Alpine Space

X-RISK-CC

PILOT DOSSIER

ARLY CATCHMENT IN SAVOIE, FRANCE

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

Interreg Co-funded by the European Union

LEAD PARTNER

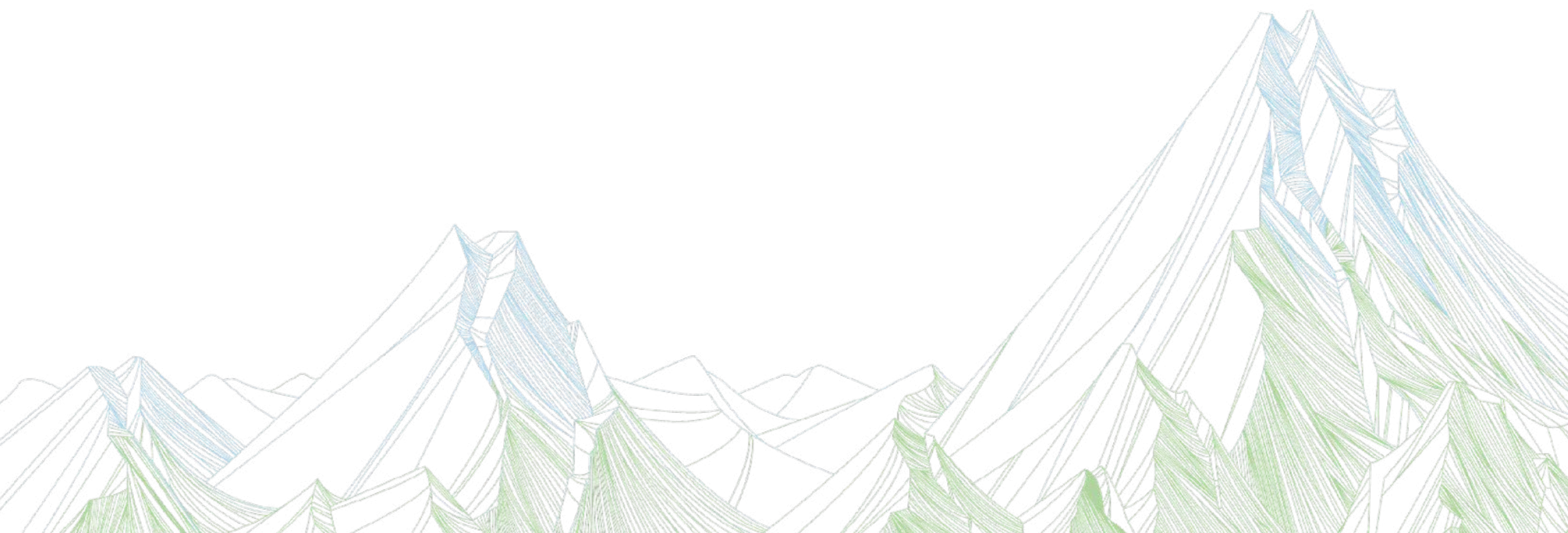
PROJECT PARTNERS

ARLY CATCHMENT
IN SAVOIE, FRANCE

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

THIS DOSSIER

The dossier focuses on the Arly Catchment in the Savoie region (France) 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.



Author List:

Auvergne Rhône-Alpes Energy Environment Agency

Eurac Research

Civil Protection Agency, Autonomous Province of Bolzano

Technical University of Munich

GeoSphere Austria

Autonomous Province of Trento

Slovenian Environment Agency

Development Agency Sora

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

Environment Agency Austria

Reference Contact:

Auvergne-Rhône-Alpes Energy Environnement Agency,
18 rue Gabriel Péri, 69100, Villeurbanne, France

laurence.monnet@auvergnerhonealpes-ee.fr

Publication Date:

November 2025

This publication is available on the project website under the “Outcomes” section:

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.

