eco.mont – Volume 13, Number 2, July 2021
ISSN 2073-106X print version – ISSN 2073-1558 online version: http://epub.oeaw.ac.at/eco.mont
https://dx.doi.org/10.1553/eco.mont-13-2s12

Two perspectives – one goal: resilience research in protected mountain regions

Lisa Huber, Eva Posch, Rainer Bell, Karl Michael Höferl, Robert Steiger, Rike Stotten, Erich Tasser & Georg Leitinger

Keywords: resilience research, Nepalese Himalayas, Austrian Alps, ecosystem services, tourism, agriculture

Abstract

Resilience at various levels of the social and environmental domains is a key aspect of sustainable development in mountain areas. However, resilience research is hampered by inconsistent definitions and conceptualizations of resilience. Using the examples of two research projects from protected mountain areas in different regions of the world (in the Austrian Alps and the Nepalese Himalayas), we illustrate two distinct perspectives on resilience: a system-based perspective and an agency-based one. We identify common characteristics of these views on resilience and apparent contradictions between them, and discuss how the two perspectives can be integrated to enhance understanding of resilience and to support sustainable development.

Profile

Protected area

Ruhegebiet Ötztaler Alpen & Nature Park Ötztal Mountain range in Austria; Sagarmatha National Park & Annapurna Conservation Area in Nepal

Introduction

Communities in mountain regions across the globe are facing numerous challenges: they are disproportionately affected by natural hazards, limited agricultural production, as well as economic and political marginalization (Sati 2014). Moreover, additional pressure is put on mountain environments by climate change, exploitation of natural resources and land use changes, affecting the provision of ecosystem services and the livelihoods of people dependent upon them (Price et al. 2004; Einhorn et al. 2015, Pepin et al. 2015, Hock et al. 2019). This interplay of natural and social factors and drivers makes mountain areas complex social-ecological systems (SES), which are challenging to investigate (Cumming & Allen 2017).

The management of mountain areas can be further complicated by the designation of protected areas subject to specific guidelines and regulations. Being rich in natural and cultural resources and providing manifold essential ecosystem services, 16.9% of mountain areas globally (excluding Antarctica) are nationally designated protected areas (status as of 2009; Rodríguez-Rodríguez et al. 2011). A protected area is defined as *"a clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values"* (Dudley 2008). In protected mountain areas, finding a balance between conflicting (interests e. g. tourism, agriculture, prevention of natural hazards) is often challenging due to differing management priorities and the perceived legitimacy of various actors involved (e. g. scientists, policymakers, NGOs and communities) (Lockwood 2010).

Subsuming the ability to respond to and prepare for change, the concept of resilience is often considered a central element of sustainable mountain development in general (Manuelli et al. 2014; Wymann von Dach et al. 2018), in particular for the establishment of protected mountain areas (e. g. Cumming et al. 2015). Despite ongoing research efforts (e. g. Nettier et al. 2017; Ingrisch & Bahn 2018), *however,* just how resilience of mountain regions, communities and environments can be defined, operationalized and assessed remains problematic. Different resilience concepts are used interchangeably and / or with ambiguous meanings (Gardner & Dekens 2007; Hosseini et al. 2016). In ecology, resilience usually defines the ability of a system to absorb disturbances while keeping the same functions, characteristics and identity (Holling 1996; Walker et al. 2004; Quinlan et al. 2016). Under this definition, the possibility of reaching alternative equilibria is included (Holling 1996). For application to SES such as protected mountain areas, the definition of resilience was extended: social-ecological resilience explicitly includes adaptability and transformability, implying that a system does not necessarily have one or more states of equilibrium but is adapting and changing continuously (Davoudi et al. 2012). In contrast to these traditional system-oriented perspectives on resilience, some recent approaches follow agency-centred perspectives, where social entities and their agency (e. g. ability and willingness to act) are the focus of attention (Bohle et al. 2009; Bristow & Healy 2013). In applying the resilience concept to protected moun-

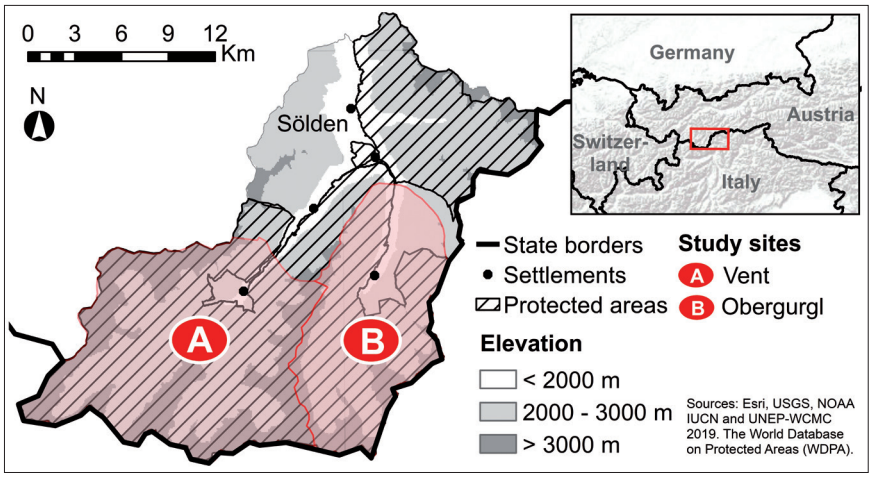

Figure 1 – Location of the study sites in the RESULT project, showing Vent and Obergurgl (both part of the community of Sölden, Tyrol, Austria).

tain areas, this means that managers, stakeholders and related institutions, and their ability and willingness to act, are explicitly investigated in resilience evaluations.

