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ADAPTATION TO CLIMATE CHANGE

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Cross-border cooperation for climate-resilient mountain areas in France, Spain and Andorra

Adapting the Pyrenees mountains to climate change through knowledge transfer

Knowledge is the basis for informed decision-making. A holistic approach enables transnational cooperation for climate-resilient land management.

Key Learnings

- **Resilient Natural Area Management**: Innovative information tools support continuous monitoring and understanding of the water cycle, enabling improved water resource management in the Pyrenees. Specific case studies illustrate concrete actions in priority sectors.
- **Mountain Economy Adaptation**: Strategies and models help ski resorts and mountain tourism areas adapt to climate change. An innovation hub encourages circular economy solutions and cross-border tourism offers, which are tied to sustainable mobility in Pyrenean tourism.
- **Multilevel Governance**: Multilevel governance adapted to the new needs of the Pyrenean Climate Change Strategy ensures vertical and horizontal coordination with local, regional, national, and European climate adaptation policies.
- **Knowledge Transfer and Replicability**: The strategy promotes synergies between mitigation sectors, integrating climate change into broader policy areas. The Pyrenean Climate Change Strategy (2018-2024) raises European and international awareness of the unique climate challenges mountain regions face and highlights the cross-border character of the Pyrenees. Demonstrative pilot cases successfully connect technical knowledge with concrete action on the ground and effective communication engages local actors.

About the region

The Pyrenees are a transnational mountain range, bordering France, Andorra and Spain. The mountain range stretches approximately 430 km across seven regions (Navarra, Aragon, Catalonia, Basque Country in Spain, Andorra, and Nouvelle-Aquitaine and Occitanie in France). Its highest peak, Aneto, is in Spain at over 3,400 metres above sea level. The mountain range harbours unique biodiversity and provides multiple ecosystem services to its inhabitants, notably water resources, as it crosses seven Water Confederations. The protected areas and natural parks spread across the mountain range feature biodiversity hotspots. Human activity such as settlement development and climate change are threatening those valuable natural assets. In addition, the southernmost glaciers of Europe are in the Pyrenees, which are iconic elements of this mountainous landscape. In the last 40 years, half of these glaciers have disappeared and the remaining 19 are retreating more and more rapidly.

Climate Hazards

Ice and Snow, Storms, Extreme Temperatures, Flooding,

Droughts

Sector

Mountain Areas, Water Management, Land use Planning,

Disaster Risk Reduction, Tourism

Key system

Water Management, Ecosystem and Nature Based Solutions

Figure 1: The Pyrenean Mountain Raing. Image Credit: Britannica.

Climate Threats

Climate change is increasingly affecting mountain ranges. In the Pyrenees, average temperature has risen by more than 1.2 C since 1959, while rainfall has decreased, especially on the southern slopes. In the extreme summer of 2023, mountain refuges like Panticosa broke new temperatures record with up to 31.5 °C at over 1,600 m altitude, causing heat strokes among hikers. This trend has led to a sharp retreat of glaciers (90% lost since 1850), a significant reduction in snow cover (−16 days/year), and a 15–20% drop in river flows, deeply disrupting the water cycle. At the same time, ecosystems are shifting upward in altitude, biodiversity is declining, and forests are increasingly under pressure. Socioeconomically, these changes are already affecting agriculture with lower yields and higher irrigation demands, and tourism is suffering from a significant loss of ski days.

Looking ahead, intensifying impacts are predicted: temperature could rise by up to 7 °C (compared to the of 1960-1990 average), glaciers may disappear before 2050, water availability will decline, ecosystems will be transformed (high-altitude ecosystems may experience species loss, upward range shifts, and changes in structure and function due to rising temperatures and reduced snow cover), and key economic

sectors like skiing and extensive livestock farming face serious threats. Those changes require urgent, cross-cutting adaptation.

An integrated Climate Change Strategy for regional cross-border adaptation

In response to the climate challenges particularly affecting high mountain ecosystems, mountain tourism, and mountain water resources in the Pyrenees, French and Spanish regional authorities, and the State of Andorra collaborated. As climate change goes beyond administrative borders, the regions and the state formed the Observatory of Climate Change (OPCC) and implemented cross-border cooperation through the Working Community of the Pyrenees. This public consortium developed a transnational governance framework and the Pyrenean Climate Change Strategy (EPiCC), which is Europe's first adaptation strategy following a systemic approach to address action-based cross-border cooperation and climate adaptation in mountain areas.