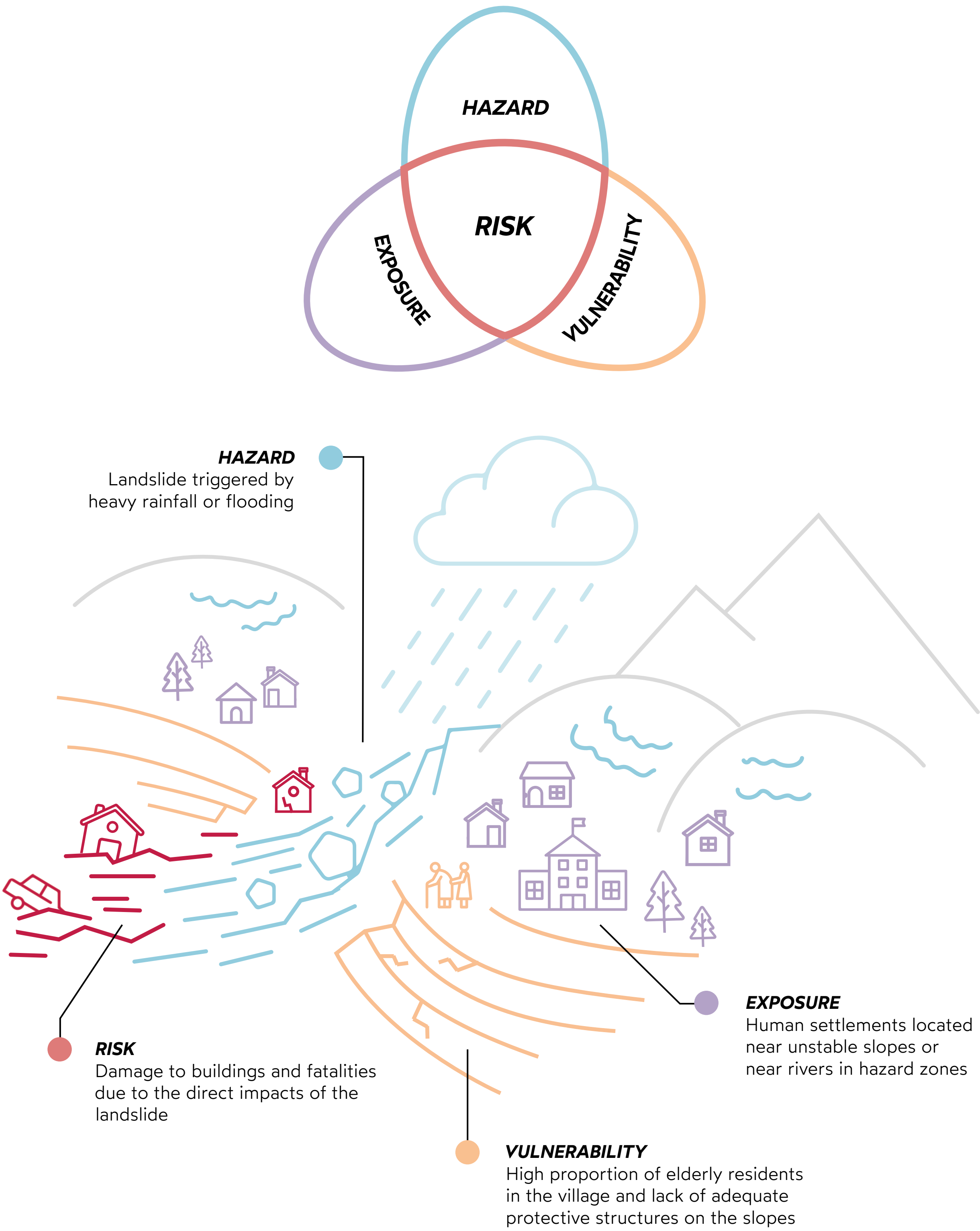


FIGURE 1: *Illustrative examples of hazard, exposure and vulnerability contributing to risk (the concept of risk is based on the framework developed by the Intergovernmental Panel on Climate Change - IPCC).*

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.

Rockslide near Les Métraux on Gorges Road D1212 (2018) - Source: Dèpartement de Savoie

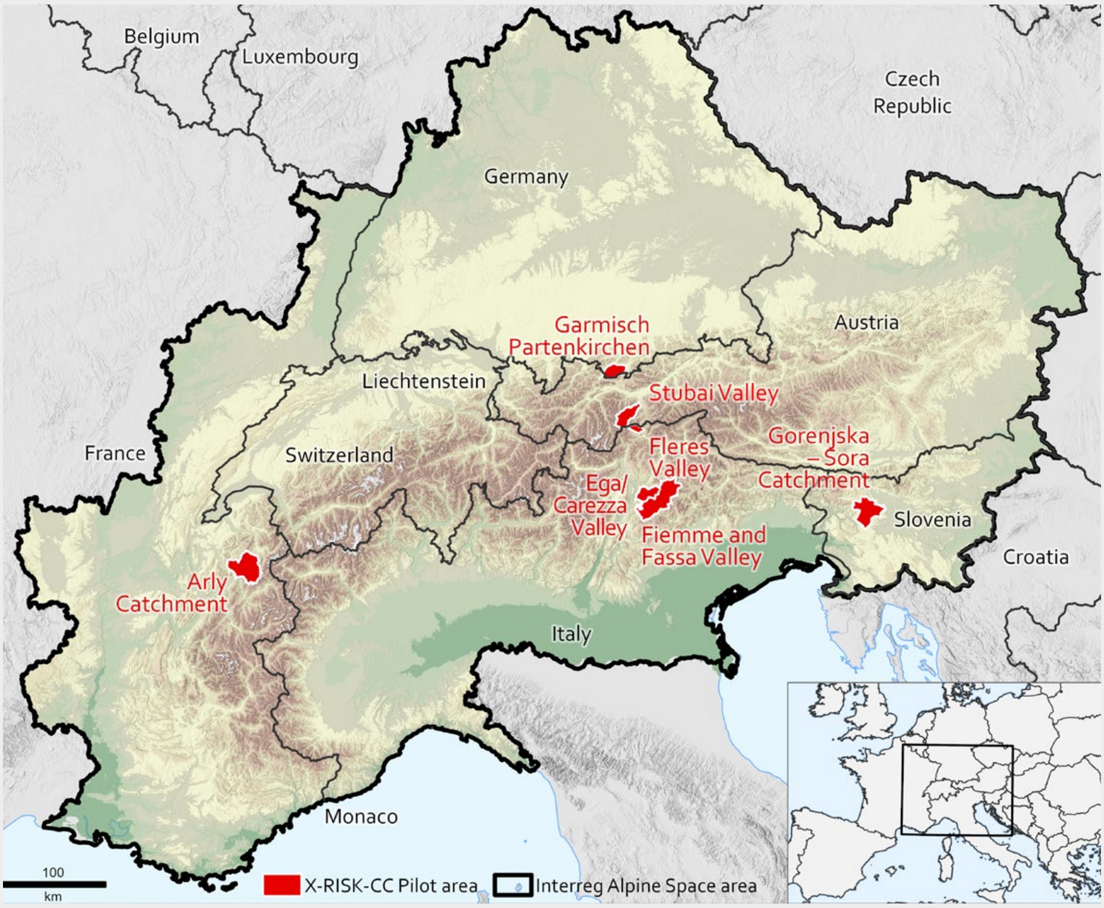


FIGURE 2: *Map illustrating the pilot areas (shown in red) of the X-RISK-CC project.*

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: ARLY CATCHMENT
(SAVOIE, FRANCE)

GEOGRAPHICAL AND ENVIRONMENTAL SETTING

The Arly Catchment is located in the region of Savoie in southeastern France (***FIGURE 3***). The pilot area extents over approximately 645 km2 in the western Alps, with elevations ranging from about 340 m above mean sea level (a. m. s. l.) to 2,700 m a. m. s. l.. It is divided into three sub-basins, with almost 300 km of water courses: the Arly, which drains the Arly Catchment and the Albertville basin, the Doron de Beaufort, which drains the Beaufortain area, and the Chaise, which drains part of the Pays de Faverges. The pilot area includes 26 municipalities with Ugine and Albertville as main urban settlements.