The aim of this paper is to compare system-based and agency-based perspectives on resilience in mountain regions by looking at their conceptual, methodological and practical differences, and discussing advantages and limitations of both approaches. We compare two projects investigating the resilience of livelihoods, in two mountain regions that are undergoing changing conditions: socio-economic changes (e.g. change of economic structure), and environmental changes (e.g. climate change, natural hazards). The case studies belong to protected areas with different designations. In both projects, the protection status has played an ambiguous role in addressing resilience, which will be examined below.

For the investigation of resilience in the case study regions, self-moderated focus groups were created, comprising all researchers of the two projects. The focus groups' findings are presented here, structured and summarized in an analytical grid. Finally, advantages and shortcomings of system- and agency-based perspectives are discussed, and suggestions for how to combine these approaches with each other are made. With these findings, this paper contributes to a more holistic understanding of resilience in mountain areas.

Material and methods: analysing resilience in protected mountain areas

To better understand the empirical implications of different theoretical approaches towards resilience in mountain regions, we present insights from two projects funded by the Austrian Academy of Sciences (ÖAW) within the 2015 Earth System Sciences research programme. Members of both research projects – from different scientific fields such as Geography, Ecology, Public Finance and Sociology – took part in a series of self-moderated focus groups (based on Stewart & Shamdasani 1991; Schulz 2012) to identify common characteristics, apparent contradictions and differing understandings of resilience research in mountain regions. First, researchers from both project teams presented their conceptualization of resilience. Based on these perceptions, several questions were developed by the authors to guide the subsequent series of focus groups. The guiding questions were:

1. How do you define resilience in your project?
2. Whose resilience is observed?
3. Do you quantify resilience? – If yes, what indicator(s) do you use?

In order to fully exploit the potential, discussions were kept open, and each participant was allowed to raise further spontaneous questions. To structure the findings, all participating researchers agreed a set of dimensions for an analytical grid to contrast the two approaches to the analysis of resilience in protected mountain areas. In addition, advantages and limitations of system- and agency-based perspectives were collected and discussed.

Social-ecological resilience: focus on the system

Using two study sites, Vent and Obergurgl in the Upper Ötz Valley, Tyrol, Austria (Figure 1), the RESULT project (Resilience through synergies between agriculture and tourism: A comparison of two contrasting trajectories in the Tyrolean Alps) investigates the effects of interactions between agriculture and the tourism industry on the resilience of mountain regions and the local communities. The research aim is to investigate the resilience of two mountain communities facing long-term changes in climate and socio-economic trajectories.

Case study sites

The two sites provide a unique opportunity to study the interdependencies between tourism and agriculture over a long time period, because both vil-

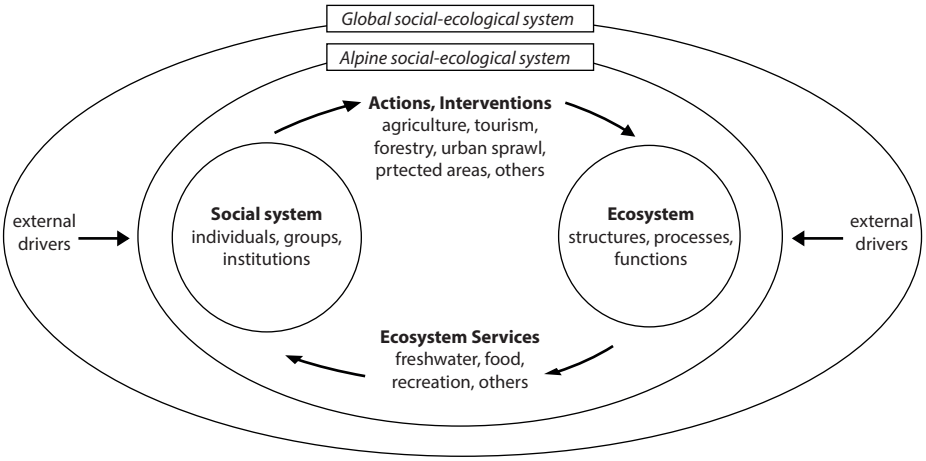

Figure 2 – The social-ecological system (adapted from Resilience Alliance 2007).

lages were typical Alpine agrarian communities that developed into tourist destinations at the beginning of the 19th century (Busse et al. 1987), but without the complete disappearance of agricultural activities. However, their touristic development trajectories are different: Obergurgl focuses almost entirely on skiing tourism, whereas Vent has positioned itself as a *mountaineering village* for gentle tourism in winter and summer (Wilson et al. 2018). Obergurgl and Vent lie in two different protected areas classified by the International Union for Conservation of Nature (IUCN): the National Rest Area *Ruhegebiet Ötztaler Alpen* (IUCN category IV), and the Nature Park *Naturpark Ötztal* (IUCN category V) (IUCN & UNEP-WCMC 2019). While in selecting the case-study sites their protection status played only a minor role, it has proven to be essential for further assessments of resilience.

Resilience understanding and methods used

Based on the resilience definition of Walker et al. (2004, p. 2), RESULT assesses resilience as *"the capacity of a system to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks"*. Instead of observing the social and the ecological systems separately, we treat the study sites as SES: *"integrated systems of ecosystems and human society with reciprocal feedback and interdependence"* (Resilience Alliance 2007, p. 1) (Figure 2).

