X-RISK-CC

PILOT DOSSIER

STUBAI VALLEY IN TYROL

HOW TO ADAPT TO CHANGING WEATHER EXTREMES AND ASSOCIATED COMPOUND RISKS IN THE CONTEXT OF CLIMATE CHANGE

LEAD PARTNER

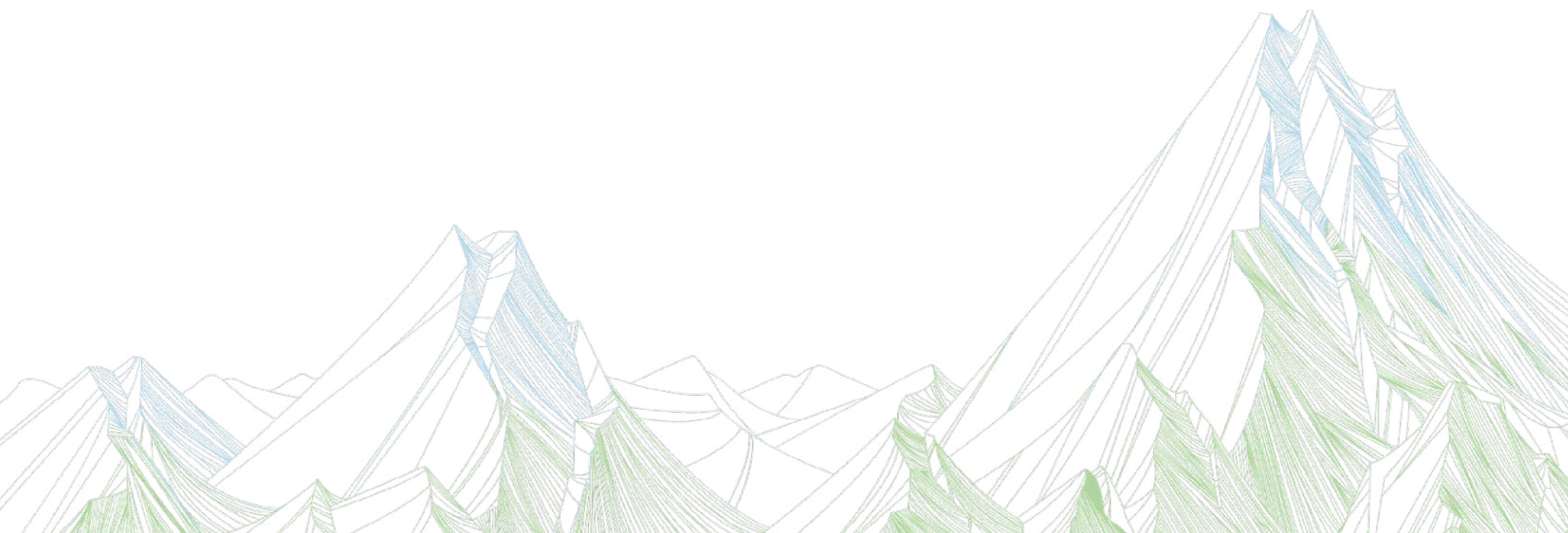
PROJECT PARTNERS

STUBAI VALLEY
IN TYROL

HOW TO ADAPT TO CHANGING WEATHER EXTREMES AND ASSOCIATED COMPOUND RISKS IN THE CONTEXT OF CLIMATE CHANGE

THIS DOSSIER

The dossier focuses on the Stubai Valley in Tyrol (Austria) used as a pilot area in the X-RISK-CC project. The dossier is designed to make the local knowledge developed by the project accessible to the general public. It provides information on past and future weather extremes, associated hazards and risks, and proposed actions to improve the future risk management in the area.



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X-RISK-CC - Alpine Space Programme

INTRODUCTION

THE BACKGROUND

In recent years, the Alps have experienced unprecedented weather extremes such as heatwaves and droughts, heavy rains and storms, which have had severe impacts on the environment, society and the economy. These events have challenged the risk management capacities of the affected Alpine regions. The scale (*magnitude*) and local severity (*intensity*) of such extremes can lead to multiple simultaneous (*compound*) impacts and cascading effects, resulting in complex, long-lasting or even irreversible consequences.

Recent scientific evidence indicates that climate change (CC) is increasing both the intensity and frequency of extreme meteorological events. However, the understanding of their compound and cascading impacts—and how to manage them—remains limited. On the regional level, these events are not adequately addressed within current Disaster Risk Reduction (DRR) frameworks. Similarly, where Climate Change Adaptation (CCA) plans exist, they often underestimate the severity of extreme events and associated risks, and frequently lack concrete, actionable measures.

THE PROJECT AND ITS GOALS

The **X-RISK-CC** project (full title: "*How to adapt to changing weather e***X***tremes and associated compound and cascading* **RISK***s in the context of* ***C****limate* ***C****hange*") is funded by the European Union and aims to improve the management of risks related to extreme weather and natural hazard events under climate change in Alpine regions. This goal is pursued through the collaboration of scientists, risk managers and policy makers on local, national and international levels.

In X-RISK-CC, risks are defined as the adverse consequences caused by weather extremes (e.g., heavy rainfall) triggering natural hazards (e.g., flooding), which in turn affect human systems (e.g., loss of private property). Risk is therefore not determined by weather and natural hazards alone, but by their interaction with exposure (e.g., buildings located in flood-prone areas) and vulnerability (e.g., lack of flood protection infrastructure) within socio-economic systems (***FIGURE 1***).

Understanding and managing current and future risks requires not only the analysis of weather extremes and resulting hazards, but also a consideration of the evolution of human systems and potential risk management solutions. Since weather cannot be controlled, risk reduction must focus on measures that decrease vulnerabilities, reduce exposure or, where possible, mitigate the hazard itself.