Upstream of the village of Flumet, the Arly Catchment is a wide, U-shaped valley typical of glacial valleys. From Flumet to Ugine, the morphology of the valley changes completely. The slopes become steep. The width of the valley diminishes sharply, becoming a narrow canyon. The river's trajectory becomes sinuous. From Cohennoz onwards, the valley widens, but the steep slopes persist until the Arly joins the La Chaise at Ugine.

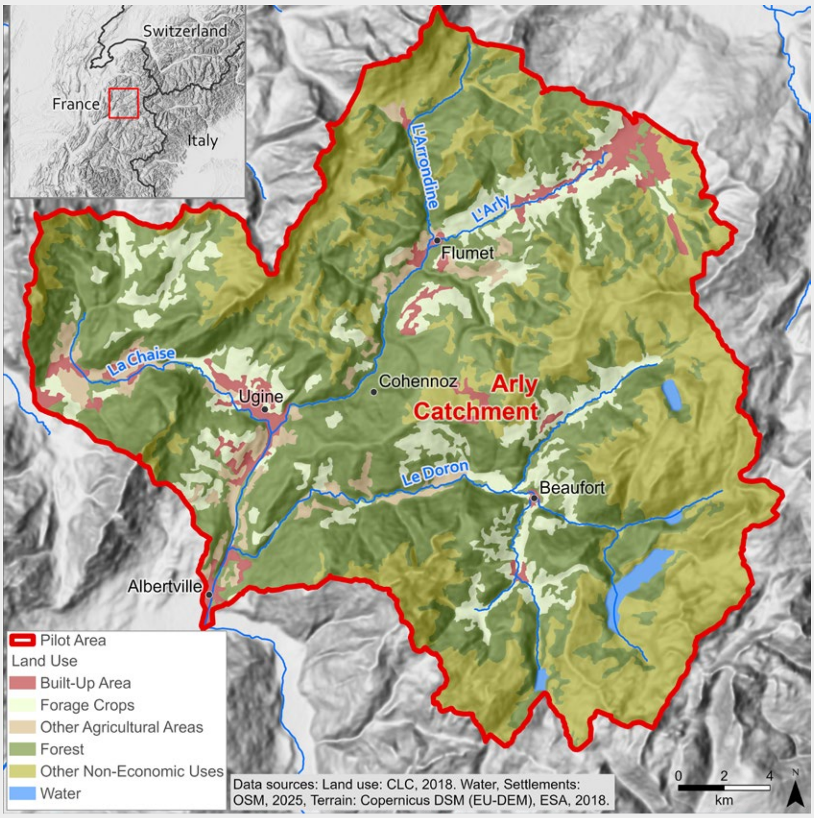


FIGURE 3: *Map of the Arly Catchment in the Savoie region in France (in red).*

The area is subjected to several natural hazards mostly driven by weather extreme events and warming effects on the mountain environment. Typical phenomena include flooding, avalanches, landslides, debris flows and rockfalls.

After a stormy beginning of the winter season, between 2nd and 5th January 2018 the area was severely hit a very intense storm episode, called Eleanor, an extratropical cyclone which extended over a large portion of Europe. Eleanor was one of the most intense storms occurred in France over the past 30 years. Wind speeds over 100 km /h, intense precipitation and above-average temperatures triggered multiple hazards in the area. Damages were extensively recorded throughout France with an estimated economic impact of 700 million euros.

Within the X-RISK-CC project, we analysed how risks related to the effects of storm events, like in the Eleanor storm, when **exceptional precipitation occurs in combination with extreme wind speed**, may evolve in the Arly Catchment in the future.

FIGURE 4: *Montgobert landslide cutting the RD1212 after the Eleanor storm in January 2018 (Source: Département de la Savoie).*

PAST AND FUTURE WEATHER EXTREMES

During the Eleanor storm in January 2018 high precipitation amounts occurred over two days reaching the maximum of 132 mm at La Clusaz. Even though no observed values reached historical records in the area, this winter precipitation episode was very rare. It was estimated to have a return period of up to 30 years in some locations. The exceptionality of the event resides in the fact that it followed a series of multiple minor storm events in the previous weeks and was accompanied by mild temperatures, exceeding the normal values for the period by more than 2 °C. The warm air brought a significant amount of humidity which turned into rainfall in most part of the catchment and exceptional snowfall at the high elevations. In combination with intense precipitation, strong winds were recorded with wind gusts up to 120 km/h at mountain sites. Besides the Eleanor storm, collected observations over the past 30 years in the Arly Catchment and close surroundings do not show a clear change in the intensity or frequency of extreme precipitation events, except for a slight intensification of one-day precipitation extremes in spring. Similarly, no clear increase in extreme wind speed can be identified at the locations analysed. However, the analysis of past trends is limited by the relatively short period covered by available observations.

⚠ 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.

Future projections show that precipitation extremes will be more frequent and more intense in the area. The annual and winter precipitation maxima over 1 to 5 days will be up to 10 % higher than today. More frequent extreme precipitation episodes will occur mostly in winter (up to + 40 % than today). The frequency of days recording extreme wind speeds and their intensity is also likely to increase both on an annual level and in winter, especially under the highest warming scenario, i.e., if a global warming of + 4 °C is reached.

As both extreme precipitation and wind speed episodes are projected to intensify and become more frequent in the future, storm episodes, like the Eleanor storm, with both conditions happening simultaneously can be more likely in the future in the Arly Catchment. Moreover, the continuous warming can make rain-on-snow episodes, i.e., when rainfall occurs on an area covered by snow, more frequent and favour wet snow conditions, which in turn increase the probability of avalanches.

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.

