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Spoke 1 Free University of Bozen-Bolzano
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# Psycho-social Aspects of Innovative Solutions to Support Well-being and Quality of Life in the Mountain Environment

**Milestone M2**
**(Jan 2023 – Dec 2023)**

**Spoke 1 – RT1A**
**Safety and Quality of Life in Mountain Environments – Mountain Social Life**

**Internal Actors**
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Dr. Battini Federico (Free University of Bozen-Bolzano)
Dr. Strapazzon Giacomo (EURAC Research)
Roveri Giulia (EURAC Research)

Fig. 1) IDM Südtirol-Alto Adige/Manuel Kottersteger.

## Objectives

Models for integrating smart tech (telemedicine) in mountain areas, considering psycho-social aspects.
Evaluation of interventions, difficulties, user adoption, satisfaction.
Analysis of population barriers to smart tech adoption in homes and work environments.

## Methodology

We adopt a multidisciplinary methodology, integrating literature reviews (using the Unified Theory of Acceptance and Use of Technology), empirical studies on the longitudinal dynamics of technology acceptance, stakeholder engagement, and technical tool development.

## Activities & Results

### Telemedicine in Mountain Areas

We are investigating the psycho-social factors influencing the acceptance and usage of telemedicine using the Unified Theory of Acceptance and Use of Technology (UTAUT) framework. Key factors considered include perceived usefulness, perceived quality, trust, social influence, technological anxiety, resistance to change, system use expectancy, and demographics. Our literature review highlights the need for a longitudinal approach to understand the dynamics of technology acceptance and usage, particularly in telemedicine contexts. We are currently identifying participants for an empirical study to collect qualitative and quantitative data on the psycho-social aspects related to adopting innovative proposals, particularly telemedicine. This sample will include community members, local organizations, and policymakers.

### Understanding Implementation Challenges

A general science article is underway to analyze the difficulties encountered during implementation, user acceptance and adoption levels, and overall satisfaction with proposed interventions related to smart technologies.

### Enhancing Organizational Well-being

In collaboration with the Municipality of Bolzano, we are exploring an innovative aspect of organizational well-being - the physical work environment. A longitudinal study is investigating factors such as perceived workload, job autonomy, work-life balance, technostress, work engagement, and burnout syndrome. The survey instrument has been refined and validated, with data collection scheduled in two waves throughout 2024.

### Smart Solutions for Residential Buildings

We have developed an open-source configurator to simulate the impact of smart solutions in buildings. This tool utilizes EnergyPlus for dynamic thermal simulations and assesses the potential improvements achievable through smart building technology, particularly in Heating, Ventilation, and Air Conditioning (HVAC) systems. The tool's validity is ensured by testing it with representative buildings from the Italian building stock.

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# Promoting One-health Strategies Focusing on the Adoption of Safety and Ergonomics Solutions, on Active Lifestyle Finalized to Well-being and Health in Mountain Environmental Conditions

**Milestone M2**
**(Jan 2023 – Dec 2023)**

**Spoke 1 – RT1A**
**Safety and Quality of Life in Mountain Environments – Mountain Habitat**

**Internal Actors**
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Dr. Martina Vacondio (University of Verona)
Dr. Giulia Roveri (EURAC)

## Objectives

- Devising tailored strategies for physical activity/exercise prescription in mountain environments (from high-level athletes to the general population).
- Promoting health and well-being in mountain areas.

## Methodology

Through the adoption of a multidisciplinary approach, we intend to conduct:

- The investigation of the physiological and health-related effects of various (physical) activities conducted in mountain environments.
- The assessment of the impact of the environmental stimuli of mountain areas (nature, climatic conditions, altitude) on the physiological and affective responses of individuals.
- The implementation of smart and wearable technologies in the context of mountain activities to individually target specific physical and health-related goals.

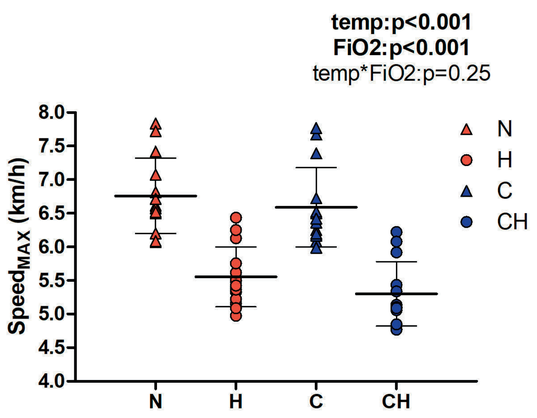


Fig. 1)

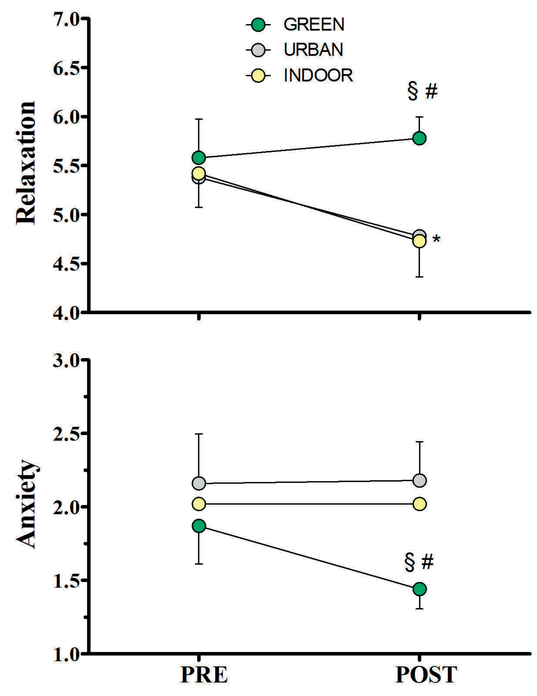


Fig. 2)