The two case study sites (Alpine social-ecological systems in Figure 2) generate ecosystem services (ES) that are crucial to human well-being (Haines-Young & Potschin 2010). In Obergurgl and Vent, the livelihoods of the inhabitants have always been based on local ES, i. e. provisioning services (e. g. agricultural products, water supply), regulating and maintaining services (e. g. regulating natural hazards, soil fertility), and cultural services (e. g. recreational and aesthetic value for tourism). To ensure the economic and social well-being of the two communities, it is crucial that the SES is able to maintain flows of desired ES within tolerable limits (Biggs et al. 2012). If the flows move outside these limits, disadvantages for society may occur (Janssen et al. 2007). Hence, for the application of the resilience concept in the study, we equated resilience with a stable flow of desired ES in the face of long-term changes to climate and socio-economic trajectories (Janssen et al. 2007; Brunner & Grêt-Regamey 2016). Changes over time include the loss of protected status by a case-study region, a factor which was taken into consideration when assessing resilience. According to Kohler et al. (2017, pp. 117–118), *"a resilient [social-ecological] system will adapt its structure to change while keeping the same set of states and associated ecosystem services"*. Therefore, the project modelled and mapped a wide range of relevant ES for five time-steps from 1860 to 2015, and the changes in ES supply and demand were quantified as a measure for resilience. The selection of the ES was based on studies by Zoderer et al. (2019) and Tasser et al. (2020), in which the importance of a large number of ES for society in the Tyrol was surveyed. In addition, Gruber (2019) verified these Tyrol-wide assessments in both local communities. Small changes in ES are practically unavoidable as the SES is characterized by constant dynamics and change (Walker & Salt 2006), but the transformation into a fundamentally different system would entail a fundamental shift in the ES bundles or even a complete loss of specific ES.

Social resilience: putting people first

Using empirical evidence from Nepal, the touRES project (Resilience of tourism systems to natural hazards in the Himalayas) analyses the resilience of owners of businesses in the tourism sector to natural hazards in two case study areas (Figure 3).

Case study sites

The two study sites Kali Gandaki Valley and Khumbu Valley provide a good opportunity to study the interdependencies between tourism and natural hazards. Both study areas belong to major tourist regions in the Himalayas, with outdoor-based activities as the central attraction (e. g. trekking, hiking, mountain biking). Additionally, natural hazard processes such as earthquakes, floods and landslides happen frequently

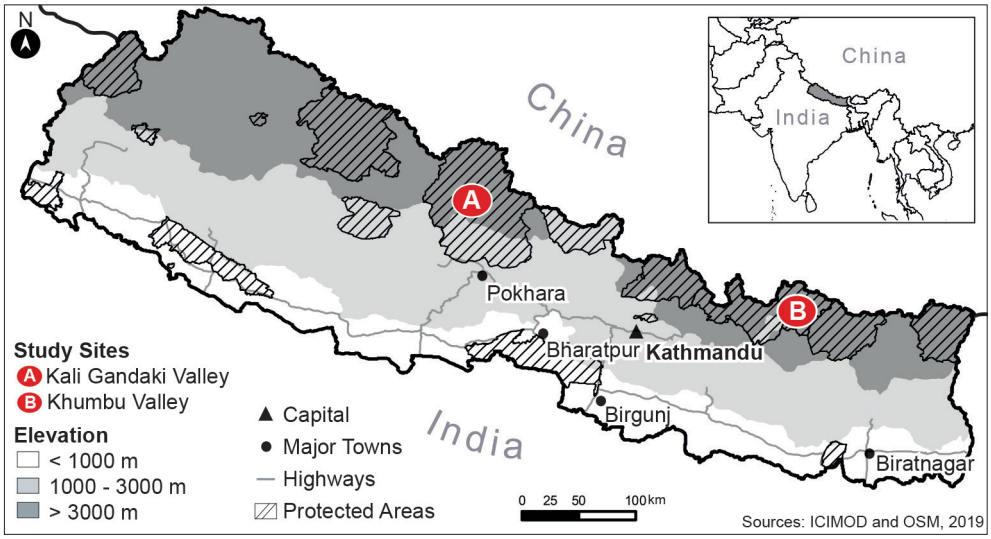

Figure 3 – Location of the study sites in the touRES project.

in the Himalayan region and could increase under conditions of global climate change (Petley et al. 2007; ICIMOD 2011; United Nations ESCAP 2015; Kargel et al. 2016). The various natural hazard processes have direct and indirect impacts on local tourism, and local businesses in the tourism sector take different actions in order to prepare for, prevent and respond to these events. Kali Gandaki Valley and Khumbu Valley were selected because they are located within two different IUCN protected areas – Sagarmatha National Park and Buffer Zone (SNP: IUCN category II) and Annapurna Conservation Area (ACA: IUCN category VI) (IUCN & UNEP-WCMC 2019). It is a general assumption that different protection designations entail different regulations for tourism activities as well as for risk management. However, while this is mostly the case, in practice it has largely proved difficult to implement the various levels of regulation, and these differences did not affect the agency of the individual actors, which was the focus of the analysis.

Understanding of resilience, and methods used

The overall aims of the touRES project are to analyse the resilience of owners of businesses in the tourism sector to natural hazards, and to provide future development paths for improving this resilience. To carry out its aims, the project follows an actor-oriented and agency-based conceptualization of resilience that is grounded in Bohle et al.'s (2009) claim of *"reframing resilience as agency"*. Building on theories from environmental psychology and health psychology – the *Value-Belief-Norm* (VBN) theory (Stern 1999) and *Protection Motivation Theory* (PMT: Rogers 1975) – the model of *Agency Towards Resilience* (ATR; Figure 4) was developed (see Posch et al. 2020).