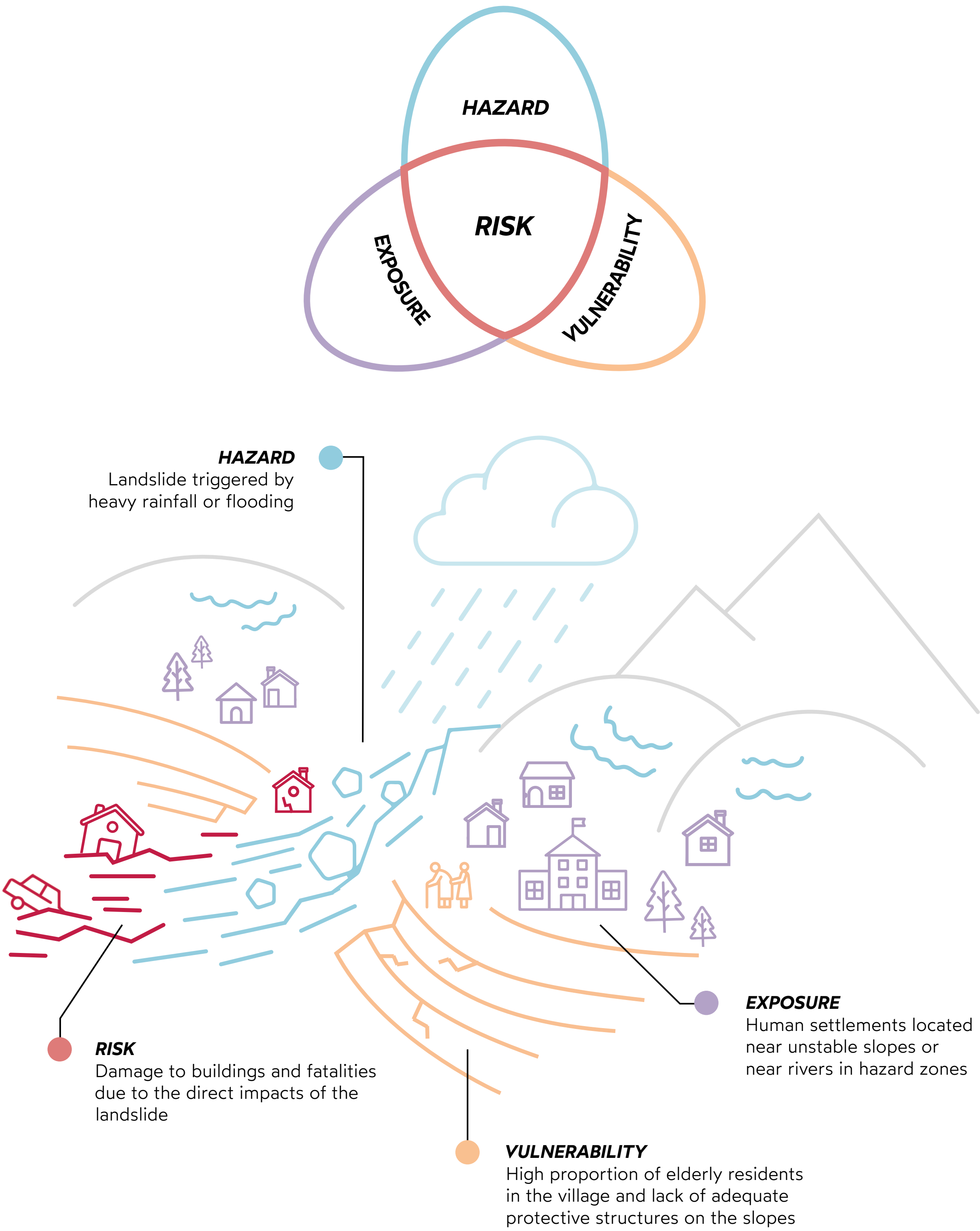


FIGURE 1: *Illustrative examples of hazard, exposure and vulnerability contributing to risk (the concept of risk is based on the framework developed by the Intergovernmental Panel on Climate Change - IPCC).*

The main questions guiding the X-RISK-CC project are:

→ Are we adequately prepared to cope with extreme weather events?

→ What gaps exist in current risk management practices, based on recent experiences?

→ How will weather extremes and related risks evolve in the Alps?

→ How can local risk management practices be improved to address future weather extremes?

The project begins with an analysis of past extreme weather events and their projected future trends, assessing the hazards they trigger and integrating these with data on exposure, vulnerability and impacts. This approach is used to evaluate existing risk management practices and to develop concrete measures that strengthen resilience to future risks.

In a complex system like the Alpine region, which is particularly prone to weather extremes and natural hazards, risk arises from multiple, often interconnected factors. Identifying effective points of intervention requires a thorough understanding of local conditions.

Flood erosion after the July 2022 event on Oberbergbach in Neustift (Source: WLV).