## Activities & Results

**ACTIVITY 1 – Independent and combined effects of cold and hypoxia on physiological and perceptual responses to exercise.** We evaluated the effects of hypoxia (3500m) and cold (-20°C) on the physiological and perceptual responses to exercise. RESULTS: Maximal and submaximal (lactate threshold) exercise workload are reduced by both a hypoxic (18-21%) and a cold (2-3%) environment with an additive effect of the two stressors combined (21-24%). The results can guide optimal exercise intensity prescription in mountain environments. STATUS: Published.

**ACTIVITY 2 – The effects of natural and urban scenes on the physiological and psychological responses under normoxic and hypoxic conditions.** We exposed the participants to images of natural or urban environments, either normoxic or hypoxic environments. RESULTS: Preliminary results indicate the influence of hypoxia on emotional states, with higher positive and deactivating emotions reported after exposure to natural images. STATUS: data collection completed.

**ACTIVITY 3 – Physical activity in natural, urban, and indoor environments**. Participants completed a light-to-moderate intensity exercise in three different environments: natural, urban, and indoor. Both physiological and psychological responses were investigated. RESULTS: Preliminary results highlight the higher restorative power of a green natural environment compared to other built environments, positively influencing heart rate variability and salivary cortisol levels. STATUS: data collection to be completed.

**ACTIVITY 4 – The effects of exposure to restorative environments in muscle fatigue recovery.** The study compares the effects of natural and built environments in mitigating the muscle, metabolic, and autonomic fatigue induced by anaerobic exercise. Physiological and psychological measurements will be collected. STATUS: Ethical approval has been requested.

**ACTIVITY 5 – Development of innovative sensors for monitoring vital parameters in emergency medicine.** We are working on the implementation of different devices to monitor vital parameters in mountain areas. STATUS: We are going to submit a paper on our first work on a prototype.

Fig. 1) (From Activity 1) Exercise performance in the four experimental conditions. N: normothermic normoxia, H: normothermic hypoxia, C: cold, CH: cold and hypoxia.
Fig. 2) (From Activity 3) Affective responses in the three investigated conditions.

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# High-Mountain Natural Hazards in South Tyrol in the Context of Climate Change: Analysis of Rock Glaciers Activity

**Milestone M2**
**(Jan 2023 – Dec 2023)**

**Spoke 1 – RT1B**
**Safety and Quality of Life in Mountain Environments – Mountain Habitat**

**Internal Actors**
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Dr. Carlo Marin
Dr. Claudia Notarnicola
(Institute for Earth Observation, EURAC)

Dr. Stefan Steger
Dr. Marc Zebisch
(Center for Climate Change and Transformation, EURAC)

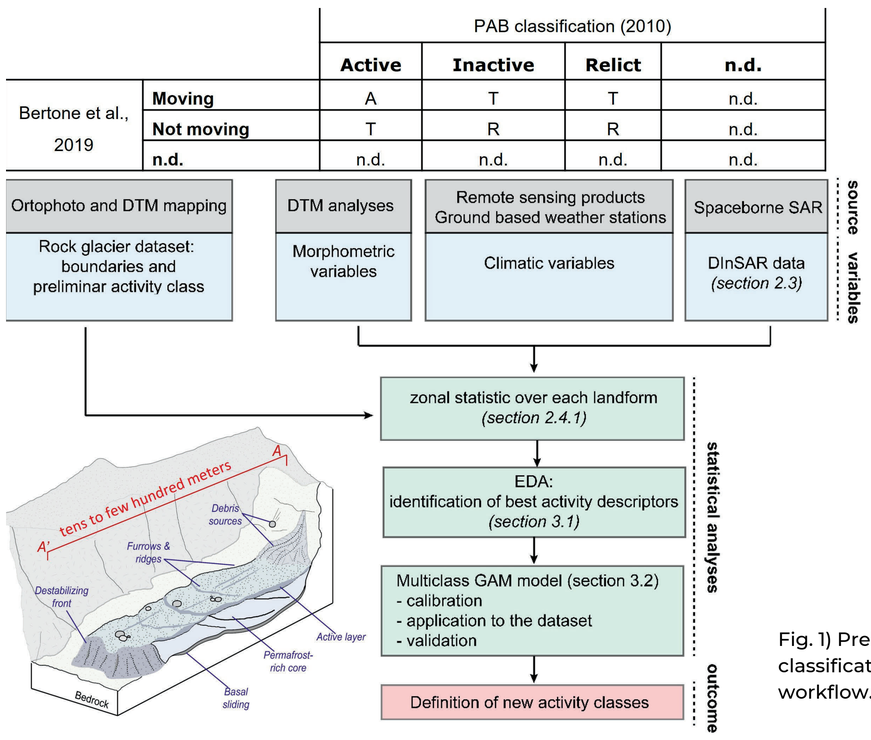


Fig. 1) Preliminary activity classification and analytical workflow.

