

MONTCLIMA: climate and natural hazards in the SUDOE mountains

Final report of MONTCLIMA project results



INTRODUCTION

The vulnerability of society to natural hazards is determined by its degree of exposure and sensitivity to them, but also by the intensity of the hazard phenomena. The main natural hazards in the SUDOE area are closely related to climate, since the climatic triggers are often meteorological conditions whose frequency and intensity are increasing due to climate change. Mountain territories have in common their high vulnerability to natural hazards. Moreover, in these particularly exposed rural areas, events often occur in cascade effect, exponentially increasing their potential damage compared to isolated events.

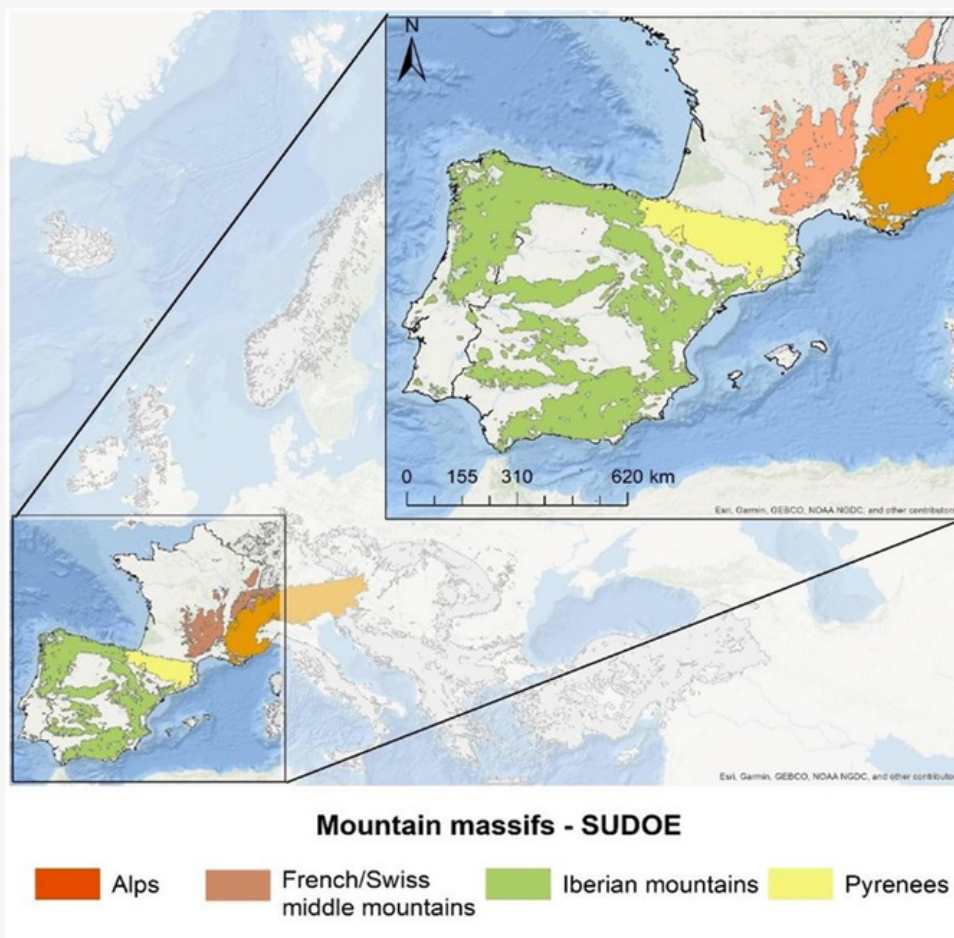


Figure 1: Mountain massifs of the SUDOE region. Source: State of the art on natural hazards and disaster risk management in mountainous regions of southwest Europe, IPB.

This phenomenon, known as the domino or cascade effect, is characteristic of medium and high mountain slopes, where after a natural event such as a forest fire induced by a severe drought, intense precipitation increases its erosive power, and in the absence of vegetation cover increases the probability of torrential phenomena occurring downhill.

Moreover, these risks, like climate change, know no administrative boundaries and require transnational coordination to improve their management and increase the resilience of mountain territories.

This action consisted in the collection, analysis and valorization of risk management and prevention tools proposed by previous European, national, regional and local projects, identifying the most adapted to the problems present in the SUDOE territory. To this end, the 9 partners have cooperated in the execution of 3 three complementary tasks.

On one hand, they have carried out a study on the state of the art of management and prevention practices for the 4 hazards addressed in the SUDOE area, based on a transnational approach. This study included the exhaustive analysis of 72 good practices and recently implemented initiatives developed in the study area. The main result of this action has been a state-of-the-art report on good practices of management and prevention of these 4 natural hazards in the SUDOE mountains (<https://www.montclima.eu/en/deliverables>).