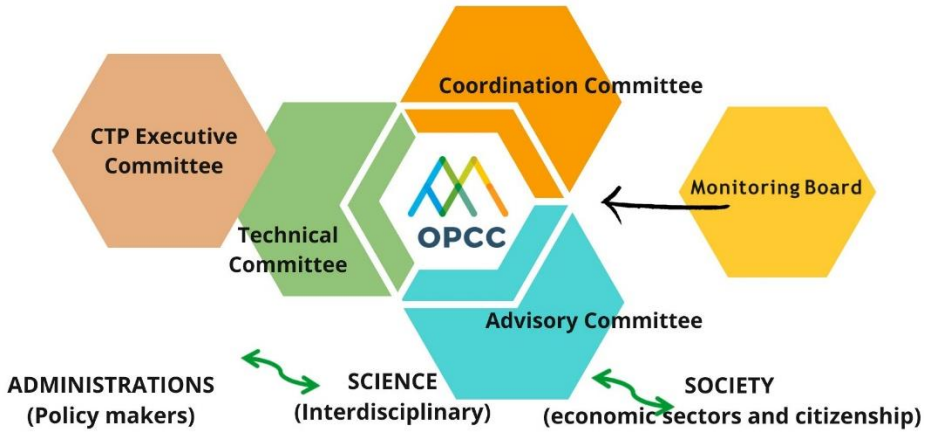

Figure 2: multilevel governance for effective cross border adaptation actions in the mountain range. Image Credit: PYRENEES4CLIMA.

- The approval of the **EPiCC** marks a major milestone for **cross-border climate action in mountain regions**. It has enabled the adoption of a **shared roadmap** that sets clear priorities for climate action across the Pyrenees.

- **Endorsed by all Pyrenean regions**, the strategy reflects a strong, collective commitment to **climate change adaptation**. Through the participation of more than **700 representatives** from key sectors and stakeholder groups, a **consensus-based action plan** was developed, identifying **72 priority lines of action** to strengthen the resilience of Pyrenean ecosystems and communities. This process was supported by the **European Commission** through a **LIFE technical assistance project**.

- Backed by a robust climate community representing all relevant sectors, these actions have become the **foundation for implementing the Operational Plan**. Building on this momentum, the approval of the **integrated LIFE project**, co-financed with **€12 million**, is now proving essential to the **deployment of climate action plans** and **33 pilot demonstration projects** across the entire transboundary Pyrenean region.

- This multi-level, multidisciplinary partnership ensures that climate actions have a real, coherent, and technically and politically supported impact.

Four fundamental pillars should strengthen climate resilience in the Pyrenees by 2030:

1. ***Implementation of the Pyrenean Climate Change Strategy***: The project actions operationalise the Strategy, ensuring that its objectives are translated into concrete on-the-ground adaptation measures.

2. ***Cross-border climate governance***: Coordinated governance among territories, administrations, and sectors reinforces cooperation between France, Spain, and Andorra, and integrates climate action into public policies at multiple levels.

3. ***Integrated territorial action***: Supporting the implementation of pilot adaptation and mitigation measures in key areas such as water, forests, biodiversity, natural hazards, and tourism, focuses on scalability and replicability.

4. ***Knowledge, awareness, and participation***: Fostering the production and dissemination of accessible scientific knowledge, climate education, communication, and the active involvement of citizens and local actors boosts transformational climate change adaptation, which fosters long-term adaptation.

To generate and transfer knowledge across disciplines and territories, identifying good practices based on lessons learned from a series of past climate change adaptation projects is key.

Case studies demonstrate effective climate adaptation

Implementing pilot cases allows testing innovative approaches and fosters collaboration between science, policymaking, implementation and society. The LIFE PYRENEES4CLIMA project has developed 33 pilot demonstration cases, conceived as “lighthouses” or beacons of adaptation. These initiatives showcase innovative, transferable solutions that strengthen climate resilience across the Pyrenees and serve as models for other European mountain regions.