## Objectives

- Comprehensive definition of activity based on the integration of climatic drivers, displacement rate, and morphological parameters.
- Improvement of standardized methodologies to define the state of activity of mapped rock glaciers.
- Replicable analysis at the regional scale.

## Methodology

Analysis of multiple variables each one describing a key evidence or predisposing condition of rock glaciers activity, integrated through **multivariate statistical analysis**. Variables are derived from diverse sources, including **multispectral** and **radar satellites**. This approach allows to gather a comprehensive range of data pertaining to rock glaciers, encompassing **morphometric and morphological factors** such as slope angle, roughness, elevation, lithology, and **climate conditions** leading to a redefinition of activity classifications for rock glaciers within the pre-existing dataset (Fig.1).

## Activities & Results

For each rock glacier polygon, 1779 in total, mean values for environmental and climatic variables were assigned based on the values within the polygon boundary. Furthermore, for DInSAR-related variables (Sentinel 1A/B velocity and coherence), additional statistical descriptors were extracted such as variance, 25th-75th, and 90th percentiles. After a preliminar EDA, we considered the most informative variables (Fig.2) as predictor variables in a multinomial response variable GAM model. Once evaluated the predictivity capability of the model (AUC ~0.9), we applied it to the entire regional dataset.

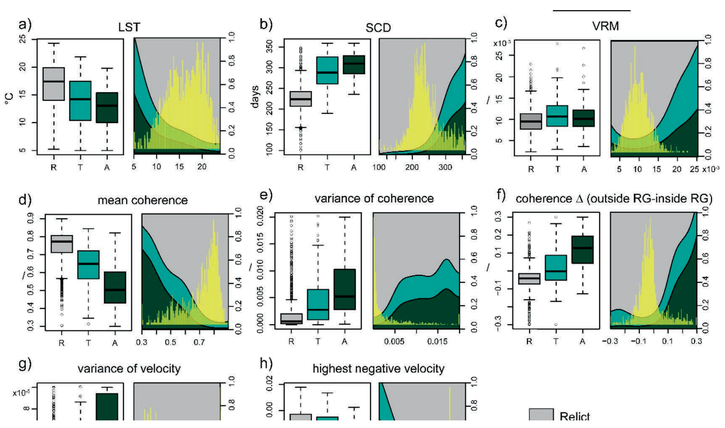


Fig. 2) Descriptive variables used in GAM model.

The model addressed gaps present in the morphological and DInSAR based techniques, enabling the classification of a greater number of landforms that were previously undefined in one or both inventories made by PAB and Bertone et al., 2019.
The results underscore a predominance of **relict** features, **1345** landforms in total, in contrast to a significantly smaller number of **active** ones, comprising **171** instances. **Transitional** rock glaciers include **200** landforms and only **63** forms **couldn't be classified** (Fig.3).

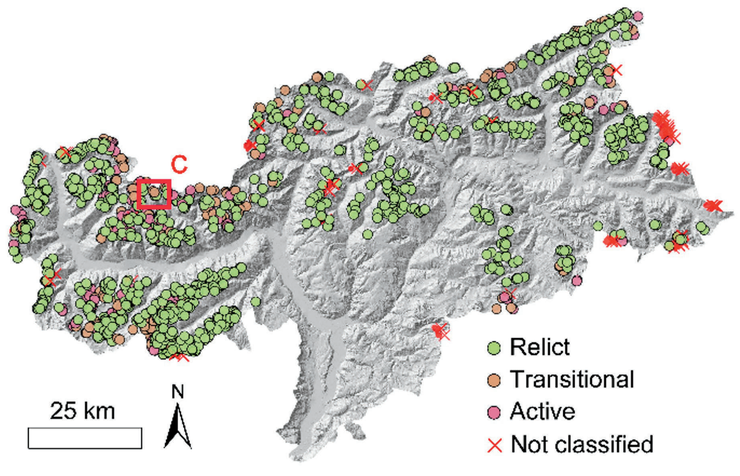


Fig. 3) Activity classes over the AOI.

From the distribution of the classes, it is evident that the transition from active to relict is not direct, but it exhibits an intermediate phase (Fig.4).
This transition is likely controlled by local factors that influence not only the activity and evolution of rock glaciers but also the velocity of the transition from one class to another.

The integration of the kinematic information with environmental variables through a multiclass GAM model effectively leveraged both linear and nonlinear relationships between features, providing a statistical definition of the key variables influencing the activity classification at the regional scale.

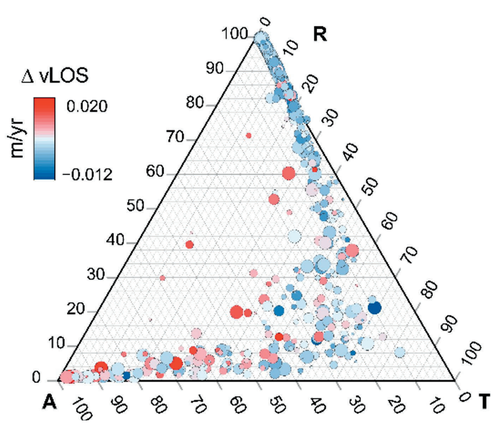


Fig. 4) Transition from A to R class.

