ISCAR

International Scientific Committee on Research in the Alps
Internationales Wissenschaftliches Komitee Alpenforschung
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Mednarodni znanstveni komite za preucevanje Alp

FORUM ALPINUM 26

Alpine Communities and territories in a time of glacier loss and climate change

Book of Abstracts

ForumAlpinum 2026

28–30 May 2026

Aosta Valley, Italy

International Scientific Committee on Research in the Alps (ISCAR)
c/o Swiss Academy of Sciences (SCNAT) - Forum Landscapes, Alps, Parks (FoLAP)
House of Academies - Laupenstrasse 7 - P.O. Box - 3001 Bern - Switzerland
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Organisers of the ForumAlpinum 2026 and the various back-to-back events:

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Session GOV-A

“GOVERNANCE of Alpine territorial systems following glacier loss”

11:00–13:00, Room B2

Mountain area governance in Italy: Bridging legislative frameworks and management realities

Giovanni Vetritto[1]

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Mountain territories constitute a defining feature of Italy's national landscape: beyond the Alpine arc, the Apennine chain extends continuously along the peninsula, shaping the ecological, cultural, and social fabric of the country. Despite this relevance, upland areas have historically been subject to persistent structural disadvantages that demand targeted policy responses. In 2025, the Italian Parliament enacted a new framework law on mountain areas, representing a landmark shift in national policy. The legislation combines formal recognition of the environmental, social, and cultural value of mountain communities with concrete support measures, including fiscal incentives for youth entrepreneurship, newborn bonuses, and preferential mortgage access for teachers and healthcare professionals. A key institutional innovation is the establishment of a National Strategy for Mountain Areas, operating on a triennial cycle and supported by a dedicated development fund, designed to complement and integrate regional strategies within a coherent multi-level governance framework. Of particular relevance to this session is the law's response to the pronounced institutional fragmentation of mountain municipalities. The dispersion of small local authorities across Alpine and Apennine territories poses significant challenges to effective governance and service delivery. The legislation addresses this by promoting inter-municipal cooperation as a strategic governance mechanism, formalising associative arrangements already emerging across upland areas. This contribution examines the governance implications of Italy's new mountain law, situating the country's approach within broader European debates on polycentric governance, subsidiarity, and the administrative reorganisation of mountain territories.

Keywords: multi-level governance, territorial policy, inter-municipal cooperation, mountain areas

Local governance as a means to enhance QoL in Alpine communities

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Quality of Life (QoL) and ways to improve it have long been debated, but less attention has been paid to local governance in these discussions. This issue is particularly relevant to the Alpine Region, considering the emerging challenges, including a shrinking population and the pressures of climate change within a sensitive environmental context. Within this framework, the contribution presents preliminary results from the GovQoL Project, funded by the Alpine Space programme. The project aims to understand how local governance can enhance QoL in Alpine communities by examining five Alpine countries: Austria, France, Germany, Italy, and Slovenia. In more detail, it explores how QoL has been addressed within horizontal governance systems from supranational to local levels, and how local governance can support implementation to improve the QoL of Alpine communities. To do so, the research employs a twofold methodology that combines desk research and empirical interviews. First, desk-based research on supranational, national, and regional policies was conducted to understand general policy frameworks. Then, to explore the practical dimension of governance, 52 interviews were conducted with the municipal representatives to understand how policies have been implemented locally. The findings show a governance gap in addressing communities' needs, particularly in public service provision, and highlight the need to strengthen civic engagement processes to improve QoL in the Alpine communities. Aiming to address these issues, municipalities implement a wide range of policies, initiatives, and governance tools, many of which adopt sectoral approaches that also address future threats such as climate change, ageing populations, and economic conditions. In general terms, while QoL is considered an important policy concern at the local level, more attention is needed on how governance frameworks can effectively address it, avoiding overlapping and institutional bottlenecks.

Keywords: Quality of Life, local governance, Alpine communities

Glacier governance and adaptive planning in the Alps: Tools, methods and scenarios for land-use regulation

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The governance of glaciers and related resources is an emerging field of research and policy, in which cryospheric transformations driven by climate change make high-altitude areas central to adaptation strategies. This contribution highlights how territorial systems, only seemingly independent, are in fact characterized by strong interdependencies between cities and mountain areas, where tourism, water, economic and cultural flows continuously reshape local equilibria, while the emergence of proglacial ecosystems of high ecological value, often lacking adequate protection (Ice&Life), poses new challenges for spatial planning.
The proposal adopts a systemic approach structured in an operational sequence: definition of the territorial system; analysis of flows and actors; evaluation of planning instruments (landscape plans, flood risk management plans, climate strategies); comparative analysis of Alpine governance models (Bavarian Alpenplan, Tyrolean policies, Vorarlberg "White Zones"); integration of monitoring tools, such as the Water Wise project for vulnerability assessment; development of adaptation scenarios; definition of guidelines for land-use regulation; and identification of implementation and monitoring devices.
The analysis highlights the need for adaptive land-use regulation structured into conservation, transition, and controlled-use areas, as well as for dynamic updating of risk maps. It further proposes the introduction of European cryosphere monitoring systems and strengthened geomorphological assessment criteria, in line with the European Glacier Governance Manifesto.
The contribution proposes an operational framework for the governance of Alpine areas based on the integration of scientific knowledge, planning instruments and monitoring systems within a multilevel, polycentric and adaptive perspective.

Keywords: adaptation, risk, ecosystems, governance, land use

Glacier retreat as a trigger for rethinking alpine development and governance

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Glacier retreat is among the most visible impacts of climate change, directly threatening summer glacier skiing (SGS), an activity in continuous decline but still practiced in some Alpine destinations. Although marginal annually, SGS plays a strategic economic role for lift operators, supports local hospitality, and remains an essential training ground for athletes and ski clubs. Gerber et al. (2024) approach this issue with a systems-thinking perspective, showing how glacier retreat and the loss of SGS destabilize lift operators' business models, tourism value chains, youth sport development, and the Alpine identity historically linked to snow sports.

Adaptation responses have largely been technical and incremental. While they reduce short-term exposure, they primarily seek to preserve existing activities and remain weakly integrated into broader climatic and socio-economic transformations. Despite increased awareness and the involvement of research institutions in knowledge exchange and climate strategy processes, structural change remains limited, raising questions about the levers needed for transformative adaptation.

This presentation will examine two questions in the context of accelerating climate change in mountain regions: What institutional, financial, and socio-cultural conditions enable genuine transformation? And to what extent can transdisciplinary approaches move beyond short-term, sector-specific adjustments toward deeper structural change?

More broadly, the decline of summer skiing offers a lens to anticipate future climate challenges in the Alps and reassess mountain habitability. We will present how glacier retreat challenges governance and development pathways, share lessons from Swiss SGS cases, and present transdisciplinary processes that can strengthen sustained local engagement.

Keywords: glacier, tourism, governance, research impact

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From (un)sustainable adaptation to just sustainability transitions: A review of climate change adaptation in ski tourism

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Global warming is impacting tourism around the world (Scott, Hall, et al. 2024), with ski tourism, amongst others, being in urgent need for climate change adaptation (CCA) (Scott & Gössling 2022). Recent accounts stress social, economic and environmental factors. Particularly, justice dimensions and social sustainability in relation to climate change issues in tourism (Rastegar & Becken 2025). In the field of CCA in ski tourism, however, only few articles have addressed this set of factors (Metzinger et al. 2025; Scott et al. 2024). This review aims to analyze and classify the discussion of sustainability in scientific research on CCA in ski tourism to provide a systematic overview of existing accounts. Findings will be critically contextualized in the light of just sustainability transitions, to propose an agenda for further research. We apply a systematic review methodology, analyzing the full academic discourse on CCA for ski tourism. To classify the different conceptualizations of sustainability present in the literature, we employ Aall et al. (2023)´s framework for sustainable CCA. This allows to link CCA in ski tourism to the notions of environmental and social sustainability, transformative change and justice. Preliminary observations suggest that the vast majority of recommended CCAs for ski tourism will fall under conventional CCA, as proposed by Aall et al. (2023). Discussions of social sustainability and justice concerns seem to be largely absent from the debate. Further findings could reveal major research blind spots, highlighting the need to emphasize social sustainability and justice in ski tourism CCA research.

Keywords: adaptation, ski tourism, sustainability, justice

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Session ENV-A

"ENVIRONMENT: The impacts of cryosphere decline on environmental and cultural systems"

11:00–13:00, Room B3

From glacier retreat to proglacial dynamics: A multi-scale, multi-method perspective since the Little Ice Age

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Glacial and proglacial environments are rapidly evolving under climate warming, driving glacier fragmentation, accelerated retreat, and heightened geomorphological hazards. We analyse a glacierized catchment at the head of the Valtournenche Valley (western Italian Alps), integrating historical imagery, orthophotos, repeated Unmanned Aerial Vehicle (UAV) surveys, and field observations. Mont Tabel and Cherillon glaciers have lost ~50% of their area since 1820; around 2005 the upper and lower sectors of Mont Tabel Glacier disconnected, after which mean retreat accelerated from 4.3 m yr^{-1} (1956–2005) to 13.0 m yr^{-1} (2005–2024). The loss of ice flux from above produced a steep, concave, stagnant front, typical of a dead ice body. Annual-scale changes (29 Aug 2024–5 Aug 2025) in the dead ice body and adjacent proglacial plain were quantified from paired 0.05 m UAV-derived DEMs following error assessment. The dead ice body and its ice cliff experienced the largest volumetric and surface-elevation losses (-5.18×10^4 m^3 and -5.67×10^4 m^3), while the proglacial plain showed a net gain of $+2.19 \times 10^3$ m^3, reflecting reworking and deposition of debris sourced from degrading ice. Increased availability and downstream transfer of loose sediment raise the likelihood of hazardous mass transport events, as illustrated by the June 2024 episode. Our results provide new insights into the evolution of an alpine glacial–proglacial system, demonstrating how glaciers fragmentation, stagnation, melt, and sediment redistribution can rapidly reshape geomorphology of high-altitude environments and escalate hazard potential.

Keywords: glacier fragmentation, geomorpholgical changes, UAV surveys

Effects of climate change and glacier retreat on different proglacial landscapes and high alpine landscapes in the Austrian and Italian Alps

Katharina Ramskogler[6], Mattia Sartori[1], Florentin Hofmeister[2], Gabriele Chiogna[3], Svenja Conzelmann[6], Andrea Danler[4], Thomas Fickert[5], Andrea Fischer[6], Tobias Heckmann[7], Toni Himmelstoss[7], Ben Marzeion[8], Madlene Pfeiffer[8], Norbert Pfeifer[10], Philipp Rastner[9], Camillo Ressl[10], Christian Unterhofer[11], Michael Becht[7], Erich Tasser[1]

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Due to climate change glaciers are retreating faster, releasing areas for ecosystem development. Since 1850, mean annual temperatures have increased by more than 2 K in the Greater Alpine region. Trends in precipitation differ between regions, and evidence shows a rising frequency of heavy precipitation capable of triggering geomorphic disturbance. These processes and land-use change alter vegetation dynamics and drive shifts in plant community assemblages. Thus, we analysed the vegetation dynamics, including total vegetation cover and plant species richness across eleven different study sites of the Central European Alps and one in the northern limestone Alps, to address the following research questions: (i) Which environmental factors have the greatest impact on the distribution of plant communities, overall vegetation cover, and species richness? (ii) To what extent does geomorphic disturbance promote certain plant families and affect therefore vegetation assemblage? (iii) How does land-use change affect vegetation assemblage? To answer these questions, we applied non-metrical multidimensional scaling including a permutational multivariate analysis of variance and generalised mixed models as well as linear models in combination with path analysis, and effect size calculations. Our results revealed that besides climate and soil development land-use change, geomorphic processes, and lithology highly influence plant community distribution. Vegetation cover and species number are affected by climate, edaphic conditions as well as time since deglaciation, lithology and different process domains, and their interactions. Disentangling the effects of climate and land-use change showed that total cover was stronger affected by land use change rather than by climate change.

Keywords: climate change, vegetation, Alpine environment, proglacial, land-use change

Climate change and mountains: A study on snow depth and water equivalent in Aosta Valley from 2007 to 2024

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In recent decades, the urgency of understanding and quantifying climate dynamics has become increasingly evident, particularly in mountain environments, which are among the most sensitive systems to variations in temperature and precipitation. Snow plays a key role as a water resource and as climatic indicator, being one of the most vulnerable components of mountain ecosystems. As a natural asset at risk, snow is strongly affected by global warming and shifting precipitation regimes. Mountain regions provide clear natural laboratories for observing climate change, with rising mean temperatures manifesting more rapidly than elsewhere.
This study analyzes the snow conditions of the Aosta Valley from 01-01-2007 to 31-12-2024. The time series was analysed considering snow seasons going from December to March, following data availability. By using snow depth (HS) data from Centro Funzionale Valle d'Aosta, snowfall (HN) and Snow Water Equivalent (SWE) were modeled with the ΔSNOW model from Winkler et al. (2021). Snow depth across the record shows a decrease, particularly in the mean and maximum values calculated over the whole season and series. Moreover, the day with the maximum snow depth and snowfall tends to occur later in the season. These results suggest a change in the snow season behaviour. The analysis of the Consecutive Snow Drought Days (CSDD) demonstrated that a high degree of snow drought as indicated by Standardized SWE Index (SWEI) does not necessarily correspond to persistent low SWE. In conclusion, the observed snow conditions changes can be traced back to ongoing global climate change with important repercussions on a regional level, and the chosen methods revealed a necessity for a re-examination or broadening of the definition of snow drought events.

Keywords: snow season behaviour, Aosta Valley, snow drought definition, snow depth (HS), Snow Water Equivalent (SWE)

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DOLOMITES – Digitaltwin of landslides over mountains under climate changes to empower sustainability

Francesca Noemi Bonometti[1]

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This PhD thesis explores the relationship between climate change and the increasing frequency of rockfall events in the Italian Eastern Alps, with a particular focus on the Dolomites. Firstly, a novel method is developed to analyse long-term climate data at varying elevations across the study area, quantifying spatiotemporal variations in key climate variables and their potential influence on rockfall frequency. This analysis reveals significant warming trends, particularly in spring and summer, with a notable increase in the frequency of high air mean temperatures. Furthermore, a decrease in the frequency and persistence of freeze-thaw cycles is observed, particularly below 2000m. These findings indicate a shift in seasonal patterns with earlier springs and delayed autumns. Secondly, a rockfall hazard assessment is conducted using HyStone numerical model. A key innovation of this research is the development and implementation of a refined parameter calibration procedure for HyStone to enhance the accuracy of simulation results. This analysis provides crucial information on rockfall susceptibility and propagation probability within a study area of Dolomites UNESCO World Heritage site, contributing to improved hazard assessment and risk management in this valuable region. The findings of this research provide valuable insights into the impact of climate change on rockfall occurrence in alpine environments. These insights are crucial for developing effective risk mitigation strategies in areas prone to these hazards, particularly within the vulnerable and tourist area of the Dolomites.