This task was complemented by the selection of 27 good practices based on criteria of vision (multi-risk vision), perspective of actions (transnational perspective) and approach (natural hazards versus climate change). The sheets of these good practices are available on the MONTCLIMA website (<https://www.montclima.eu/en/best-practices>).



Figure 2: : State of the art on natural hazards and disaster risk management in mountainous regions of southwest Europe

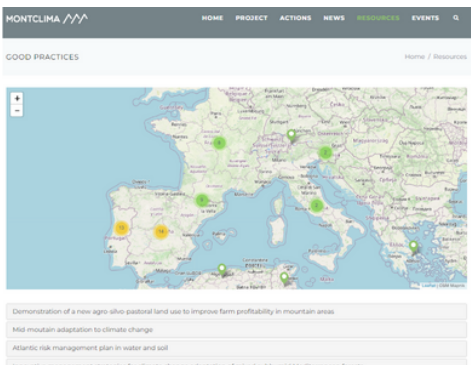


Figure 3: MONTCLIMA natural risk management and prevention best practice viewer.

In parallel, we have carried out the so-called capitalization missions: the 5 most successful practices were selected in order to deepen our understanding of their work methodology and implementation details through interviews and on-site visits (<https://www.montclima.eu/en/capitalization-missions>).

On the other hand, MONTCLIMA has developed a cartographic viewer on natural hazards and climate change in the SUDOE mountains. It is a web mapping tool that allows to valorize and aggregate in a single application all the available information on the past, present and future (potential) vulnerability of these mountain territories. Thanks to this mapping tool, more than 200 datasets of information on past and future vulnerability to the 4 hazards under study have been valorized. In addition, specific layers have been generated with all the cartographic details of the 6 MONTCLIMA pilot cases.



Figure 4: Example of 2020 PHUSICOS project sheet resulting from capitalization missions

The analysis tool that integrates this map viewer also allows customized queries on the observed and projected evolution of the 4 natural hazards, whose results can be downloaded in several formats (<https://www.montclima.eu/en/geoportal>).

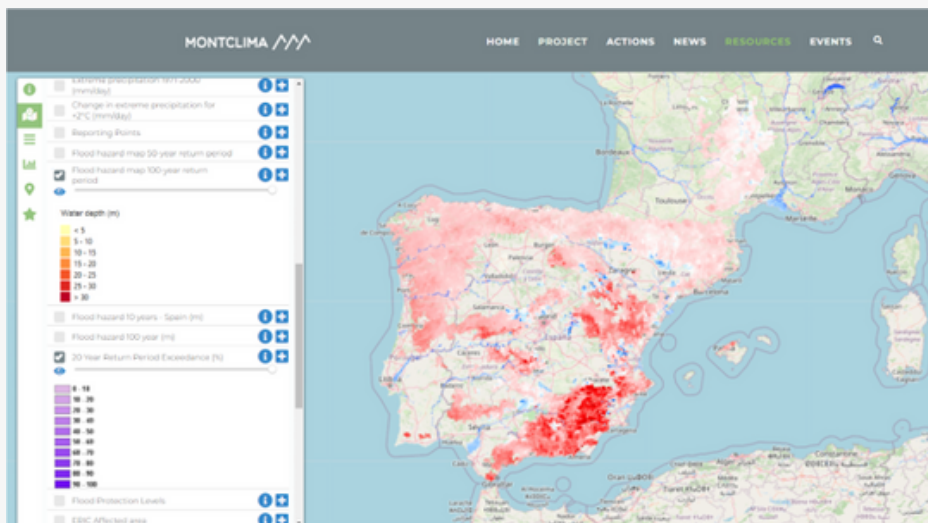


Figure 5: the MONTCLIMA map viewer, with more than 200 datasets of information on erosion, floods, fire and drought hazard.

Finally, MONTCLIMA carried out a technical and legal analysis of risk management in the SUDOE territories. This study, resulting from the joint collection and analysis of all the partners, made it possible to identify the strategic guidelines in terms of governance, administrative organization, sources of funding in terms of risk management and prevention in the SUDOE territory. In addition, it made it possible to identify some key links between climate policies and risk management tools in the territories studied. This analysis resulted in the elaboration of a technical and legal report on risk management and prevention in the SUDOE territories (<https://www.montclima.eu/en/deliverables>).

The second pillar of MONTCLIMA has consisted of the development of a Transnational Strategic Framework to improve the management and prevention of natural hazards in the mountain areas of the SUDOE (<https://www.montclima.eu/en/deliverables>).