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# Assessing the Effects of External Drivers on Water quality, Biodiversity and Ecosystem Functions

**Milestone M2**
**(Jan 2023 – Dec 2023)**

**Spoke 1 – RTIB**
**Safety and Quality of Life in Mountain Environments – Mountain Habitat**

**Internal Actors**
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Dr. Roberta Bottarin
(Eurac Research, Bolzano-Bozen)

Fig. 1) High mountain catchment belonging to the study area.

## Objectives

Abiotic and biotic analysis of mountain freshwaters, to valuate climate change effects on habitats and biodiversity as well as the impact of different land use types on the water courses, their catchments (soil-plant interactions) and ecosystem functions.

## Methodology

- Field activities: samples from snowmelt, rainfall, glacier melt, glacier ice, rock glacier ice, ice melt waters and stream water (chemistry, isotopes, temp., DOC, fluorescence indexes, pH, susp. solids, nutrients), macroinvertebrate communities, soil cores, plant samples (e.g. texture, density, C concentrations/stocks, fluorescence indices, enzimatic activities, morphology indices);
- study of the impacts of land-use intensification on mountain biodiversity and soil associated functions using different habitat types to simulate land-use intensification;
- simulation of the conjoined impact of climate change and anthropogenic activities on the quality of water resources and related freshwater ecosystem services in the Adige River basin, by means of a Machine Learning (ML) model trained and validated with historical monitoring data.

## Activities & Results

**Biodiversity monitoring**

- Macrobenthic fauna and abiotic parameters were sampled in 27 sites in the Vinschgau-Valley.
- Almost 60,000 individuals were counted and classified.
- Biological data and abiotic data have been analysed.

**Hydrochemical monitoring**

- Snow sampling and snow water equivalent estimations at five locations in the Schnals and Martell catchments, 19 field campaigns for the installation and maintenance of gauges, discharge measurements, samples collection.
- Characterization of the chemical and isotopic conditions of snowmelt, rainfall, glacier melt, glacier ice, and rock glacier ice and ice melt waters (25 streams).
- Analyses of DOC and various indexes of fluorescence, to estimate the relation between dissolved trace element concentrations and organic carbon, on 12 stream sites in the Schnals and Martell catchments.

**Soil-plant system monitoring**

- 5 meadows and 6 pastures located in Trentino Alto Adige were anaysed: Topsoil (0-15 cm) cores were collected from each site and analysed.
- Some enzymatic assays have been carried out including phosphomonoesterase and urease, involved in the phosphorus and nitrogen cycle respectively, as well as fluorescein diacetate hydrolase, used as total biomass activity proxy.
- Plant samples were collected (considering the 10 most abundant species; 70% of total cover) and analysed, functional traits were determined, plant physiology and leaf structure were investigated.

**Conjoined impact of climate change and anthropogenic activities**

- Review of the state of the art of methodologies for the quantitative assessment of Water-Energy-Food-Ecosystems interactions under climate change was finalized.
- A DPSIR framework has been elaborated (case study: Adige River) to depict how most relevant productive sectors in the area interacts with climate change and land use change/intensification.
- Sectoral data including historical water quality monitored data, historical land use change, climatic and hydrological data from the period 2000–2020 has been collected to be used in the next step of the analysis for the training of the ML-model.

Fig. 2) Sampling macroinvertebrates in the Saldur River.

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# Promoting One-health Strategies Focusing on Understanding and Mitigation of Geohydrological Risks and Its Forecasting

**Milestone M2**
**(Jan 2023 – Dec 2023)**

**Spoke 1 – RT1B5**
**Safety and Quality of Life in Mountain Environments – Mountain Social Life**

**Internal Actors**
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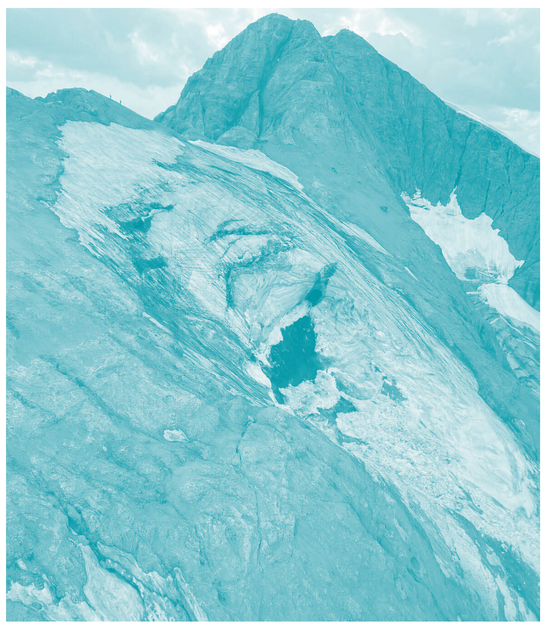

Fig. 1) Glacier in Marmolada massif in July 2022. Photo credit: Provincia autonoma di Trento, Archivio Ufficio Stampa – CC BY 3.0.