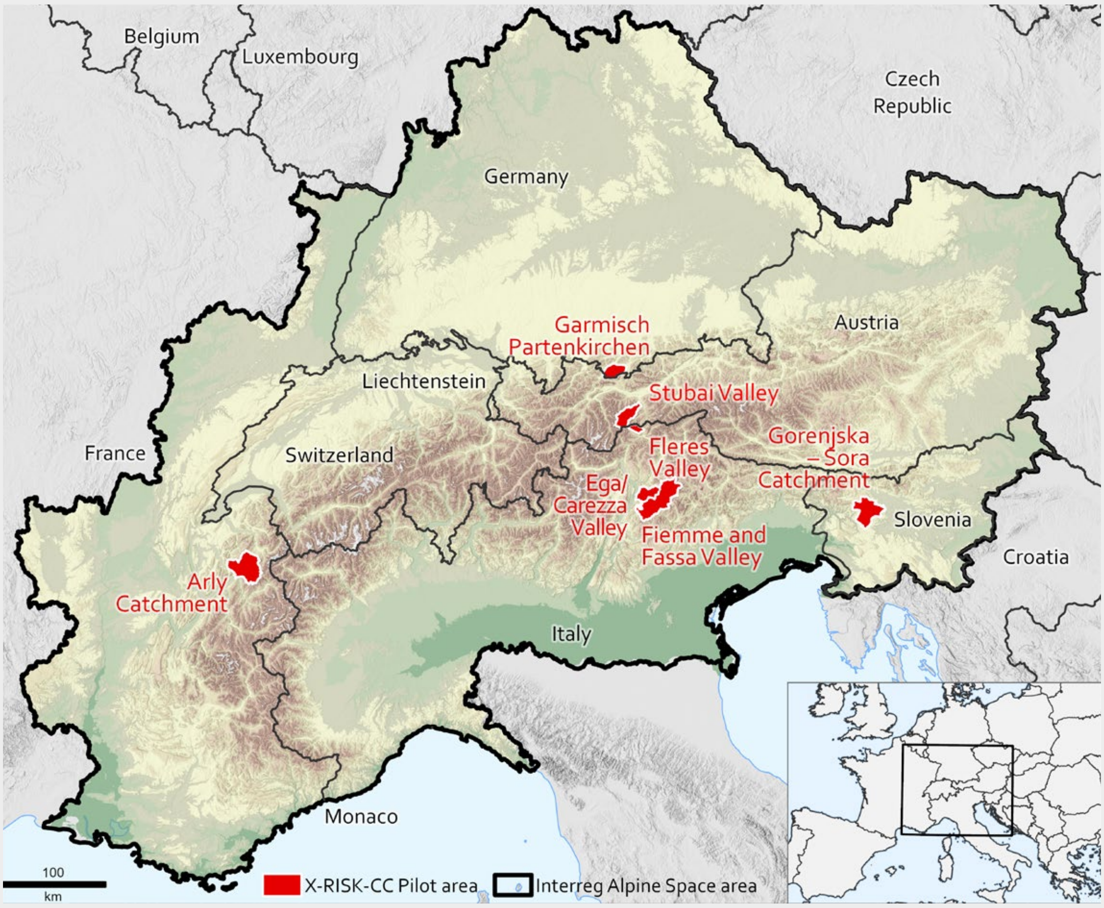


FIGURE 2: *Map illustrating the pilot areas (shown in red) of the X-RISK-CC project.*

To this end, specific pilot areas across the Alps (***FIGURE 2***) have been selected as representative case studies for detailed analyses and the development of tailored risk management solutions. In these areas, progress is driven by close collaboration with local risk managers and stakeholders. Their active involvement is essential both for identifying effective measures and for translating local knowledge into transnational recommendations.

PILOT AREA: STUBAI VALLEY
(TYROL, AUSTRIA)

GEOGRAPHICAL AND ENVIRONMENTAL SETTING

The Stubai Valley is located in Tyrol in western Austria, in the centre of the Alps, and spans approximately 282 km². The valley extents into a northeasterly direction from the main Alpine ridge toward the surroundings of Innsbruck. Elevations range from about 780 m above mean sea level (a. m. s. l.) in the northeast to 3,500 m a. m. s. l. at the southwestern edges. The main villages – Fulpmes, Mieders and Neustift im Stubaital – are situated along the valley floor (***FIGURE 3***).

In addition to the main river, the Ruetz, the Stubai Valley is intersected by several secondary valleys and streams flowing into the main valley. Due to its topography, the area is prone to natural hazards, particularly debris flows, which are mostly triggered by intense rainfall events typically occurring during the summer season. These phenomena can cause significant damage to settlements and infrastructure, while the mobilised sediments may reach the valley floor, block channels and lead to subsequent flooding.

Such processes affect not only local residents but also tourists, as the Stubai Valley is a popular tourist destination in both winter and summer.

Within the X-RISK-CC project, we analysed how the risks associated with **extreme events trigged by heavy rainfall** may evolve in the pilot area in the future.