Keywords: climate change, Alpine environment, Dolomites, rockfall hazard, risk management

Thermo mechanical behaviour of a permafrost-affected rock pillar in the Dolomites: Sas da Lech case study

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This study analyzes the thermo-mechanical behavior of the Sas da Lech dolomite rock pillar (Dolomites, Italy), which experienced a collapse in September 2018 involving ca. 3,500 m³ of rock. The detachment posed a risk to a mountain trail and the nearby mountain hut. This work integrates two years of in-situ temperature and deformation monitoring with thermo-mechanical numerical modelling. Subsurface temperatures were measured using a borehole thermistor chain, while fracture kinematics were tracked with borehole deformation sensors and surface extensometers installed across selected discontinuities. An analytical 1-D heat-diffusion solutions provided a transparent benchmark for the observed amplitude damping and phase delay with depth, allowing estimation of effective thermal diffusivity and the characteristic depth scale of seasonal forcing. A three-dimensional conductive heat-transfer model was used to interpret the propagation of the thermal signal at depth and to explore warming trajectories under RCP4.5 and RCP8.5. Mechanical stability and potential failure kinematics were evaluated through shear strength reduction analyses applied to pre- and post-detachment geometries under alternative discontinuity strength assumptions. The observations show a strong depth-dependent attenuation and phase lag of the seasonal thermal wave and an near-zero temperature zone consistent with warm, marginal permafrost conditions. Deformation is markedly heterogeneous: neighboring discontinuities exhibit opposite displacement signs, and several time series do not return to their initial baseline after a seasonal cycle, indicating that seasonal deformation is superimposed on a non-recoverable component. The thermal model reproduces the observed depth filtering and projects progressive warming transmitted to depth, while the mechanical analyses highlight a dominant structural control, with instability modes that are sensitive to transient weakening along major discontinuities. Overall, the combined dataset and modelling framework provide a process-oriented interpretation of current behaviour and a basis to discuss potential future sensitivity under climatic warming.

Keywords: cliff fall, monitoring system, FEM analysis, permafrost degradation, temperature

Session SOC-A

"SOCIETY: The challenges posed to the economy and society"

11:00–13:00, Room B4

Demographic scenarios, residential mobility and impacts of climate change in the Alps

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In recent years, the Italian Alps have emerged as a strategic observatory for understanding the interactions between demographic dynamics, residential mobility, and environmental change in mountain regions. Moving from original data, presented in the report "Demographic scenarios, residential mobility and impacts of climate change in the Alps" (Membretti et al. 2025), the presentation analyses transformations between 2013 and 2023, updating the evidence produced by the Fifth Report on the State of the Alps (Alpine Convention 2015) and providing policy-relevant insights for sustainable development and climate adaptation. The findings depict a demographically "hybrid" territory. On the one hand, the Alpine population has slightly declined, driven by low fertility rates and pronounced ageing: individuals aged over 65 now exceed 25% of residents, while the working-age population has decreased. The natural balance remains negative, reflecting structural demographic fragility. On the other hand, positive internal and international migration has partially offset these trends, preventing widespread depopulation in many valleys and villages. A growing number of Alpine municipalities register positive migration balances both within the Alpine area and with non-Alpine territories, highlighting the expansion of "metromountain" mobility between cities and mountain areas. Small and well-connected low-altitude municipalities have become particularly attractive. International migration has intensified, with increasing inflows from non-European regions compensating for the emigration of young Italians to neighbouring Alpine countries. Overall, the Italian Alps are no longer solely characterised by decline but by increasing internal differentiation. While ageing and climate change pose persistent challenges, migration, new residential models, and lifestyle transformations introduce elements of resilience.

Keywords: demographic change, human mobility, climate change, New Highlanders, ageing

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Living in the metro-mountain in times of great transitions

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The research project "Abitare la metromontagna al tempo delle grandi transizioni", led by Forwardto and funded by Alpine Lions Cooperation, explores the evolving conditions of inhabiting alpine and peri-alpine territories in the context of environmental change, demographic transformation, and socio-economic restructuring. Focusing on the Metropolitan City of Turin and the Aosta Valley Region, the study examines the "metro-mountain" as a hybrid rural-urban system increasingly shaped by climate impacts and new forms of residential mobility. The project aims to provide an integrated analytical and foresight framework to support territorial planning and public policy in mountain areas facing both fragility and renewed attractiveness. The research combines quantitative analysis with strategic foresight methods to investigate emerging trends, including ageing populations, internal and international migration, and the growing phenomenon of "vertical migration" from lowland urban areas toward higher-altitude settlements, partly driven by climate adaptation dynamics. The research is structured in two sections. The first presents an analysis of territorial characteristics, demographic dynamics, residential mobility, and climate change impacts across 218 municipalities with diverse levels of urbanisation and environmental exposure. The second develops qualitative insights through foresight activities, involving interdisciplinary expertise to identify key drivers of change and to construct alternative future scenarios. Through anticipatory analysis and scenario-building, the research outlines possible implications and development pathways related to climate resilience, quality of living, and territorial cohesion. The project ultimately proposes a replicable methodological approach for anticipating transformations in alpine regions and supporting long-term strategic decision-making.

Keywords: metromountain, vertical migration, strategic foresight, climate change

Vertical migrations in Europe: Human mobility, climate change and mountain commons in Europe

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The presentation will focus on the main results of the transdisciplinary analysis developed in the collective volume "Vertical Migrations in Europe. Human Mobility, Climate Change and Mountain Commons" (to be published within the end of 2026 for Springer Nature). This volume - edited by Membretti et al. - investigates contemporary forms of human mobility toward European mountain regions through the analytical framework of "vertical migrations" (Membretti et al. 2024), with respect to their implications for mountain commons and considering different "mobility regimes" that affect different categories of "vertical migrants".
Building on interdisciplinary scientific debates from recent seminars organized in Italy and Switzerland, the contributors adopt a socio-geographical and anthropological perspective to examine movements linking urban and mountain areas, also referring to the space that in Italy is called "metro-mountain" (Barbera & De Rossi 2021). Verticality is therefore understood not merely as spatial relocation, but as a process in which dynamics of adaptation, appropriation, and belonging are negotiated, also including possible dynamics of self/hetero ghettoization, in relationships to the wider and ongoing processes of gentrification and social exclusion.
The analysis situates vertical migrations at the intersection of three key processes: climate change as a driver of upward mobility and environmental vulnerability; transformations in the governance of rural commons, shaped by both demographic renewal and risks of privatization; and international migration from the Global South, which has long affected rural and mountain areas while often reproducing inequalities in access to resources and decision-making.
The analysis considers a wide range of actors, including labor migrants, refugees, neo-rural settlers, climate migrants, digital workers, amenity migrants, and affluent seasonal residents.
Focusing on the Alps, with comparative insights from the Apennines and Pyrenees, the contributions offer an interdisciplinary framework for understanding the socio-ecological implications of vertical migrations and for advancing more equitable models of mountain governance. The results presented derive from a wide quali-quantitative set of research activities conducted in recent years at European level by the authors, within their institutions, in the framework of different national and international projects.

Keywords: vertical migrations, metromontane, human mobility, commons, climate change

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Deciphering climate-mobility links: How patterns vary across altitude areas in the Metropolitan City of Turin

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While migration is widely recognised as a non-linear, complex, and multicausal process, existing research shows diverse results across climate indicators, mobility types, and study areas. However, the extent to which climate change shapes migration patterns remains insufficiently explored. Furthermore, the literature's predominant focus on the Global South raises the question of whether similar dynamics apply in the Global North. Using the Metropolitan City of Turin as a case study, this paper answers to what extent people have migrated to areas less affected by heat and drought. Employing a tri-dimensional conceptual framework covering social, urban-built, and natural environments, this study draws on residential data from 2006 to 2022 (based on data availability), along with summer temperature, precipitation, and humidity anomalies. The bivariate mapping method allows for visualising spatial variations between lowlands and highlands. The fixed-effects regression model reveals that rising temperatures are significantly associated with outmigration trends in the area. Yet, these climate-related indicators have greater relevance in lowlands than in mountainous areas. These findings emphasise the need to consider the inherent characteristics of the territory and how climate change impacts vary even in a relatively small region. Although heat and drought-affected lowlands and hills appear less attractive for inbound mobility, these patterns vary and cannot be generalised. This study provides novel evidence of climate-mobility links in a less-studied geographical area while offering a new perspective on the diversity of emerging mobility patterns in low and high-altitude territories – essential for effective adaptation strategies and long-term resilience, particularly for Alpine communities facing environmental pressures.

Keywords: migration, residential mobility, climate change, highlands, temperature

Agency and structural constraints in vertical migration processes: Categorizing new inhabitants of Italian mountain areas

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Recently, there has been a new human mobility towards the Alps, reversing the urbanization that characterized these areas in the past. In the context of ongoing demographic, technological and climatic transformations, this work draws on the perspective of migratory stratifications to propose - with reference to migratory movements to the Italian mountains - a theoretical reflection on the relationship between agency and structural constraints (Carling & Collins 2020). Within the migratory stratifications approach (Della Puppa et al. 2024), a categorization of metromontane populations appears to be of particular interest (Membretti 2021). Therefore, it is possible to identify three main groups of new inhabitants of Italian mountain areas: amenity migrants - rich people, often retired, coming from metropolitan areas or from abroad with high cultural and economic capital; mountain dwellers by choice - young adults, highly educated, and coming from urban areas; mountain dwellers by necessity and by force - economic migrants and asylum seekers/refugees, often forced to live in the mountains due to work necessity or government policies.
The proposed categorization aims to emphasize the analytical relevance of a diachronic and cumulative perspective on migratory stratifications for the interpretation of the structural complexity underlying vertical migration processes. This lens seems appropriate for revealing the processes of transculturation and the dynamics of social change and negotiation between different migrant populations. In this framework, an in-depth analysis of metromontane populations is relevant to understand their potential for integration and social innovation, in a context shaped by environmental challenges accelerated by climate change.

Keywords: agency, environment, mountain, metromontane, migrations

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New mountain dwellers for changing landscapes: Capacity building as a resilience strategy in the Western Alps

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Alpine territories face a dual challenge: long-term demographic contraction and accelerating impacts of climate change. While depopulation weakens local networks, a counter-trend of "aspiring mountain dwellers" is emerging (Membretti 2021). Recent data from MICLIMI Project (www.miclimi.it) confirms this demand is increasingly driven by urban climate stressors like heatwaves. However, nearly 50% of those potential migrants admit to lack the specific skills necessary to inhabit highland ecosystems. To bridge this gap, this contribution presents "Vivere in Montagna", a support model by SocialFare and the University of Turin (Barbera et al. 2024) , aimed at aligning urban desires for mountain life with concrete ecosystem understanding, turning potential climate migrants into active agents of local development and resilience.
The development of the intervention model took the form of an action-research project (Lewin 1946), involving a range of local stakeholders (local authorities, aspiring mountain dwellers, small businesses, long-standing residents, etc.) in identifying the support needs for life and business in the mountains, alongside solutions to meet this growing demand for settlement.
On the basis of those results, the developed model hybridizes Systemic and Service Design with sociological research through two pillars: an Orientation Desk provides guidance on life/work ideas; a 3-day residential Mountain School engages participants with local experts and inhabitants. Through co-design and peer-mentoring, participants acquire a systemic vision to develop the "micro-alliances" essential for integrating and contributing to territorial development. Tested since 2022 across five editions in Piedmont (Val Susa, Valli di Lanzo, Val Pellice, Valle Orco) and Abruzzo, the initiative involved over 200 aspiring dwellers, successfully moving them beyond romanticized views to structure sustainable life projects based on realistic territorial understanding, while generating a self-sustaining community of practice. Future developments aim to scale the model, facilitating a new generation of conscious future mountain dwellers to drive collective sustainability across the Alps. From 2026, the project will take on a transnational and cross-border dimension, linking the Alpine regions of north-western Italy with neighbouring French regions, as part of an initiative to define multi-local and international living and working scenarios.

Keywords: resilience, adaptation, depopulation, education, innovation

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Session SOC-B

"SOCIETY: The challenges posed to the economy and society"

11:00–13:00, Room B5

Ashes: Ritual fires as a tool for resilience and commoning in a community in the Piedmont Alpine arc

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This paper investigates how ritual practices contribute to community resilience and identity re-articulation in Alpine contexts undergoing socio-economic and environmental change. Focusing on the revival of the Carcavegia ritual in Premosello Chiovenda (Verbano Cusio Ossola, Northern Italy), the study asks: how do reactivated midwinter rites function as forms of commoning and collective response to post-industrial decline and emerging environmental uncertainties?

The Carcavegia, celebrated on the eve of Epiphany, involves the burning of effigies representing the "old man" and "old woman," symbolizing transition and renewal. Based on ethnographic fieldwork, participant observation, and analysis of local archival and narrative sources, the paper situates the ritual's reactivation since the 1990s within the broader context of industrial decline in the Ossola Valley.

Theoretically, the study draws on approaches to rituality, liminality, and commoning to interpret the event as a performative space where social relations, local knowledge, and shared meanings are renegotiated. In addition, the analysis considers how such practices intersect with shifting environmental perceptions in Alpine areas, including climate change and landscape transformation, which contribute to a sense of uncertainty and the need for symbolic frameworks of continuity.

By comparing Carcavegia with other European midwinter fire rituals, the paper highlights recurring themes of inversion, renewal, and cohesion. It argues that the contemporary revival of the ritual operates as both a cultural strategy for local identity-making and a form of community-based resilience, aligning with broader debates on socio-ecological transitions in Alpine regions.

Keywords: heritage, rituality, liminality, commoning, embodiment

Resilience of Alpine communities to energy shocks through energy cooperatives

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The presentation provides an overview of the historic electric cooperatives located in the Italian Alpine regions. These cooperatives originated in the late 19th century as grassroots initiatives led by farmers, artisans, entrepreneurs, and local communities seeking energy independence in remote rural areas neglected by large national utilities. They relied primarily on hydropower resources available in the mountains. Today, the network includes around 30 historic cooperatives, with a workforce of over 200 employees, more than 34,000 members, and 65,000 connected delivery points. Their infrastructures comprise nearly 3,000 km of medium- and low-voltage lines, around 1,000 substations, and 47 municipalities served. The cooperatives manage a diversified portfolio of energy-production assets: 75 hydroelectric plants (105 MW, 270 GWh annual production) 77 photovoltaic plants (7.5 MWp) Biomass district heating systems with both thermal and electric output.

Keywords: cooperatives, resilience, sustainability

S.H.A.P.E.-ing Alpine resilience: Toponymy and eco-grief in glacier loss adaptation on Monte Rosa

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In the Alpine region, the accelerated retreat of glaciers is not merely a cryospheric data point but a "total social phenomenon" affecting territorial identity, safety, and economic stability. Within the framework of the Horizon Europe project LIQUIDICE, this paper presents the application of the S.H.A.P.E. methodology (Socio-Historical Anthropology of Perception and Environments), developed by the BAE-REMHI unit (CMCC), to the Monte Rosa case study.
Data were collected through a combination of semi-structured interviews with long-term residents, mountain guides, and local administrators; ethnographic observation during community events; and systematic archival and toponymic research. Participants were recruited through purposive sampling to capture generational and occupational diversity in climate perception.
Two analytical pillars structure the findings. First, drawing on the concept of ""toponymy as a risk archive,"" the research investigates how place-names (e.g., Lavinaz, Ganda) function as ""linguistic fossils"" preserving long-term environmental memory of hazards otherwise absent from instrumental records — offering a baseline for validating scientific models through traditional ecological knowledge (Berkes 2018; Dall'Ò 2025). Second, the emotional landscape of glacier loss is examined through the frameworks of ""eco-grief"" (Cunsolo & Ellis 2018) and ""solastalgia"" (Albrecht 2019). Practices such as glacier funerals, documented during fieldwork, reveal how collective mourning can be reframed as a driver of agency (Douglas 1992).
The findings demonstrate that adaptation policies gain social traction when they are ""culturally inhabitable"": co-designed with communities, grounded in local memory, and attentive to affective dimensions of environmental change. By bridging high-resolution climate modeling with deep anthropological insight, S.H.A.P.E. offers a replicable pathway to reduce social backlash and strengthen institutional trust in contexts of profound cryosphere decline.