## Objectives

Understanding and mitigation of geo-hydrological risks, focusing on the impact of climate change on health in alpine environments.

## Methodology

We have been working inside a multidisciplinary group aiming to establish an “Adaptation South Tyrol factsheet” to climate changes and natural disasters. We analyzed Climate Change's impact on Human Health in Alpine Environments using the Impact Chain model. These models comprehensively link components contributing to specific risks, aiding in risk reduction strategies. Integrating inputs through interdisciplinary approaches and local experts' insights is vital. Our work focused on three interconnected components: environmental, socio-ecological, and economic systems.

We have also been working on the implementation of international mountain registries in order to enables a systematic collection of data on strategies for the medical care in the out-of-hospital setting. Those registries are accessible on www.mountain-registries.org.

## Activities & Results

**National conference**
Roveri G. *Mountain Registries*: IX edizione convegno HEMS “Elisoccorso sanitario tra prospettive e realtà” (Novembre, 2023).

**International conference**
Strapazzon G.. *Marmolada Glacier Accident*. International Commission of Alpine Rescue (ICAR) Congress 2023 (Dobbiaco – October, 2023).

**Paper submitted**
Roveri G, Strapazzon G – *Climate Change and Human Health in Alpine Environments: an Interdisciplinary Impact Chain Approach. Understanding today's risks to address tomorrow's challenges.*

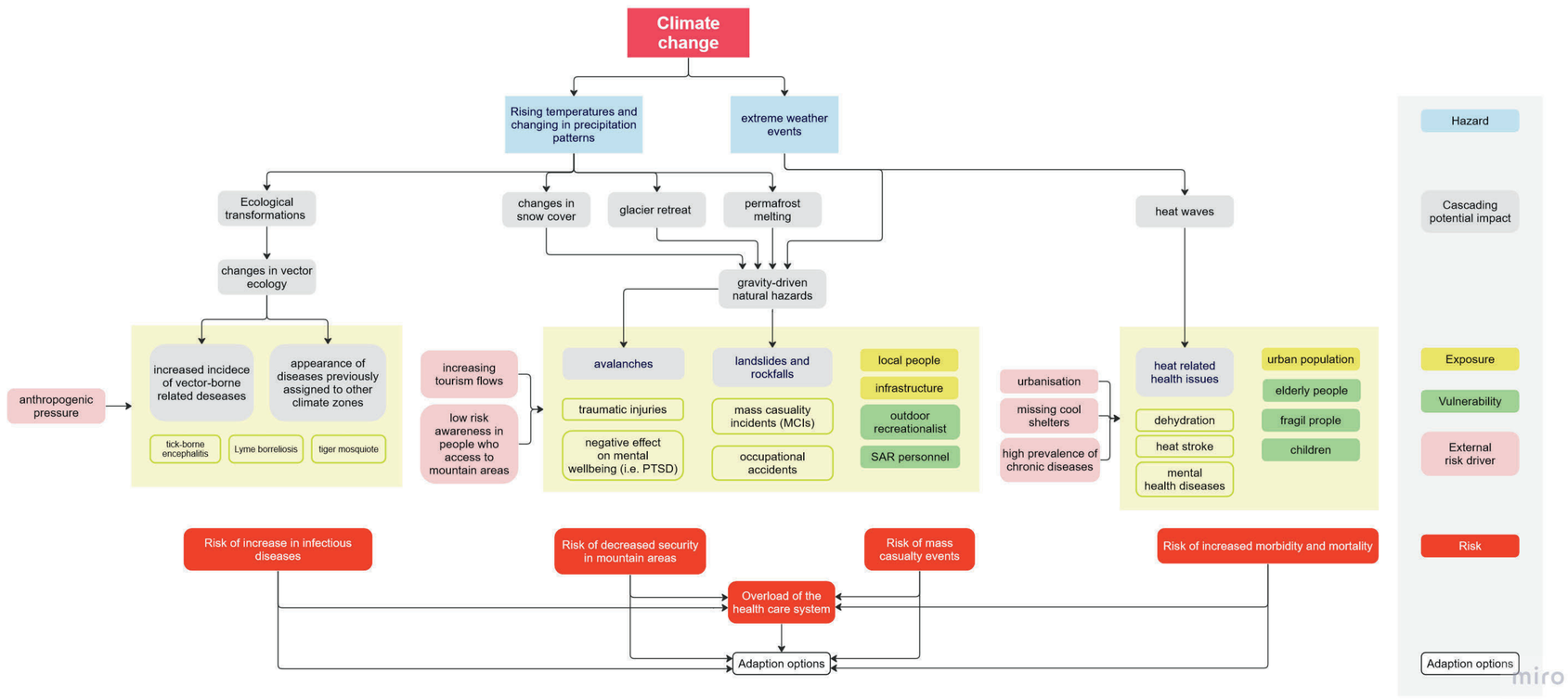


Fig. 2) Impact chain for climate change-induced health consequences in the alpine environments. Hazards, Cascading potential impacts, Exposure, Vulnerability, External drivers and Risks are respectively in Blue, Grey, Yellow, Green, Pink and Red boxes. All components leading to specific risks for climate change-induced health consequences are linked based on a cause-effect perspective. Credit: Giulia Roveri/Eurac Research.

