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Framing the Human Dimensions of Mountain Systems: Integrating Social Science Paradigms for a Global Network of Mountain Observatories

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The Global Network of Mountain Observatories (GNOMO) is an international initiative seeking to increase communication and collaboration and align methodologies to assess commonalities and differences across the world's mountain landscapes. Oriented toward sustainable mountain development, GNOMO requires the integration of social and natural sciences, as well as a diverse array of stakeholder perspectives. This paper highlights challenges associated with integrating social sciences because of the inherent paradigmatic differences within the social sciences. The value orientations of mountain researchers, as well as the divergent societal and institutional values regarding mountains, create a need for new approaches to observing mountain landscapes. A framework is presented to organize complex information about mountain social–ecological systems based on human conditions (from vulnerability to wellbeing), environmental actions (from degradation to stewardship), and environmental conditions that vary across time, space, and scales. A multiparadigmatic, multimethod approach is proposed to combine theory-driven quantitative indicators, qualitative perspectives from diverse knowledge standpoints, and critical inquiries into power relationships to fully represent dynamic mountain systems.

Keywords: *Social science; mountain observatories; paradigms; sustainable mountain development; vulnerability; wellbeing; environmental action.*

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Introduction

Mountain landscapes are widely acknowledged to have local, regional, national, and global significance for reasons ranging from cultural identity to natural resource and biodiversity provision (Debarbieux and Price 2008). For at least a quarter of a century, international effort has focused on coordinating scientific endeavors with regard to sustainable mountain development around the world (UNCED 1992; Debarbieux and Price 2008; Messerli 2012; UN 2015). More recently, the Mountain Research Initiative and others have led an effort to build a network of observatories focused on the sustainability of mountain social and ecological systems around the world (Greenwood 2013). The Global Network of Mountain Observatories (GNOMO) (http://gnomo.ucnrs.org) has emerged as an interdisciplinary effort to increase communication and collaboration and align methodologies to assess commonalities and differences across the world's mountain landscapes. The pursuit of global research platforms to support sustainability led by the Future Earth initiative calls for full integration of scientific disciplines, coproduction of knowledge with societal partners, and development of new insights, data, and tools to help address global challenges (Future Earth 2014). Yet the challenges of such interdisciplinary and transdisciplinary approaches, particularly the inclusion of social sciences, are often profound (Kinzig 2001; Strang 2009; Mooney et al 2013; Brown et al 2015).

The mountain research community has long recognized the importance of mountains to people and communities, the environmental and social impacts of human actions, and the broader cognitive, cultural, political, economic, and ecological dimensions of mountains (Price 1986; Messerli and Ives 1997; Price et al 2013). The GNOMO initiative shares the Future Earth perspective that sustainable mountain development requires a holistic understanding and comparison of social–ecological systems. Yet the systematic inclusion of the social sciences in mountain observatory efforts has lagged behind that of the biophysical sciences (Björnsen Gurung et al 2012; Greenwood 2013). This paper explores the challenge of integrating the social sciences into the mountain research agenda, and into the GNOMO effort specifically, by highlighting complexity within the social sciences and the need to recognize the fundamental role of values in science and society in driving human–nature relationships in mountain landscapes. An agenda is offered here and organized according to a multiparadigmatic and multimethod framework to help the mountain research community meet interdisciplinary and transdisciplinary goals associated with sustainable mountain development.

What are the challenges of integrating social science approaches?

The call for integrating natural and social sciences to understand social–ecological systems is not new (Kinzig 2001), and mountain landscapes have been presented as a logical focal point for such integration (Freudenburg et al 1995; Price et al 2013). Yet the integration of natural and social sciences continues to be a challenge. MacMynowski (2009) suggested, "The two discussions are running in parallel with stunningly little crossover." Kinzig (2001: 715) wrote, "We will have to overcome or dismantle several barriers to such research" and "Our biggest challenge will lie in seeing what we discover in the process." Brown et al (2015) pointed to conflictual power dynamics and misinterpretations between social and natural scientists. The conjoint constitution of and contingent interconnections among physical and social mountain landscape characteristics varying across time and space make it imperative that these sciences be integrated for sound assessment and understanding (Freudenburg et al 1995).