The individual actor is the starting point of the analysis. Practical actions are taken at different social levels, ranging from the individual to the collective, and directly and indirectly improve their resilience (Hutter & Lorenz 2018). These practical actions towards resilience depend on the actor's ability and willingness

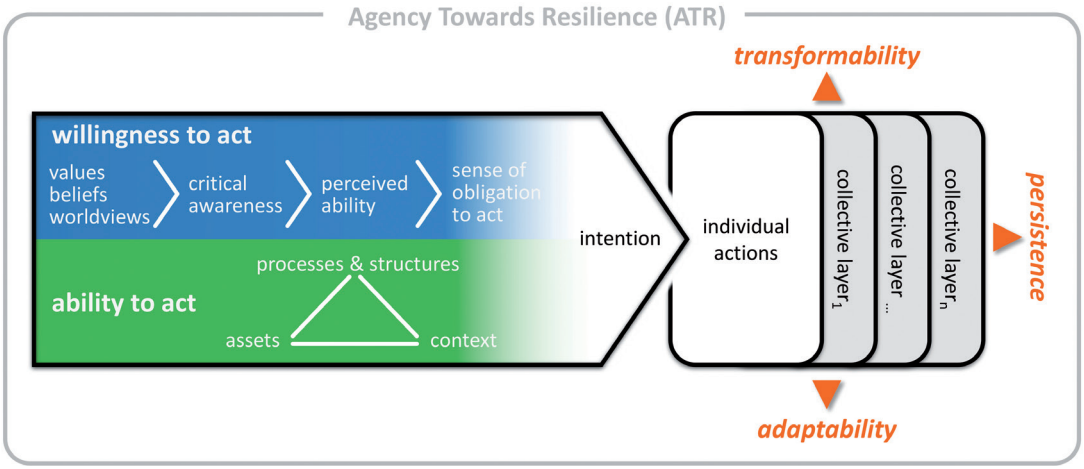

Figure 4 – The Agency Towards Resilience (ATR) model (based on Posch et al. 2020).

to act. While the ability to act is based on access to assets and on the context (e.g. policy setting, institutional, political, historical, demographic, social, environmental, and socio-economic conditions) (Scoones 1998), the willingness to act is shaped by individual goals and trade-offs, which are rooted in, among other things, values, beliefs, critical awareness, and the perceived ability to act and an obligation to do so (Rogers 1975; Stern 1999). In our study, we argue that human agency cannot be reduced to whether or not social entities have access to assets and resources; nor can it be equated with these entities' capabilities and skills to act. A human-agency perspective acknowledges that actors' rationales differ, that they use different strategies, and have different levels of willingness to act (Pain & Levine 2012; Darnhofer et al. 2016). Access to economic, social, natural, physical or human assets is not seen as the main determinant of an entity's resilience. Therefore improved access to assets does not necessarily lead to an increased level of resilience (Adger 2003; Norris et al. 2008; Speranza et al. 2014). Thus, a better understanding is needed of why social entities behave or act in certain ways, why they make certain choices, and why they have certain priorities and goals (Bristow & Healy 2013).

Results: dimensions of resilience research in mountain areas

In the two projects presented, different approaches are used to investigate resilience in mountain regions involving different scales of analysis and methodologies. These are outlined in an analytical grid (Table 1). Within the focus groups, we framed five dimensions that characterize the approaches of resilience research in mountain regions: (1) resilience of whom / what; (2) scope / scale of analysis; (3) resilience to what; (4) methodological approach; and (5) aim of the analysis.

In the RESULT project, the crucial *resilience of whom / what* question is centred on a mountain social-ecological system. In contrast, the focus of the touRES project is on owners of businesses in the tourism sector. RESULT does not account for individual elements of the system and their behaviour, whereas the tourism-business owners in the touRES project are considered active actors with a certain ability and willingness to proactively prepare, prevent and adapt, as well as to respond reactively, to disturbances. These definitions of subjects seem to determine the *scope / scale of analysis*: the RESULT project deals with the overall behaviour of the system (system-based perspective); the touRES project studies the individual system elements (agency-based perspective).

The aspect *resilient to what* is also viewed from contrasting perspectives. In the RESULT project, the resilience to long-term changes in climate and socio-economic trajectories is observed, changes being identified from an external perspective by collecting data (on climatic variables, demographic development, agricultural change, tourism change, infrastructure expansion, etc.) from publicly available databases and literature (Huber et al. 2020). In the touRES project, on the other hand, resilience to natural hazards is central and is studied by investigating people's critical awareness of natural hazards in two regions after developing an inventory of past, present and potential future natural hazard events.

Moreover, the *methodological approach* of the two projects differs. In the RESULT project, resilience assessment is based on measurement, modelling and mapping of ES (Schirpke et al. 2019; Huber et al. 2020). In contrast, the ATR model of the tourRES project (Posch et al. 2020) avoids measuring resilience, which often results in benchmarking, implying that social entities always behave as homogeneous, rational agents (Darnhofer et al. 2016; Quinlan et al. 2016). Instead, the touRES approach is based on investigating the range of actions that people are able and willing to perform, and examining the factors behind peoples' ability and willingness to act (e.g. access to assets, structural conditions, values, beliefs and worldviews) (Posch et al. 2019).