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# Implementing Actions for Monitoring the Effects of External Drivers on Emergency Healthcare in Mountainous Areas

**Milestone M2**
**(Jan 2023 – Dec 2023)**

**Spoke 1 – RT1B7**
**Safety and Quality of Life in Mountain Environments – Mountain Social Life**

**Internal Actors**
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Dr. Vacondio Martina
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Prof. Strapazzon Giacomo
(Eurac Research)
Dr. Roveri Giulia
(Eurac Research)

Fig. 1) Eurac Research/Andrea De Giovanni.

## Objectives

Addressing specificities of emergency healthcare in the mountain areas, focusing on the training of health care personnel involved in the search and rescue mission in mountain areas and on professionals' soft skills.

## Methodology

Employing a multidisciplinary methodology, our work endeavors to empirically examine the influence exerted by soft skills upon out-of-hospital emergency health care professionals.

Additionally, we endeavor to construct a robust tool for the systematic assessment of these soft skills, thereby discerning optimal avenues for the training and refinement of these professionals in the context of these pivotal competencies. Our approach integrates conventional medical research methodologies with insights from the domain of psychology, alongside the utilization of psychometric tools.

## Activities & Results

The collaboration between the University of Verona's Human Sciences Department and the Institute of Mountain Emergency Medicine at Eurac Research focuses on addressing challenges in mountain rescue operations. It emphasizes enhancing training for emergency healthcare professionals and improving soft skills like teamwork and communication. Giulia Roveri and Martina Vacondio presented this project at the IX edition of the HEMS congress in Bergamo, Italy, on November 17th, 2023.

To initiate the project, Giulia Roveri and Martina Vacondio conducted a **retrospective analysis of critical incidents** reported at the Operation Center (112) of Trento from 2017 to 2023. This anonymized report led by emergency medical services personnel aims to scrutinize the epidemiology and root causes of accidents to establish effective risk management strategies.

In assessing training effectiveness, Giulia Roveri and Giacomo Strapazzon organized a **simulation training event** for the medical commission of the International Commission of Alpine Rescue (**ICAR**). They evaluated the effectiveness of advanced medical procedures under normal and cold temperature conditions (-20°C), aiming to improve emergency medical personnel training and patient outcomes in challenging settings.

A multidisciplinary research project explores the **impact of soft skills on stress experienced by medical professionals** during out-of-hospital emergency rescue operations. The study compares organized versus disorganized medical bags in simulated rescue scenarios, including emotional baseline assessments and self-evaluations to measure individual differences.

Another initiative seeks to develop a comprehensive **tool to assess soft skills in out-of-hospital emergency-rescue professionals**. It involves an extensive literature review, observations of helicopter rescue teams, and collaboration with medical doctors and psychologists to discern variations in soft skills among different stakeholders in emergency care scenarios, with future steps including professional interviews and tool refinement.

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# Winter and Mountain Industry

**Milestone M2**
**(Jan 2023 – Dec 2023)**

**Spoke 1 – RT2**
**Safety and Quality of Life in Mountain Environments – Mountain Social Life**

**Internal Actors**
Dr. Roveri Giulia
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Prof. Strapazzon Giacomo
(Eurac Research)

## Objectives

We run an in-field study to investigate the effectiveness of a new developed auto rescue device for avalanche burial victims. We assessed gas changes, respiratory and cardiovascular responses, and subjective stress level and workload.

## Methodology

We run a randomized, controlled and single-blinded in-field trial to investigate the effectiveness of a new auto rescue device for avalanche burial victims and the patho-physiological changes occurring in the context of critical burial under snow and hypoxia.

A snow pile mimicking an avalanche deposit using a snow groomer was prepared. 30 participants were included and randomly assigned to either the intervention or the control group. Inclusion Criteria were healthy subjects. Exclusion Criteria were ASA class II or higher, chronic cardiovascular or pulmonary disease, claustrophobia, psychiatric or neurological disease. We investigated the effectiveness of the device and the influence on physiologic parameters (i.e. End-tidal CO2 (EtCO2), Minute ventilation (VE), Cerebral Regional Oxygen Saturation (rSO2), NASA-task load index (NASA-TLX)).

Fig. 1 ) Credit: Giulia Roveri/Eurac Research; Caption: In-field Avalanche Study Location – Passo Rolle (Dolomites).

## Activities & Results

**In-field study**

In January and February 2023, the preparation for the study involved a recruitment phase, resulting in the selection of 30 participants from 120 applications. Preliminary medical tests were also conducted during this period to assess the health status and suitability of the subjects. These rigorous procedures ensured a well-prepared and reliable participant pool for the study.

In the beginning of March 2023 we run the in-field study at Passo Rolle (Dolomites – Italy). The study was conducted by a multi-disciplinary team comprising emergency physician's expert in the field of Mountain Emergency Medicine (i.e. Giulia Roveri and Giacomo Strapazzon from the Institute of Mountain Emergency Medicine of Eurac Research), snow expert from di WSL Institute for Snow and Avalanche Research SLF (Switzerland), biologists and statisticians.