In the mountain research community, there are signs of progress. Natural and social scientists have come together at conferences in recent years to pursue understanding of mountain systems and to establish GNOMO (eg Perth III: Mountains of Our Future Earth in Perth, Scotland, in 2015, and the Global Fair and Workshop on Mountain Observatories in Reno, Nevada, USA, in 2014). However, despite having these venues for scientific integration, full collaboration and coupling of human–natural systems through interdisciplinary science remains elusive.

The pursuit of GNOMO raises the question of what to observe and how; the answer is often framed from the vantage point of the observers (Williams 2014). In other words, what mountain researchers deem important to observe is likely to differ depending on their experiences and perspectives. Within the earth and natural sciences, shared adherence to scientific methods and underlying laws regarding how mountain biophysical systems function creates more common ground for interdisciplinary research. Within the social sciences, however, there are even stronger underlying ideological boundaries and more competing ways of making sense of the world than there are in the natural sciences (Westley et al 2001).

Different disciplinary languages, focal points, traditions, and methods exist, along with deep divisions among scientific paradigms, leading to seemingly irreconcilable differences about how the social world works and how it can and should be observed—and, in turn, about what aspects of mountain social systems should be observed and how this should be done. This can confuse and frustrate the integrative process, particularly when awareness of these differences is low. Thus, a key challenge for the integration of social science into mountain observatory efforts is that of integrating the social sciences themselves.

Approaches to social science can be loosely grouped under 3 paradigms, with the caveat that there are myriad hybrid and alternative approaches in practice:

1. *Positivist* (also known as realist) approaches are premised on the notion that there are observable, measurable realities in the social world (Neuman 2006). Much like biophysical science approaches, positivist observations are guided by theory and hypothesis testing with the goal of generalization and classification, and quantitative methods are common. This deductive approach to science works well when relative concepts and hypotheses are well understood and operationalized (Bliss 1999).
2. *Constructivist* approaches emphasize subjective meanings constructed in context; methodologically, they focus on capturing relevant voices and assessing values and lived experiences (Irwin 2001; Neuman 2006). This more inductive approach—taken to explore patterns and processes through observation to build, rather than test, theory—often incorporates more qualitative research methods and analysis (Bliss 1999).
3. *Critical* social science approaches focus on theories of macro-level power dynamics and social structures that enable or constrain capacities of actors in social systems to illuminate injustices and change society (Neuman 2006). While often more abstract and highly theoretical in general, critical social science approaches applied to environmental and natural resource issues, as in political ecology, incorporate empirical qualitative or quantitative data to assess power relationships and institutions (Scoones 1999; Robbins 2011). Critical theorists may be strongly theory driven, like positivists, but they accept the premise of social constructions of reality and do not assume their work is objective.

These 3 broad approaches to social science represent different ways of finding meaning in social phenomena. Researchers tend to be firmly entrenched within one of them, and lines of distinction are often intellectual battlegrounds despite urgings to "unthink our intellectual fetters" (Wallerstein 1991: ix). These tensions find their way into processes such as the pursuit of a global network of mountain observatories. Untangling them is key to finding a balance between local relevance and generalization (Peralvo and Bustamante 2014).

Science for sustainable mountain development is value driven

The mountain observatory effort is tied to the mission of sustainable development (Greenwood 2013). What should be sustained and developed are questions of value (Leiserowitz et al 2006). Values and attitudes are uncomfortable spaces for positivists and natural scientists who claim to work in the realm of facts and objectivity, yet accepting the importance of reflexivity is key to transforming science for sustainable development (Kläy et al 2015).