Keywords: glacier loss, toponymy, eco-grief, Monte Rosa, social resilience

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Between risk and identity: Rethinking community resilience in Alpine contexts

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Mountain regions are increasingly exposed to converging environmental, socio-economic, and demographic pressures that challenge their long-term stability and development trajectories. Within this context, community resilience is widely mobilized as a key framework to address structural risk and social fragility, shaping processes of territorial transformation through spatial governance.
This contribution critically reflects on the concept of community resilience, questioning its capacity to account for deeper structural transformations. Resilience is conceptualized as a multi-dimensional construct articulated across three interrelated domains: systemic vulnerability and structural fragilities; communal adaptive capacity; transformative potential grounded in processes of social innovation and spatial reconfiguration. Within this framework, resilience is understood as an operational and relational substrate through which communities negotiate and respond to risk perception, identity conceptualization, and development strategies.
The ongoing research adopts a case study-based approach combining participatory processes, spatial analysis, and qualitative inquiry to assess and operationalize community resilience in (and beyond) Alpine contexts. Attention is given to the role of participation not merely as a procedural tool, but as a socially embedded process. In this perspective, collective memory of past hazard events and persistent attachment to place are considered foundational conditions for community engagement. These elements enable a progression from adaptive practice - aimed at managing and coping with risk - towards more transformative processes, capable of redefining the relationship between community, territory, and identity.
The empirical focus is the abandoned settlement of Zambana Vecchia (Trentino, Italy), a village historically subject to forced relocation due to hydrogeological hazards. In this context, resilience is intertwined with processes of identity continuity and reconstruction. The case reveals a profound renegotiation of the community–territory relationship, informing new approaches to spatial planning, sense of place, and forms of collective agency.
The objective of the research is to understand how the community assumes responsibility in decision making processes. In line with this purpose, the Zambana Vecchia case contributes to a participatory model that moves beyond standard engagement procedures, outlining a scalable and adaptable methodological framework for Alpine territories. At the same time, it highlights the need to reconsider resilience not only as a capacity to adapt, but as a potential driver—yet also a possible limitation—of transformative change.

Keywords: community resilience, adaptation, mitigation, spatial transformation

New territorial configurations and instruments for territorial transition: The case of Arroscia valley

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Climate change is profoundly affecting Alpine territories, particularly mid-altitude mountain communities whose development models have long relied on winter tourism. In these areas, decreasing snow reliability and increasing environmental vulnerability are accelerating socio-economic fragility, demographic decline and territorial marginalisation. This contribution focuses on the case of Monesi, a former ski destination at 1,300 metres in the upper Arroscia Valley (Ligurian Alps, Italy). Once the only ski resort in the Liguria Region, Monesi is emblematic of small mountain communities seeking to redefine their development trajectory in response to climate-related transformations. The paper presents results of a research-action conducted within the Alpine Space project BeyondSnow, aimed at supporting transition processes in snow-dependent territories. Adopting a territorial approach, the study combines spatial analysis, semi-structured interviews and participatory workshops to examine how local actors reinterpret their resources in a context marked by tourism decline and long-term uncertainty. Attention is paid to the collective dimension of this process and to the ways community resilience takes shape through the reactivation of local networks and the exploration of strategies beyond the mono-functional ski model. The findings highlight a "variable-geometry" mountain system in which environmental heritage, agro-food productions, historical buildings, cultural practices and community bonds become levers for regeneration. Finally, the paper presents a territorial governance instrument implemented in the area: the Chart for Territorial Transition, based on flexibility, transcalar inclusion and voluntary participation, offering an example of strategic planning combining different administrative levels and new territorial configurations.

Keywords: territorial transition, community resilience, Alps, sown-dependency, tourism

Session GOV-B

"GOVERNANCE of Alpine territorial systems following glacier loss"

15:00–17:00, Room B2

Integrating community-led local development into local governance framework in mountainous Georgia

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Rural communities play a vital role in shaping their own future, and strong local governance is key to their success. In many countries, including Georgia, Local Action Groups (LAGs) have been created to bring people together to make decisions about rural and mountain development. These groups follow the LEADER approach, a European model that encourages local participation and cooperation. However, since Georgia and other Eastern Partnership (EaP) countries are not part of the European Union, their experiences with this model have been different, and we still have a lot to learn about how LAGs function in these contexts. This study explores how LAGs in Georgia are structured, how they work with local governments, and how they make decisions that impact mountain communities. To do this, we collected information through surveys, interviews, and official documents from different LAGs across the country. We also looked at the fairness of decision-making processes, who gets to participate, how resources are distributed, and whether all voices are heard. Our research found that LAGs operate in different ways depending on their location and community needs. Some work closely with local governments, while others maintain more independence. The way board members are selected, the level of transparency in decision-making, and the involvement of different social groups all influence the success of these groups in supporting rural development. By understanding how LAGs function and what challenges they face, we can improve policies and support systems to make them more effective. Compared to LAGs in Alpine regions, which operate within mature EU rural development frameworks and benefit from longer institutional histories, Georgian LAGs navigate more constrained governance environments yet demonstrate comparable capacities for community mobilization and participatory decision-making. These cross-contextual parallels offer transferable lessons for reinforcing LAG adaptability, inclusivity, and resilience in Alpine mountain communities facing similar governance and participation challenges. Ultimately, this research provides useful insights for policymakers, development organizations, and local communities aiming to strengthen local governance and community participation in Georgia and beyond.

Keywords: community-led development, Local Action Groups (LAGs), mountain communities

A multi-criteria methodology for avalanche risk assessment of the built environment in Alpine regions

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Glacial retreat and climate change are progressively modifying environmental conditions in Alpine territorial systems, influencing the frequency and intensity of extreme natural events, including snow avalanches. In this evolving context, structured and reliable approaches to territorial risk governance become essential for technicians, policymakers, and the entire community. This contribution proposes a simplified, multi-level methodology to support risk management in such avalanche-prone areas. Starting from the systematic mapping of the exposed elements - buildings, infrastructures, and strategic public facilities - the method develops a risk classification framework based on a multi-criteria assessment of hazard, vulnerability, and exposure factors. Hazard is evaluated considering the intrinsic susceptibility of the territory under analysis; vulnerability encompasses both physical and functional dimensions of the built environment; exposure integrates potential human and economic losses. The methodology is conceived as an operational decision-support tool for local and regional authorities. It offers a standardized and scalable framework to support resource allocation, mitigation planning, and adaptation strategies in contexts characterized by limited financial capacity and high exposure concentration. By bridging technical risk assessment and territorial governance, the methodology contributes to discussions on the vulnerability and resilience of territories exposed to climate change-driven transformation.

Keywords: avalanche risk assessment, risk management

Bridging the gap from visioning to action: Co-creating transformative pathways with mountain communities

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Climate change is radically reshaping mountain landscapes and the livelihoods of their communities. In this context, compelling visions of desirable futures serve as vital starting points for guiding the profound changes required for sustainability transformations in ice-free futures. Transdisciplinary processes that cultivate collective imagination and a shared sense of purpose can strengthen both individual and collective commitment to action. However, despite the variety of visioning approaches, translating visions into tangible on-the-ground action remains a persistent challenge. Participatory visioning involves the co-creation of shared visions, the identification of pathways to achieve them, and the development of implementation strategies. These processes are inherently transdisciplinary, integrating diverse perspectives and forms of knowledge. However, to truly drive transformative action, participatory visioning must be designed to yield outcomes that go beyond the formulation of visions or strategies. Such outcomes often spark social innovations by generating new ideas, transforming relationships, fostering shared understandings, reshaping governance practices, and building collective capacities. In doing so, they contribute to environmental, cultural, and economic change. This contribution draws on insights from two research projects: 1) An in-depth case study of a transition management process aimed at achieving climate neutrality in the Eastern Bernese Oberland region in Switzerland. 2) A synthesis project that developed an action-oriented guiding framework to support researchers and practitioners in designing, realizing, and evaluating participatory visioning processes. Hence, participatory visioning can help mountain communities govern transition processes toward more sustainable and resilient futures.

Keywords: visioning, transdisciplinarity, innovation, transformation

A barrier–action analytical approach to climate transition strategies in two Alpine mountain communities

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Mountain territories across the Alps face accelerating climate risks, from hydro-geological instability to forest vulnerability and water scarcity. Yet the capacity of small municipalities to plan and implement adaptation measures remains uneven. This contribution presents empirical results from two Alpine mountain communities in Lombardy (Val Seriana and Valli del Verbano) that have developed Climate Transition Strategies (CTSs). We apply a multi-method analytical approach that combines: a) the collection of perceived barriers through a structured questionnaire and a context-sensitive categorization of barriers and CTS actions; b) a barrier–action linkage analysis; and c) a budget assessment. Results show that although local authorities most frequently perceive informational and institutional barriers, these constraints only partly shape how resources are allocated. The number of CTS actions is relatively balanced across thematic categories, and linkage analysis indicates that actions generally respond to the identified barriers. Measures also reflect local needs, particularly in forest management, ecosystem restoration and hydro-geological risk reduction. Budget analysis shows that mountain communities concentrate resources on eco-hydrological and forest-related interventions consistent with their exposure and institutional context. However, high-cost physical measures absorb a large share of funds, while enabling functions such as governance, monitoring, data systems and capacity-building receive comparatively limited allocations. This does not imply a cost mismatch but highlights how strategic, lower-cost functions may remain under-supported. The study proposes a transferable analytical framework for strengthening climate transition planning in Alpine mountain regions and provides practical recommendations to rebalance adaptation investments and reinforce local governance and institutional capacities.

Keywords: mountain communities, adaptation planning, barrier analysis

Caring for the Alpine legacy: Co-design experiences in Valle d'Aosta Region

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Climate and economic change are transforming Alpine territories and revealing the limits of traditional relationships between architecture, landscape, and settlement, evolving their traditional vocations. This proposal describes a research-by-design experience initiated in 2021 in Valle d'Aosta that assumes abandoned and underused buildings as strategic assets for sustainable future alpine development. Through systematic mapping, co-design with local communities, and pilot projects, the work reframes reuse as a care-based practice, rather than mere preservation. Moving beyond extractivist and top-down "patrimonialisation" approaches, the project develops territorial and architectural guidelines that prioritise sustainable values, enabling compatible new uses. Reactivating abandoned buildings and higher-altitude infrastructure offers opportunities to reduce pressure on low valleys, fostering socio-economic regeneration and territorial resilience. By enabling community participation to elaborate long-term visions, the approach promotes sustainable material, temporal, and social pathways for alpine new habitability. Describing this ongoing work, we intend to demonstrate how reuse can unlock latent spatial resources, support balanced land-use patterns, and cultivate future-oriented relationships among the built environment, communities, and regional development.

Keywords: research-by-design, Cc-design, pilot projects, Alpine region

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From strategies to measures: Climate change adaptation in small Alpine tourism destinations

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Climate change is intensifying pressures in Alpine regions and raises urgent questions about how tourism-dependent communities can adapt in practice. This contribution builds on an article examining how five small mountain tourism destinations in the European Alps translate adaptation strategies into concrete measures developed within the Interreg Alpine Space project BeyondSnow. Small destinations are a critical test case because adaptation is often community-driven, yet constrained by limited staff, budgets and implementation capacity. Using the Framework Method, we constructed a structured assessment matrix that links strategic objectives and measure categories to implementation instruments (MEANs) and to the destination elements they address (TARGETs). Across cases, year-round tourism, cooperation and sustainable development were the most frequent objectives. At the measure level, Product/Concept development, Communication & marketing and cooperation dominated; frequent TARGETs included activity infrastructure and experiences, mobility, accommodation and the destination community. Beyond descriptive patterns, the analysis highlights recurring implementation pathways: offer-led diversification to reduce climate-sensitive dependencies; cooperation-led alignment to coordinate actors and extend portfolios; and targeted activation approaches that engage specific audiences (e.g., residents or youth) to build legitimacy and uptake. We discuss how sequencing low-barrier actions before selective capital-intensive steps can support momentum, learning and scalability. By shifting the focus from strategy statements to the design and roll-out of measures, the contribution offers a practical lens for researchers and practitioners to compare adaptation options, anticipate trade-offs and support locally grounded transition processes in small Alpine tourism destinations.

Keywords: climate, change, tourism, adaptation, governance

Session ENV-B

“ENVIRONMENT: The impacts of cryosphere decline on environmental and cultural systems”

15:00–17:00, Room B3

Glacial lakes as vulnerable ecosystems in the mountain landscape

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Glacial lakes are a fundamental part of the mountain landscape, providing essential ecosystem services. They are becoming an increasingly common feature in the progressively deglaciating high-mountain regions. Besides representing fundamental water resources, they have a high esthetic value and constitute a touristic attraction. Research on glacial lakes has mostly focused on risk-related issues or hydrological features. However, attention should be paid also to water quality issues and conservation: due to their peculiar characteristics, glacial lakes may host specialized biological communities, with still partly unknown ecology and biodiversity. These fragile ecosystems are threatened by environmental pressures, including atmospheric pollutant deposition, climate change, and increasing tourism, all of which affect water quality and aquatic habitats. Glacier retreat affects lakes in different ways, influencing their morphology and the physical and chemical properties of water. In this contribution we present examples from long-term studied lakes in the Western Alps, where global change has caused important environmental shifts. Observed variations include increasing concentrations of major ions, change in nutrient levels and ratios, shift in water color and transparency. These changes occurred in relatively short periods of time, prompting the need for investigation into the possible effects on habitats and biological communities. Research and monitoring programs are essential to track these changes, integrating multiple pressures and combining approaches from in-situ data collection to remote sensing. Quantitative evidence is essential to support informed decision-making and to guide environmental management and protection policies aimed at preserving the ecological integrity of these vulnerable mountain ecosystems across different governance levels.

Keywords: water chemistry, climate change, long-term data

Assessing Alpine permafrost degradation impacts on infrastructure

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Mountain permafrost is defined as any lithological substrate that remains at temperatures below 0 °C for at least two consecutive years. In the European Alps, it generally occurs above 2300–2500 m a.s.l., although this threshold varies depending on slope orientation and the specific alpine sector. Even where visible surface indicators are absent, permafrost can extend deep within slopes and rock masses, influencing ground stability and potentially affecting nearby infrastructure. Unusually warm summers and increased precipitation are accelerating permafrost degradation leading to a lowering of the permanently frozen layer and a gradual thickening of the surface active layer, where infrastructure is typically anchored. Within the Frost.INI project, these challenges are addressed through the integration of in-situ geophysical techniques and remote sensing approaches to comprehensively characterize selected case studies located across the border between Italy and Austria. This approach combines remote sensing observations, including satellite-based multispectral and radar data as well as UAV imagery, with in-situ geophysical investigations such as Electrical Resistivity Tomography (ERT), Ground Penetrating Radar (GPR), and electromagnetic (EM) measurements. The collected datasets provide valuable information on surface displacement patterns and ground properties, enabling the identification of subsurface permafrost extent, and its characteristics. These results support both engineering and geological assessments and contribute to the development of digital twins of the investigated slopes. Such digital models represent current ground conditions and serve as predictive tools to evaluate the future evolution of permafrost under changing climatic conditions and potential external triggers.