Thus, *the aim of analysis* is also different for the two projects. The RESULT project aims at finding recommendations for ensuring and improving ES supply for the local inhabitants, whereas the touRES project does not recommend *optimal* actions, because they may be ineffective or inappropriate (Pain & Levine 2012). Instead, the focus is on *local optima* (e.g. actions people are able and willing to carry out) that can be encouraged or facilitated by outside support and may serve as entry points to enhance resilience.

Table 1 – Analytical grid of characteristics in the two projects' views on resilience.

Dimension	RESULT	touRES
1. Resilience of whom / what	Mountain social-ecological systems (mountain ecosystems and their local inhabitants)	Owners of tourism businesses
2. Scope / Scale of analysis	System-based	Agency-based
3. Resilience to what	Long-term changes in climate and socio-economic trajectories.	Natural hazards
4. Methodological approach	Mapping, modelling and quantifying ecosystem services (by spatial modelling in geographic information systems, surveys, expert interviews).	Understanding poly-rational values and worldviews, evaluating actions taken/not taken (by surveys and interviews), natural hazards analysis.
5. Aim of analysis	Develop recommendations to ensure and improve the supply of ecosystem services to local inhabitants.	Improve local optimum by identifying the range of actions people are able and willing to take that increase their resilience to natural hazards.

Discussion

The projects differed not only in the definition of the units of analysis, but also as to which aspects they should be resilient to, their methodological approach, and the aim of the analysis. The system-oriented and agency-centred perspectives each offer various advantages and limitations, which will be discussed in this section. We will end with some thoughts on whether these approaches and methodologies are mutually and strictly exclusive, or whether some integration of the two is possible and even desirable.

Advantages and limitations of system- and agent-based perspectives

It seems to be an advantage of system-based approaches such as the one used in the RESULT project that optimal solutions for improving system resilience can be derived from models that simulate interactions within the system as well as consequences of external impacts. However, although the practical implementation of resilience-enhancing measures can be suggested by scientists, implementation by local and / or political actors at different spatial levels presents a great challenge (Davoudi et al. 2012). Here, the actors' knowledge might be insufficient to understand the complexities of the system or the effects (and effectiveness) of measures, leading to ineffective measures or even non-action (Herrera 2017). We find a further limitation in the need to reflect whether resilience is used as a normative, an analytical or a descriptive concept (Kruse et al. 2017). If resilience analysis implies the identification of optimal resilience-enhancing measures, one needs to ask what the desired outcome is, and for whom. While certain outcomes may be perceived by some as optimal and therefore desirable, they might not be so perceived by others (Davoudi et al. 2012). Another controversial question is that of who decides what being *resilient enough* is (MacKinnon & Derickson 2012).

In our projects, the protection status of the mountain regions offered two interesting findings: in the touRES project, the protected area designation was a substantial reason for selecting the case study sites, as the designation was assumed to be crucial for tourism and natural hazard management practices. However, it turned out to be of minor importance for the agency of individual actors – the unit of analysis of the study. On the other hand, in the RESULT project, the protection designation was unimportant for the selection of the case study sites but subsequently proved to be of great significance for the resilience assessment, because the loss of protected status of part of the study area had an impact on the provision of ecosystem services, which we were able to analyse using the particular resilience assessment methodology applied.

However, even if sufficient specialist knowledge is available, discrepancies between objective knowledge, behavioural intentions and actual behaviour can be expected (Hurlimann et al. 2009). In the worst-case scenario, no improvement of the system can be reached at all, because what is known as effective practice from theory and science is not actually implemented in policy and practice (Fixsen et al. 2005). Reasons for ineffective measures or non-actions can include conflicting (hidden) interests, worldviews or cultural backgrounds. In the touRES project, for example, an important link between peoples' values, beliefs and their engagement in disaster preparedness and prevention activities was examined (Posch et al. 2019). A possible solution is to consider the willingness and abilities of agents to act by using an agency-based approach. Following this approach, measures to improve the system can be tailored to the needs and potential of the agents, but it is likely to create a dilemma for science: against empirical findings, *good* rather than the scientifically determined *optimal* measures are suggested. In the worst case, this can mean that the aim of the research (e. g. improvement of the system) cannot be attained, because the measures that are accepted and implemented by the local and political actors are insufficient to fully implement *optimal* measures. Thus, instead of giving *optimal* recommendations, a transdisciplinary approach in research projects may help to achieve a more comprehensive range of plausible options by involving non-academic actors in the formulation of the research questions, problem definition, and understanding of solutions (Sarkki et al. 2013).

Combining the two perspectives?

To model complex system phenomena that involve human and / or institutional behaviour, it can be helpful to use an agent-based modelling approach. Such approaches are used to simulate the behaviour and mutual interactions of autonomous agents in order to assess the response of a system as a whole (An 2012). Here, inviting practitioners to define the behaviour of the model's agents, in what is called *participatory agent-based modelling*, is recommended. Stakeholder involvement in the modelling processes can reduce the inherent limitations and improve understanding of the relevant system components (Voinov & Bousquet 2010); in this way, participatory modelling not only helps the scientists to incorporate local knowledge into system modelling but also enhances the stakeholders' system knowledge and gives them a chance to reflect on possible consequences of their individual willingness (or not) to act. As a minimum, participatory modelling supports the scientists in identifying the limits of the willingness to act, which is the first prerequisite if actors are going to be engaged in increasing their willingness to act. Particularly appealing ways to include stakeholders in modelling are found in serious *games*, where scientific models are implemented in computer games and role-playing (see e. g. Meadows 1986; Resnick & Wilensky 1998).