Recent survey data obtained by the author and the Mountain Research Initiative from participants attending the Perth III: Mountains of Our Future Earth conference in Scotland in October 2015 (Gleeson et al 2016, in this issue) suggest that biophysical and social scientists alike hold strong values about mountains. This shared affinity for mountain landscapes may create common ground among mountain researchers, despite paradigmatic and disciplinary differences. An overwhelming majority (80%) of 302 survey respondents (82% of biophysical scientists and 78% of social scientists) indicated agreement with the statement "Mountains have special meaning or personal value to me." We tend to study what we are interested in and care about, but this raises the questions of whether we might be reifying mountains as operating under unique processes and whether we might have an underlying normative perspective in our science, driven by what we believe should be studied and why, rather than merely how things work. Thinking about our "positionality" or situated vantage point as mountain researchers is important:

> *All observers may attain only a partial or incomplete comprehension of the world due to their embedded and inevitable positionality within any particular province of spatial–temporal reality. This applies both to so-called objective scientific observers who seek to stand apart from the world and to people going through their daily lives embedded in concrete places.*
>
> *(Williams 2014: 75)*

Given that mountain researchers come to the observation of mountain social–ecological systems with emotion, values, and norms about what the goals of sustainable mountain development should be, opening the logic of scientific inquiry and observation beyond hypotheticodeductive methods to more inductive ways of thinking is essential (Wu 2006).

Observing mountain landscapes inherently extends the importance of mountain values to other people—in addition to scientific researchers—who live and work in mountains, because they also hold values, experiences, and identities attached to mountains as places and home. Those who visit mountains for recreation or other amenities are also motivated by values, and these may or may not be compatible with those of local people. People, institutions, and industries have different resource-related and financial interests based on different perspectives on the relationship between humans and nature (Flint et al 2013). Flows of ecosystem services spread far beyond what we might delineate as mountain landscapes, given regional and global interactions and connections (Grêt-Regamey et al 2012). There are both synergies and tradeoffs among these values. While some of these landscape, resource, or ecosystem values can be monetized or at least quantified, some cannot, and in some instances, to try to do so is deemed hostile or offensive (Gómez-Baggethun and de Groot 2010). Assessing the economic, social, and ecological costs and benefits associated with actions taken to advance diverse environmental values requires integrating knowledge from across disciplinary divides and beyond science to fully embrace a transdisciplinary approach to sustainable mountain development.

Proposing an integrated environmental social science framework

While the paradigmatic differences within the social sciences are challenging, there are examples of interparadigmatic integration for understanding patterns, processes, and change in social–ecological systems. The more successful efforts focus on nomothetic or general orienting concepts such as resilience, rather than on specific disciplines, theories, methods, contexts, and units of analysis. As GNOMO seeks to improve understanding of what is generalizable and what is context-specific across mountain landscapes, we need overarching concepts and innovative ways to combine paradigms and methodologies. Within general conceptual space, however, space should remain for individuals or teams to engage in their own research endeavors. A framework structured around key concepts can transcend disciplinary differences and provide an adaptive structure to the mountain observatory initiative.

One such framework is offered here (Figure 1). It combines two human dimensions—conditions of wellbeing and vulnerability and environmental choices leading to degradation or stewardship—and a third dimension of biophysical conditions in the environment. All 3 dimensions are dynamic across time, space, and scale and frame components of mountain observations that together can be used to assess or guide progress toward sustainable development. It would enable mountain observatories to take into account historical experience and future projections or goals, heterogeneity across places, and scales from individual and local to national and transnational.

Human conditions (wellbeing and vulnerability)

Social science mountain researchers often seek to make sense of changes in the wellbeing of individuals, communities, and governance systems in and across mountain landscapes. Depending on their disciplinary orientation, this may involve assessing health, livelihoods, happiness, relationships (social wellbeing), prosperity