Keywords: permafrost, infrastructures, geophysics, in situ measurements

Beyond glacier retreat: Anthropogenic controls on Alpine geomorphic systems

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Deglaciating Alpine landscapes result from the interplay between climate-driven glacier retreat and intensifying human interventions since the nineteenth century. In many Alpine catchments, hydropower infrastructures, tourism facilities and slope modifications interact with sediment production, transport and storage, complicating the attribution of present-day geomorphic responses to climate forcing alone. This study investigates how anthropogenic modifications have reshaped geomorphic processes and landscape configuration in high-altitude Alpine environments over the last two centuries. Archival documents, historical aerial photographs, multi-temporal remote-sensing datasets and detailed geomorphological field mapping are integrated to reconstruct former landscape settings and constrain the timing and spatial extent of human-induced changes. Results highlight recurring effects, including reorganisation of sediment source areas, modification of hillslope gradients, altered runoff pathways and channel adjustments. In glacier-proximal sectors, engineered structures locally modify base levels and sediment connectivity, influencing erosion patterns, sediment storage and slope stability. Where glacier retreat is ongoing, these interventions condition the magnitude and spatial distribution of geomorphic responses, producing landscapes shaped by the simultaneous action of climate-driven and infrastructure-related processes. The integrated approach allows identification of anthropogenic signatures, spatial delimitation of modified process domains, and estimation of sediment redistribution volumes linked to infrastructure development and tourism-related slope reshaping.

Keywords: geomorphology, anthropogenic, deglaciation, sediment

Gut-content DNA metabarcoding reveals the assembly of plant–arthropod trophic interactions following glacier retreat

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As glaciers retreat and vanish worldwide due to global warming, new terrains are rapidly colonized by living organisms, including plants and their associated animals. Although plant–animal interactions are key for biodiversity maintenance and ecosystem functioning, the consequences of glacier retreat for trophic interactions and the assembly of food webs remain poorly understood. Here, we investigated plant–arthropod interactions along a 140-year chronosequence in the Mont Miné glacier foreland (Switzerland) using DNA metabarcoding of arthropod gut contents to reconstruct food webs.

We uncovered numerous previously undocumented interactions, with Poaceae, Ericaceae and Asteraceae plant families representing the most abundant food resources. We also report the initially positive effects of glacier retreat on trophic niche overlap among arthropods, indicating resource partitioning as succession proceeds. This can lead to the increase in competition, with potential negative effect on local population. Simultaneously, glacier extinction reduces diet richness and trophic niche breadth, influencing long-term biodiversity change. Notably, interaction diversity shifted more rapidly than species diversity and community composition of plants and arthropods. These findings indicate that glacier retreat reshuffles trophic interactions beyond simple species turnover, with potential consequences for the stability of emerging food webs as glacier vanish. In conclusion, we highlight the importance of reconstructing the food webs to improve biodiversity conservation by accounting for trophic interactions in the rapidly changing environment.

Keywords: arthropod diet, food-web, glacier retreat, trophic network

Climate change in the Eastern Alps in a systematic photographic comparison: Implications for mountain agriculture and tourism development

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More than 3,000 color slides and black-and-white photographs taken between 1890 and 1960 from all parts of the Eastern Alps have been and are being re-photographed from the exact same vantage points. For about one third of the repeat-photography long-term monitoring sites, up-to-date comparison images are already available. From over 1,000 image pairs and triplets distributed across the entire Eastern Alps, robust overall trends that can be generalized beyond local contexts can already be identified.
The large sample size allows for semi-quantitative trend assessments regarding sub-aspects such as climate-change-driven and natural erosion processes, altitudinal and species shifts in mountain forests and the krummholz zone, forest expansion and shifts between wooded and open areas, mechanical damage to alpine ecosystems, loss of open land and ecological fragmentation of habitable and accessible areas, glacier retreat and vegetation development in glacier forefields and moraines, changes in historic building structures in valley settlements and mountain farms, and shifts in mountain agricultural practices, among others.
Some findings from our large-scale investigations diverge from previously published working hypotheses on climate change-driven landscape development.
Among the many results that can be extrapolated across large regions, the sub-aspect of soil loss and erosion dynamics is highlighted here as an example through image comparisons and area statistics.

Keywords: mountain agriculture, erosion dynamics, landscape, tourism development

Three millennia of ice at risk: Rapid deglaciation in Viševnik Cave (Julian Alps)

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Ice caves in mid latitude mountains can preserve long lived ice bodies that record past climate and hydrology. We document rapid deglaciation in Viševnik Cave (Ledena jama pri planini Viševnik), a high alpine cave in the central Julian Alps (NW Slovenia) with an entrance at 1,597 m a.s.l., 3,024 m of passages and 286 m depth. In 1939 the entrance chamber was described as completely ice filled; observations from the 1950s–1990s report continued loss. In 2008 retreat of the lower ice exposed a passage to deeper parts of the cave, altering air exchange and accelerating melt.

Ice loss was quantified by repeat photography (2008–2025) and terrestrial LiDAR surveys begun in 2023. The ice surface lowered by 2.5 m between 2008 and 2015 (~0.30 m yr^{-1}) and thinned by 1.0–1.3 m over two LiDAR seasons (~0.50–0.65 m yr^{-1}), indicating faster thinning in the most recent years. Cave climate monitoring started in 2013, one of the longest temperature series for Slovenian caves; in 2023 it was expanded to include air, rock and ice temperatures, airflow, dripwater discharge and temperature. We also analysed stable water isotopes ($\delta^{18}O$, $\delta^{2}H$), tritium, and elemental geochemistry (23 elements) from ice and water collected in 2012–2013 and 2023.

Radiocarbon dating of wood emerging from retreating ice provides minimum ages for ice persistence. A European larch (Larix decidua) log dates to 1515–1650 CE; ring evidence suggests the tree began growing in 1565–1703 CE and entered the cave about two decades later. A European spruce (Picea abies) log yields 3085–2961 BP (pith) and 2887–2767 BP (bark). Clear ice layering indicates dripwater freezing as the main accumulation process, and the logs likely entered during short intervals of entrance opening. The dated horizons fall near known cool intervals (Homeric Minimum; Maunder Minimum), supporting multi millennial ice survival. Together, the stratigraphy, dating and monitoring show that Viševnik Cave has retained ice for at least ~2,700 years, yet is now thinning rapidly, making it a priority site for continued observation and time critical sampling.

Keywords: ice caves, climate warming, Holocene, radiocarbon dating, Slovenia

Session SOC-C

"SOCIETY: The challenges posed to the economy and society"

15:00–17:00, Room B4

Building mountain destination crisis resilience in the Alps and Caucasus

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Mountain tourism destinations are vulnerable to a wide range of crises, from natural hazards and climate change impacts to economic shocks and pandemics. Strengthening crisis resilience in these contexts requires a systematic, place-sensitive, and participatory approach that bridges scientific knowledge with practical application. This research examines crisis resilience in two contrasting mountain destinations: Kaunertal in the Austrian Alps and Mestia in the Caucasus. The objective is the development of a mountain destination Resilience Index, then Digital Monitoring Resilience Platform, a composite, indicator-based tool designed to assess and monitor the resilience of mountain destinations across diverse geographic, socioeconomic, and institutional contexts. The methodological framework followed a structured, multi-stage process grounded in participatory research principles. An initial systematic literature review established the conceptual foundation for resilience indicator identification. This was followed by stakeholder identification and institutional mapping in both study regions to ensure inclusive involvement of local actors throughout the research process. The resulting list of candidate indicators was subsequently validated for contextual relevance and data availability. Variables not available through secondary sources were collected via a quantitative data collection instrument administered in both destinations. The Resilience Index of mountain destination is structured across seven thematic domains: Community Well-being, Social Support Systems, Infrastructure, Vulnerability, Health, Economic Resilience, and Tourism Demand. A final set of 38 variables was incorporated into the index, enabling a multidimensional assessment of destination resilience.

Keywords: Alps, Caucasus, mountains, tourism, resilience

Beyond statistics? How ethnography can complement demographic research in the Alps

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Drawing both on my experience as part of the team working on the recent report Demographic scenarios, residential mobility and impacts of climate change in the Alps (Membretti et al., 2025), and on my long-term involvement in anthropological research in the Western Italian Alps, my aim is to present a theoretical and methodological reflection on the usefulness of integrating demographic data with ethnographic investigation. The ethnographic focus on small contexts appears to be a highly effective methodological tool for observing the layered practices of inhabiting through which mountain communities cope with the delicate climatic, social and demographic changes affecting the Alps. Anthropological fieldwork allows us to apprehend "montanity" as a relational space between humans and their environment, and to investigate key issues for the future of the Alps that are revealed by the collection of updated demographic data, but may benefit from in-depth ethnographic inquiry in order to be properly understood. What interpretative frames do mountain communities use to express their views on climate change, and how is this experienced by different demographic and social groups? How do the new dynamics of mobility intertwine with population ageing, and which outcomes can this produce in terms of services to citizens? Specific ethnographic examples from the Western Alps, with distinctive dynamics, will help us to demonstrate how integrating quantitative analysis with qualitative research allows us to observe the processes involving these localities within the broader territorial scenarios to which they belong, thus highlighting the complex and sometimes tense relationships between Alpine populations and the institutions called upon for responding to their needs

Keywords: anthropology, statistics, ethnography, inhabiting, montanity

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Practicing the Alps: Social reconfigurations of mountain territories in a changing climate

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In the context of glacier retreat and climate change, Alpine territories are undergoing environmental, economic and cultural transformations that affect not only ecosystems and infrastructures, but also everyday practices and the social meanings attached to mountain landscapes. This paper addresses the social dimension of these changes by focusing on hiking as a key form of territorial use in contemporary Alpine regions. The objective of the contribution is to analyse who attends mountain areas, how they experience them and why they go, to understand how everyday practices participate in the reconfiguration of Alpine communities and territories. The paper draws on findings from Un Rifugio per Amico (2024–2025), a citizen-science project promoted by the University of Bergamo in collaboration with the Italian Alpine Club (CAI – Bergamo and Friuli Venezia Giulia sections). The analysis is based on 525 complete questionnaires collected in the Orobie (Lombardy) and Friuli Venezia Giulia. The results show a predominantly adult, highly educated public, with 86% classified as regular or intensive hikers and 41% affiliated with the CAI. Two territorial patterns emerge: the Orobie function mainly as a destination area attracting medium- and long-distance visitors, whereas Friuli Venezia Giulia displays a stronger proximity-based model. Practices are characterized by limited formal preparation, strong car-dependence, predominantly relational forms of hiking, and a central motivation linked to the need to disconnect from everyday life. The contribution conceptualizes hiking as a socially patterned practice contributing to the redefinition of Alpine territories in a time of climate-induced change.

Keywords: Alps, hiking, huts, identity

A new trend in vertical migration? – Initial findings from the analysis of the RSA 5 migration database update

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Supported by the Permanent Secretariat of the Alpine Convention, Italian Presidency and statistical offices of the contracting parties, a joint working group of ÖAW in Innsbruck and University of Turin is updating for another decade a municipality-based Alpine-wide data set on RSA 5 (Alpine Convention 2015) with its detailed population/migration structure data. Initial analyses are being carried out, e.g. on migration patterns in the NUTS3 region of Innsbruck. This region represents an intra-Alpine labour market region strongly influenced by long-distance migration, as well as a housing market area characterised by rural-urban and urban-rural migration. Since around 2000, there can be noticed a steady increase in mobility with a clear trend towards a decline in migration to the city and an increase in migration to higher-altitude communities. Based on the predominant population groups involved (families, nationals), it can be hypothesised that this trend is part of suburbanisation, now spreading beyond the Inn Valley up to the higher side valleys. This observation is supported by a comparison of land prices at the place of origin and destination, which suggests that typical suburbanisers are seeking out new locations with lower housing costs. Deducing from generally cyclical urban regional migration patterns, the trend observed should be fundamentally reversible. Long-term observation and analysis is therefore advisable. In this sense, the presented analyses serve to highlight the potential of the database for identifying Alpine-wide trends and establishing corresponding working hypotheses. They should also motivate to maintain the database as a basis for the future work of the Alpine Convention.

Keywords: migration, population development, urbanisation, database, RSA 5 Update

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Tourism development and territorial conflicts in the context of climate change: The case of Colere–Lizzola

Maurizio Ratto[1], Pietro Piana[1]

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This contribution examines the socio-environmental conflict that has emerged within the mountain communities of Colere and Valbondione (Orobie Alps) in relation to an infrastructure project intended to connect the ski resorts of Colere and Lizzola. The project, which involves the construction of new ski slopes and lifts, a 450-metre tunnel and a reservoir to support artificial snowmaking, has generated divisions among local stakeholders. Part of the population, including authorities, argues that the connection could stimulate regional economic development, counteract depopulation and increase tourism competitiveness, offering residents greater opportunities to remain in the area. Conversely, opponents argue that the project would damage high-altitude ecosystems, criticize the significant public investment benefiting a private actor and question the continuation of a winter tourism model that they consider obsolete and climatically unsustainable. Placing the case study within a broader debate on the transformation of Alpine territories, this contribution investigates the causes of conflict, highlighting how different visions of territorial development, perceptions of climate change and conceptions of the future can generate tensions within local communities. The research combines qualitative analysis, based on interviews with residents, and quantitative assessment, which aims to explore future trends and the climatic sustainability of the project through the analysis of climate data. The objective is to understand the dynamics of consensus and opposition to the project and to assess its compatibility with future climate scenarios, analysing how the interaction between public policies, climate change and tourism development influences the vulnerability of the local community.

Keywords: land-use conflicts, climate change, winter tourism, adaptation, governance

Sediment management in Alpine torrent watersheds in the context of climate change: Findings from field studies, monitoring, and numerical simulations

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Concepts for sediment management in Alpine watersheds have been developed since the founding of the Austrian Service for Torrent and Avalanche Control in 1884. The sediment load in lower-elevation mountain and lowland rivers varies greatly depending on the region. Some receiving streams are unable to handle the large volumes of sediment resulting from debris flow or debris flood transport processes due to their morphology and stream characteristics. The naturally formed alluvial cones or fans are silent witnesses to such torrential transport processes. The situation is different for torrents in alpine regions, where the dominant processes are fluvial sediment transport and flooding. The sediment carried along serves as a sediment source for the downstream water systems, which are of great ecological importance both for stabilization and due to the dynamic stream bed. In this case, water-use structures and flood protection measures often lead to a sediment deficit in the middle reaches of torrents during normal hydrological years. As a result, many Austrian valley rivers now exhibit a deficit of sediment and, above all, bedload. A surplus of sediment typically occurs during so-called design events (debris flow or debris flood with a return period of over 100 to 150 years) that cause significant damage to infrastructure and populated areas. Sediment surpluses or deficits resulting from a disrupted sediment balance have negative impacts on the ecosystem, water management, and flood protection. The development of sediment management concepts is complex and time-consuming and requires the availability of natural measurement data. However, it is evident that these are fundamental to resilient and sustainable management.