Conclusion

In this paper, we compared different conceptual, methodological and practical approaches in resilience research in protected mountain areas. Based on two research projects in protected regions in the Austrian Alps and the Nepalese Himalaya, we framed 5 dimensions that characterize approaches of resilience research in mountain regions: (1) Resilience of who / what, (2) Resilience to what, (3) Scale of analysis, (4) Methodological Approach, and (5) Aim of Analysis. These dimensions cover typical characteristics of system-based and agency-oriented views on resilience. Both approaches have advantages and limitations regarding practical applicability and societal desirability. Future research could cover the integration of the two conceptual, methodological and practical approaches, for example by participatory agent-based modelling that is rooted in a transdisciplinary tradition.

Acknowledgment

This work was funded by the Earth System Sciences Program of the Austrian Academy of Sciences and the University of Innsbruck.

References

Adger, W.N. 2003. Social Capital, Collective Action, and Adaptation to Climate Change. *Journal of economic geography* 79: 387–404.

An, L. 2012. Modeling human decisions in coupled human and natural systems: Review of agent-based models. *Ecological Modelling* 229: 25–36.

Biggs, R., M. Schlüter, D. Biggs, E.L. Bohensky, S. BurnSilver, G. Cundill, V. Dakos, T.M. Daw, L.S. Evans, K. Kotschy,. A.M. Leitch, C. Meek, A. Quinlan, C. Raudsepp-Hearne, M.D. Robards, M.L. Schoon, L. Schultz & P.C. West 2012. Toward Principles for Enhancing the Resilience of Ecosystem Services. *Annual Review of Environment and Resources* 37: 421–448.

Bohle, H.-G., B. Etzold & M. Keck 2009. Resilience as Agency. *IHDP update*: 8–13.

Bristow, G. & A. Healy 2013. Regional Resilience: An Agency Perspective. *Regional Studies* 48: 923–935.

Brunner, S.H. & A. Grêt-Regamey 2016. Policy strategies to foster the resilience of mountain social-ecological systems under uncertain global change. *Environmental Science and Policy* 66: 129–139.

Busse, H., T. Seidel, D. Munz & H. Heuberger 1987. Der sozioökonomische Strukturwandel des inneren Ötztales (Gemeinde Sölden) – Untersuchungen über Bevölkerungsentwicklung, Arbeitskräfte und Fremdenverkehr. In: Patzelt, G. (ed.), *MaB – Projekt Obergurgl*: 25–114. Innsbruck.

Cumming, G. & C. Allen 2017. Protected areas as social-ecological systems: perspectives from resilience and sociol-ecological systems theory. *Ecological Applications* 27: 1709–1717.

Cumming, G.S., C.R. Allen, N.C. Ban, D. Biggs, H.C. Biggs, D.H.M. Cumming, A. De Vos, G. Epstein, M. Etienne, K. Maciejewski, R. Mathevet, C. Moore, M. Nenadovic & M. Schoon 2015. Understanding protected area resilience: a multiscale, social-ecological approach. *Ecological Applications* 25: 299–319.

Darnhofer, I., C. Lamine, A. Strauss & M. Navarrete 2016. The resilience of family farms: Towards a relational approach. *Journal of Rural Studies* 44: 111–122.

Davoudi, S., K. Shaw, L.J. Haider, A.E. Quinlan, G.D. Peterson, C. Wilkinson, H. Fünfgeld, D. McEvoy, L. Porter & S. Davoudi 2012. Resilience: A Bridging Concept or a Dead End? "Reframing" Resilience: Challenges for Planning Theory and Practice Interacting Traps: Resilience Assessment of a Pasture Management System in Northern Afghanistan Urban Resilience: What Does it Mean in Planning Practice? Resilience as a Useful Concept for Climate Change Adaptation? The Politics of Resilience for Planning: A Cautionary Note. *Planning Theory and Practice* 13: 299–333.

Dudley, N. 2008. *Guidelines for applying protected area management categories*. IUCN.

Einhorn, B., N. Eckert, C. Chaix, L. Ravanel, P. Deline, M. Gardent, V. Boudières, D. Richard, J.-M. Vengeon, G. Giraud & P. Schoeneich 2015. Climate change and natural hazards in the Alps. *Revue de géographie alpine*. doi: 10.4000/rga.2878

Fixsen, D.L., S.F. Naoom, K.A. Blase, R.M. Friedman & F. Wallace 2005. *Implementation Research: A Synthesis of the Literature*. FL: University of South Florida, Louis de la Parte Florida Mental Health Institute, The National Implementation Research Network.

Gardner, J.S. & J. Dekens 2007. Mountain hazards and the resilience of social-ecological systems: lessons learned in India and Canada. *Natural Hazards* 41: 317–336.

Gruber, C. 2019. *Landschaft im oberen Ötztal: Wandel - Wahrnehmung - Wertschätzung*. Innsbruck.

Haines-Young, R. & M. Potschin 2010. The links between biodiversity, ecosystem services and human well-being. In: Frid, C.L.J. & D.G. Raffaelli (eds.), *Ecosystem Ecology: A New Synthesis*. Cambridge.

Herrera, H. 2017. Resilience for Whom? The Problem Structuring Process of the Resilience Analysis. *Sustainability* 9.

Hock, R., G. Rasul, C. Adler, S. Cáceres, S. Gruber, et al. 2019. High Mountain Areas. In: Pörtner, H.-O., D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama & N.M. Weyer (eds.), *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*.

Holling, C.S. 1996. Engineering Resilience versus Ecological Resilience. In: Schulze, P. (ed.), *Engineering Within Ecological Constraints*. Washington, DC.