The objective of this document is to provide mountain territories with a series of strategic and operational recommendations for improving the management and prevention of natural hazards directly linked to climate change. This framework document is intended to serve as an inspiration for the integration of improvements and new approaches at all levels: to better understand the risks including the consideration of climate change and the multi-risk approach, to reduce the vulnerability of goods and people and to mitigate the impacts of these episodes by benefiting from transnational cooperation.

The document, the result of a collaborative co-creation process involving the project partners, associated partners and key stakeholders in the prevention and management of natural hazards in the SUDOE territories, was elaborated based on all of the project's actions.

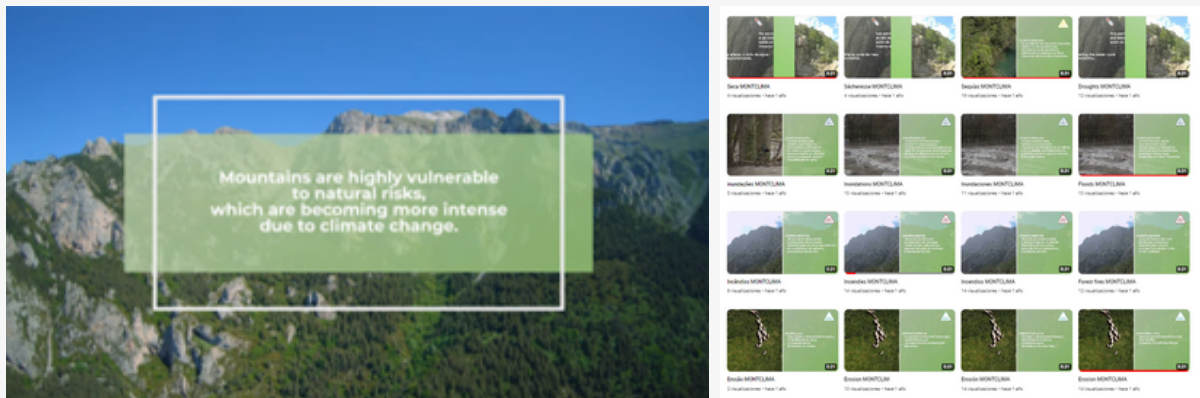


Figure 6: visit the audiovisual information on risks and mountain areas on the youtube channel OPCC (<https://www.youtube.com/channel/UCWCLPjJcTuZmxWlaQ3qz99g>)

On the one hand, the results of the CAPITALIZATION action have allowed us to illustrate the framework with success stories and concrete good practices. In addition, the findings of the legal and regulatory analysis of risk management at the level of the entire study area have also been integrated.

On the other hand, the transnational strategic framework has also considered the conclusions and lessons learned in the 5 international TRANSFERABILITY seminars, during which, internationally recognized experts in the evaluation, management and prevention of the 4 hazards addressed in MONTCLIMA have participated.

Finally, the 6 DEMONSTRATIVE PILOT CASES have allowed to assess some of the operational recommendations for the improvement of the management of these hazards, illustrating the document with inspiring demonstrative experiences to improve the resilience of mountain territories against natural and climatic hazards.

DEMONSTRATIVE PILOT CASES

An action is worth a thousand words. Moreover, many of the innovative recommendations to improve risk management and prevention need to be tested on a small scale before they can be deployed on a larger scale. MONTCLIMA has therefore defined 6 concrete action plans to address the natural and climatic challenges of different representative mountain areas in Southwest Europe. These 6 action plans have been tested and validated through the implementation of 7 experimental pilot sites. Each pilot has been complemented by the drafting of specific action report, containing practical advice and technical details on how to replicate the strategies adopted in each action plan in other sites.

The lessons learned through the deployment of the pilot experiences have set the guidelines for the strategic framework to improve resilience to each risk, with special emphasis on the governance and monitoring of the process.

The MONTCLIMA pilot cases are:



Application of adaptive forest management in the Montnegre corridor natural park to reduce forest vulnerability to fire risk.