Fig. 2) Credit: Giulia Roveri/Eurac Research; Caption: Study Setting.

Additionally, the team consisted of expert professionals from various European countries including Italy, Austria, Switzerland, and Norway.

From April 2023 to November 2023, statistical analyses of the data were conducted.

**International conference**
*Influence of active air supply during avalanche burial on ventilation and oxygenation*.
28. Internationale Bergrettungsärztetagung (Innsbruck – November, 2023).

Fig. 3) Credit: Giulia Roveri/Eurac Research; Caption: Study Group.

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# System Modeling of Energy Supply and Distribution in Alpine Contexts

**Milestone M2**
**(Jan 2023 – Dec 2023)**

**Spoke 1 – RT3A**
**Decentralization of Mountain Structures and Infrastructures**

**Internal Actors**
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Dr. Matteo Giacomo Prina (Eurac Research)
Dr. Giuseppe Rotondo (Eurac Research)
Dr. Wolfram Sparber (Eurac Research)

## Objectives

The Objectives focus on developing optimized, integrated renewable energy systems for North-East Italy's mountain areas using advanced modeling. This involves addressing both economic factors and climate goals in energy supply and distribution optimization.

## Methodology

To achieve the stated objectives, a methodology centered around the Oemof framework is employed. This framework optimizes energy supply and distribution in North-East Italy's mountainous terrain. The partial electrification of road transport is considered, evaluating grid electricity demand for electric passenger cars, buses, light and heavy freight using the emobpy tool. The work then evaluates benefits of smart charging and vehicle-to-grid integration with multi-node representation regionally. The methodology also monitors key indicators like emissions, final energy consumption. Further analysis of the South Tyrol energy system will be done using PyPSA to examine the multi-nodal region in greater depth and precision.

## Activities & Results

Through the use of the oemof tool, the hourly electrical consumption for recharging vehicles was calculated, considering different future scenarios including different degrees of electrification of the circulating fleet. The flow of electrical power between the various nodes was then calculated. Important discoveries reveal that if all transportation modes transition to electric power by 2050, there could be a 28% rise in electricity demand and an additional 50-250 MW on top of the existing 652 MW peak demand, putting pressure on the capacity of the system. However, introducing smart charging for half of the vehicles could cut peak charging by utilizing surplus renewable energy during nighttime. Moreover, enabling vehicle-to-grid capabilities for half of the vehicles could reduce reliance on energy imports from the rest of Italy.
After obtaining the first results using the oemof framework, the following activities have been carried on fulfilling the next objective of using the Python for Power System Analysis (PyPSA) linear programming energy system framework to further analyse the South-Tyrol territory:

- Initiation of PyPSA Usage: We have embarked on the use of the Python for Power System Analysis (PyPSA) framework, a significant step towards sophisticated energy system modeling.
- Data Collection: Essential data on the transmission grid and generation units have been meticulously collected. This data forms the backbone of our energy system model, providing the necessary details for accurate simulation and analysis.
- Model Setup: Currently, we are in the phase of setting up the PyPSA model. This involves integrating the collected data into the framework and configuring the model to accurately reflect the unique energy requirements and resources of the North-East Italian mountain areas.