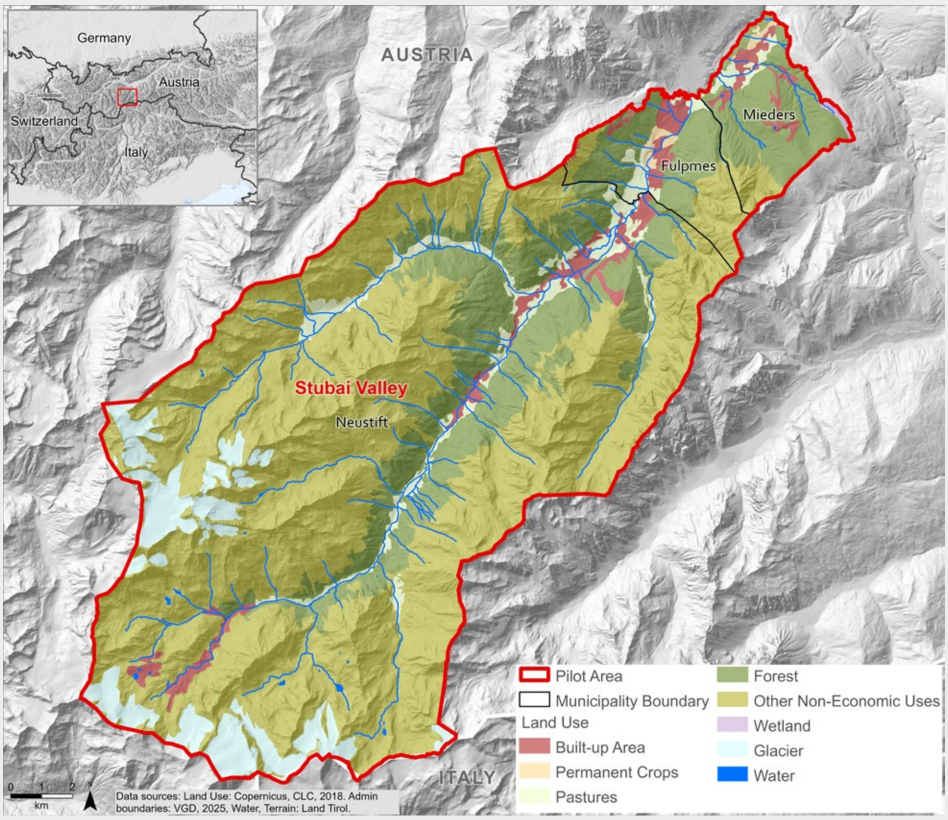


FIGURE 3: *Map of the pilot area Stubai Valley (in red).*

PAST AND FUTURE WEATHER EXTREMES

Annual 1-day precipitation maxima recorded over the past 40 years (1980-2022) in the area show an overall increase in precipitation intensity in nearly all locations analysed. The most pronounced and significant increases have been observed in the eastern portion of the pilot area, where daily precipitation intensities have risen by approximately 14 % per decade.

Looking ahead, both the frequency and intensity of heavy precipitation events are projected to increase in Stubai Valley over the coming decades, with the magnitude of change depending on the level of global warming reached by the end of the century. As a result, phenomena that are currently rare are expected to become more frequent – that is, their return periods will decrease. A 100-year event today could become up to 24 % more intense by 2100 if a global warming level of + 4 °C is reached.

Temperatures are expected to continue rising, leading to accelerated glacier and permafrost melting, as well as an overall decrease in snowfall and snow cover in the area. Additionally, higher temperatures may increase the likelihood of drought conditions.

As warmer air can hold more moisture, which can later be released as rain, short duration extreme precipitation events (lasting from one to few hours) are also projected to intensify in the coming decades. Humidity in the atmosphere, and consequently, potential rainfall rises by approximately by 7 % per degree of warming. Based on this relationship, a 1-hour intense rainfall event could increase from 8 mm today to 24 mm by 2100 under the worst global warming scenarios.

⚠ Dealing with uncertainties

Climate projections are derived from different models, each of them providing different results. For simplicity, projections are often averaged, even though the scenarios consist in a range of plausible values, whose width depends on the level of uncertainty of the models in representing the future evolution of a certain process. Moreover, projected numbers must be interpreted as an estimate of the magnitude of changes and not as exact predictions for specific locations and dates (e.g., rainfall on a particular day in October 2050). Nevertheless, the consistent signal of increasing precipitation extremes is an important message for risk managers: the likelihood of natural hazards and cascading impacts, especially when precipitation extremes occur in combination with high wind speed, is rising.

The **return period**, also known as recurrence interval, is the estimated average time between events of a certain magnitude, expressed in years and based on statistical analysis. For example, a 100-year return period for a flood means there is a 1/100 or 1 % chance of such a flood being exceeded in any given year.

HAZARDS IN PRESENT AND FUTURE CLIMATE

Due to the topography and climatic characteristics of the area, debris flows are the most frequent weather-induced hazardous events in Stubai Valley. These events are typically triggered by intense rainfall, especially when preceded by a period of persistent precipitation that saturates the soil. The localised nature of debris flows often makes them difficult to predict, so that they can occur with little warning.

In addition to short-duration heavy rainfall, other factors, such as long-lasting precipitation, erosion processes and sediment availability, can influence both the occurrence and magnitude of debris flows. Since 1970, around 30 events have been documented by the Torrent and Avalanche Control Tyrol in the five analysed catchments in the valley: Mutterbergbach, Grawanockbach, Oberbergbach, Margaretenbach and Mühltalbach.

The number of debris-flow events has increased significantly since 2010, particularly during the most recent years (2020-2024). These events have also shown a notable rise in the volume of mobilised material per event. One of the most severe debris-flow events occurred on 22nd July 2022, when an intense rainfall – exceeding 100 mm in a single day in some locations – triggered multiple debris flows throughout the Stubai Valley.

Global warming levels are used to illustrate future scenarios where specific increases in mean global temperature with respect to the preindustrial period (1850-1900) are reached. A global warming level of + 3 °C indicates a world 3 °C warmer than in 1850-1900.

The term **permafrost** refers to soil that remains frozen (i.e., at or below 0 °C) for at least two consecutive years. In the Alps permafrost is retreating and shifting to higher elevations due to warming. Where permafrost disappears, soil stability decreases, increasing the likelihood of collapses and the amount of sediment that can be mobilised.

In the future, the combined effects of increasing precipitation extremes and permafrost thaw may raise both the likelihood and intensity of debris flows. More unstable soils and greater precipitation may lead to larger mobilised volumes. In high-altitude catchments – such as Mutterbergbach, Grawanockbach and Oberbergbach – sediment availability is expected to increase due to glacier retreat and permafrost melting. Additionally, reduced snow cover or accelerated snow melt caused by rising temperatures can increase surface runoff and peak discharge.

In catchments with high sediment availability, it is estimated that areas already prone to debris flows could experience three times as many events by 2050 compared to current levels. Meanwhile, forest expansion at higher altitudes – driven by warming – may enhance slope stability, particularly in Mühltalbach, Oberbergbach and Margaretenbach. However, increased tree disturbances (e.g., bark-beetle infestations, drought and windthrow) could weaken root systems and reverse these stabilising effects.

Although currently a marginal issue in Stubai Valley, wildfires could become an emerging hazard in the coming decades due to rising temperatures and more frequent drought conditions.

