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Tackling Inter- and Transdisciplinary Challenges: A New Research Approach for the Institute for Interdisciplinary Mountain Research

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Mountain areas are defined by their high relief energy, dynamic nature, and diverse geo-, hydro-, eco-, and anthroposystems. They are significantly affected by climate change and globalization, presenting complex research challenges from local to global scales (Klein et al 2019). Since 2006, the Institute for Interdisciplinary Mountain Research (IGF), Austrian Academy of Sciences, has focused on human–environment relations, with long-term monitoring in areas such as biodiversity, population and settlement, glaciers, protected areas, natural hazards, digital landscapes, and social–ecological transformations. Over the past year, IGF's team has identified the main challenges of mountain research through a series of workshops. The 3 Ds—Drivers, Diversity, and Dynamics—emerged as central factors for gaining new knowledge and promoting sustainability transformations in mountain regions. New ways of conducting research and activities, including long-term living labs and the integration of artificial intelligence for data-based multi- and transscalar analyses, are being implemented to support this research.

The 3D concept

We have adopted the 3D concept, which stands for Drivers, Diversity, and Dynamics, to anchor all research activities in an institute-wide conceptual framework. Under the 3D concept, we examine the interplay of drivers (natural and human factors influencing mountain systems), diversity (variability, differences, and composition of the study field), and dynamics (continuous and complex interactions between natural processes and human activities within a defined system and scale) in mountain systems. Hence, the concept provides us with a better and more comprehensive understanding of mountains systems, enabling insights that support sustainable management and adaptation strategies. The objectives of research activities encompassing the 3 Ds are to (1) capture and comprehensively analyze the most diverse manifestations of the 3 Ds in mountain regions, (2) better connect the research findings of various disciplines, (3) contribute to a broader understanding of human–environment interactions for ecologically intact and socioculturally sustainable mountain regions in the European Alps and beyond, and (4) foster interdisciplinary collaboration.

We plan to implement the concept through research and monitoring, capacity building, and global collaboration. Collaborating with other research institutes, policymakers, and international organizations will help us to modify and adapt the 3D concept and build on knowledge and insights from the community to help advance mountain research. We are currently in the process of embedding the 3D concept into our daily work as researchers.

In summary, the concept offers an interdisciplinary approach to understanding and managing mountain systems, promoting sustainable development, biodiversity conservation, and the wellbeing of mountain communities.

Living labs

Living labs are defined areas where research is carried out in real-life contexts (see eg Filho et al 2023; Soini et al 2023). Living labs first emerged in the early 2000s. They are used to provide solutions to issues related to environmental and climate change, sustainable management of natural resources, sustainable tourism, resilience of local communities, and other challenges, with all stakeholders actively participating in codesigning and testing innovations—for example, sustainable agricultural methods adapted to the mountain climate, or green mobility solutions that respect the fragile alpine ecosystem. Living labs are the basis for researching and evaluating transformation. The aim is to generate knowledge, develop and validate solutions to real-world problems, and create technologies and services in existing environments, integrating experimentation and research into the daily lives of users. At the IGF, we are convinced that living labs can play a crucial role in researching and developing innovative solutions to current challenges in mountain areas. Careful planning and close cooperation between all stakeholders are essential. Logistical and implementation barriers can be reduced by establishing appropriate technological infrastructure, while establishing inter- and transdisciplinary teams and facilitating continuous

and transparent dialogue can help resolve conflicts of interest and improve coordination. By initiating long-term living labs that will last beyond the typical project duration, we aim to ensure that long-term relationships with stakeholders are maintained for the benefit of both the communities involved and the IGF. In addition, we plan to use various mobile technologies and data management platforms to optimize real-time information collection and analysis, enabling more agile adaptation to changing conditions in the Alpine environment.

Database

Our vision is to create a dynamic platform that stores diverse datasets and employs advanced artificial intelligence (AI) and machine learning to analyze and visualize data, fostering data-driven scientific inquiry. The aim of this database is to uncover hidden connections and interrelationships across different scientific disciplines, driving innovation and collaboration.

Conventional scientific databases are limited by their disciplinary focus and predefined research questions. Our envisaged database will serve as a comprehensive repository where diverse data types coexist and interact through AI-driven functionalities. This will stimulate new scientific questions and enable data-driven discovery, fostering interdisciplinary collaboration and promoting scientific innovation.

A key aspect of the approach is the development of a user-centric web interface. This will evolve continuously through feedback from the scientific community, ensuring it meets the needs of diverse users. Our commitment to the scientific community is underscored by the open-source approach. All developments will be documented and made available for adaptation and use.

Leveraging AI for data analysis is central to our strategy. Advanced natural language processing techniques will extract meaningful insights from unstructured text data, while deep learning algorithms will explore complex relationships within and between datasets. This will facilitate a new form of scientific exploration.

Synthesis

Gaining new knowledge and promoting sustainability transformations in an inter- and transdisciplinary mountain research context requires a jointly agreed concept accompanied by a methodological approach. As part of the joint endeavor toward sustainable mountain development (Bardy-Durchhalter et al 2022), the IGF has brought together different disciplinary perspectives to develop a vision and take the first steps in the implementation of a common research approach. In this context, the implementation of the 3D concept, along with the living labs and an AI-driven research database, are novel requirements for breaking boundaries and preparing the ground for future "undisciplined" mountain research.

ABOUT THE AUTHORS

Valerie Braun is Managing Editor of eco.mont and manager of several projects at the Institute for Interdisciplinary Mountain Research (IGF) of the Austrian Academy of Sciences (ÖAW). Mathieu Gravey is Junior Group Leader of the Digital Landscapes working group at the IGF/ÖAW and specializes in geostatistics, remote sensing, and machine learning, with a focus on developing innovative algorithms. Andreas Haller is a geographer in the Cultural Landscape and Land Use working group at the IGF/ÖAW, with a particular interest in mountain regions and human–environment interactions. Kati Heinrich is a cartographer und technician at the IGF/ÖAW. Margreth Keiler is the director of the IGF/ÖAW and professor at the Institute of Geography of the University of Innsbruck, specializing in geomorphology, natural hazard research, and risk management, with a focus on resilience and sustainable mountain development. Annemarie Polderman is a geographer in the Coupled Human–Landscape Systems: Risk & Resilience and the Cultural Landscape and Land Use working groups at the IGF/ÖAW. Fernando Ruiz-Peyré is Junior Group Leader of the Social-Ecological Transformations working group at the IGF/ÖAW, with a focus on sustainability and dynamics of societal change.

WEBSITE

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