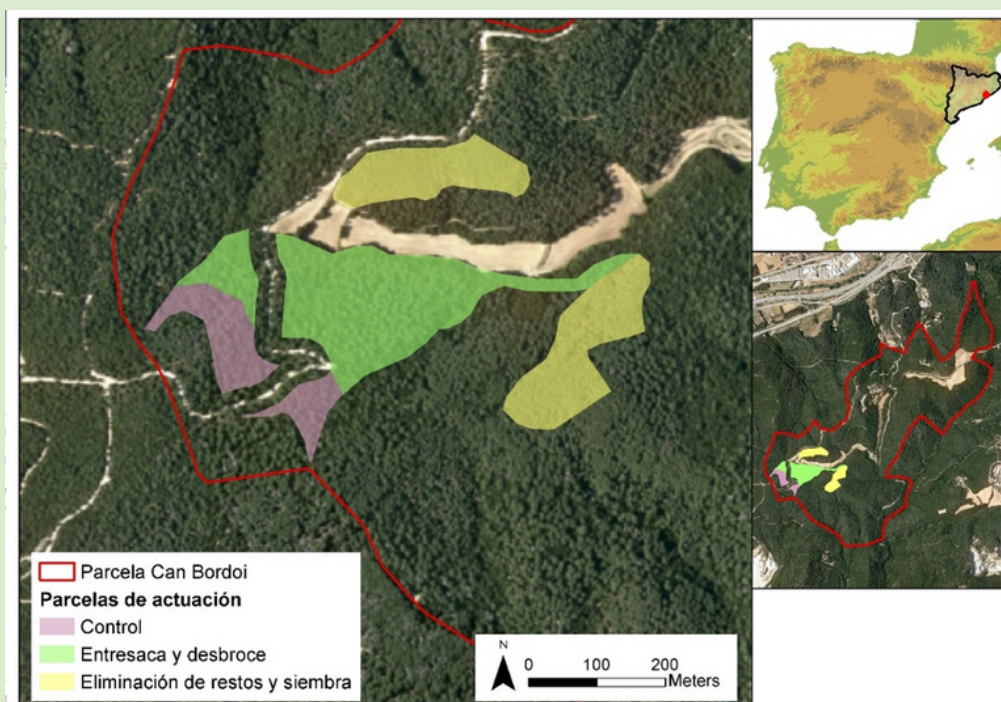


Figure 7: Delimitation of the action plots within the Can Bordoï property. Source: CREAM

This pilot test has been carried out in a Mediterranean Holm oak forest in the Montnegre-Corredor Natural Park (Catalonia, Spain) with the objective of reducing the vulnerability of the forest to fire risk.

DEMONSTRATIVE PILOT CASES

The experimental trial consisted of applying adaptive forest management measures in a Strategic Management Point (SMP) for the control of large forest fires.

The SMPs are places in the territory where the modification of the fuel and/or the conditioning of the infrastructures allow the extinguishing services to carry out safe attack maneuvers that reduce the advance of a large forest fire. In this sense, they represent spaces that, due to their spatially strategic location, have a key role as a protective effect on a relevant area of the Natural Park. The pilot test has been carried out in the Can Bordoi estate, which has an area of 214 ha. Within this farm, the test was carried out in the southwest corner, since in case of a large forest fire coming from the west, which would be the most likely in the area, the actions would have the ability to reduce the intensity of the fire, thus facilitating the firefighters' extinguishing tasks and preventing the flames from spreading to the rest of the massif.



Figure 8: Initial state of the Can Bordoi holm oak forest (left) and final state (right) after the application of adaptive forest management

Thanks to this MONTCLIMA experimental site, we have been able to prove that adaptive forest management measures applied in strategic locations in mountainous areas can act as a barrier to the advance of large fires, also allowing to strengthen the resilience of the forest mass against the impacts induced by droughts.



Evaluation of the use of spontaneous cover crops to mitigate erosion risk in vineyards.

Soil is a finite and non-renewable natural resource that provides key ecosystem or environmental services. Soil degradation is one of the greatest threats of the 21st century.

DEMONSTRATIVE PILOT CASES

Soil degradation processes have already affected 33% of the Earth's land surface, which is leading to a significant reduction in soil quality and functionality. Among the soil degradation processes, water and wind erosion are the most important.

Within the framework of the MONTCLIMA project, a study of soil erosion has been carried out in a vineyard in Rioja Alavesa with a high risk of erosion due to its topography. However, the study area is representative of the general situation of vineyards in the Rioja Alavesa, since most of them are located in areas with steep slopes. In this sense, it is essential to find specific soil management measures to reduce erosion, also considering that in a scenario of climate change, it is expected that the risk of water erosion will be accentuated by changes in the rainfall regime.

