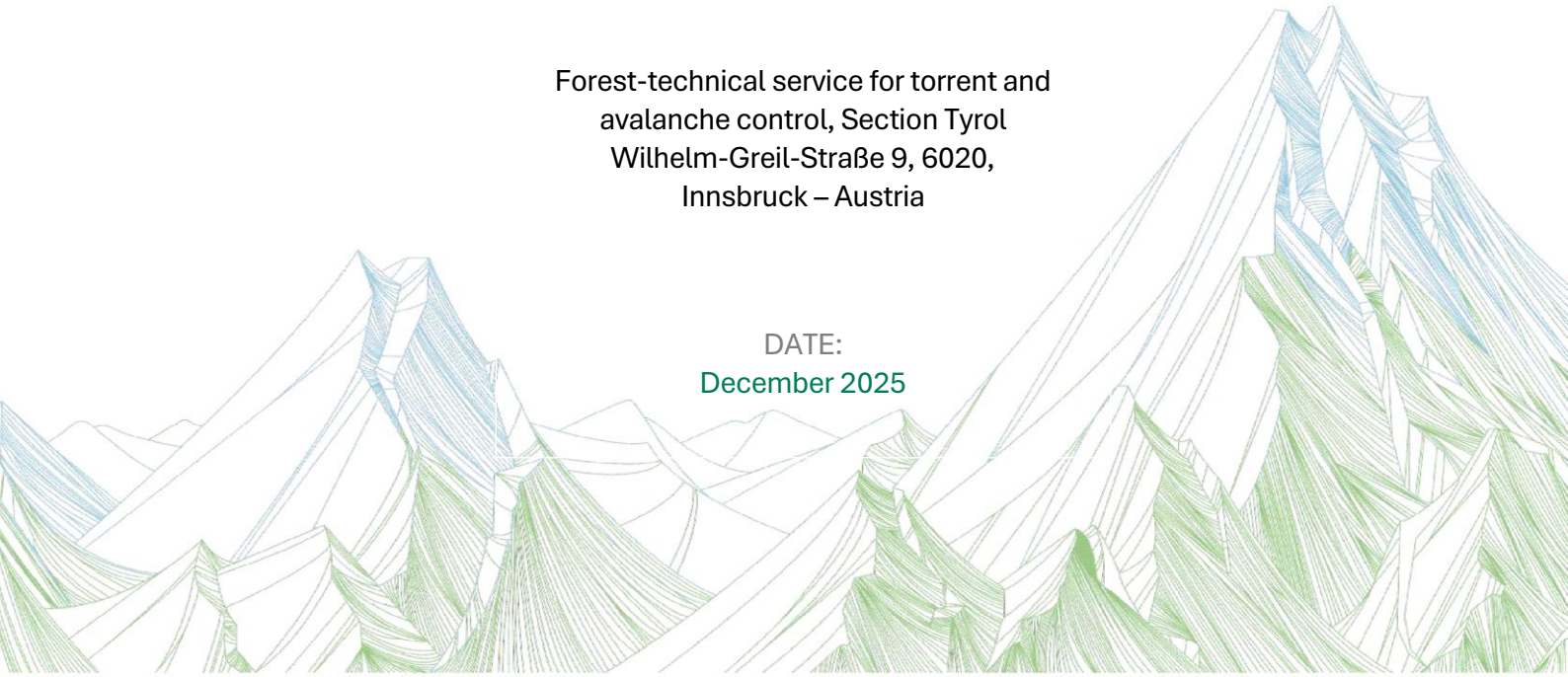
DATE:
December 2025



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