Rockslide near Les Métraux on Gorges Road D1212 (2018) - Source: Département de Savoie

HAZARDS IN PRESENT AND FUTURE CLIMATE

The Arly Catchment is particularly prone to natural hazards like landslides, rockfalls, debris flows, floods and avalanches, which sometimes occur simultaneously or successively. Most of these processes are induced by heavy precipitation episodes and might be further favoured by above-normal temperatures. For example, at the beginning of May 2015, extensive flooding and landslide events in the Arly Gorges mobilised approximately 400,000 m^3 of sediment and inundated infrastructure downstream. The passage of the Eleanor storm in January 2018 triggered at least 30 natural hazard events, including torrential floods, landslides and mudslides, causing numerous damages in the Arly Catchment. More recently, a sequence of heavy rainfall conditions in November and December 2023 led to numerous compound and cascading hydrological, gravitational and torrential phenomena in the Arly Catchment, with three successive floods in less than a month.

Natural hazards during the Eleanor storm (January 2018)

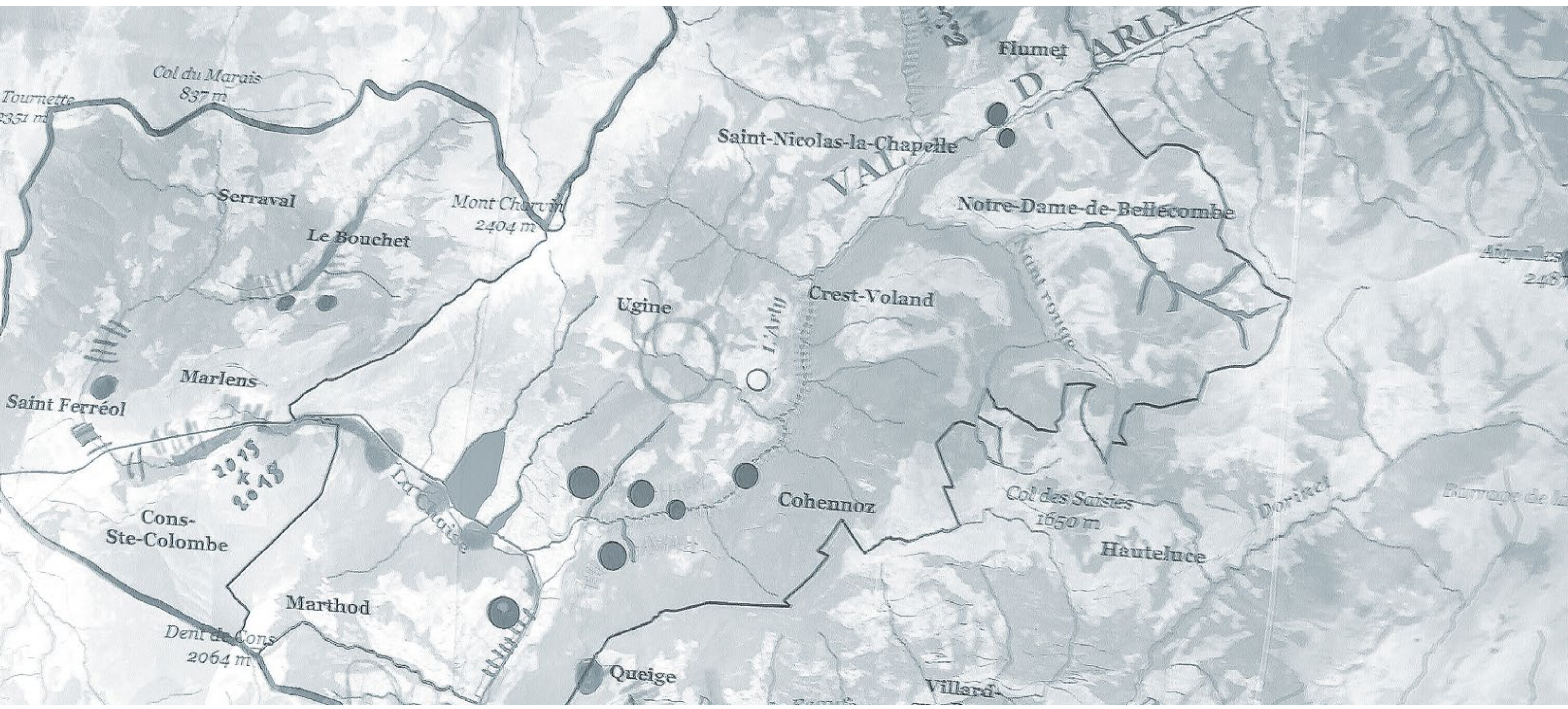
Between 2nd and 5th January 2018 an intense extra-tropical cyclone, called Eleanor storm, brought intense precipitation and strong wind speeds in the region. The storm was anticipated by a rainfall-rich period which left soils already wet and snow in the mountains. Precipitation brought by the Eleanor storm was not absorbed by the soil, already saturated, and caused heavy runoff, while exceptional snow amounts were accumulated in the mountains. A rapid increase in temperatures caused rain-on-snow events and triggered substantial snow melt and soil instability which led to numerous torrential floods, mudslides, landslides throughout the catchment. The flood in La Chaise basin was particularly exceptional, reaching 80 m^3/s and estimated as a 50-year event.

Consequence of landslide near Mont Gombert sector, Gorges Road D1212 (Close-up view) (2018) - Source: Département de Savoie

Based on the database of the French Torrent and Avalanche Control Service, the rockfall and debris-flow activity has increased in the area over the last decades. Intense flood episodes, exceeding 300 m^3/s, have been also occurring more frequently over the last years. In general, across France, the number of avalanches in high-mountain areas (above 2000 m a. m. s. l.) has increased and anticipated in December.

Mountain forests play a key protective function increasing the slope stability. However, possible disturbances affecting trees, such as high temperatures, drought, windthrown and bark beetle infestations, can reduce their protective role and further increase the probability of hazards like landslides, debris flows, rockfalls and avalanches.

Due to the projected intensification of precipitation extremes, all observed phenomena related to floods, erosion processes and mass movements are also expected to intensify in the future. With continuous warming, milder conditions are likely to cause rapid melting of the snowpack and rain-on-snow events such as those observed in January 2018 during the Eleanor storm and during repeated flooding events in November and December 2023. Moreover, if heat-waves and droughts become more frequent, forest disturbances and damaging events like wildfires and pest outbreaks can also increase, thus resulting in more unstable slopes.