FIGURE 4: *Parking space affected during the debris flow event in summer 2022 - estuary Mutterbergbach (Source: Torrent and Avalanche Control Tyrol).*

CURRENT AND FUTURE IMPACTS AND RISKS

The main settlements and most of the population in Stubai Valley are located on the valley floor, while the higher altitudes are characterised by forests, managed meadows and pastures. The elements most exposed to potential damage from debris flows include residents, private properties and buildings, agricultural land (particularly livestock farms and agricultural activities near slopes and along the main rivers), and connections, including roads and bridges, the Stubaital tramline, and water and energy supply systems.

As a popular touristic destination, the Stubai Valley sees a significant increase in population during both summer and winter seasons. Consequently, tourism infrastructure and visitors are also highly exposed to

What is a Hazard Map?

A hazard map illustrates areas potentially affected by a specific natural hazard. It uses colour coding to represent the **likelihood and intensity** of a hazard occurring in each location. Hazard maps are essential tools for **disaster risk management** and **spatial planning**, as they help guide land use decisions, infrastructure development, and emergency preparedness.

Tourist car stuck in debris-flow deposits after the July 2022 event on Grawanockbach in Neustift (Source: WLV).

hazardous events. Debris flows and flooding primarily affect the summer tourism sector, posing risks not only to infrastructure but also to individuals engaging in outdoor activities in unprotected areas. Summer tourism continues to grow, with over 6 million arrivals and 23 million overnight stays per year. Every new gondola station, restaurant or bike park built into the Alpine landscape increases the exposure of both infrastructure and visitors to hazard events.

It is important to consider that the consequences of such events – such as road or bridge closures – can last for days or even months, depending on the severity of the damage and the scale of the required reconstruction efforts. Debris flows can also damage existing protective measures, increasing the risk of cascading hazards. For example, a series of large debris flows in the Grawanockbach Catchment in 2022 and 2023 caused significant road damage, backfilling and partial erosion of the avalanche dam. Since then, the mitigation structures in the deposition area were substantially modified and upgraded.

If the population and tourism growing trends observed in recent decades (Land Tirol) continue, an expansion of built-up areas will likely be necessary to accommodate new buildings and infrastructure. However, the mountainous terrain of the Stubai Valley – with steep slopes and narrow valley floors – limits suitable space for development. As a result, new expansion areas may fall within a hazard-prone zone. With the projected increase in the frequency and magnitude of debris flows under climate change conditions, current hazard zone classifications may need to be revised, and new protective measures may be required even in areas previously considered not at risk.

THE ROLE OF VULNERABILITY IN RISK

The impacts of a hazard event can be exacerbated not only by the event's intensity or the number of exposed elements, but also by other factors such as social characteristics (e.g., an ageing population, low risk perception, or lack of awareness) and the condition and maintenance of buildings and infrastructure. Tourists—particularly international visitors—are expected to be especially vulnerable, as they often lack the same level of risk awareness and familiarity with local emergency procedures.

Greater impacts are also more likely when risk management practices are inadequate—for example, in the absence of protective measures such as rockfall barriers—or when preparedness is low for responding to multiple simultaneous or cascading hazards (e.g., a debris flow triggering a flood).

In this context, a thorough evaluation of current risk management measures and their adaptation to changing conditions is crucial for the safety of residents, visitors and their activities.

RISK MANAGEMENT

RISK MANAGEMENT CYCLE

Effective management of natural hazard risks requires systematic planning and coordination. Risk management provides a structured and iterative process aimed at minimizing risks and enhancing community resilience. This process involves a continuous cycle of interconnected actions, as illustrated in the infographic.

The main phases of the **risk management cycle** include:

PREVENTION	PREPAREDNESS
RESPONSE	RECOVERY

The interphases —the transitions between phases— are critical components of the risk management, as they involve shifts in responsibilities, resources, and attention. These interphases (Prevention-Preparedness, Preparedness-Response, Response-Recovery, and Recovery-Prevention) require particular attention to ensure smooth transitions, clear communication across phase boundaries and to avoid potential gaps in risk management.

Debris-flow deposits after the July 2022 event on Mühltalbach in Mieders (Source: WLV).

Activities and measures taken in advance to ensure effective response.

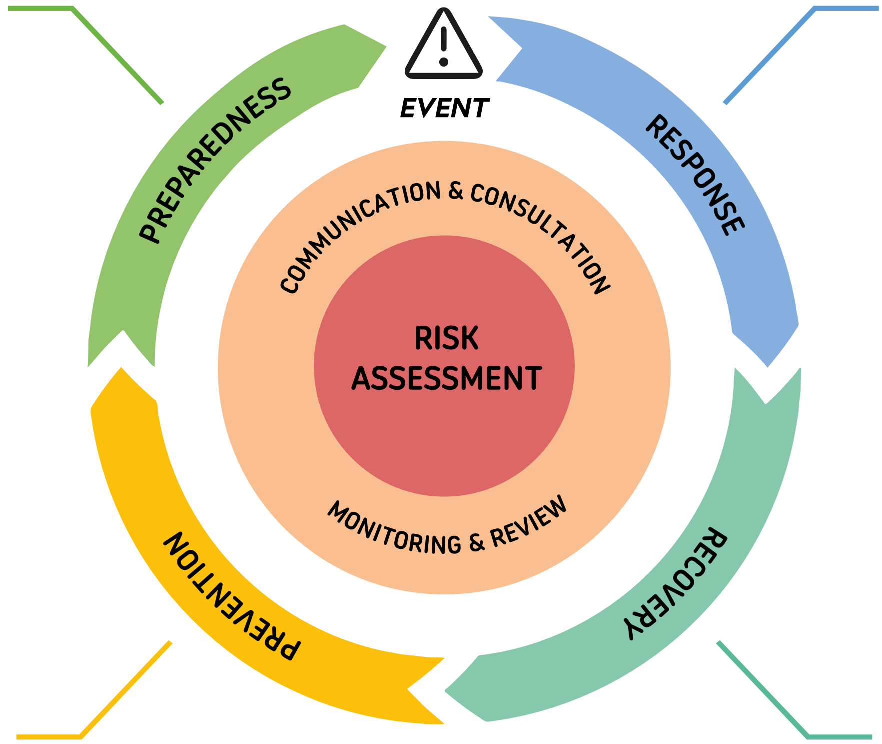
Early warning systems, emergency planning, training and exercises, resource pre-positioning, public awareness campaigns, and establishment of coordination mechanisms.