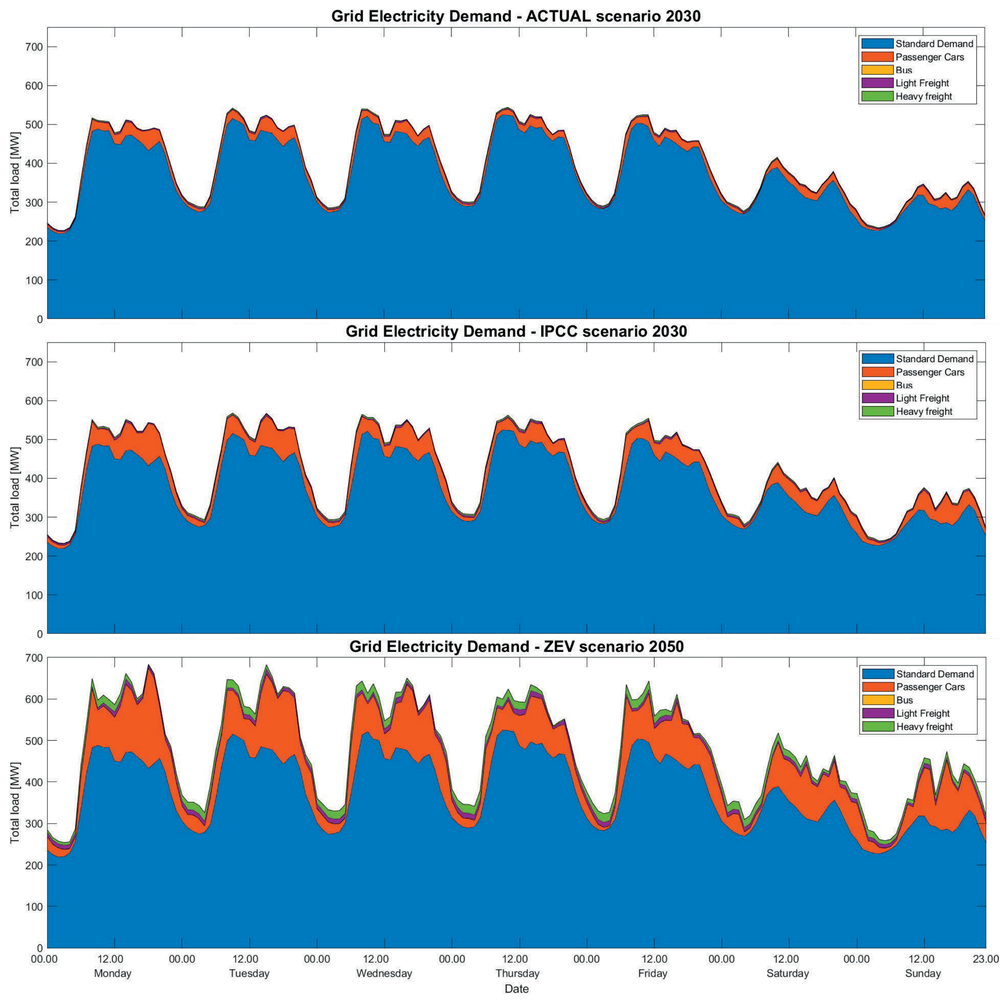


Fig. 1) Inputs and outputs of the emobpy tool [1] used to evaluate the demand profile of the electric vehicles. [1] C. Gaete-Morales, H. Kramer, W. P. Schill, and A. Zerrahn, "An open tool for creating battery-electric vehicle time series from empirical data, emobpy," Sci Data, vol. 8, no. 1, Dec. 2021, doi: 10.1038/S41597-021-00932-9.

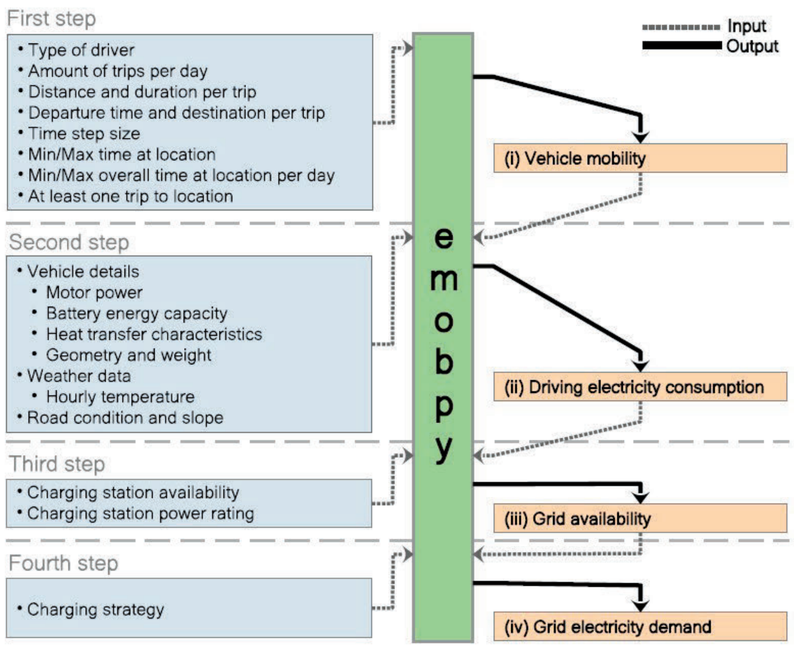


Fig. 2) Grid electricity demand for the three scenarios considered for a winter week.

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iNEST Ecosystems for mountain innovation

# Analysis of the State of the Art of Mountain Logistic Strategies and Definition of Innovation Strategies

**Milestone M2**
**(Jan 2023 – Dec 2023)**

**Spoke 1 – RT3B**
**Logistic Strategies**

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**Objectives**
Identification of strategies for the decarbonization of the logistics sector in urban and rural mountainous areas

**Methodology**
The research is composed of several methodological approaches: Literature review on the last-mile, long-haul fleet decarbonization policies and technologies; Literature review on the existing strategies of public-transport-freight integration for urban-rural connections; Structured logistics and decision-makers stakeholder assessment and opinion elicitation; Methodological approach for road freight transport CO2 balance calculation; Optimization model development for the optimization model to determine the minimum number of electric vehicles required to replace the existing diesel/petrol-based fleet of a given logistics sector.

**Activities & Results**
The main activities within this study are the following:
**1.** Detailed literature review on the trends in long-haul truck electrification (Fig. 2), indicating that battery electric and hydrogen-fuelled technologies are the two main zero-emission options that are seen to substitute the conventional diesel HDV. Both technological solutions present a high potential for the CO2 emission reduction both in well-to-wheel and tank-to-wheel assessment. It was found that more than half of TTW emissions in HDV sector can be reduced with the deployment of electric and hydrogen vehicles in Japan by 2050.

**2.** First optimization model development for the optimization model to determine the minimum number of electric vehicles required to replace the existing diesel/petrol-based fleet of a given logistics sector. The optimization problem in this study can be formulated as a mixed-integer linear program, with the decision variables representing the number of vehicles and their assignments to routes, and constraints enforcing requirements like route coverage and vehicle charge levels. This problem structure represents the ideal mathematical formulation for finding the globally optimal fleet size and assignments.