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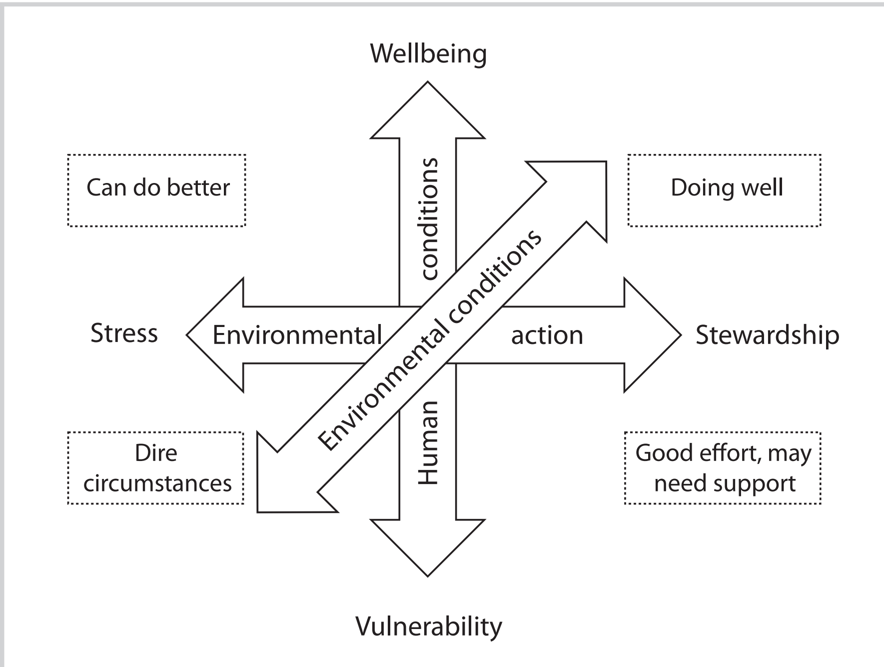
FIGURE 1 Basic framework for observing the human dimensions of mountain development.



(economic wellbeing), governance capacity, or justice. Several well-known indices have quantified such indicators—including the International Organisation for Economic Co-operation and Development's Better Life Index (OECD 2016), which offers 11 dimensions and 24 indicators; the US Environmental Protection Agency's Human Wellbeing Index, with 8 domains (similar to OECD dimensions), 25 indicators, and 79 metrics (Summers et al 2014); and the United Nations Development Programme's Human Development Index (UNDP 2016), which contains just 3 indicators (Table 1). These indices represent positivist approaches to wellbeing—with vast differences in variables, how the variables are weighted in different global contexts, and the availability of the information they seek to measure.

Taking a more constructivist orientation, Larson et al (2015) suggested that community wellbeing should be the focal point of inquiry, providing a context for combining individual, social, and ecological dimensions of wellbeing. Common ground perceived among people sharing a common purpose, identity, and place forms a foundation for community wellbeing that is uniquely contextual in experience (Wilkinson 1991). The notion of wellbeing provides a unifying dimension for observation that allows people from different disciplines and paradigms to communicate and work together. Placed in this relatively simple framework, details, nuances, and differences become greater than the sum of their parts and provide a more holistic picture than would be possible within a single discipline or paradigm (Pohl and Hirsch Hadorn 2007).

Regarding vulnerability, there is consensus that exposure and sensitivity to harmful stressors combine to create vulnerabilities that are offset by adaptive capacities and that this vulnerability nexus is influenced by change drivers at multiple scales (Prosperi et al 2014). Social and biophysical vulnerability, like wellbeing (as illustrated earlier), are often operationalized and measured with quantitative indicators (Cutter et al 2003; De Lange et al 2010). However, Eakin and Luers (2006: 388) cautioned against a formulaic interpretation of vulnerability: "Vulnerability assessments thus appear most successful—or perhaps most relevant—when they are conducted for defined human–environment systems, particular places, and with particular stakeholders in mind."

Given that what is perceived to be real is real in its consequences (Thomas and Thomas 1928), the subjective interpretations or social constructions of vulnerability, such as risk perceptions, experiences, and forward-looking scenario assessments, are important to observe in mountain landscapes, as well as the quantitative, measurable indicators of processes and conditions. Furthermore, critical social science approaches investigate how power dynamics influence inequities in vulnerability, as well as adaptive capacities to mitigate risks, and where changes might lead to more sustainable options. Within the conceptual space of vulnerability and wellbeing, social scientists from different disciplinary and paradigmatic orientations can contribute to mountain observatories to fully document past and current conditions, as well as future trajectories.

TABLE 1 Key wellbeing indices and their indicators.