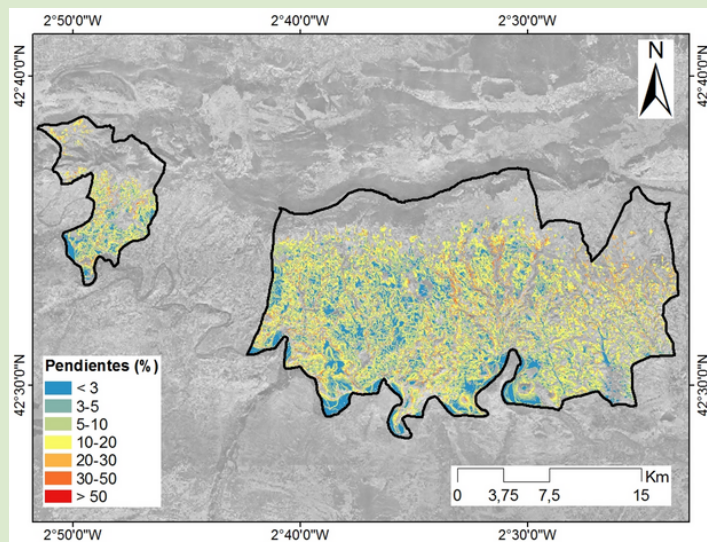


Figure 9: Map of slopes in the vineyards of Rioja Alavesa. Source: NEIKER



Figure 10: Image of the Gerlach boxes installed in the plot. Source: NEIKER

With MONTCLIMA, we have been able to demonstrate that soil management in vineyards through spontaneous vegetation cover, is a highly effective measure against soil loss. Furthermore, it has been proven that this type of soil management strategy does not affect the quality and quantity of the harvest, nor the organoleptic properties of the final product.

DEMONSTRATIVE PILOT CASES



Implementation of adaptive forest management measures to limit fire risk in a forest with an important defense function against gravitational events (block falls)

In Andorra, the Pyrenean Country, forests occupy more than 40% of the territory and play a fundamental role in the prevention of risks such as landslides, snow avalanches or torrential lava flows. Therefore, the development of mitigation strategies is very important and can be carried out through the study and analysis of natural disasters, but also through the assessment of their impacts. In Andorra, as in many mountain territories, mitigation strategies focus on a multi-risk approach to the actions to be implemented, since, for example, a forest for protection against falling blocks is also subject to fire risk.

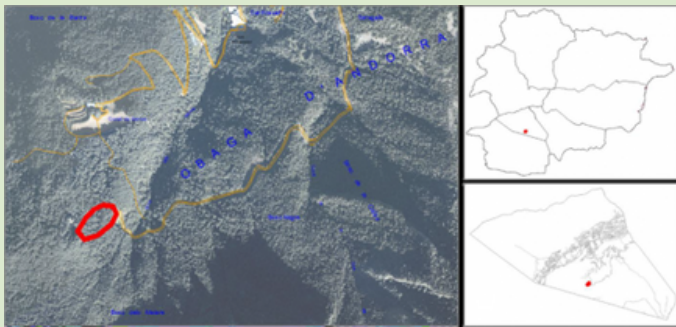


Figure 11: General location of the study area within the Principality of Andorra and the northern slope of the parish of Andorra la Vella. Source: AR+I

This pilot test has focused on designing and implementing measures for adaptive forest management to enhance the protective role of a forest against the risk of falling boulders.

However, the forestry intervention has also been designed aiming at the co-benefits of these forestry actions on the improvement of forest resilience against wildfire risk. In particular, the action has included silvicultural works in a forest of protection against falling blocks located in the parish of Andorra la Vella, in the area of La Comella, very close to important population centers. In this forest of protection against falling blocks, located near a recreational area, it has been possible to reduce the risk of forest fires as well as the magnitude of these in case of occurrence.

By doing so, it is intended to preserve the protective function of this forest mass even in the event of fire.



Figure 12: Left: pruning of the shrub layer; the left side shows the initial height of the boxwood / Right: shrub layer after the intervention. Source: AR+I.

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Application of nature-based measures to limit erosion and flood risk in a protected mountain area.

This pilot action, also developed in Andorra, aims to mitigate the risk of floods and torrential lavas in the Madriu-Perafita-Claror valley. The pilot area is located in the culminating zone of a UNESCO protected area. This area is dominated by gullies and rocky areas with some patches of sparse vegetation. During heavy rainfall events, mudflows often affect populations directly and indirectly. In particular, this site has suffered numerous drinking water supply cuts due to incidents caused by mudslides in the water treatment plant downstream.



Figure 13: Pilot site of revegetation conducted in 2015 (top) and revegetation conducted in 2016 (bottom).

The strategy applied thanks to MONTCLIMA consisted of implementing a combination of nature-based measures. On the one hand, degradable dikes were installed in the main ravine channels to limit water erosion. In addition, the area was also revegetated by sowing wild seeds of *Festuca eskia*. The area was fertilized in a natural way with the passage of livestock, also allowing the land to be adapted for planting. This combination of nature-based measures has proved effective in reducing the risk of erosion in a protected area, where gray or infrastructural mitigation measures are not possible.



Pilot case in the eastern Pyrenees: qualification of erosion phenomena after a fire

Forest fires are an increasingly important problem in the mountains of the Mediterranean region. Rainfall shortly after a fire can cause significant damage in terms of runoff volume and material transport.