Keywords: sediment management, disrupted sediment balance

Posters Young researchers –

Poster Pitches 10:30, Ground Floor

The decline of cross-border public transport in the Franco-Italian "High Valleys": A misalignment between European cooperation frameworks and territorial dynamics

Maxime Bernard[1]

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The poster examines the persistent scarcity of cross-border regional rail services in the Franco-Italian "High Valleys," despite existing infrastructure, European funding, and sustained local political support. Focusing on the Maurienne, Briançonnais and Susa valleys along the Mont-Cenis/Fréjus corridor, it aims to explain this decline, arguing that it results less from technical barriers or insufficient demand than from long-term functional and governance transformations. Based on archival timetable analysis, documentary research and semi-structured interviews, the study first revisits the historical relationship between international and regional services. During much of the twentieth century, international trains combined long-distance and local functions, ensuring effective cross-border accessibility. Progressive commercial and operational specialization, linked to high-speed development and revenue-oriented strategies gradually dissolved this dual role, leading to a structural divergence between international and regional logics. The poster then examines the effects of rail regionalisation and multi-level governance. While interoperability differences persist, evidence suggests that governance fragmentation, asymmetric power relations, and weak coordination mechanisms are more decisive. The national border thus remains a boundary of political responsibility, despite European cooperation instruments such as INTERREG. Finally, the study questions the assumption of insufficient demand. An exploratory gravity-based model of potential flows along the Chambéry-Turin axis, independent of current supply constraints, suggests that cross-border mobility could represent a significant share of regional travel under improved connectivity.

Keywords: cross-border, transport, mobility, governance, policies

Designing context sensitive nudges for natural hazard risk mitigation: A participatory design thinking framework

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Natural hazards intensified by climate change require not only technical and infrastructural measures but also a deeper understanding of human behavior, risk perception, and decision making. This poster presents how behavioral and participatory tools can strengthen multi risk management, offering Alpine stakeholders a replicable pathway to integrate human behavior into climate adaptation, territorial planning, and long term resilience strategies. Within the RETURN project (multi Risk sciEnce for resilienT commUnities undeR a changiNg climate), this applied research introduces a novel, transdisciplinary framework for co-designing context sensitive behavioral nudges to mitigate natural hazard risks. Nudges, small adjustments in how choices are presented, help guide people toward safer behaviors without limiting their freedom, making them a simple and cost-effective way to overcome common cognitive biases in risk situations. Building on the IDEAL method and grounded in design thinking, the framework integrates insights from behavioral economics, policymaking, and product design to support community experts in collaboratively prototyping interventions tailored to territorial specificities.
Tested across three workshops, the method produced actionable nudge prototypes addressing wildfire preparedness, heatwave response, and drought adaptation. Findings demonstrate the framework's ability to bridge the theory practice gap, enhance social acceptability, and generate ethically grounded, behaviorally informed interventions. This work provides a replicable model for participatory behavioral design in disaster risk reduction (DRR).
Although the workshops were not originally tailored to Alpine contexts, the approach is highly transferable to mountain communities facing intensifying water scarcity, ecosystem shifts, and fire susceptibility due to climate change.

Keywords: behavioral nudges, disaster risk reduction

Si.Te.Pro.: A Proactive Territorial System for the Esino Frasassi area

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The Esino Frasassi area, identified as the "Fabriano district" and as the heart of Italy's industrial "White District," is currently undergoing a profound socio-economic metamorphosis. The decline of the traditional industrial model triggered an urgent need for new visions that integrate the territory's manufacturing heritage with its exceptional natural and cultural capital. Within this challenging scenario, the Si.Te.Pro. (Proactive Territorial System) project emerges. Coordinated by Politecnico di Torino and the Unione Montana Esino Frasassi, the initiative employs research-action activities to uncover the "implicit project"—an hidden latent potential—to establish firm foundations for an organic and resilient territorial macro-system. The project uses a mixed quantitative-qualitative investigative method to define specific innovation drivers. Primarily, natural heritage—including Natura 2000 sites and the Gola della Rossa e di Frasassi Park—is structured along two strategic paths: a North-South axis focused on Apennine biodiversity, and an East-West axis connecting valley infrastructures with local production. Furthermore, the agro-food system is identified as a pole of excellence for landscape and cultural values, while the wood and forest system serves as a vital pillar for the green and circular economy. Elements such as air quality, archaeological heritage, and the hydrographic system are also integrated as historical assets for future development. This territorial reconfiguration creates dynamic networks capable of activating new bio-economic chains. The expected outcome is the birth of a mountainous "Knowledge Land," where biodiversity protection and technological innovation cooperate to generate renewed, wide-scale territorial prosperity and long-term sustainable growth for the entire community.

Keywords: terrritorial transition, industrial crisis, heritage, knowledge land

Heat, snow, and survival: Life-history constraints in a high-elevation Alpine bird

Sebastian Dirren[1], Carole Niffenegger[1], Christian Schano[1], Anne-Cathérine Gutzwiller[1], Michelle Eichenberger[1], Fränzi Korner[1,2]

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Climate warming is rapidly altering alpine ecosystems, with strong consequences for cold-adapted species such as the White-winged Snowfinch. This small, iconic bird is endemic to the Alps and other southern European mountain ranges, and it inhabits high-elevation environments year-round. Snowfinches feed their nestlings with arthropods that they collect along snowfield margins, closely linking reproductive timing to snow conditions.

In this long-term study at the Swiss Ornithological Institute, we investigate how rising temperatures and a changing cryosphere affect the survival and the breeding biology in this high-elevation specialist. Specifically, we found that: (i) limited flexibility in breeding relative to earlier snowmelt may create mismatches between nestling demand and food availability; (ii) higher temperatures during breeding shorten the breeding window, further constraining reproductive output; (iii) elevated summer temperatures reduce apparent female survival; and (iv) seasonal fat accumulation reflects a circannual energy management strategy that may become maladaptive under rising temperatures and increasingly frequent extreme events.

These findings highlight how organisms can be constrained in adjusting to the rapidly warming environment. Limited shifts in breeding timing, alterations in breeding season duration, potentially maladaptive circannual energy management, and reduced female survival under high summer temperatures may all compromise resilience in this cold-adapted alpine species. Our results emphasise the importance of snow-dependent foraging sites and suggest that ongoing climate change could have compounding effects on alpine bird populations.

Keywords: snowfinch, high-elevation, snow, temperature, climate

Monitoring climate and land-use change impacts on Alpine grassland vegetation dynamics and carbon sinks

Daria Ferraris[1], Marta Galvagno[2], Ludovica Oddi[3], Gianluca Filippa[2], Edoardo Cremonese[4], Paolo Pogliotti[2], Federico Grosso[2], Umberto Morra di Cella[2], Sofia Koliopoulous[2], Chiara Guarnieri[2], Georg Wohlfahrt[5], Georg Leitinger[5], Mirco Migliavacca[6], Albin Hammerle[5]

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Terrestrial vegetation is a major global carbon sink and plays a crucial role in climate change mitigation. Improving our understanding of vegetation dynamics is essential for enhancing carbon storage in natural and managed ecosystems. Alpine environments are particularly vulnerable, as the Alps are warming at twice the global average and experiencing more frequent droughts and heatwaves. At the same time, socio-economic transformations have led to widespread land abandonment, altering plant species composition and distribution. In the Aosta Valley, land-cover and land-use changes are driving woody species encroachment into formerly managed mountain pastures below the forest line. This study investigates how climatic and socio-economic drivers promote the expansion of woody vegetation into subalpine grasslands, reshaping carbon sequestration patterns. Research was conducted at the ICOS site of Torgnon (IT-Tor), an abandoned pasture at 2100 m a.s.l. dominated by Nardus stricta. A 15,000 m² area undergoing recolonization by Larix decidua and shrub species (Calluna vulgaris, Juniperus communis, Vaccinium spp., Rhododendron ferrugineum) was monitored through repeated surveys in 2015, 2018, 2021, and 2024. Using high-precision GNSS, we mapped larch individuals, measured structural traits, and quantified shrub expansion. The site provides continuous CO_2, water flux, and meteorological data since 2008; in 2024, an additional eddy covariance tower was installed in the encroached area to capture flux differences. Results show a marked increase in larch abundance between 2015 and 2018, with numbers nearly doubling, followed by slower but ongoing expansion. These trends indicate a progressive shift from grassland to woody vegetation, with significant implications for carbon and water dynamics. The study highlights the importance of land-use change in shaping current and future carbon sinks.

Keywords: encroachment, land-use-change, pasture abandonment

Large Language Models contribution in scientific data analysis for geo-hydrological risk assessment

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Artificial Intelligence (AI) is an increasingly used tool that has become integrated into our daily lives to streamline simple tasks and speed up information retrieval on the Internet. In a scientific context, these technologies are used for more sophisticated tasks and complex reasoning across various disciplines. Our study focuses on using Large Language Models (LLMs) to extract and elaborate data from a large set of sheets to create a database capable of performing scientific and standardized analyses. Focusing on the Aosta Valley, a small alpine region in northwestern Italy, we utilized the regional landslide repository called “Catasto Dissesti," collecting data on rockfall events from 1600 to 2024. The main challenge is to extract key information from textual forms that have standard fields but are compiled heterogeneously and subjectively by operators after rockfall events. Our project analyzes 854 PDF forms from 2011 to 2023, using only LLMs. Through chat-based interfaces, we iteratively refined and optimized numerous prompts to reduce inconsistent performance and AI hallucinations, extracting information such as the date of the event, location, volumes, and more. This approach was also tested on a historical document from 1934, containing handwritten notes and a geological cross-section of a landslide, with similar results. Future developments will aim to achieve systematic extraction and structuring of data to build a comprehensive database for studying the above-mentioned phenomena, like frequency analysis and risk reduction methods.

Keywords: AI, rockfall, historical document, landslide database, Aosta Valley

Satellite Data Fusion for GLOF Hazard Cascade Monitoring and Downstream Risk Assessment: A Conceptual Framework

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Retreating glaciers across the European Alps and global mountain glaciers are generating a rapidly expanding inventory of proglacial lakes whose failure can trigger Glacial Lake Outburst Floods (GLOFs). These cascading hazards – spanning dam destabilization, sudden outburst, and downstream flood propagation – threaten hydropower infrastructure, communities, and transport corridors with minimal warning time. Copernicus satellites already capture relevant precursor signals, yet revisit intervals of multiple days are insufficient for rapidly developing events, and no operational system links lake instability to downstream asset and population exposure.
The AISTec project proposes a conceptual framework to close this gap. It integrates multi-source Copernicus data fusion (Sentinel-1, Sentinel-2, and DEM's) with downstream flood propagation modelling and infrastructure exposure mapping to directly connect lake and slope instability, debris flows, and permafrost signals to assets and communities at risk. IoT sensors, mobile platforms, and commercial high-revisit satellite data are being considered to address critical observation gaps, including lake bathymetry, where satellite retrieval is fundamentally limited. A machine learning classification layer supports risk state monitoring and early warning across key components of the hazard cascade. Intended as a cost-effective and transferable approach across mountain regions, the concept was developed at the ESA CASSINI 2026 hackathon. This poster invites critical discussion on methodology, validation, and operational integration.

Keywords: GLOFs, Copernicus, data-fusion, hazard-cascades, infrastructure

Who inhabits the Alps? Developing innovative indicators for emerging demographic trends in mountain territories

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In recent years, the Alps have become the setting for profound and interconnected transformations: from an environmental perspective, the climate crisis is altering several natural, cultural and economic dimensions of these territories; from a demographic standpoint, new settlement trends are emerging (Viazzo & Zanini 2020), further accelerated by the Covid-19 pandemic, which has contributed to the construction of increasingly attractive – and often idealised – imaginaries of mountain life (Barbera et al. 2022). Understanding who truly inhabits the mountains has therefore become crucial, both for environmental and territorial policies. This research aims to identify innovative indicators to quantify the effective presence of people in Alpine territories, moving beyond official residency data to include forms of metromountain dwelling (Barbera & De Rossi 2021), the use (or non-use) of second homes, and the "vertical migration" from large urban centres in the plains towards the mountains (Membretti et al. 2024). These phenomena, despite being on the rise, remain difficult to capture through traditional statistical tools and therefore call for an innovative methodological approach. The identification of these new indicators is part of a research project carried out by the UniTo-Istat working group – composed of Gerardo Gallo, Andrea Membretti, Daniela Yanez, Flavio Biasucci, Marco Fortini, Claudia Carpino and Sofia Lanfranchi – on behalf of the Italian Presidency of the Alpine Convention, focusing on the case study of the Aosta Valley, and building on the September 2025 report "Demographic scenarios, residential mobility and impacts of climate change in the Alps.

Keywords: demography, indicators, migration, metromountain, mobility

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Droughts in glacierized catchments of the Italian Alps: Evolution and emerging high-elevation variabilities (2000–2024)

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Mountain regions are experiencing increasingly frequent and severe droughts, raising concerns about the long-term reliability of alpine "water towers." In glacier-fed catchments, drought emerges from interactions among atmospheric forcing, snowpack variability, glacier melt, and runoff generation across multiple spatial and temporal scales. However, drought propagation in glacierized basins remains insufficiently understood. This study analyzes drought occurrence and evolution in glacier-fed catchments of the Italian Alps from 2000 to 2024. We focus on basins in Piedmont, Aosta Valley, and Trentino, a climatic transition zone influenced by both Mediterranean and continental regimes. These headwater systems sustain downstream hydropower production, irrigation, drinking water supply, and alpine ecosystems. Drought development is assessed across meteorological, cryospheric, and hydrological compartments. Precipitation and temperature anomalies are derived from the BigBang dataset, while snow drought conditions and glacier melt contributions are quantified using snow water equivalent and melt simulations from the S3M Italy model. Hydrological drought signals are evaluated through streamflow observations from regional monitoring networks. By examining spatial and temporal variability and cross-compartment propagation, we investigate how glacier melt and high-elevation processes influence drought duration and intensity, and how these relationships have evolved over the past two decades. This integrated assessment advances understanding of drought mechanisms in glacierized alpine basins and provides new insight into emerging high-elevation drought signals and their implications for alpine water resources under ongoing climate change.

Keywords: glacier retreat, Alpine drought, high-elevation water resources

Tracing drought impacts across elevations in the Po basin: Evidence from newspaper records (2000–2023)

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Drought events in the Po Basin (2003, 2006, 2012, 2017, 2022) are increasingly reshaping mountain systems. Climate driven glacier retreat, reduced water resources, biodiversity pressures and damages to pastoral and livestock based alpine economies highlight the growing vulnerability of mountain "water towers." This study examines georeferenced drought impact records from newspapers since 2000 to assess correlations among impacts across elevation ranges. Specifically, it investigates whether drought conditions in the lowlands anticipate impacts in mountain areas, and how elevation dependent propagation affects water management. Impact data reveal a strong cross elevation relationship between lowlands and mountains across all events, with significance improving when excluding 2012, which behaves as an outlier over the Po Basin. Although patterns vary by event, their evolution consistently converges. In 2022, impacts clearly begin in the lowlands before appearing in mountain areas. In 2003, onset in lowlands and mountains is almost simultaneous. In 2006, 2012 and 2017, early signals emerge in mountain zones but rapidly align with lowland trajectories, confirming that high elevation impacts are not independent and largely follow lowland dynamics. This dependence reinforces competition among water users and increases tensions between lowlands and alpine areas, which must react to restrictions and needs originating downstream. Yet impact categories and types remain difficult to generalize across elevations. These findings confirm the need for stronger cooperation and basin wide water source management, ensuring coordinated measures between lowlands and mountains while expanding multi altitude impact data monitoring to further complement existing drought impact databases.