Capacity to act and prepare before a hazardous event strikes.

Actions taken during and immediately after an event to save lives, reduce impacts, protect the environment and meet basic subsistence needs.

This includes effective coordination, emergency operations, search and rescue, evacuation, emergency communications, and immediate humanitarian assistance.

Emergency response requires the coordinated intervention of all civil protection actors.



Measures taken to mitigate the risk. This includes structural measures and non-structural measures.

STRUCTURAL MEASURES
protective structures, nature-based solutions, retention areas, asset protection measures

NON-STRUCTURAL MEASURES
land-use planning, hazard zone maps, education, communication and legislative frameworks

Supports acceptable levels of risk society is willing to live with.

Actions taken after a disaster to overcome the event and enhance resilience through build back better principles.

This includes restoration of infrastructure and services, economic recovery, psychosocial support,participative reconstruction planning, and implementing lessons learned.

Integrates adaptive actions and long-term thinking.

*Key actions and measures associated with each phase of the risk management cycle, including both **structural** and **non-structural** measures that support prevention, preparedness, response, and recovery.*

STAKEHOLDER INVOLVEMENT APPROACH

Three participatory workshops were held in the pilot area to analyse and improve local risk management of natural hazards driven by weather extremes. Participants included different entities dealing with risk: municipalities, forest services, civil protection, torrent control authorities, local enforcement bodies, technical experts, research institutions, and representatives from different levels of administration. During **the first workshop** the recent extreme events were reviewed to evaluate what worked well and what failed in terms of risk management so to identify entry points for future improvements; in **the second workshop** participants were invited to evaluate the current capacity and potential challenges in managing similar events but in a plausible future context, based on analysed climate projections and possible socio-economic evolution; **the third workshop** was focused on developing concrete action plans for improving the management of future risks related to climate extremes. All workshops were guided by the SMART approach—setting goals that are **Specific, Measurable, Achievable, Relevant, and Time-bound**—to ensure the results were realistic, actionable, and tailored to the region's needs.

1. Workshop

ANALYSE THE PAST AND FIND THE GAPS

2. Workshop

LOOK AT THE FUTURE AND DEFINE CHALLENGES

3. Workshop

MAKE THE PLANS

Participants of the workshops in the Stubai Valley pilot area

- 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

RISK MANAGEMENT GAPS

In the first workshop held in the pilot area, relevant stakeholders came together to debrief and reanalyse the 2022 debris flow events that impacted the municipalities of Mieders, Neustift, and Fulpmes. The session helped identify both existing strengths and gaps in local risk management.

At the time of the first workshop, the municipalities had no formal "municipal operations management" in place—partly due to recent local elections and a general lack of operational experience. Nonetheless, several systems performed well: weather forecasts were accurate, SMS warnings from GeoSphere Austria to fire departments and mayors were timely, hazard maps proved reliable, and existing protection measures functioned as intended. However, uncertainties in determining exact thunderstorm cell locations, combined with the absence of standardized procedures for interpreting and acting on extreme weather warnings, made decision-making difficult. Emergency services, such as fire brigades, relied heavily on local knowledge and informal practices, which were mostly unwritten. Despite these gaps, on-site coordination was effective, with a responsive operation management team that adapted well to fast evolving conditions. Other key challenges included managing onlookers and ensuring public safety, long traffic disruptions—especially affecting tourism—and the lack of a pre-warning system for road closures. Finally, the workshop was recognized as a valuable reflection point, while no formal joint debriefing took place after the event, highlighting a gap in institutional learning and future preparedness.

The second participatory workshop identified key improvements for future risk management. Raising awareness among residents and tourists was a central focus, with suggestions including parking restrictions in risk zones, school and community projects, tourist information, and involving the public in debriefings and training activities. At the municipal and regional levels, civil protection plans were found to need better adaptation to future debris-flow scenarios and extreme weather warnings, while more training will be required for local authorities. The importance of pre-defined and authorized deposit areas for debris during events was also emphasized as a priority for regional planning.

GAPS PER PHASE

The key gaps identified for past events and for the projections for the future through the participatory workshop process are reported in the following sections, first for each phase of the risk management cycle, then for the interphases between them.

Group work in the second workshop in Mieders (Source: WLV).

GAPS PER PHASE

PREVENTION

- Maintaining protective structures is expensive and challenging. Debris retention basins are often not large enough to handle expected future extreme events. They also require frequent clearing, which is sometimes not affordable, particularly for smaller municipalities.

- Until now, training and exercises on disaster response plans are only partially conducted, and coordination between municipalities needs to be encouraged. In addition, there is mostly no special training for dealing with torrent and debris flow events.

- In spatial planning construction-free-zones and zones where safe construction is possible have to be better identified and designated. There are often no legally pre-defined areas for storing debris or sediment after an event, which can lead to delays in cleanup and recovery operations and cause conflicts between property owners, municipal authorities and emergency responders .

- Hazard zone planning is a static system and many hazard maps are outdated. The plans show mainly where problems used to happen, not where new risks are developing because of climate change and potential compound events (such as storms combined with heavy rain). Future hazard maps should include those climate change scenarios, the design events should be adapted and it has to be paid more attention to residual risk.