DEMONSTRATIVE PILOT CASES

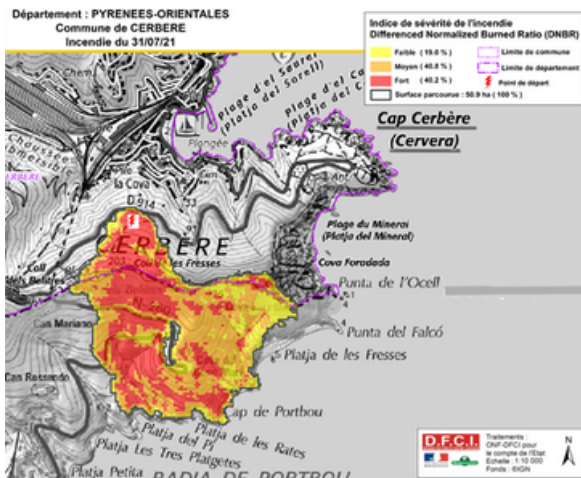


Figure 14: Location and extent of the Monze forest fire, pilot case study area. Source ONF

In this pilot case of MONTCLIMA, a study was first realized on the impact of fires on forest vegetation and their consequences on erosion and torrential risks. Then, an initial assessment was conducted on the impact of a large fire that occurred in the municipality of Monze (Aude department) on August 14, 2019. In a second phase, instrumentation was installed on several key sites in the municipality of Cerbère (Pyrénées-Orientales department), which suffered a 50 ha fire on July 31, 2021.

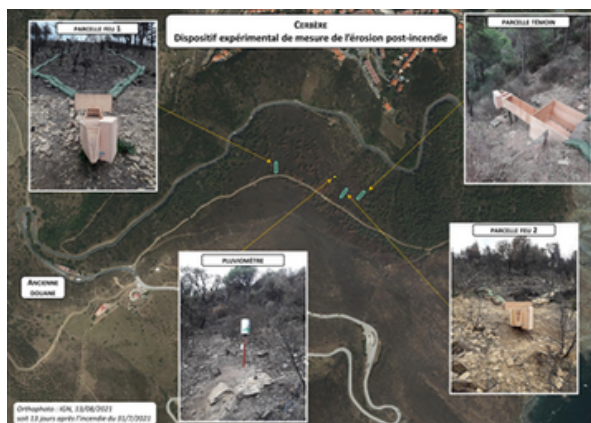
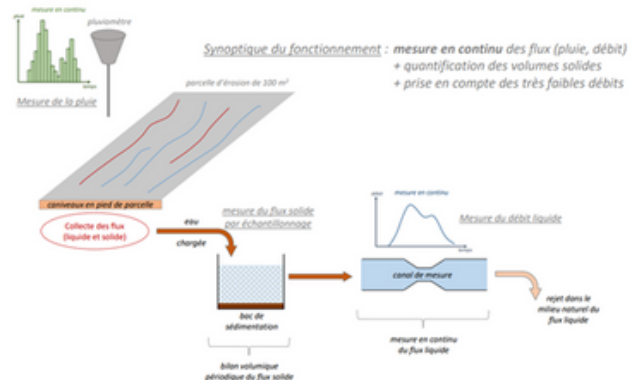


Figure 15: Location of the experimental devices and synoptic scheme of the experiment operation. Source: ONF



To better understand the mechanisms of soil water erosion, three experimental plots were installed in September 2021. The installed instrumentation allowed the monitoring of rainfall events during a hydrological season. During the 2021-2022 hydrological season, measurements of rainfall, flow rate, water height and sediment quantities were taken. Thanks to the actions carried out in this pilot case (bibliographic phase, the Monze fire feedback study and the instrumentation of the burned plots in Cerbère) MONTCLIMA has further deepened the definition of the guidelines necessary to improve the mitigation of the torrential risk induced by the occurrence of forest fires.

DEMONSTRATIVE PILOT CASES



Pilot case in the eastern pyrenees: evaluation of the erosion phenomena in a torrent after an extreme storm

In January 2020, the eastern part of the Pyrenean Mountain range was hit by the storm Gloria, which provided an opportunity to deepen the knowledge of erosion phenomena during torrential rains within the framework of MONTCLIMA. The ONF-RTM partner is monitoring a large number of sites in the Pyrénées-Orientales department. One of them is located in the basin of the Bailemarsanne torrent (tributary of the Têt river).