Analysis of hazards in Ugine for the X-RISK-CC project (2025) - Source: Alpine Centre for Studies and Research on Natural Risk Prevention (PARN)

CURRENT AND FUTURE IMPACTS AND RISKS

In the Arly Catchment, natural hazards can lead to severe consequences for the population and the socio-economic activities, especially agriculture, forestry, tourism and hydropower production. The area counts approximately 50,000 residents with 50 % of them living in Albertville and Ugine. However, during the peak of the winter season, tourists increase the population by 2.5 times.

Roads are the most important connections between villages and access to main attractions, however traffic disruptions and accidents caused by rockfalls, landslides, avalanches and floods are frequent, sometimes involving costly road repairs. Even though many protection measures, including galleries and slope barriers, have been implemented since 1970s, damage can still occur. RD1212 is recognized to be the road mostly exposed to the hazards in the Arly Catchment.

Impacts of the Eleanor storm (January 2018)

During the Eleanor storm, floods, landslides and avalanches created substantial damages to the road network of the region and buildings. Interrupted roads and bridges limited access to villages and led to economic costs for restoration work. The fire brigade responded to many requests for flooding damages to private properties, mainly in Ugine. The fire brigade also responded to falling trees in Flumet and several avalanches and landslides in La Giettaz. In Ugine, the Gorges de l'Arly road (RD1212) remained closed together with two other secondary roads for one month due to numerous landslides. Substantial restoration work over more than two months was required due to filled storage areas, overflowing torrents, broken culverts, and destruction of protective structures. In the catchment area, the cost of emergency work or repairs was almost 190,000 euros.
The municipalities of the Arly Catchment also applied for recognition of the state of natural disaster to obtain compensation for the restoration of damage.

Consequence of the landslide near Mont Gombert sector, Gorges Road D1212 (2018) - Source: Département de Savoie

Tourism is the main socio-economic activity in both summer and winter seasons for the area, which hosts lots of tourist centres and ski resorts. High number of tourists implies an increase in people potentially exposed to the hazardous processes. The loss of accessibility due to frequent road closures as well as power supply interruptions due to natural hazards are likely to impact the socio-economic activities in the basin. When these closures occur during peak tourist periods, especially in winter, additional resources are required to assist stranded travellers.

If the number of residents and tourists will increase in the future, the overall population exposed to hazards will grow. To answer to the increasing demand, new infrastructure and buildings will be required so that areas for new construction located outside hazard-prone zones must be identified. However, the increasing intensification of meteorological extremes could expand the areas prone to natural hazards, so that safe locations now might be exposed to a non-zero risk in the future. The loss of protective forests concurrent to the intensification of precipitation phenomena further heighten the probability of hazards, also in areas previously considered at lower risk. Moreover, the increase of heatwaves and drought combined with the increase of population and required services, might lead to episodes of water shortages and conflicts in the management and use of water resources for civil use, hydropower, agriculture and tourism.

THE ROLE OF VULNERABILITY IN RISK

The impacts of a hazard event can be exacerbated not only by the event 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 for multiple simultaneous or cascading hazards is low, e.g., multiple river flooding or consecutive flood episodes in the same area with the second flood aggravating the damage caused by the previous one.

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.

Third workshop in Ugine for X-RISK-CC project (2025) - Source: Alpine Centre for Studies and Research on Natural Risk Prevention (PARN)

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 in the workshops in the pilot area of the Arly Catchment

- Auvergne-Rhône-Alpes Énergie Environnement (AURA-EE)
- Alpine Centre for Studies and Research on Natural Risk Prevention (PARN)
- Representatives of municipalities in the Arly Catchment
- Representative from Local Offices
- Union of rivers and watershed services
- Office for Civil Protection (SDIS)

RISK MANAGEMENT GAPS

The flooding caused by the Eleanor storm in January 2018 had significant impacts in the Arly Catchment. The debriefing during the first workshop with local stakeholders and responders revealed key structural weaknesses, particularly during the recovery phase, alongside strong learning and adaptation processes.

One major challenge was the contradiction in riverbank maintenance: landowners are responsible for upkeep, but slow and restrictive authorizations for machinery use in riverbeds often delay necessary interventions. The cumbersome procedures and the overlapping roles of elected officials—as both residents and decision-makers—complicated timely governance also during the event.

Participants emphasized the need for tools that capture today's complex, multi-risk realities. While some effective practices exist, institutional memory is weak and valuable local knowledge—especially from elder residents—remains underutilized.

Despite these challenges, stakeholders in Arly Catchment showed notable strength as a learning organization during recovery. Local actors actively reflected on the event, documented lessons, and demonstrated a willingness to improve resilience and civil protection planning.

Looking ahead, stakeholders recognized that extreme weather events will become more frequent in the area, making thorough preparation essential. Clear communication and sharing of local knowledge are vital to raising awareness. Proposed adaptation efforts focus on expanding crisis management training, better defining flood-prone areas, limiting urban sprawl, and restoring natural landscapes. Regularly updating risk maps and emergency plans, along with improving coordination and warning systems, are recognized as key for effective response. Encouraging urban development away from vulnerable zones and appointing observers to capture lessons would also support resilience. However, time, financial, and human resources remain pressing challenges to address in future 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.

Third workshop in Ugine for X-RISK-CC project (2025) - Source: Alpine Centre for Studies and Research on Natural Risk Prevention (PARN)

GAPS PER PHASE

PREVENTION

- The current warning system lacks local precision (particularly due to poor weather radar coverage) and coordination between the various agencies (Météo France, flood forecasting service (SPC), French electrics (EDF), municipalities). The APIC tool does not fulfil its function in mountain areas. The lack of centralised data and unified command sometimes delays crisis management. It is proposed to strengthen warning systems by pooling information between stakeholders, testing local alerts (sirens, text messages) and developing contextualised communication for residents to reduce response time.