- There is a lack of adequate awareness and preparedness for natural hazard events. Public acceptance of risk prevention measures is low, and participation in preparedness activities is limited. Tools such as risk dialogues, preparedness checklists, and clearly defined action plans can help improve understanding. Involving citizens directly in crisis management exercises could improve preparedness within communities.

- Protective Forests help reduce risks from hazards like debris flows and avalanches, but only if they are healthy and well-managed. They are getting weaker because of drought, pests, storms and climate stress. Forestry needs more support to plant strong forests that can handle climate change. However, many small private owners make it hard to manage the forests well. Also, the role of hunting in forest health and hazard prevention needs more attention.

PREPAREDNESS

- While short-term weather warnings are available, they often cannot predict the exact location or intensity of storms at the local level. Local, accurate alerts (e.g. for debris flows) are still missing. Current forecasts are difficult to interpret for local decision-making. In some areas, radar coverage is incomplete, which limits the effectiveness of forecasting.

- Municipalities often do not know what to do when a warning is issued. Standard procedures for responding to weather warnings are missing, and not all relevant actors have access to already implemented warning tools like "Wetterbox Tyrol".

- Certain locations within municipalities are more vulnerable to hazards like debris flows, but these hotspots are often underestimated. Preparing for potential evacuations and updating hazard assessments in these areas is complex. Municipalities should identify these critical points together with all relevant actors and establish clear processes for reviewing them regularly and agreeing on precautionary measures.

- Improved communication between municipalities—and within individual communities—is essential. A "natural hazard commission", a model similar to avalanche commissions, could help coordinate efforts related to other natural hazards.

- Municipalities are tasked with an extremely broad range of responsibilities. As a result, natural hazards are often just one item on a long list and municipal emergency plans are often incomplete or outdated. Clear, standardized checklists and procedures for emergencies are still missing in many places. Some local fire departments have their own practices for storm and mudflow events, but these are usually informal and vary between communities. Also, many other actors (e.g., mayors, police, road maintenance services) are involved, but joint exercises and plans are rare. Communication inside municipalities is sometimes difficult, e.g. contact lists are outdated, or people do not know how to use technical equipment.

- People don't always understand or correctly react to warnings (e.g., sirens) and tourists often don't know how to behave in emergencies and sometimes even block emergency services.

RESPONSE

- There is currently no early warning system or standardized procedure for deciding when and how to close roads during a hazard event. Responsibility varies depending on the road type. Sometimes it's unclear who is in charge. This creates delays and uncertainty during fast-moving situations.
- Standardized emergency procedures for public authorities and civil protection units are lacking in some municipalities.
- There is significant room for improvement in how the public is informed and involved during a crisis. Many people are unsure how to respond to alerts such as civil protection sirens. There is also a need to manage public behavior (e.g., curious onlookers, tourists, self-organized cleanup efforts) and clarify responsibilities. Fast, clear and effective communication to the public is crucial but hard to achieve.
- During disaster events, many volunteers—including those from outside the community—want to help. However, there is often no clear system to register, assign, or lead these individuals effectively and to guarantee their safety. Municipalities need a process to integrate and manage spontaneous helpers.
- There is often no formal "Municipal Crisis Management" set up during events. Crisis management is typically handled by a few individuals (e.g., mayors) and is heavily dependent on personal experience and contacts. Those key figures often lack support or are overloaded with responsibilities. Clearly defined roles, standardized procedures, and reliable communication channels are essential.
- Redundant systems are critical to maintaining emergency services. This includes backup power supplies, alternative communication systems, and functional radio networks to ensure coordination during outages. These backup systems are not always available and ready.
- Rapid access to financial resources for municipalities is essential for quick action in the immediate aftermath of a disaster. Funding mechanisms must be optimized and efficient to meet urgent needs.

RECOVERY

- Funding for reconstruction of protective measures is often insufficient. Financial aid in general is often complex, slow, and spread across many agencies (“funding jungle”). Municipalities and individuals need better guidance and coordination to navigate the application process effectively.

- Follow-up discussions and documentation after disaster events are not yet standard practice. Currently, these processes happen inconsistently and mainly within individual organizations. A structured and institutionalized post event review process is needed to ensure that lessons learned can be translated into better prevention and preparedness. Recovery should be seen as an opportunity to improve resilience.

- There are often no pre-designated sites for storing debris and sediment after events, which causes delays due to legal and property issues. Approval processes are slow, and conflicts with landowners are common. A coordinated strategy for debris and sediment management is needed, so that already before an event everything is clearly arranged.

- Communicating clear and positive examples of successful recovery can reduce fear and build trust within the community. It is important to involve citizens in discussions, planning, and education around risks and resilience. Exercises, trainings, and information events should not be limited to the aftermath of disasters but also take place during "quiet" times to build long-term awareness and readiness.

- Reconstruction should be used as a chance to “build back better” and reduce future risks—but this opportunity is often missed.

- There is no standardized system for recording and analyzing events and each organization does it differently.

GAPS PER INTERPHASE

PREVENTION → PREPAREDNESS

- There are many tools to warn people, but most people do not know how to react when alarms go off. That makes warnings less effective.
- Some areas are better prepared than others, depending on past experience. There is no standard level of readiness.
- Emergency plans often forget that systems can fail. This leaves big gaps in how well a community can respond when protection structures are exceeded.
- Hazard zone mapping only shows the design event. Due to climate change, events become more frequent and intense. Those extreme scenarios are most of the time not displayed in the hazard zone map and therefore also not considered in spatial planning.