Keywords: drought, impacts, Po basin, propagation

Floods as agents of territorial change: Insights from the June 2024 event in Valnontey (NW Italian Alps)

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Glacierized mountainous regions are becoming increasingly unstable and highly sensitive to climate change, as they are warming at a comparatively faster pace. In recent decades, disastrous impacts of high-magnitude floods driven by an increased frequency of short-duration extreme precipitation have been reported across European Alpine regions. Despite this evolving hazard, a critical research gap remains in integrated, event-based studies that relate extreme rainfall forcing to the hydro-geomorphological response of deglaciating Alpine catchments and the cascading impacts on infrastructure, ecosystems, and territorial governance, which are needed to understand the dynamics of triggered processes that reshape Alpine landscapes and affect community resilience. The Valnontey catchment in Cogne, Valle d'Aosta (NW Italian Alps), was impacted by an extreme rainfall-induced flood event on 29–30 June 2024. The rainstorm delivered over 120 mm of rainfall within 24 hours, and the resulting historical peak runoff caused severe damage to roads and bridges, interrupted electricity and water supplies, severely affected tourism, leading to socio-economic losses for local communities. The valley's river network also underwent significant changes due to debris flows and landslide activity. However, the destruction of monitoring stations necessitated detailed post-event campaigns to reconstruct the hydro-geomorphological response of the catchment, providing critical insights into the mechanisms driving extreme floods. The analysis highlights that extreme rainfall can act as a driver of territorial change, reshaping ecological, infrastructural, and social landscapes in deglaciating Alpine catchments. Consequently, adaptive governance and resilient strategies are essential to protect communities, cultural landscapes, and Alpine ecosystem services in a climate-unstable future.

Keywords: Alps, extreme rainfall, floods, hydro-geomorphology, resilience

Defining spatial conditions for quality of life in the Alps

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Quality of life has a distinct spatial component, as the concept describes living conditions in a specific area and identifies factors that influence quality of life in this place. Spatial conditions vary from location to location and describe the objective situation in a given area using measurable data. Similar to the quality of life concept there is no unified perception what everything can be understood as spatial conditions, most common they entail infrastructure, accessibility to services, housing, and environment. The state of these conditions often influences residents' perceptions of quality of life, however, no unified framework exists for identifying or monitoring them in the Alpine context. In this research, the key topics of spatial conditions in the Alps are identified through a systematic literature review and an assessment of available data sources. The selected topics will be described using objective indicators either deriving from the existing databases or created in the process, including the composite indicators. Based on existing literature and the specific characteristics of the Alpine region, such as mountainous terrain, remoteness, dispersed settlement patterns, and economic focus on tourism, three main topic are most relevant: environment (e.g. environmental quality, protected areas, climate conditions), infrastructure (e.g. transport, tourist and recreational infrastructures), and housing (e.g. housing availability and affordability, secondary residences). Defining these spatial conditions and their indicators will provide a systematic overview of living conditions in the Alps, comparison between the regions and support monitoring of quality of life.

Keywords: spatial conditions, quality of life, Alps, regions, indicators

Short-term climate signals in Alpine environment: Analysis of temperature anomalies in Valle d'Aosta (2017–2024)

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Alpine regions are widely recognized as climate change hotspots and therefore require systematic investigation and monitoring to detect ongoing trends, anticipate future developments, and policy decisions. In this context, Valle d'Aosta (Northwestern Italian Alps) is the focus of the present climatological analysis. The study is based on the dataset provided by the Centro Funzionale Valle d'Aosta and covers the period 2017–2024. Air temperature observations from 39 meteorological stations, distributed homogeneously across the regional territory, were analysed. The stations were grouped into four elevation classes: valley, mountain, subalpine and alpine area, to evaluate the sensitivity of temperature variations to altitude. Maximum and minimum temperature anomalies were calculated using the Standardized Anomaly Index (SAI) at annual, seasonal, and monthly time scales. The use of SAI allows for a consistent comparison among stations located at different elevations (Kraus 1977). Trend analysis was performed on the anomaly time series using the Mann–Kendall test (Mann 1945; Kendall 1975). In addition, the Pettitt test was applied to the monthly SAI series of the 39 stations to detect potential abrupt shifts, which may indicate changes in the underlying climate regime. Results show a consistent increase in annual minimum temperature across all elevation classes, largely driven by winter conditions. Maximum temperatures exhibit a more heterogeneous behaviour, with increases in winter and decreases in spring and autumn, suggesting a possible elevation dependence response. Overall, this analysis provides useful indications that may be important for regional adaptation planning and for highly sensitive Alpine environments.

Keywords: climate change, temperature, trends, Standardized Anomaly Index (SAI), Elevation Dependent Warming (EDW)

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Project Posters –

Poster Pitches 14:00, Ground Floor

NextWater_ST: a Nexus perspective for adapting water management in South Tyrol to future changes

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Climate change and intensified human activity are increasingly complicating water management in the Alps, as warmer temperatures, altered rainfall, reduced snow cover, and shrinking glaciers diminish water resources. South Tyrol faces changed streamflow patterns, more frequent droughts, and heightened competition for water, emphasizing the critical need for integrated, local adaptation strategies. The NextWater_ST project addresses these challenges by using a Water–Energy–Food–Ecosystems (WEFE) nexus approach to clarify connections between water availability and sectoral demands in Alpine settings. The project collaborates with local agencies, agricultural groups, and the energy sector, aligning with the South Tyrol Climate Plan and responding to stakeholder needs. Supported by the Autonomous Province of Bolzano, NextWater_ST aims to assess water supply and demand, identify drought-prone areas, co-create knowledge with stakeholders, and evaluate adaptation strategies for mountain environments. In its first phase, the project established a unified modeling framework based on historical data to estimate water availability and demand. The hydrological model delivers daily estimates for discharge, snow, evapotranspiration, soil moisture, and hydropower use, incorporating detailed land-use data and Alpine crop coefficients to better capture irrigation and ecosystem needs. These results feed into the WEFE framework to spot mismatches between supply and demand. Led by Eurac Research, in partnership with the Free University of Bozen–Bolzano and Laimburg Research Centre, the project supports scenario analysis, stakeholder involvement, and integrated adaptation strategies for sustainable Alpine water management.

Keywords: climate change adaptation, water resources, Water-Energy-Food-Ecosystem Nexus

Shrinking Cryospheric Buffers in the Alps: Declining Glacier Capacity to Mitigate Summer Droughts in the Upper Adige River Basin

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Glacier and snow meltwater are key components of Alpine water resources, sustaining summer streamflow and providing an important natural drought buffering capacity in mountain regions. However, ongoing cryosphere decline is progressively weakening this function, with important environmental and socio-economic implications for Alpine territories and downstream communities. This study investigates how glacier retreat affects the capacity of Alpine catchments to mitigate summer droughts in the upper Adige River Basin (Italian Alps), where hydropower, irrigation and ecosystem need often compete for water during dry periods.

We integrated a dynamic glacier module into the semi-distributed hydrological model ICHYMOD-TOPMELT to simulate glacier evolution and meltwater contributions between 1997 and 2022, during which glacier area in the basin declined from 111 km² to 79 km². Model results show that glacier melt contributed on average 4.5% of summer streamflow, reaching up to 30% in highly glacierized sub-basins and during major drought events. However, despite higher melt rates during warm years, the progressive loss of glacier area has significantly reduced the absolute buffering effect of glaciers. For an extreme drought such as the 2022 event, glacier retreat has already reduced the drought-mitigating contribution of glaciers by about 40%, compared to conditions three decades ago.

These findings highlight a critical transition in Alpine socio-hydrological systems: as cryospheric storage declines, summer water availability becomes increasingly dependent on precipitation and seasonal snow conditions. This shift creates growing environmental pressures and socio-economic risks for water-dependent sectors and ecosystems, emphasizing the need for socio-hydrological adaptation strategies and water governance approaches that explicitly account for diminishing glacier contributions in glacier-fed Alpine basins.

Keywords: cryosphere decline, glacier retreat, drought buffering, Alpine water resources, socio-hydrological adaptation

SEED 4EU+ Project "CREST - Cryosphere remote sensing and hazards monitoring in environmental transitions", an opportunity to investigate the natural and human influence on geomorphological hazards in the Belvedere Glacier area (Italian Alps)

Irene Maria Bollati[1], Lukáš Brodský[2], Vít Vilímek[3], Marcus Nüsser[4], Roberto S. Azzoni[1], Susanne Schmidt[4], Jan Kropáček[3], Manuela Pelfini[1]

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High mountain environments are undergoing massive transformations, on both short- and long-term scales, and quantifying their rates and spatial variability is crucial for geomorphological hazards detection Such regions provide relevant abiotic ecosystem services (i.e., regulating, supporting, provisioning and cultural) to Society. The 4EU+ mini grants (2021-2024) involving Charles University (Prague, Czech Republic), Heidelberg University (Germany), and University of Milan (Italy), and, in particular, the SEED 4EU+ project entitled "CREST - Cryosphere remote sensing and hazards monitoring in environmental transitions" in 2025 focused on the area of an iconic debris-covered glacier and of its tributary basins, affected by relatively frequent and varied geomorphological and glaciological hazards: GLOFs (Glacier Lake Outburst Floods), ice and rock avalanches, debris flows, moraine sliding. These projects aimed at spatio-temporal characterizing, geomorphological processes through i) UAV surveys to acquire very high resolution digital elevation models to quantify volume changes; ii) satellite imagery analysis and historical photography to monitor and to analyse changes of Belvedere glacier's surface and of glacial lakes in particular since the 19th century; iii) collection of data for absolute and relative dating to define the temporal dimension of hazardous processes. All these activities have been accompanied by geomorphological mapping constantly updated on an annual basis. All these data will be made available through an open access spatial database, functioning as a showcase of the knowledge up to now attained, allowing stakeholders to have a comprehensive view on the Belvedere status for an adequate territorial planning.

Keywords: 4EU+ alliance, geomorphological hazards, debris covered glacier, multidisciplinary approach

Nevediversa: Rethinking winter tourism in a changing climate

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The poster presents the Nevediversa project, an initiative promoted by Legambiente, which explores how winter tourism is changing in the Alps and other mountain regions under the effects of climate change. Declining natural snow, rising temperatures, and increasing weather variability are challenging the traditional development model based mainly on alpine skiing and ski-lift expansion. The poster emphasizes the need to rethink winter tourism in a rapidly changing climate. Its goal is to highlight the environmental costs and limitations of common adaptation strategies—particularly artificial snowmaking and infrastructure expansion—while presenting sustainable alternatives.
The content draws on data, territorial analyses, and citizen science contributions from the Nevediversa campaigns. These campaigns monitor ski resorts, abandoned ski lifts, forms of "therapeutic persistence" in struggling areas, and tourism reconversion practices. Using maps, data, and case studies, the poster shows how some mountain communities are experimenting with alternative development models based on low-impact tourism, landscape enhancement, outdoor activities not dependent on snow, and greater economic diversification.
Together, these experiences suggest the possibility of a "different snow": a future for mountain regions that does not rely solely on artificial snow, but on more resilient and sustainable adaptation strategies.

Keywords: climate, tourism, adaptation, communities, low-impact

Glacier Caravan

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Glacier Caravan is a scientific monitoring, outreach and awareness campaign dedicated to the condition of Alpine glaciers and to the effects of the climate crisis on the cryosphere. Promoted by Legambiente in collaboration with the Italian Glaciological Committee (CGI) and CIPRA Italy, this international initiative travels each year across different Alpine areas with the aim of observing glacier evolution, collecting scientific data and communicating ongoing changes to the public. Through field expeditions, monitoring activities, public meetings and outreach events, Glacier Caravan connects the scientific community, associations, local authorities and citizens. In this way, the project helps make visible the rapid transformations affecting Alpine glaciers, including shrinking glacier surfaces, retreating fronts and mass loss—phenomena closely linked to rising global temperatures. Alongside its scientific and cultural dimension, the campaign increasingly focuses on adaptation policies in mountain regions. The rapid retreat of glaciers has significant implications for water availability, slope stability, natural hazard management and territorial planning across the Alpine regions. Glacier Caravan promotes dialogue between scientific research, public administrations and local communities in order to identify strategies capable of addressing the impacts of the climate crisis and fostering more sustainable management of mountain resources and ecosystems. The poster presents the main objectives, activities and results of the campaign, highlighting the role of glacier monitoring as a scientific, educational and policy tool for understanding ongoing changes and supporting more effective climate and adaptation policies in the Alpine regions.

Keywords: glaciers, global warming, monitoring, cryosphere, adaptation

From imaginaries to relation: Engagements with the Alpine glaciers beyond climate change

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This PhD project examines human–glacier relations in the European Alps beyond climate change. Drawing on interdisciplinary glacial scholarship in the social sciences and critical engagements with modernity and its nature–culture division, it investigates how perceptions of glaciers have been shaped by visual cultures and climate crisis discourses, deepening understanding of human–glacier relations beyond narratives of loss. Over the past two decades, representations of melting glaciers have saturated social media, news media, exhibitions, and documentary film, consolidating glaciers as icons of environmental crisis. While powerful, this framing reduces glaciers to symbols of disappearance and obscures the ways ice remains embedded in everyday life. This research therefore asks which human–glacier relationships emerge when climate change is not the sole interpretive frame through which ice is understood. The study traces glacier imagery from Romantic sublime aesthetics to contemporary climate iconography, identifying Eurocentric genealogies and contrasting them with local histories of interaction that exceed crisis narratives. In dialogue with Ice Humanities, it foregrounds relational and more than human perspectives, challenging colonial wilderness narratives that marginalise local communities. Empirically, the research focuses on the Monte Rosa massif across Italy and Switzerland. Combining semi structured interviews, ethnographic filmmaking, soundscape recording, and digital ethnography, it explores how glaciers are encountered and contested. Integrating historical analysis, media study, and sensory ethnography, the project advances political glaciology, offering a nuanced account of glaciers as ecosystems entangled with social and political life.

Keywords: Alps, glaciers, nature, culture, relations

Multitemporal reconstruction of the Miage Glacier area (Valle d'Aosta Region) through historical aerial photogrammetry

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Climate change is profoundly reshaping mountain environments, with cryospheric areas experiencing some of the most rapid and significant geomorphological transformations observed in recent decades. Reconstructing the morphological evolution of these systems requires reliable historical datasets, which can be derived from archival aerial imagery using modern photogrammetric techniques. This contribution presents a methodological workflow for generating Digital Elevation Models (DEMs) from historical aerial photographs of the Miage Glacier area using a Structure-from-Motion (SfM) approach. Aerial photographs were retrieved from the IRPI archive, which preserves aerial imagery covering Northern Italy from the 1930s. Photographs from the 1988, 1991, and 2003 campaigns were identified and digitized at 1600 dpi. The SfM workflow was implemented in Agisoft Metashape. Fiducial marks were detected on each frame to establish interior orientation, while camera calibration parameters, including focal length and lens distortion coefficients, were extracted from camera calibration reports and refined by self-calibration. Image orientation was then performed to estimate camera positions and generate sparse point clouds, followed by dense point cloud reconstruction and DEM generation. To ensure geometric consistency across epochs, a cascading approach was adopted: the 2003 dataset was processed using 10 Ground Control Points extracted from the publicly available Valle d'Aosta regional orthophoto from 2012 (0.2 m spatial resolution) and DEM from 2008 (2 m). The resulting DEMs, combined with the open-source 2 m DEM from 2008, were used for multitemporal geomorphological mapping and DEM of Difference calculations to assess volumetric and morphological changes over the last four decades.