- Faced with droughts, storms, fires and pests, the watershed forest's protective function is being undermined. The aim is to improve knowledge and management of the stands through a study of their vulnerability and protective role, as well as an inventory of available resources. This approach aims to strengthen the resilience of forests and maintain their ecological and protective functions against natural hazards.

- Flood data is scattered across several organisations, making it difficult to use and coordinate responses. The creation of a digital platform will enable the centralisation of hydrometeorological data, field observations and network information. This tool will facilitate real-time monitoring of events, crisis management and decision-making, while improving communication between the Joint Association of the Arly River Basin, local authorities and partners.

- The population remains ill-prepared for crisis situations and is still unfamiliar with the correct procedures to follow in the event of an evacuation. To strengthen risk awareness, there are plans to step up awareness-raising activities in schools, businesses and local communities, and to organise regular multi-stakeholder simulation exercises. These actions aim to develop the right reflexes in the event of major incidents and to strengthen collective preparedness across the region.

- The general public's awareness of the risks and memory of past events remain limited. An awareness-raising video will highlight historical floods and the coexistence of other hazards such as landslides. This visual aid will promote understanding of local issues and projections for exposed areas and will help to develop a culture of risk awareness and resilience in the region.

- The intensification of climatic events highlights the limitations of current flood management measures. The work planned for the area aims to strengthen structural prevention by creating flood diversion areas and flood expansion areas. These developments will improve flood absorption, reduce the impact on urbanised areas and decrease the need for repeated remedial action.
- Hazard maps are currently inconsistent and often limited to the municipal level, without a coherent inter-municipal vision. It is necessary to standardise and update risk mapping at the watershed level, incorporating non-urbanised areas and sectors subject to recent changes. This approach will improve spatial planning and multi-risk prevention.
- Certain areas of the basin, particularly the Arly Gorges, present a significant risk of landslides and massive sediment deposits, which are very difficult to predict at present. In order to anticipate these phenomena and their consequences on watercourses, it is proposed to set up appropriate detection and warning systems. These systems will enable better monitoring of unstable areas and faster intervention in the event of a proven threat.

PREPAREDNESS

- The current structure effectively manages everyday situations but shows its limitations during major events, particularly in the event of communication breakdowns or information overload for those working in the field. The lack of standardised training and unfamiliarity with certain protocols hamper responsiveness. It is therefore necessary to strengthen inter-municipal coordination through an Inter-Municipal Safety Plan (PICS), improve communication between municipalities, clarify the roles of the various stakeholders, and increase the number of simulation exercises and training sessions for all stakeholders.

- There is still too little anticipation of the effects of disasters, leading to responses that are often reactive rather than preventive. To overcome these limitations, it is necessary to develop a better understanding of the risks and prepare proportionate responses. This involves developing realistic scenarios, identifying sensitive areas, improving the maintenance of structures and installing automated measurement systems. Such preparation will enable efforts to be focused on saving lives and reducing the vulnerability of infrastructure.

- Alert management remains confusing, with an excess of minor warnings leading to a loss of attention and difficulty in recognising genuine crisis situations. This lack of gradation in the response reduces the effectiveness of the systems in the event of a major incident. It is therefore essential to define clear thresholds to adapt the alert to the level of severity, while strengthening the risk culture through regular training and extreme simulations. These actions will make the decision-making chain more reliable and increase collective responsiveness.

- Many municipalities still have incomplete or outdated plans, often limited to restricted scenarios and rarely tested. This situation weakens collective preparedness for major crises. It is becoming imperative to generalise Municipal Safety Plans, ensure they are regularly updated and make them operational through field exercises. The identification of assembly points and evacuation planning must complement these measures in order to strengthen local resilience and inter-municipal coordination in the event of a major incident.

RESPONSE

- The lack of remote sensing tools currently limits the ability to anticipate and manage floods in real time in the Arly Catchment. To address this shortcoming, several river monitoring sites need to be equipped with video or photo devices connected to a centralised digital platform. This equipment will provide a continuous view of water level changes, improve the responsiveness of interventions and enhance the accuracy of hydrological forecasts.
- The dissemination of alerts remains imperfect, despite the use of tools such as FR-Alert and social media, communication systems remain fragile during extreme events, as demonstrated by several recent intense events in France. To overcome this vulnerability, it is necessary to designate sector representatives capable of transmitting information in the event of a network failure, and to strengthen technical resources by acquiring radio equipment. This organisation will enable more robust, responsive, and coordinated communication between operators in the field.

RECOVERY

- Reconstruction that is carried out too quickly after disasters, often in exactly the same way as before, does not allow lessons learned from the events to be incorporated. This haste limits future prevention and resilience. It is therefore essential to engage in collective reflection on the causes of disasters, consult experienced residents and give local elected officials greater leeway. Reconstruction must become a time for analysis and training, supported by mapping of the affected areas, in order to improve risk awareness and land management in the long term.
- Information from debriefings and post-crisis observations often remains scattered and insufficiently shared, which hinders collective learning. A systematic approach is needed to capitalise on experiences, in particular by appointing observers and documenting observed phenomena, such as ice jams or blockages. By promoting the transmission of local knowledge and the analysis of causes, each event becomes a resource for continuous improvement, strengthening the culture of risk and the capacity for collective response to future disasters.

GAPS PER INTERPHASE

PREVENTION → PREPAREDNESS

- **Inform the public about what to do** in the event of an incident, targeting specific groups (schools, businesses, communities), as the measures currently in place are too general and therefore not easily implemented by these different groups.
- Consider using **fusible structures** that allow certain low-risk areas to be "sacrificed" in order to protect high-risk areas.

PREPAREDNESS → RESPONSE

- **Mapping of potential events**: current maps do not adequately reflect the "dynamic" nature of phenomena and how they evolve depending on intensity, making it difficult to target priorities for action in the event of a crisis. These maps therefore need to be refined in order to inform graduated plans.
- **Definition and coordination of the roles of stakeholders**: municipal managers (police powers), watershed managers (engineering expertise) and companies (interventions) must work together upstream to get to know each other and train together in order to be more responsive and effective in the event of incidents.