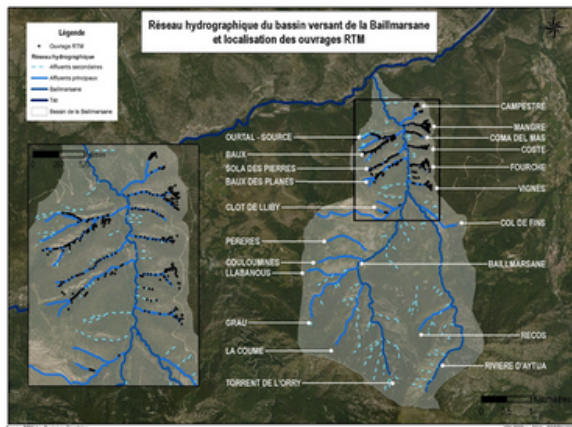


Figure 16: hydrographic network of the study area, the Bailemarsanne basin. Source: ONF-RTM

In 2017, a first mapping campaign was conducted using LIDAR (a device that allows determining the distance from a laser emitter to an object or surface using a pulsed laser beam). Given the good results obtained from this first LIDAR scan, it was proposed to carry out a second campaign in 2022 through MONTCLIMA, with the objective of carrying out a hydro-sedimentary assessment of the headwaters of the basin, known for the high intensity of erosive phenomena.

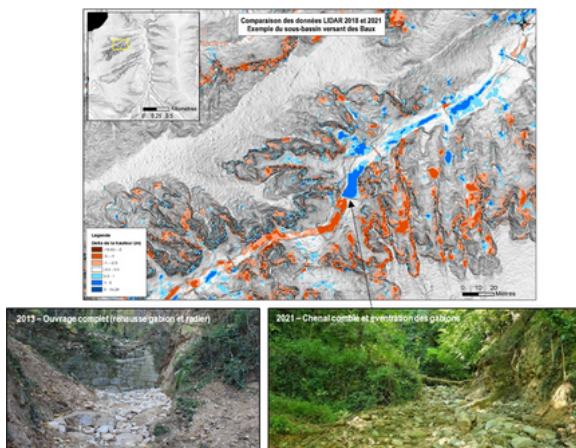


Figure 17: Comparison of LIDAR data between 2018 and 2021 (blue represents deposition zones and red represents erosion zones). Source: ONF-RTM

In the first place, orthophotographs and shadings made before and after the Gloria storm were visually compared. Thanks to these techniques, it was possible to accurately identify the changes in erosional and depositional formations linked to Gloria. The quantification of the soil erosion phenomenon and the estimation of the accumulation of materials constitutes a second line of work. With this type of technology it has been demonstrated that it is possible to process data at various scales, from a catchment scale to a very specific area,

making it possible to quantify the volumes of erosion and accretion during a given period or even after a specific event. This type of data processing is even more interesting in catchments prone to erosion after heavy rainfall. The comparison of longitudinal and transverse profiles over different time periods makes it possible to highlight sectors of bank recession or even the elevation of a bed in a particular torrent, even on a very localized basis.

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Territorial resilience to risks in the mountain areas of the valentin valley

The Valentin valley, located in the municipality of Les Eaux-Bonnes in the western French Pyrenees, is an area where all types of natural hazards coincide. It is therefore an ideal pilot case for the definition of multi-hazard strategies to increase the resilience of a mountain territory. The first step of this case study was the definition of a detailed inventory of the various risks that converge in this area of the French Pyrenees. This required the identification, collection and aggregation of information from historical avalanche reports, press articles, archives and records, as well as from the events database of the French state service RTM/MTES or from local witness testimonies and statements.

A total of 680 events have been recorded over the last two centuries, including 604 avalanches, 33 landslides and mudflows, 33 torrential events and 11 rockfalls. The potential runoff risk map produced by the CEREMA partner using the EXZECO method has made it possible to complete this inventory of natural phenomena in the valley.

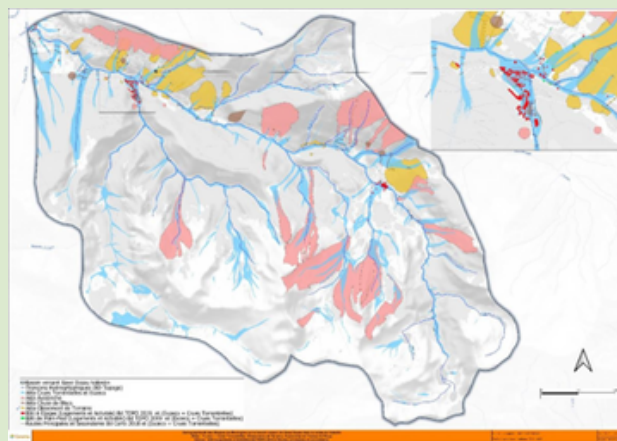


Figure 18: Detailed mapping of natural hazards in the municipality of Les Eaux-Bonnes. Source: CEREMA