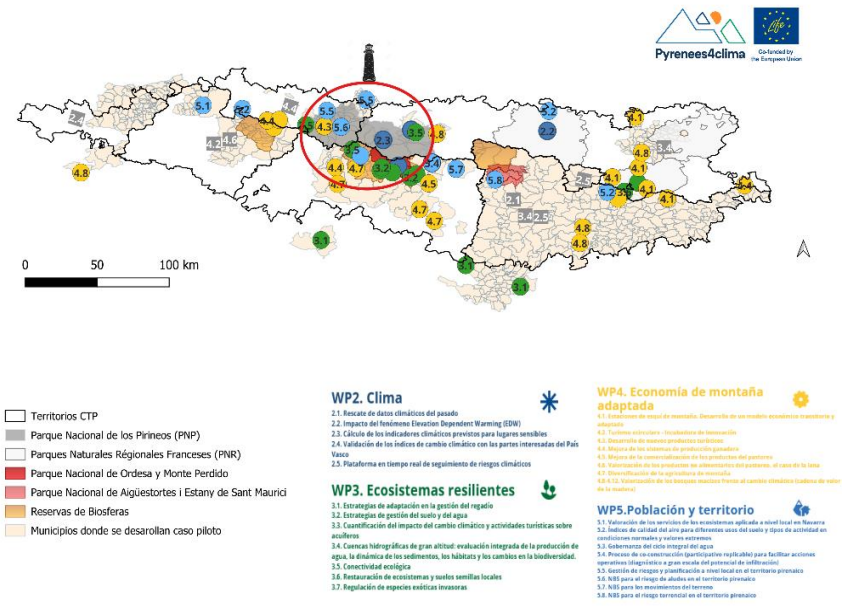

Figure 3: Distribution of pilot cases across the Pyrenees. Image Credit: PYRENEES4CLIMA.

Organised into five key adaptation systems – climate, resilient ecosystems, adapted mountain economy, population and territory, and governance – the pilots address complementary aspects of cross-border climate action. In the climate system, one pilot develops advanced observation and modelling tools to anticipate impacts and guide territorial planning – a methodology easily replicable in other mountain areas. Within resilient ecosystems, restoration and monitoring actions in high-mountain habitats enhance ecological connectivity and adaptive capacity, offering transferable approaches for biodiversity management. The adapted mountain economy pilot promotes sustainable agro-silvo-pastoral practices that combine local breeds, adaptive grazing and wildfire prevention, linking environmental and economic resilience. In population and territory, a pilot on sustainable mountain tourism diversifies activities and

promotes low-carbon mobility, balancing economic development and environmental protection. Finally, in governance, a lighthouse case fosters multi-level cooperation and citizen participation through shared planning and climate governance models.

OPCC Map viewer: a strategic tool for consolidating and mobilising key knowledge on climate change adaptation across the Pyrenees

Knowledge transfer and making data accessible about innovative pilot experiences and climate observations enhance replicability among all users. The OPCC Map viewer is a cartographic tool to facilitate data accessibility to support informed decision-making by allowing users to visualise and explore key data on climate change in the Pyrenees. It offers maps, indicators, and data layers on variables such as temperature, precipitation, river flow, as well as the evolution of glaciers, peatlands, lakes, forests, fauna, flora, and natural hazards.

Integrating historical data, current observations, and future projections with an intuitive design makes data accessible to technical users and the general public, enabling customised queries and supporting decision-making. Centralising information on adaptation projects and initiatives in the region serves as a key reference point for understanding, planning, and acting on climate change in the Pyrenees.

The **OPCC map viewer** is a **dynamic and continuously updated tool** that compiles key information on completed projects, ongoing initiatives, and pilot demonstration cases. It stands as a **model example** of effective knowledge management: on one hand, it consolidates and preserves essential information on climate adaptation in a single, accessible platform, ensuring its long-term availability. On the other hand, the **methodologies used to calculate many of its indicators are replicable and transferable** to other European mountain regions.

Some of the key themes are:

- ***Glaciers*** shows the evolution and status of glaciers in the Pyrenees, highlighting their retreat due to climate change. It provides accurate maps, historical data and model outputs to better understand the impact of temperature and precipitation shifts on glaciers and their environment.