RESPONSE → RECOVERY

- **Emergency measures unrelated to long-term recovery:** during floods, temporary repairs, such as rapid infrastructure restoration, are often carried out under pressure, without any real connection to a sustainable recovery plan. While these interventions may restore access in the short term, they risk causing recurring damage and increasing future costs when long-term solutions are delayed. It is therefore essential to engage in **a concerted local discussion,** involving elected officials, technicians and residents, and to **share the results of these discussions with as many people as possible** in order to ensure coherent and sustainable reconstruction choices.

RECOVERY → PREVENTION

- **Capitalising on information**: currently, too little time is devoted to capitalising on the impacts experienced, even though this information is essential for better preparing prevention phases. Based on a reporting protocol, it would be very useful for all stakeholders to compile their observations.

UNDERSTANDING RISK TERMINOLOGY

What is the APIC tool?

The **APIC** service, developed by **Météo-France**, provides real-time warnings of **exceptionally heavy rainfall** at the municipal level. Based on radar and rainfall measurements taken every **15 minutes**, it is triggered when cumulative rainfall exceeds **local climatological thresholds**, covering all **municipalities in the country.**

What is an Inter-municipal Safety Plan (PICS)?

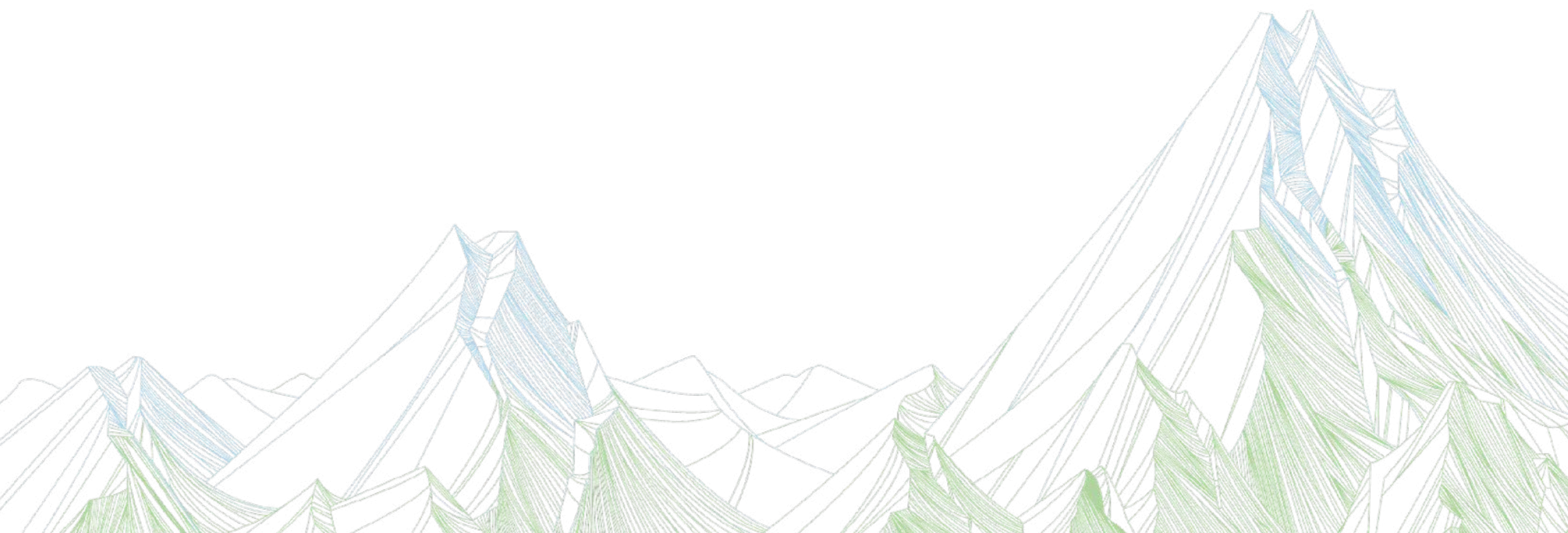
The **Inter-municipal Safety Plan (PICS)** is drawn up by public inter-municipal cooperation bodies, in consultation with the **mayors of member municipalities**. It aims to pool resources and coordinate crisis management when an event exceeds the capabilities of a single municipality. This plan is based on an inter-municipal risk assessment and defines crisis governance at the territorial level, the terms and conditions for logistical support and mutual assistance between municipalities, as well as a business continuity plan for inter-municipal competences.

What is a Municipal Safety Plan (PCS)?

The **Municipal Safety Plan (PCS)** is the responsibility of **the mayor.** Its purpose is to organise the municipality's response to any major event that could threaten the population or local infrastructure. This plan is based on an analysis of the risks identified in the area and defines the structure of the municipal crisis unit, the procedures for alerting and securing residents, and the inventory of human and material resources.

What is FR-Alert?

FR-Alert is the national public alert and information system. It enables prefects to send real-time, geolocated notifications to the mobile phones of people in a risk area to inform them of the safety measures they need to take.



CO-DESIGNED TAILORED ACTIONS FOR THE PILOT AREA

Following the identification of major shortcomings in flood forecasting and management in the Arly Catchment, a set of actions to prioritise has been structured around the phases of prevention, preparation, and response in order to increase the resilience of the territory.

Prevention focuses on strengthening a more accurate and coordinated alert system, centralizing data via a flood monitoring platform, updating hazard maps in a consistent manner, and developing flood expansion facilities that take into account forest management and ground movements monitoring.

Preparation aims to consolidate inter-municipal crisis governance through a PICS (Inter-municipal Crisis Management Plan), to better define alert thresholds through a Graduated Action Plan, to generalize PCS (Municipal Crisis Plans), and to strengthen training and multi-stakeholder exercises.

Finally, the operational response will be improved through the acquisition of remote sensing tools (photos/videos) and more robust emergency communication system, based on field designated agents and additional radio resources.