Hosseini, S., K. Barker & J. E. Ramirez-Marquez 2016. A review of definitions and measures of system resilience. *Reliability Engineering and System Safety* 145: 47–61.

Huber, L., U. Schirpke, T. Marsoner, E. Tasser & G. Leitinger 2020. Does socioeconomic diversification enhance multifunctionality of mountain landscapes? *Ecosystem Servi*ces 44: 101122.

Hurlimann, A., S. Dolnicar & P. Meyer 2009. Understanding behaviour to inform water supply management in developed nations - a review of literature, conceptual model and research agenda. *Journal of Environmental Management* 91: 47–56.

Hutter, G. & D.F. Lorenz 2018. Social Resilience. In: Fuchs, S. & T. Thaler (eds.), *Vulnerability and Resilience to Natural Hazards*: 190–213 Cambridge.

ICIMOD 2011. *Glacial lakes and glacial lake outburst-floods in Nepal*. Kathmandu, Nepal.

Ingrisch, J. & M. Bahn 2018. Towards a Comparable Quantification of Resilience. *Trends in Ecology and Evolution* 33: 251–259.

IUCN & UNEP-WCMC 2019. *The World Database on Protected Areas (WDPA)*. UNEP World Conservation Monitoring Centre, Cambridge.

Janssen, M.A., J.M. Anderies & E. Ostrom 2007. Robustness of Social-Ecological Systems to Spatial and Temporal Variability. *Society and Natural Resources* 20: 307–322.

Kargel, J.S., G.J. Leonard, D.H. Shugar, U.K. Haritashya, A. Bevington, et al. 2016. Geomorphic and geologic controls of geohazards induced by Nepal's 2015 Gorkha earthquake. *Science* 351. doi: 10.1126/science.aac8353

Kohler, M., C. Devaux, K. Grigulis, G. Leitinger, S. Lavorel & U. Tappeiner 2017. Plant functional assemblages as indicators of the resilience of grassland ecosystem service provision. *Ecological Indicators* 73: 118–127.

Kruse, S., T. Abeling, H. Deeming, M. Fordham, J. Forrester, S. Jülich, A.N. Karanci., C. Kuhlicke, M. Pelling, L. Pedoth & S. Schneiderbauer 2017. Conceptualizing community resilience to natural hazards – the emBRACE framework. *Natural Hazards and Earth Systems* 17: 2321–2333.

Lockwood, M. 2010. Good governance for terrestrial protected areas: A framework, principles and performance outcomes. *Journal of environmental management* 91: 754–766.

MacKinnon, D. & K.D. Derickson 2012. From resilience to resourcefulness. *Progress in Human Geography* 37: 253–270.

Manuelli, S., T. Hofer & A. Vita 2014. FAO's Work on Sustainable Mountain Development and Watershed Management. *Mountain Research and Development Journal* 34: 66–70.

Meadows, D. 1986. *Fishbanks*. Software.

Nettier, B., L. Dobremez, S. Lavorel & G. Brunschwig 2017. Resilience as a framework for analyzing the adaptation of mountain summer pasture systems to climate change. *Ecology and Society* 22.

Norris, F.H., S.P. Stevens, B. Pfefferbaum, K.F. Wyche & R.L. Pfefferbaum 2008. Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. *American journal of community psychology* 41: 127–150.

Pain, A. & S. Levine 2012. *A conceptual analysis of livelihoods and resilience: addressing the 'insecurity of agency'*. HPG Working Paper. Overseas Development Institute (ODI).

Pepin, N., R.S. Bradley, H.F. Diaz, M. Baraer, E.B. Caceres, N. Forsythe, H. Fowler, G. Greenwood, M.Z. Hashmi, X.D. Liu, J.R. Miller, L. Ning, A. Ohmura, E. Palazzi, I. Rangwala, W. Schöner, I. Severskiy, M. Shahgedanova, M.B. Wang, S.N. Williamson & D.Q. Yang 2015. Elevation-dependent warming in mountain regions of the world. *Nature Climate Change* 5: 424–430.

Petley, D.N., G.J. Hearn, A. Hart, N.J. Rosser, S.A. Dunning, K. Oven & W.A. Mitchell 2007. Trends in landslide occurrence in Nepal. *Natural Hazards* 43: 23–44.

Posch, E., K.-M. Höferl, R. Steiger & R. Bell 2020. Another take on reframing resilience as agency: The Agency Towards Resilience (ATR) model. In: Santos, P.P., J. v. Meding, K. Chmutina & E. Raju (eds.), *Understanding Disaster Risk*.

Posch, E., K.-M. Höferl, R. Steiger, R. Bell & L. Gurung 2019. Ke garne? How values and worldviews influence resilience to natural hazards: A case study from Mustang, Nepal. *Mountain Research and Development Journal* 39.

Price, M.F., L.F. Jansky & A.A. Iatsenia 2004. Key issues for mountain areas. Tokyo - New York - Paris.

Quinlan, A.E., M. Berbés-Blázquez, L.J. Haider, G.D. Peterson & C. Allen 2016. Measuring and assessing resilience: broadening understanding through multiple disciplinary perspectives. *Journal of Applied Ecology* 53: 677–687.

Resilience Alliance 2007. *Assessing and managing resilience in social-ecological systems: A practitioners workbook*. Version 1.0.

Resnick, M. & U. Wilensky 1998. Diving Into Complexity: Developing Probabilistic Decentralized Thinking Through Role-Playing Activities. *Journal of Science Learning* 7: 153–172.