PREPAREDNESS → RESPONSE

- Emergency plans are often based on fixed scenarios. They struggle to adapt when something unexpected happens.
- Decisions can be slow during fast-moving events, especially if leadership is unclear or priorities aren't set. This is even worse during unpredictable "Black Swan" events.
- When disasters cross multiple towns or cities, planning is often fragmented. It is hard to coordinate resources without a shared plan. Gaps exist in how well systems are ready when a real response is needed.
- Many residents and visitors are unsure how to interpret alerts or act during emergencies, weakening community-level responses and delaying critical protective measures.

RESPONSE → RECOVERY

- Knowledge is often lost when experienced staff leave. There are not enough systems to train new people or keep important information.
- Long-term recovery is rarely planned well. Instead of building back stronger and safer, communities often return to how things were before.
- Local people are not always involved in recovery planning. That means missed chances to use local knowledge, build trust, strengthen cooperation and preparedness for future events.
- Once the immediate crisis is over, recovery efforts often stop, without thinking about long-term rebuilding or resilience.

RECOVERY → PREVENTION

- Rebuilding is a chance to do better—but this chance is often missed. Infrastructure is repaired quickly, without thinking about future risks.
- Lessons from disasters are not always written down or shared. This makes it harder to learn and prepare for the next time.
- There is often not enough time or funding to improve things like land use or infrastructure after a disaster. Opportunities for safer relocation are missed.
- Public education and awareness often end after recovery, leaving people unprepared for the next event. Public attention fades quickly after disasters. It's hard to keep people interested in disaster preparedness when nothing is happening.
- Risk maps and emergency plans are not always updated after a disaster, leaving the same weaknesses in place for the future.

UNDERSTANDING RISK TERMINOLOGY

What does "residual risk" mean?

Residual risk is the risk that remains after you have taken steps to reduce or control it. Even with safety measures and controls in place, some risk still exists. Knowing the residual risk helps people and organizations prepare for any remaining dangers and make better decisions.

What is the “Wetterbox Tyrol”?

A digital platform that provides weather data, forecasts and warnings for municipalities and authorities to enable quick targeted response during critical weather events.

BLACK SWAN Theory

“Unknown unknowns” – The Black Swan theory reminds us that some events are rare and hard to predict, but they can have a huge impact. These extreme events are often left out of risk planning, making communities more vulnerable when they strike.

Damaged series of checkdams after the debris flow event in July 2022 on Margaretenbach in Fulpmes (Source: BFV Kufstein).

What is a "Municipal Crisis Management"?

It is the central leadership structure in a community response during a disaster. It defines who leads the operation, allocates resources, and ensures all actions are coordinated. It also establishes communication channels between different agencies and with the public. During an event, this command enables faster decision-making, avoids duplication of tasks, and creates clarity about responsibilities.

What does "build back better" mean?

It means, not just repairing damage after a disaster, but rebuilding in a way that reduces future risk, avoids repeating past mistakes and makes communities better prepared for future events (more resilient). This approach can include changing building locations, improving infrastructure standards, updating hazard maps and planning regulations, or restoring ecosystems that offer protection.

Flooding of the Ruetz at the confluence with Margaretenbach in Fulpmes after the July 2022 debris-flow-event (Source: BFV Kufstein).

CO-DESIGNED TAILORED ACTIONS FOR THE PILOT AREA

The workshops held within the X-RISK-CC project strengthened the understanding among participating actors and their specific requirements and points-of-view. Several of the proposed measures have already been implemented. Following the first 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. In January 2025, the Tyrolean Crisis and Disaster Management act was updated, improving the regulation of responsibilities between municipalities and the state regarding management of an event. Concerning the adaptation of hazard zone maps to climate change scenarios, Austria's 2021 hazard zone regulation introduced the possibility to designate residual risk areas, or areas that could be affected by a 300-year flood in the hazard zone maps. This feature is currently implemented in the GIS-tool of torrent and avalanche control and is more and more used in practise. Further plans include educational projects in schools to teach children about natural hazards, risks and safety. To raise public awareness more broadly and strengthen societal resilience, a joint participatory information event with all involved authorities is planned for spring/ early summer 2026.

The complete list and details of the tailored actions devised for the pilot area of Stubai Valley are published in a separate document called "Tailored Action Plan: Stubai Valley" which can be found at:

X-RISK-CC - Alpine Space Programme

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

Group work in the first workshop in Fulpmes (Source: WLV).

CHALLENGES AND PERSPECTIVES

To address the upcoming risks, we need stronger cooperation, proactive preparation, and a long-term-perspective. Everyone has a role to play: local authorities, emergency services, experts, the public — even tourists. This project has been an important first step. The coming together of the various stakeholders and the consideration of risk management from different perspectives at the workshops has already had some positive effects.

Although progress has been made, many challenges remain to adapt risk management to climate change. Land for construction in the alpine valleys is limited, placing significant pressure on authorities. Accurate prediction of extreme events in terms of location, intensity and timing and the assessment of their impacts remains challenging. The key future challenge will be to strike a delicate balance between ensuring safety of population and allowing sustainable development.

Damaged series of checkdams after the debris flow event in July 2022 on Margaretenbach in Fulpmes (Source: WLV).

USEFUL RESOURCES

Wildbach- und Lawinenverbauung

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

Gefahrenzonenplan Österreich | GZP

https://gefahrenzonenplan.at/

RIS - Krisen- und Katastrophenmanagementgesetz 2025, Tiroler - Landesrecht konsolidiert Tirol, Fassung vom 26.09.2025

https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrT&Gesetzesnummer=20001011

X-RISK-CC - Alpine Space Programme

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

X-RISK-CC - Eurac Research

https://www.eurac.edu/it/institutes-centers/center-for-climate-change-and-transformation/projects/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

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Debris-flow check dam filled to capacity after the event in July 2022 on Margaretenbach in Fulpmes (Source: BFV Kufstein).

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