Keywords: climate change, Structure-from-Motion, multitemporal DEM analysis, glacial retreat

Why viability is not enough: Bankability lessons from the Alpine Space ForestEcoValue Project

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Forest ecosystem services (FES) generate widely acknowledged environmental and societal benefits, yet they continue to attract very limited private debt finance. This gap is commonly explained by insufficient expected profitability. Drawing on evidence from the Alpine Space ForestEcoValue project, this contribution advances a different interpretation: many FES projects may be financially viable but remain structurally unbankable because they fail to satisfy lenders' joint requirements on downside-risk protection, outcome robustness, and institutional credibility of revenues over the financing horizon.

The analysis covers five Alpine FES business models examined within ForestEcoValue and evaluates seven policy instruments modelled as structurally distinct interventions affecting non-substitutable primitives of bankability, including diversification, scale economies, governance arrangements, revenue floors, and long-term institutional anchoring. Using Monte Carlo simulations (20,000 trials per scenario), policy impacts are assessed through distribution-based indicators derived from net present value outcomes—median NPV (financial viability), tail-risk severity (Expected Shortfall and Value-at-Risk), outcome dispersion (robustness), and an explicit feasibility classification reflecting institutional commitment. In line with the analytical framework, composite aggregation is deliberately avoided to preserve the non-compensability of these dimensions.

Initial results show a systematic decoupling between financial viability and bankability. Policies that increase expected returns often leave downside risk and robustness materially unchanged, while risk-transfer instruments improve tail protection but fail to unlock finance in the absence of credible institutional anchoring. Only policy bundles that jointly address risk, robustness, and governance constraints emerge as finance-compatible under Pareto screening with explicit feasibility filters.

Building on this diagnostic framework, the paper introduces a Bankability Index (BI) as an operational admissibility check derived from the same indicators used in the policy analysis. The findings suggest that improving FES financeability requires less emphasis on subsidy magnitude and greater attention to institutional design, policy sequencing, and commitment durability.

Keywords: bankability, forest ecosystem services, policy design, institutional conditionality, Alpine Space

Melting mysteries: Revealing the impacts of climate change on ice caves through citizen science

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Glacier melting is one of the most visible indicators of global climate change. In 2000-2014 period, Alpine glaciers lost around 16% of their volume, and up to 90% of all Alpine glaciers could disappear by 2050. However, climate change is also affecting the ice in Alpine karst caves, where the average temperatures are increasing by around 0.2°C per decade. In Slovenia, there are 229 karst caves with permanent ice. Although research on ice caves is less extensive, they provide valuable data on local and regional climate change. Current research within the framework of project "Supporting Holocene Climate Reconstruction with High-Resolution Cryospheric Proxies from the Karst Ice Caves of Slovenia" focuses on four ice caves, where scientists monitor climate variables and ice mass changes. Results show accelerated ice loss, but more comprehensive research is needed to fully understand the impact of climate change on cave environments. Past conditions can be reconstructed using cave maps, archival documentation from the Cave Registry, and photographs to compare them with current data. Caving volunteers and associations are key partners in this research, as their expertise and records significantly complement scientific efforts. The project will gather photographs, collect data on cavers' observations, and establish a methodology for temperature and ice mass monitoring. Findings will be shared through lectures, exhibition, and a geoinformation portal to raise awareness on the impacts of climate change and promote protection of these fragile environments, while strengthening collaboration between scientists, cavers and a wider public.

Keywords: ice caves, climate change, archival materials, monitoring, citizen science

ForcorAttiva. The co-design of strategies as a tool for territorial transition and sustainable development

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This poster outlines the experience of the ForcorAttiva project, led by Politecnico di Torino in collaboration with the Comunità Montana Valli del Verbano. Funded by the Fondazione Cariplo's "Montagne in Transizione" call in 2024, the project stems from the urgent need to identify effective responses to the necessary ecological and socio-economic transition of the Forcora area (Province of Varese). Historically, this region was defined by snow tourism; however, this model has been drastically dampened by the almost complete absence of snow cover caused by climate change. This specific system—located at a low altitude in a sensitive cross-border area (IT-CH)—is characterized by a structural dependence on the urban-lake context it overlooks, leading to progressive depopulation and the abandonment of mountain lands in favor of urban centers along Lake Maggiore.
Through co-design activities involving project partners, local stakeholders, and a population heavily scattered and fragmented across the territory, the project develops concrete actions to implement a transition toward sustainable development models. The expected results are twofold: fostering sustainable living for residents and promoting a conscious use of the mountains. Raising awareness among inhabitants and visitors regarding climate challenges, alongside the revaluation of local heritage, forms the strategic basis for integrating the Forcora system into wider supra-local networks. Consequently, this poster presents the project's results achieved so far—from methodological, strategic, and applicational perspectives—in order to stimulate a multidisciplinary discussion and gather feedback on the ongoing territorial transition, ensuring the long-term resilience of this area.

Keywords: mid-mountain areas, sustainable territorial development, territorial co-design, territorial transition, climate change

BeyondSnow: Enhancing the resilience of Alpine space snow tourism destinations and communities to climate change

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Alpine tourism destinations are increasingly affected by climate change through rising temperatures, shifting precipitation patterns, more frequent extreme weather events, and growing uncertainty for local economies and community well-being. These dynamics create practical challenges for municipalities, DMOs, businesses, and residents: how to maintain quality of life and livelihoods, manage competing expectations and land-use interests, and make adaptation decisions that remain legitimate over time. To tackle these issues, the Interreg Alpine Space project "BeyondSnow" engaged 10 Pilot Working Areas (PWAs) to develop and test transition pathways for climate change adaptation in tourism-dependent mountain communities in the Alps. Project partners facilitated participatory processes in which public authorities, DMOs, SMEs, and civil society jointly developed Transition Strategies. These strategies translated locally perceived risks and opportunities into shared priorities and feasible roadmaps, strengthening cooperation. Subsequently, PWAs implemented more than 20 Pilot Actions to explore what adaptation measures can look like in practice, such as seasonal diversification, tourism-management and cooperation measures, and improvements in landscape- and infrastructure-related services. To support transferability, BeyondSnow synthesized pilot experiences into a structured overview of resilience-relevant dimensions and indicators. Furthermore, the project also developed resilience-oriented policy guidelines and recommendations aimed at strengthening enabling conditions for adaptation, including multi-level coordination, capacity building, and coherent incentives. The poster will present the project's approach, examples of implementation, and key lessons on locally owned transition pathways. It invites discussion on strengthening community resilience while addressing conflicts, ensuring inclusion, and maintaining quality of life under accelerating climate change.

Keywords: climate, change, tourism, adaptation, governance

Integrating radar and optical satellite data for detecting fresh supraglacial deposits

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Climate warming is rapidly transforming high-altitude mountain environments. Rising temperatures are accelerating glacier retreat and degrading permafrost, which destabilizes steep slopes and promotes paraglacial processes such as rockfalls and landslides. These processes often deliver fresh debris onto glacier surfaces, modifying glacier energy balance and potentially affecting alpine routes. Detecting these new supraglacial debris deposits, however, remains challenging due to frequent cloud cover, seasonal snow, and the complex characteristics of alpine terrain. To address this challenge, we propose a methodology that integrates spaceborne radar and multispectral satellite observations to detect and classify glacial surface changes while compensating for the limitations of individual sensors. The workflow consists of two main steps. First, cloud-free Sentinel-2 images within a user-defined time range are analyzed distinguishing snow and ice from exposed rock. Second, areas that remain unclassified in the optical analysis are examined using Sentinel-1 radar observations. Temporal differences between accumulation and ablation periods are used to identify surface disturbances consistent with newly deposited debris linked to slope instabilities and permafrost-related degradation. The combined use of Sentinel-1 and Sentinel-2 data achieved an overall end-to-end accuracy of about 90%, compared with roughly 70% when relying on radar data alone. Although performance decreases in highly heterogeneous or persistently cloud-covered areas, the integrated approach improves the reliability of optical-only methods. Overall, this workflow provides a robust satellite-based strategy for detecting supraglacial debris linked to slope instability and permafrost degradation, offering a useful tool for monitoring geomorphological responses to climate change in high-mountain environments.

Keywords: climate change, remote sensing, landslides, change detection

Commons of the Alps – An open archive for craftsmanship, tradition and innovation

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How can endangered Alpine craftsmanship knowledge be made digitally accessible – in an open, participatory, and collaboratively expandable way? The SNF project "Commons of the Alps – An Open Archive for Craftsmanship, Tradition and Innovation" is developing a prototype for a digital archive of craft practices from Graubünden – namely in the model regions of Biosfera Val Müstair, Beverin Nature Park, Parc Ela, Parco Val Calanca, and the UNESCO Engiadina Val Müstair Biosphere Reserve. Together with craftspeople, institutions, and local experts, we're testing tools, data models, and collaboration methods. Our poster outlines our research questions, methodology, and the significance of our study. An overview of the model regions and thematic focus areas clearly illustrates the project's scope. In this, the forum benefits from real-world perspectives drawn from highlighted projects, including, among others, the textile, wood, ceramics, and metalworking crafts. Beyond that, we exemplify how a design commons could work. Extending past the project context, our proposed poster provides a basis for discussing how digital knowledge commons can strengthen regional value creation and cultural sustainability. In doing so, it helps counterparts understand how digital archives can be activated, local communities engaged, and which models of openness and participation are suitable for Alpine commons. Our project offers transferable insights into the organisation, participatory development, and technical infrastructures of digital commons in Alpine regions.

Keywords: commons, crafts, archive, sustainability, collaboration

Assessing climate change impacts on winter tourism: The Monte Rosa case study within the LIQUIDICE Project

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Rising temperatures are causing rapid changes to snow, ice and permafrost, elements that play a vital role in regulating the Earth's climate system. These transformations threaten ecosystems and water resources in many regions, including the Alps, while also generating socio-economic impacts. Understanding these changes is crucial for managing their negative effects. In this context, the EU funded project LIQUIDICE (LinkIng and QUantifying the Impacts of climate change on inlanD ICE) brings together multidisciplinary collaborations, across 18 European research institutions, to address these challenges. In particular, within LIQUIDICE, CMCC focuses on developing adaptation strategies for winter tourism in the Monte Rosa area, a key economic sector that is strongly dependent on snow reliability and which is already recognised at high risk. However, designing effective and long-term adaptation strategies require a clear and comprehensive understanding of risk that goes beyond climate hazards alone and also considers the local context, while actively involving stakeholders and local communities into the assessment process. From the methodological perspective, our risk assessment follows the approach promoted by IPCC (AR6), which considers the risk as a function of hazard, exposure, vulnerability and adaptive response. The study begins with an assessment of climate hazards and then integrates socio-economic and contextual information, collected through interviews and focus groups, to assess vulnerability and response capacity. Finally, in this process, the active participation of communities not only enriches the analysis with local knowledge but also supports awareness and dialogue on sustainable pathways for climate adaptation in the area.

Keywords: climate change, risk assessment, participation, adaptation, tourism

HumanFactor

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People - not just policies - determine the success of sustainability transitions. This is where HumanFactor comes in. We empower Alpine communities to actively shape transformation and put a spotlight on the "human factor" in decision making and implementation activities. HumanFactor is about bridging the implementation gaps, through knowledge building, networking, and hands-on support. Our cross-border approach harnesses the collective intelligence of the Alpine region and enables mutual learning across boundaries to turn local actors into sustainability pioneers.

Keywords: human factor, implementation gap, collective intelligence, transition policies

Beyond the ice: Bridging inter- and transdisciplinary gaps to achieve positive proglacial futures

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Accelerating glacier retreat is creating extensive proglacial areas worldwide, characterized by rapid landscape and ecosystem change and by the emergence of new ecological, social, and governance challenges. As glaciers disappear, these newly exposed areas may play an important role for biodiversity conservation, while also attracting growing interest for human uses such as tourism, and hydropower development. However, these uses raise important questions of governance, as they involve multiple stakeholder perspectives and potentially competing priorities. Although natural science research has substantially advanced understanding of proglacial geomorphic and ecological dynamics, societal, cultural, and economic dimensions remain insufficiently integrated into research and governance. The BeyondIceFutures project, funded by the Mountain Research Initiative, addresses this gap by developing an inter- and transdisciplinary framework for envisioning and guiding positive futures for newly deglaciated areas. The project investigates three main questions: a) which knowledge gaps and Nature's Contributions to People (NCPs) are most relevant from the perspectives of scientists, practitioners, and stakeholders; b) which of these gaps can be addressed through synthesis of existing knowledge; c) and what attractive visions and practical guidelines can support positive proglacial futures. To achieve these aims, the project combines a global online survey (completed March 2026), a collaborative assessment of survey results, and an in-person workshop in Innsbruck (1–3 October 2026), alongside a synthesis of current knowledge on proglacial landscape and ecosystem development, management, and governance. The outcomes will inform a scientific publication, a policy brief, and a larger future research proposal.

Keywords: proglacial areas, deglaciated landscapes, futures thinking, interdisciplinary research, ecosystem services

When the glacier leaves: Assessing post-glacial water security of Alpine mountain huts through remote sensing

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For over a century, the location of Alpine mountain huts was shaped by glacial proximity. As glaciers retreat, huts that once relied on meltwater now face a supply regime governed by volatile rainfall and diminishing snow reserves. The consequences extend beyond individual sites: mountain huts are critical nodes in the Alpine trail network, and their closure compromises mountaineering safety and tourism economies. Despite growing awareness, systematic tools to assess which sites are most vulnerable remain scarce. This project presents a remote sensing workflow to quantify the hydrological resilience of Alpine hut sites, developed and tested at the Neue Prager Hütte (2,796 m, Hohe Tauern, Austria). The site's former supply glacier has retreated over 1.5 km beyond reach; water scarcity forced premature season closures in 2023 and 2024. The workflow integrates automated catchment delineation from high-resolution terrain data (validated against field reference, Jaccard coefficient = 0.93), satellite-based snow cover reconstruction (Sentinel-2, 2018–2025), and gridded precipitation records (SPARTACUS v2.1). Results show that catchment snow cover has fallen below 15% by July in every year since 2022. From mid-summer onward, water availability depends entirely on precipitation, which fluctuates widely. The site enters a phase of high supply volatility precisely when visitor demand peaks. The workflow relies exclusively on open geodata and requires no on-site instrumentation, making it transferable to any hut site. Current work focuses on scaling the analysis to additional sites in coordination with the Austrian and German Alpine Clubs, and on integrating climate projections to prioritise adaptation across Alpine hut networks.