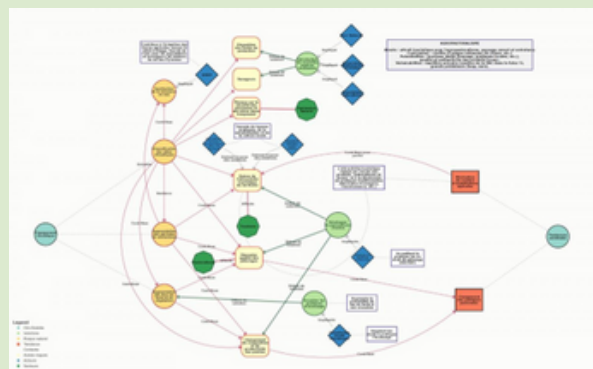


Figure 19: Causal diagram of the effects of natural hazards and climate change on the agropastoralism sector in Les Eaux Bonnes. Source: participatory process with the local community of the municipality of Les Eaux-Bonnes.

Following this first diagnostic phase, a prospective support process was initiated with local authorities and other stakeholders to jointly define and prioritize measures

to increase the territory's resilience to natural hazards. This participatory process, supported by the use of the "resilience compass" methodology, made it possible to make the most of local knowledge and the inspiring experiences of other territories, to define and catalogue concrete, consensual and prioritized actions among all the stakeholders involved

Thanks to this "participative laboratory", it was possible to define the premises of an action plan that takes into account the impacts of climate change on the management of natural risks in the mountains, as well as the interrelation between natural risks.



The fourth pillar of MONTCLIMA is to ensure the transferability of project results through transnational thematic seminars and field visits to pilot actions. Five transnational thematic seminars were organized, with a participatory approach aimed at nurturing the engagement of all relevant stakeholders in the areas studied. Each of them was organized to create a space for exchange and transfer of tools and lessons learned, aimed at improving the management and prevention of the 4 hazards under study in the mountains of Southwest Europe.

Each transfer seminar was also attended by key actors in the field of natural hazards in the European territory. These invited speakers aimed at establishing the state of the art of the evolution, management and prevention of each of the natural hazards at different scales: from the European to the national scale, and finally at the local scale.

- The link between **natural hazards and climate change** in mountain areas of the SUDOE territory, Soria
- **Fire risk** management and prevention in the SUDOE mountains, Leiria
- Strategies for the **management and prevention of drought impacts** in the mountains of the SUDOE area, Barcelona
- Strategies for **soil protection** against the impacts of climate change: erosion risk and carbon sequestration, Bilbao
- Strategies for **flood risk management and prevention** in the SUDOE mountains, Andorra.

Each seminar has an associated transfer report that provides a detailed description of the elements discussed in these spaces for exchange and transnational cooperation.

Download the reports here:

<https://www.montclima.eu/en/deliverables>



CONCLUSIONS

Mountain areas are among the territories most affected by natural hazards. Moreover, some natural hazards are expected to increase in frequency and intensity due to the effects of climate change in the coming decades (more severe droughts, higher average temperatures, changes in precipitation patterns), and southwestern Europe is particularly exposed. These risks know no administrative boundaries and require transnational coordination.

The MONTCLIMA project has developed a transnational strategic framework for the prevention and management of natural hazards in mountain areas for the SUDOE territory. Based on the analysis of current prevention and management tools, as well as the capitalization of virtuous projects and initiatives in the field, MONTCLIMA has been able to summarize the main strategic and operational recommendations to improve the resilience of mountain territories. In this regard, the multi-risk approach, transnational cooperation, the capitalization of good practices and the testing of strategies through representative pilot cases have provided the necessary ingredients.

Some innovative elements of MONTCLIMA are particularly noteworthy, such as the ability to design and test 7 pilot experiences for the implementation of solutions and action plans to improve the management and prevention of natural hazards. In turn, the robustness of the recommended strategies through the analysis and integration of lessons learned from previous projects and the capitalization of existing resources. The creation of a new cartographic viewer MONTCLIMA is also a useful tool for managers and to raise awareness of the so-called risk culture. This tool has made it possible to gather in a single application all the relevant information on these 4 risks in the mountain areas of the SUDOE and make it available to the public.



PARTNERS AND ACKNOWLEDGEMENTS

The Climate Change Observatory, an initiative of the CTP (Working Community of the Pyrenees) is grateful to the whole MONTCLIMA partnership for its collaboration and good work, as well as to the SUDOE Joint Secretariat and the Spanish, French and Portuguese Management Authorities for their trust and commitment to this type of project, which is essential for the progress of a more resilient society based on knowledge and efficient management, helping to highlight the mountain territory.

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