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

X-RISK-CC - Alpine Space Programme

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

Third workshop in Ugine for X-RISK-CC project (2025) - Source: Alpine Centre for Studies and Research on Natural Risk Prevention (PARN)

CHALLENGES AND PERSPECTIVES

The gaps identified in the participatory workshops carried out in the Arly Catchment show that all risk management stakeholders need to work together to advance the various management phases. This analysis calls for a multi-stakeholder, multi-risk and integrated approach. In order to drive progress in these areas, it seems essential to develop specific engineering techniques to facilitate this collective progress, drawing on collective intelligence to determine action programmes that will need to be supported by public institutions at regional and national level. This systemic dynamic requires the support of all stakeholders and necessarily develops over a period of time, generally a long one, to allow for the individual maturation that is essential to collective decision-making. This dynamic is therefore sometimes perceived as being far removed from the urgent interventions that need to be put in place in view of the speed at which the impacts of climate change are evolving.

However, at the level of the Arly Catchment, two action programmes have been launched in parallel with the consultation work carried out with participants as part of the X-RISK-CC project:

→ A **PAPI project (Flood Prevention and Action Programme)** comprising seven areas of prevention: 1) improving knowledge and awareness of the risk, 2) monitoring and forecasting of high water levels and floods, 3) alert and crisis management, 4) taking flood risk into account in urban planning, 5) reducing the vulnerability of people and property, 6) slowing down runoff, and 7) management of hydraulic protection structures. These actions will be carried out by the SMBVA and its partners (inter-municipal authorities, municipalities, etc.) with 50 % support from the State.

→ An **INMR (Integrated Natural Risk Management – „GIRN" in French)** project comprising four areas of focus: 1) project coordination, 2) design of a flood monitoring platform, 3) crisis management, 4) risk culture. These actions are supported by the European Regional Development Fund.

USEFUL RESOURCES

X-RISK-CC - Alpine Space Programme

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

Resource Centre for Territories in Transition in Auvergne-Rhône-Alpes

https://www.auvergnerhonealpes-ee.fr/sinspirer/projets/tous-les-projets/detail/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

APIC-Vigicrues Flash service

https://apic.meteofrance.fr/

The Fr-Alert public alert and information system

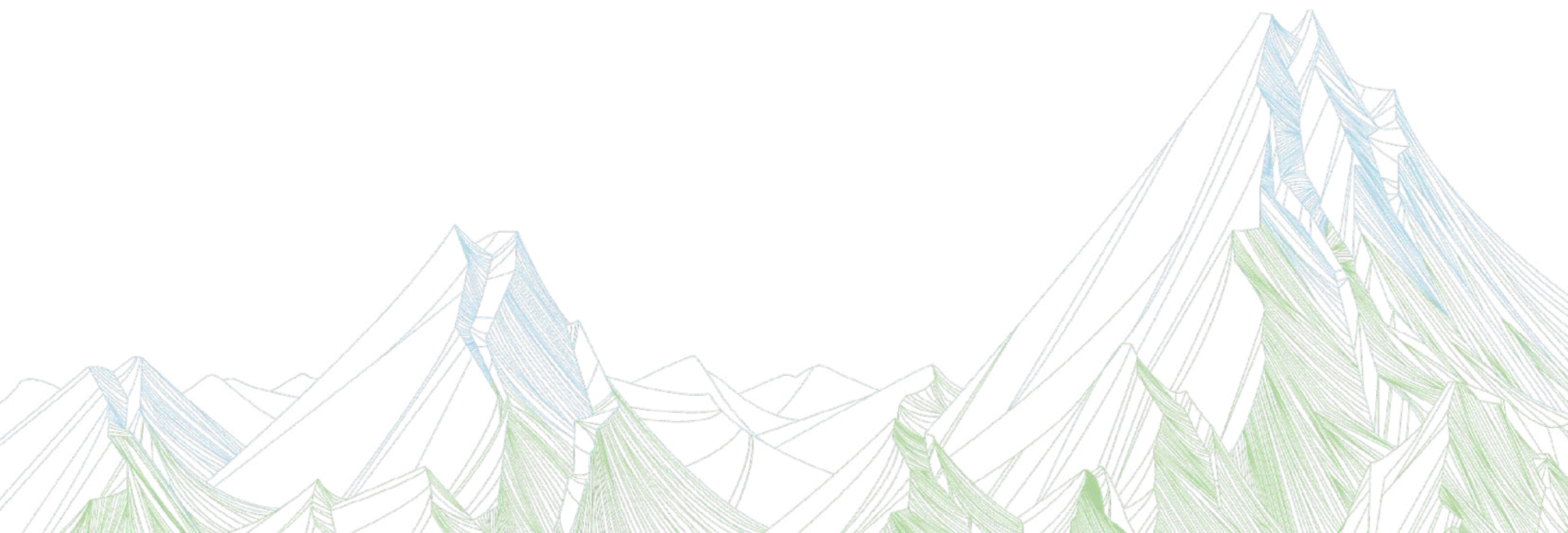
https://fr-alert.gouv.fr/

The Alpine Centre for Studies and Research on Natural Risk Prevention (PARN):

https://risknat.org/girn/

PAPI project (Flood Prevention and Action Programme) of SMBVA:

https://www.riviere-arly.com/papi/



ACKNOWLEDGMENTS

We would like to thank all those who participated in the workshops organised during the three-year project, particularly the Arly Catchment area union and services, the representatives of the municipalities in the Arly Catchment area, the representatives of the local offices and the Departmental Fire and Rescue Service for their valuable time; the Alpine Centre for Studies and Research on Natural Risk Prevention (PARN) for its technical and expert support on the issue of natural risks; and the Savoie Department for sharing images of the Eleanor storm and its consequences.

Third workshop in Ugine for X-RISK-CC project (2025) - Source: Alpine Centre for Studies and Research on Natural Risk Prevention (PARN)

Consequence of landslide near Mont Gombert sector, Gorges Road D1212 (Close-up view) (2018) - Source: Département de Savoie

Auvergne-Rhône-Alpes Energy Environnement Agency,
18 rue Gabriel Péri, 69100, Villeurbanne, France

laurence.monnet@auvergnerhonealpes-ee.fr

LEAD PARTNER

PROJECT PARTNERS