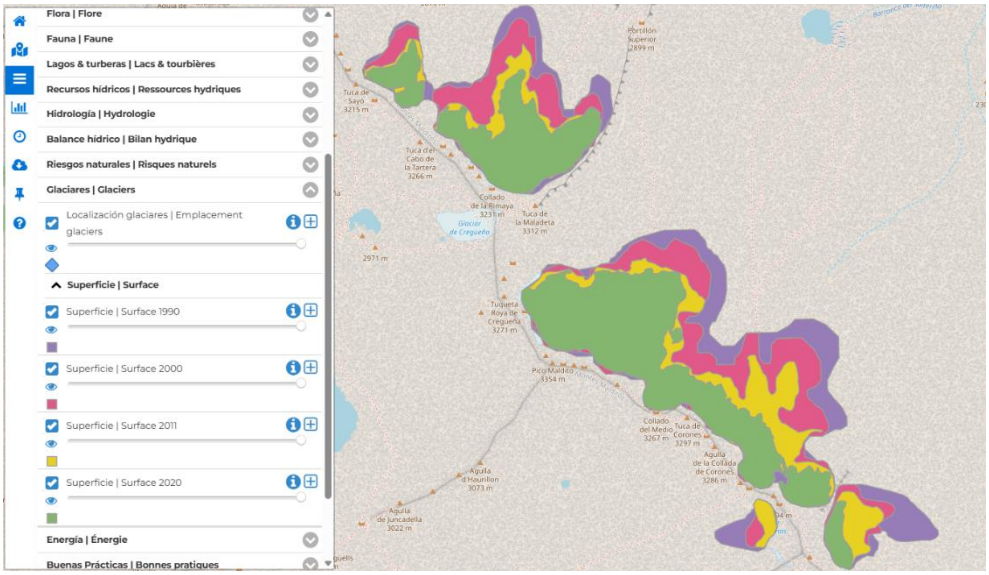

Figure 4: Glacier visualisation. Image Credit: PYRENEES4CLIMA.

- ***Water resources*** provides easy-to-read maps and data on how climate change is affecting water in the Pyrenees. It shows trends in rainfall, river flows, snow, and underground water, helping users understand water availability now and in the future. The tool also lets users explore different scenarios by adjusting time, location, or climate conditions.

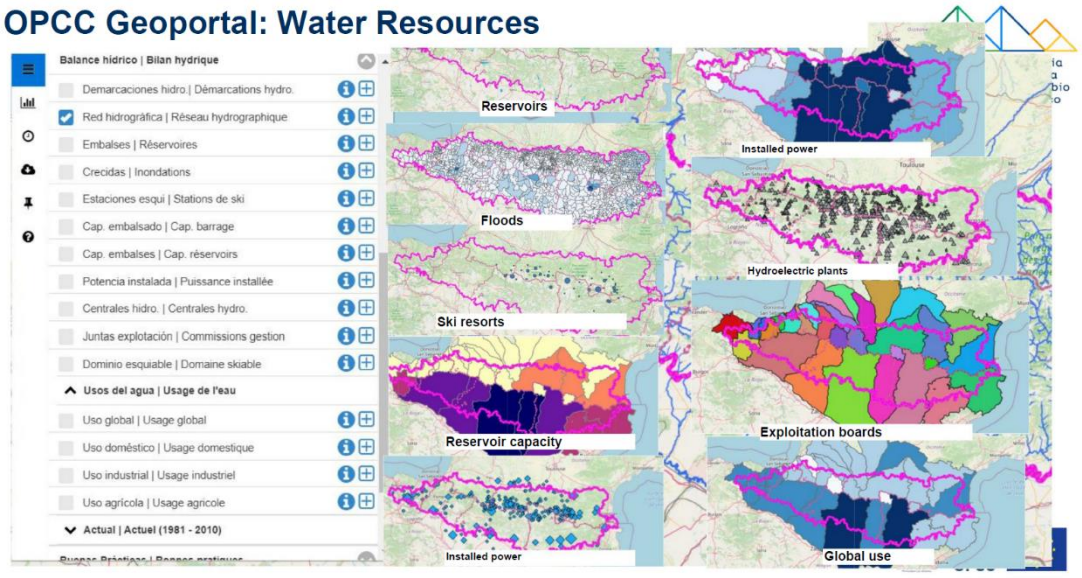

Figure 5: Water Resource Layer depicting different topics under climate change. Image Credit: PYRENEES4CLIMA.