Keywords: post-glacial water supply, Alpine mountain huts, hydrological resilience, remote sensing

An early warning system for Alpine biodiversity: A shared framework for monitoring and protecting glacial and post-glacial ecosystems

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Despite the Alps being one of the most extensively monitored natural regions in the world, significant gaps remain in our understanding of overall alpine biodiversity status. Administrative barriers continue to hinder access to, and comparability of, all the biodiversity data collected. Within the framework of the Interreg ASP AlpsLife project, one of the project goals is developing an Early Warning System (EWS) for alpine biodiversity, a transboundary structure designed to harmonize monitoring of species dynamics and ecosystem health at Alpine scale. In a context of accelerating climate change, alpine ecosystems are rapidly transforming, with glacial habitats facing severe pressures. The proposed EWS may offer a resilience strategy for the conservation of glacial/post-glacial ecosystems and provide a replicable framework for future conservation in these threatened environments. The EWS integrates a set of standardized common indicators with a harmonized data comparison strategy, linked to critical threshold values (defined by trends or presence/absence data depending on indicator) and embedded within a shared, locally adaptable management framework. By establishing common monitoring and management strategies at Alpine scale, the EWS aims also to strengthen the coordinated protection of glacial/post-glacial ecosystems, with Alpine Protected Areas covered by glaciers as the primary focus. Ultimately, the AlpsLife EWS represents a concrete step toward a unified understanding of the general status of alpine biodiversity at Alpine scale including specific ecosystems (e.g. post glacial & wetlands), providing the shared knowledge base needed to inform a common conservation vision and guide coordinated protection strategies across borders and generations.

Keywords: Alpine biodiversity, early warning system, post-glacial ecosystems, biodiversity monitoring, transboundary management

Higher education as a territorial resilience lever in arid peripheral regions: The experience of Laâyoune-Sakia El Hamra in Southern Morocco

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Climate change increasingly exposes peripheral territories to environmental constraints, socio-economic vulnerabilities, and pressures on local development systems. While Alpine regions face glacier retreat and cryosphere decline, arid territories such as Laâyoune-Sakia El Hamra encounter comparable structural challenges, including water scarcity, fragile ecosystems, youth employability, and territorial adaptation. This poster presents the experience developed through higher education governance and academic innovation at Université Ibn Zohr, particularly through the strategic transformation of the Higher School of Technology in Laâyoune. It demonstrates how higher education institutions can act as territorial resilience actors by aligning academic programs with regional socio-economic priorities, environmental challenges, and public policy orientations. Key initiatives include the creation of professionally oriented programs tailored to local labor market needs, the promotion of student entrepreneurship, the development of interdisciplinary digital innovation spaces, and the strengthening of applied research linked to territorial sustainability. Special attention is given to educational responses addressing desert environments, marine resources, digital transition, and local governance capacities. This contribution argues that in climate-sensitive peripheral territories, higher education can play an adaptive role similar to that expected in Alpine regions: producing knowledge, supporting youth integration, reinforcing institutional capacity, and generating innovation ecosystems connected to territorial realities. The poster offers a comparative perspective that contributes to current discussions on resilience, education, and regional adaptation beyond mountain contexts, providing transferable insights for environmentally constrained territories.

Keywords: higher education, territorial resilience, climate adaptation, peripheral regions, youth, innovation, Southern Morocco

Young Glacier Voices

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Alpine glaciers are melting at an accelerating rate, and without stronger climate action, they could vanish by 2100. The Erasmus+ project "Young Glacier Voices," led by CIPRA International, CIPRA Italia, CIPRA Slovenia, and Girls* on Ice Austria, aims to make the consequences of the climate crisis tangible and to empower young people to use their voices to call for more climate protection.
The project's main goals are to increase environmental awareness among youth and enable them to actively engage in their communities. This will be achieved through an international glacier expedition in Austria, a youth camp in the Slovenian mountains, educational activities targeting broader audiences, and awareness campaigns led by young participants.
Young Glacier Voices also aims to make scientific knowledge about the climate crisis and Alpine glaciers accessible. Complex data will be communicated through creative methods, eg. art, to turn science into engaging, understandable stories. Ultimately, the project seeks to broaden the climate conversation beyond traditional environmental circles, reaching diverse audiences and fostering knowledge exchange. By combining education, creativity, and youth activism, it aspires to inspire meaningful social and political change and empower the next generation to protect the Alps' glaciers.

Keywords: glaciers, climate communication, youth participation, fight against climate change, green skills

Recovery of the tourist destination in the Upper Savinja Valley after the 2023 Floods: Examples of good practice and climate change adaptation

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In August 2023, Slovenia was affected by catastrophic floods. The increasing frequency of weather extremes is becoming a new reality, requiring greater societal preparedness. Alpine valleys represent areas that are highly exposed to erosion and flood-related processes, while at the same time being attractive tourist destinations. This study examines the recovery of the tourist destination of the Upper Savinja Valley, two years after the natural disaster. It presents examples of good practices in post-disaster mitigation, reconstruction and highlights adaptation measures to climate change. One of the most severely impacted areas were the Upper Savinja Valley, located at the foothills of the Kamnik–Savinja Alps. The disaster occurred during the peak tourist season, significantly affecting both the local population and visitors. Despite unfavourable conditions and uncertainty, local tourism stakeholders, institutions, and government authorities developed coordinated measures and implemented recovery activities. Tourist arrivals gradually increased, and by 2025, Visit Savinjska had become one of the fastest-growing tourist destinations in Slovenia. The main purpose of this research is to analyze the recovery of the tourist destination following the floods. Based on a comparative analysis of the tourism sector immediately after the disaster and two years later, the study aims to identify changes, assess the current condition of the destination, and determine factors influencing its recovery. The objective is to identify measures and examples of good practice that have contributed positively to the destination's recovery and to present examples of climate change adaptation in Alpine communities within the tourism sector.

Keywords: natural disaster, recovery, tourism, climate change adaptation, Slovenia

Biodiversity conservation in the era of outdoor recreation and climate change

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Ecologically fragile Alpine sites are increasingly exposed to overcrowding and the rapid expansion of nature-based activities (NBAs), with significant consequences for ecosystems, species habitats, and overall biodiversity. Climate change is further reshaping these dynamics through longer and hotter summers, decreasing snow cover, and retreating glaciers. Beyond determining direct ecological effects, these phenomena amplify pressure on biodiversity by attracting more visitors to mountain regions and redirecting flows toward previously undisturbed habitats. To fulfil their conservation mission, Alpine Protected Areas must adopt strategies capable of addressing the "overtourism paradox", where visitors end up destroying the very places they seek to experience. The LiveAlpsNature project (Interreg Alpine Space Programme) responds to this challenge by analysing the current impacts of NBAs on biodiversity and developing scenarios to assess how these pressures may evolve under climate change. Building on this, it designs concrete management measures and biodiversity-compatible tourism offers grounded in the One Health approach, which seeks to reconcile human, animal, and environmental health. To further support behavioural change among visitors, the project combines these solutions with conservation-oriented guidance via digital outdoor platforms – a crucial source of information for NBA practitioners. Pressures from NBAs are particularly relevant in glacial and post-glacial environments, also due to "last chance" tourism, and are increasingly associated with safety risks for outdoor recreation. The strategies developed within LiveAlpsNature – management measures, biodiversity-compatible offers, and digital guidance – can support more responsible glacier-related NBAs, raise visitor awareness, and strengthen evidence-based conservation strategies for some of the most vulnerable Alpine landscapes.

Keywords: biodiversity conservation, overtourism, climate change

AGRI28. Challenges and innovations for a sustainable mountain farming in Aosta Valley

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AGRI28 is an ongoing action-research project promoted by the GREEN Center (University of the Aosta Valley) and the Regional Agricultural Department of Aosta Valley. It aims to imagine new, place-based solutions for the manifold challenges currently faced by mountain farming in the Italian Alps, such as climate change, Alpine water management, new CAP policies, generational turn, etc. The project is led by researchers, technicians, politicians and decision-makers, and approximately 40 professional associations, NGOs, educational and training institutes who meet regularly to define further steps in farming regulation and better coordinate their practices. By using ethnographic, participatory and highly contextual methods, the research group is documenting emergent societal issues and points of view among livestock keepers, cultivators, beekeepers, winemakers in the Alpine region of Aosta Valley, as well as younger generations. At the current state, the project has allowed the research group to identify in shifting social structures (family and land), poor acknowledgement (communication), and reduced inter-farm collaboration and innovation the three main threats to sustainable mountain farming in Aosta valley, especially in regard to new generations. Because of this, the project resorts to knowledge dissemination to nurture, encourage, and sustain innovative experimentations among farmers, in a close dialogue with decision-makers and public institutions, aiming to collectively co-construct the new regional CAP policies for the 2028-2034 EU programme. More largely, by addressing shared issues related to mountain farming, the research will contribute to imagining new paths and practices for agriculture in the whole Alpine area.

Keywords: mountain farming, participatory methods, new generations, social structures, social innovation

Rural practices related to climate change resilience

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Research (SURF: SUstainable Rural Future, Erasmus KA) was conducted in rural localities in Slovenia, Italy and Spain with a focus on identifying and understanding practiced activities related to climate change resilience. Research question adopted a critical perspective on locally-led adaptations: How might a rural community overcome two key barriers - (1) participation of local population and (2) access to the contemporary knowledge - within climate resilience process?

The poster will focus on selected Slovenian Alpine rural communities, where a combination of qualitative methods was applied in identifying and understanding how rural communities and rural localities perceive, mitigate and adapt to climate change. Thematic on-field workshops (with local residents and geography students), media and projects context analysis, interviews with local stakeholders provided a sound basis for the empirical, practical and theoretical implication of Participatory Agency Approach (addressing the first barrier) while co-creating and piloting the SURF training programme (addressing the second barrier). Herewith, we tried to address transformative resilience.

Several rural practices related to climate change resilience were mapped by applying SURF online web browser, which enables access to numerous cases using two filters (economic activity and climate risk addressed).

In order to increase visibility and strengthen knowledge and experiences exchange, an international network of rural communities and rural areas (SURF European Rural Network) was designed to share findings and continuously mutually inform and help co-designing a climate resilient rural future.

Keywords: rural areas, climate change, resilience, Alps, Slovenia

Altra Quota: A field-based monitoring and education initiative in the Western Italian Alps

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Effective Disaster Risk Management (DRM) education requires geoscientific knowledge to be rooted in local contexts and translated into practical skills for risk prevention and emergency response. Altra Quota is a monitoring initiative in the Western Italian Alps that combines real-time environmental monitoring, field research, and outreach, in close collaboration with local authorities and stakeholders exposed to hydro-meteorological and cryospheric hazards.
A key objective is capacity building through risk communication and the use of monitoring data. Hydrological, meteorological, and geomorphological observations are integrated into hands-on activities for students, practitioners, and decision-makers. These activities help participants interpret real data, understand early warning systems, and explore decision-making under uncertainty. Field training, laboratory work, and dissemination initiatives connect theoretical knowledge with operational DRM practices, enhancing communities' ability to understand risks and respond effectively.
An important component is the long-term monitoring of the Ciardoney Glacier, in collaboration with the Italian Meteorological Society. Its retreat provides a valuable case study of climate change impacts on alpine water resources and related risks. By combining ground observations, satellite data, and modeling, the project offers engaging and context-based learning experiences.
Overall, Altra Quota links research, education, and community engagement, fostering risk awareness, strengthening science–society dialogue, and supporting informed decision-making under changing climatic conditions.

Keywords: monitoring, education, hydrology, collaboration

Landscapes of loss? The (un-)making of ecological loss in glacial worlds

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The Alps are among the regions in Europe most severely affected by climate change, and the retreat of their glaciers is attracting increasing public attention. Mourning ceremonies for individual glaciers – such as Pizol (2019), Nördlicher Schneeferner (2023) and Morteratsch Glacier (2023) – have come to symbolize a collective concern over the fate of alpine environments. While research has primarily interpreted these ceremonies through the lens of 'ecological grief', this thesis addresses a preceding question: How is the disapperance of a glacier constructed as loss in the first place? Drawing on qualitative interviews, ritual analysis, and historical contextualization, the project examines the cultural practices, interpretive frameworks, and discourses that render glacier retreat affectively and politically meaningful. Its aim is to understand the conditions under which changing glacial landscapes come to be produced, experienced, and politicized as ecological loss – and how such interpretations are challenged, relativized, or undone.

Keywords: glacier retreat, ecological loss, environmental anthropology, climate change perception

PRESINMED: Integrating science and communities to protect Mediterranean mountains

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The Biodiversa+ PRESINMED project "Preserving The Singularity Of Mediterranean High Mountain Biodiversity Hotspots: A NBS Approach" aims to create a pan-Mediterranean strategy to protect high mountain biodiversity hotspots such as grasslands and support their sustainable territorial management. These ecosystems are among the most endemic rich habitats of the Mediterranean region and are extremely vulnerable to climate change. PRESINMED goal is to diagnose and mitigate the combined impacts of climate change – particularly drought – and local stressors, such as herbivory pressure and tourism-related disturbance, by implementing effective, sustainable, and co-designed Nature-based Solutions (NbS) in five high-altitude Mediterranean areas: Gran Paradiso National Park (GPNP) and Maiella Park (Italy), Serra da Estrela (Portugal), Sierra Nevada (Spain), and High Atlas (Morocco).
Concerning the Italian Alps, two study areas were identified in GPNP to assess the effect of grazing and irrigation on alpine grasslands. An interdisciplinary approach was chosen, based on the combination of in-situ data related to biodiversity and ecosystem functioning, CO2 fluxes, meteo-climatic and environmental variables, remote sensing data combined with aerial photographs, and socio-economic data. This comprehensive approach enables a robust understanding of the drivers and consequences of environmental change in mountain regions, supporting the development of evidence-based strategies for their sustainable management. Particular attention is given to the social acceptability of NbS by actively involving local and regional stakeholders in co design and co implementation activities, fostering transformative change to preserve and improve ecosystems. Promoting transdisciplinary research, PRESINMED aims to raise public awareness and reinforce the connection between local communities and territories.

Keywords: Mediterranean mountains ecosystems, biodiversity conservation, Nature-based Solutions (NbS), participatory governance, transdisciplinary research

Sustainable Climate Change Adaptation in Skiing Tourism

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Climate change poses a significant threat to the long-term viability of alpine tourism (François et al. 2023). Warmer temperatures and increased weather variability cause a drastic decline in natural snow cover, worsening conditions for technical snowmaking, and thus endanger the viability of the winter season (Steiger et al. 2019). Tourism regions located at relatively low altitudes are particularly at risk and require urgent action. However, there has been no systematic implementation of sustainable climate change adaptation strategies in particularly vulnerable tourism regions in Austria to date. Therefore, whether a region actually takes adaptation measures and whether these have the potential to adapt the region sustainably to a changing climate cannot be adequately explained by the predicted climate vulnerability. To close this research gap, the SCAST (Sustainable Climate Change Adaptation in Skiing Tourism) research project is investigating the social, economic, and political conditions that enable sustainable climate change adaptation in Austrian communities that are heavily dependent on winter tourism. We employ a mixed methods approach to conduct a multidimensional analysis of the economic, institutional, and cultural prerequisites for sustainable climate change adaptation. Through a comprehensive quantitative analysis, we select four fitting regions in Austria with different levels of climate vulnerability and adaptation. For each case study, we will conduct in-depth stakeholder interviews, a stakeholder workshop and a population survey. The aim of the project is to provide stakeholders with the tools necessary to design and implement climate change adaptation in an ecologically sustainable, economically successful, and socially desired way.

Keywords: climate change adaptation, ski tourism, sustainability

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