Rodríguez-Rodríguez, D., B. Bomhard, S.H.M. Butchart & M. Foster 2011. Progress towards international targets for protected area coverage in mountains: A multi-scale assessment. *Biological Conservation* 144: 2978–2983.

Rogers, R.W. 1975. A Protection Motivation Theory of Fear Appeals and Attitude Change1. *Journal of psychology* 91: 93–114.

Sarkki, S., H.I. Heikkinen & T.P. Karjalainen 2013. Sensitivity in transdisciplinary projects: A case of reindeer management in Finland. *Land Use Policy* 34: 183–192.

Sati, V.P. 2014. *Towards Sustainable Livelihoods and Ecosystems in Mountain Regions*. Cham, Heidelberg, New York, Dordrecht, London.

Schirpke, U., A. Altzinger, G. Leitinger & E. Tasser 2019. Change from agricultural to touristic use: Effects

on the aesthetic value of landscapes over the last 150 years. *Landscape and Urban Planning* 187: 23–35.

Schulz, M. 2012. Quick and easy!? Fokusgruppen in der angewandten Sozialwissenschaft. In: Schulz, M., B. Mack & O. Renn (eds.), *Fokusgruppen in der empirischen Sozialwissenschaft: Von der Konzeption bis zur Auswertung*. Wiesbaden.

Scoones, I. 1998. *Sustainable Rural Livelihoods: A Framework for Analysis*.

Speranza, C.I., U. Wiesmann & S. Rist 2014. An indicator framework for assessing livelihood resilience in the context of social-ecological dynamics. *Global Environmental Change* 28: 109–119.

Stern, P.C. 1999. A Value-Belief-Norm Theory of Support for Social Movements: The Case of Environmentalism. *Human Ecology Review* 6: 81–97.

Stewart, D.W. & P.N. Shamdasani 1991. *Focus groups: theory and practice*. 3. print edition. Newbury Park, Calif.

Tasser, E., U. Schirpke, B.M. Zoderer & U. Tappeiner 2020. Towards an integrative assessment of land-use type values from the perspective of ecosystem services. *Ecosystem Services* 42. doi: 10.1016/j.ecoser.2020.101082.

United Nations ESCAP 2015. *Disasters in Asia and the Pacific: 2015*. Year in Review.

Voinov, A. & F. Bousquet 2010. Modelling with stakeholders. *Environ. Modell. Softw.* 25:1268–1281.

Walker, B., C.S. Holling, S.R. Carpenter & A.P. Kinzig 2004. Resilience, Adaptability and Transformability in Social-ecological Systems. *Ecology and Society* 9.

Walker, B.H. & D. Salt 2006. *Resilience thinking: sustaining ecosystems and people in a changing world*. Washington, DC [u.a.].

Wilson, G.A., M. Schermer & R. Stotten 2018. The resilience and vulnerability of remote mountain communities: The case of Vent, Austrian Alps. *Land Use Policy* 71: 372–383.

Wymann von Dach, S., C. Brache, M. Peralvo, K. Perez & C. Adler 2018. *Leaving no one in mountains behind: Localizing the SDGs for resilience of mountain people and ecosystems*. Centre for Development and Environment and Mountain Research Initiative, Bern, Switzerland.

Zoderer, B.M., E. Tasser, S. Carver & U. Tappeiner 2019. Stakeholder perspectives on ecosystem service supply and ecosystem service demand bundles. *Ecosystem Services* 37. doi: 10.1016/j.ecoser.2019.100938

Authors

Lisa Huber[1]

is a project collaborator and PhD candidate at the Department of Ecology, University of Innsbruck. Her research focus lies on the analyses of social-ecological systems and the modelling and mapping of ecosystem services in the European Alps. E-mail: Lisa.Huber@uibk.ac.at

Eva Posch[2]

is a project collaborator and PhD candidate at the Department of Geography, University of Innsbruck. Her research interests are the interfaces of disaster risk management, social resilience, and tourism development in mountain regions. E-mail: Eva.Posch@uibk.ac.at

Rainer Bell[3]

is Postdoc researcher at the Department of Geography, University of Bonn. His research focuses on geomorphology, and integrative natural hazard and risk analysis and management in mountain regions.

Karl-Michael Höferl[2]

is a Senior Lecturer at the Department of Geography, University of Innsbruck. His research focuses on resilient and responsible development.

Robert Steiger[4]

is Assistant Professor at the Department of Public Finance, University of Innsbruck. His research interests are in the field of sustainable tourism development, man–environment relationships, and climate-change impacts on tourism and tourist behaviour.

Rike Stotten[5]

is Assistant Professor at the Department of Sociology, University of Innsbruck. Her research interests are in the fields of agri-food studies and rural sociology in mountain areas.

Erich Tasser[6]

is Senior scientist at the Institute for Alpine Environment, Eurac Research. His research encompasses landscape ecology, geostatistical analysis and links with socio-economic science, with a particular focus on the effects of land-use changes on biodiversity and ecosystem services.

Georg Leitinger[1]

is Associate Professor at the Department of Ecology, University of Innsbruck. His research integrates ecosystem and landscape ecology, with a special emphasis on social-ecological systems, to analyse ecosystem functions and services across spatial and temporal scales.

[1] Department of Ecology, University of Innsbruck, Austria
[2] Department of Geography, University of Innsbruck, Austria
[3] Department of Geography, University of Bonn, Germany
[4] Department of Public Finance, University of Innsbruck, Austria
[5] Department of Sociology, University of Innsbruck, Austria
[6] Institute for Alpine Environment, Eurac research, Bozen, Italy