- ***Peat bogs*** *and lakes* are fragile high-mountain ecosystems that help store water, support wildlife, and capture carbon. The tool maps their location, shows how they are changing over time, and highlights threats like rising temperatures and habitat loss. Case studies show how climate and human activity affect these areas.

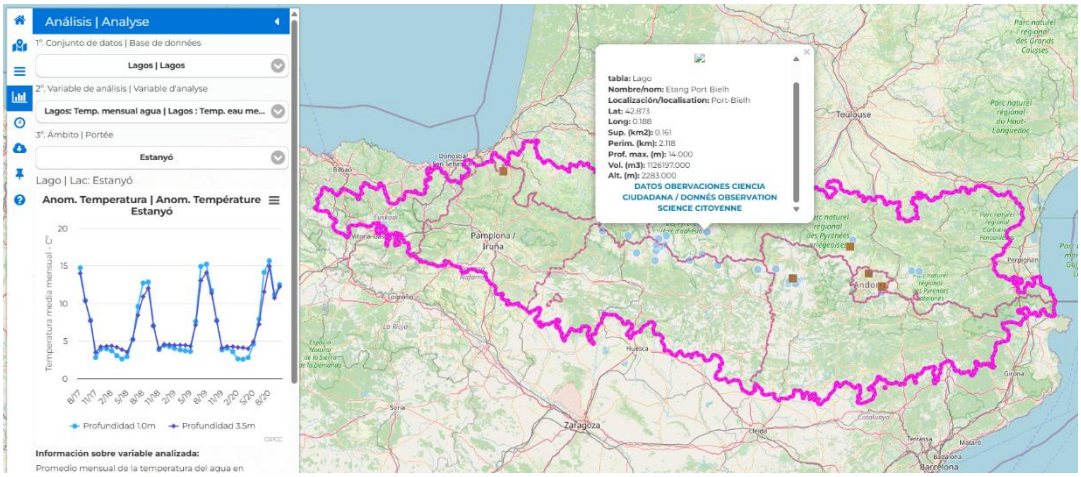

Figure 6: Map of peat bog and lake selection. Image Credit: PYRENEES4CLIMA.

- ***Forests*** shows the distribution, status, and evolution of forest ecosystems. It shows how forests are affected by heat, drought, wildfires and pests, with data on the vulnerability of the 13 main tree species.

Enabling personalised data consultations with six datasets providing more than 60 variables, downloads in various formats, such as maps (shapefile or WMS), databases (xls or txt) and temporal graphs (JPG or GIFF) supports comprehensive adaptation decisions.

“Addressing the challenges of climate change in the Pyrenees through a coordinated, cross-border, and science-based approach supports climate adaptation in mountain regions. An added value lies in an integrative focus, aligning policies, territories, and key sectors to build a more resilient, cohesive, and climate-prepared region. Demonstrative actions, common indicators, and innovative governance tools strengthen cooperation between Spain, France, and Andorra, positioning the Pyrenees as a benchmark laboratory for climate change adaptation in mountain areas.”,

Juan Terrádez Mas (OPCC Project Manager)

Summary

Strengthening water resilience, natural ecosystem management, and sustainable land use in a mountainous cross-border context requires several adaptation measures and a comprehensive strategy. Key actions in the Pyrenean Climate Change Strategy (EPiCC) include adaptive wet and peatland management to preserve their water storage and carbon sink functions, developing early warning systems for floods and droughts, restoring riverbanks and riparian zones to protect aquatic ecosystems, and participatory local-scale water governance to ensure fair distribution of resources. Additional pilot measures involve modelling future water availability under climate scenarios, adjusting agriculture and irrigation practices, and assessing tourism's impact on groundwater, particularly in limestone areas. The OPCC Geoportal data supports these interventions, providing climate indicators, hydrological models, and biodiversity monitoring tools. Together, these measures promote informed, locally tailored, and replicable solutions to the evolving climate challenges in the Pyrenees, leading to the project's success. Strong cross-border collaboration between Spain, France, and Andorra, the active involvement of a broad strategic partner network with expertise in environmental management, territorial planning, and climate science, and a clear commitment to applied science, with data, indicators, and tools support decision-making. Integrating regional governments as active stakeholders in the project, enabling the alignment of climate action with public policies and strengthening each territory's response capacity has been a fundamental element.

Further information

The work presented in this adaptation story is part of the EPiCC strategy and the PYRENEES4CLIMA project.

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