Better Life Index (OECD)[a]	Human Wellbeing Index (US Environmental Protection Agency)[b]	Human Development Index (UNDP)[c]
Health Life expectancy, self-reported health	**Health** Population with a regular family doctor, satisfaction with healthcare, asthma mortality, cancer mortality, diabetes mortality, heart disease mortality, infant mortality, life expectancy, suicide mortality, alcohol consumption, healthy behaviors index, teen pregnancy, teen smoking rate, happiness, life satisfaction, perceived health, adult asthma prevalence, cancer prevalence, childhood asthma prevalence, coronary heart disease prevalence, depression prevalence, diabetes prevalence, heart attack prevalence, obesity prevalence, stroke prevalence	**Life expectancy at birth**
Education Educational attainment, student skills, years in education	**Education** Mathematics skills, reading skills, science skills, adult literacy, high school completion, participation, postsecondary attainment, bullying, contextual factors, physical health, social relationships and emotional wellbeing	**Education** Mean years of schooling for adults aged 25 years, expected years of schooling for children of school-entering age
Income Household net adjusted disposable income, household net financial wealth **Jobs** Employment rate, job security, long-term unemployment rate, personal earnings	**Living standards** Food security, housing affordability, incidence of low income, median household income, persistence of low income, median home value, mortgage debt, job quality, job satisfaction	**Standard of living** Gross national income per capita
Housing Dwellings without basic facilities, housing expenditure, rooms per person	—	—
Community Quality of support network	**Social cohesion** Belonging to community, city satisfaction, discrimination, helping others, trust, interest in politics, registered voters, satisfaction with democracy, trust in government, voice in government decisions, voter turnout, extended screen time guidelines, frequency of meals at home, parent–child reading activities, participation in group activities, participation in organized extracurricular activities, volunteering, close friends and family, emotional support	—
Civic engagement/governance Consultation on rule-making, voter turnout	—	—
Environment Air pollution, water quality	**Connection to nature** Connection to life, spiritual fulfillment	—
Safety Assault rate, homicide rate	**Safety and security** Accidental morbidity and mortality, loss of human life, property crime, violent crime, community safety, social vulnerability index	—
Life satisfaction	**Spiritual and cultural fulfillment** Performing arts attendance, rate of congregational adherence	—
Work–life balance Employees working long hours, time devoted to leisure and personal care	**Leisure time** Average nights on vacation, physical activity, leisure activities, adults who provide care to seniors, adults working long hours, adults working standard hours	—

[a] OECD 2016.
[b] Summers et al 2014.
[c] UNDP 2016.

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Environmental actions (degradation and stewardship)

Examining actions and resulting conditions over time under various circumstances of human action provides longitudinal assessments of trends, anomalies or surprises, and emergent issues. There are commonly accepted ways of measuring and classifying the impact of environmental actions as degradation or stewardship. Indicator-based approaches such as the Ecological Footprint (Holmberg et al 1999) or the US Environmental Protection Agency's Environmental Quality Index, designed to account for environmental hazards in built and natural environments and associations with adverse health effects at the county scale (Messer et al 2014), are 2 examples among many at multiple scales around the world for assessing the environmental consequences of human actions. What is needed for GNOMO, however, is a classification scheme or typology to describe not only the impacts of human activity on the environment but also the array of environmental actions undertaken, along with their motivations, that lead to outcomes or changes along an environmental degradation–stewardship continuum. Globally relevant indicators or assessments of environmental action will likely need place-based interpretation for contextualization. For example, community-based natural resource management is a type of collective environmental action that may have varying environmental outcomes or impacts around the world (Kumar 2005).

Integrated approach

Coupling the social science assessment of environmental actions with biophysical assessment of environmental conditions is essential for full coupling of the social–ecological system; it requires the integration of the social sciences and of the social and natural sciences (Lassoie and Sherman 2010). An integrated approach that connects observations made from multiple social science paradigms with environmental conditions may help to differentiate mountain places, communities, and landscapes that are in dire circumstances, are making good effort but needing support, have the capacity to do better, or are doing well on the road to sustainability (Figure 1). In this way, the framework for integrating environmental social sciences into mountain observation may not only improve the robustness of scientific assessments but also inform policy- and decision-makers.

How to integrate social science in mountain research for sustainable development

Breaking down disciplinary and paradigmatic barriers to integrate social science approaches for more holistic and comparative understanding is essential for a robust global network of mountain observatories. A mixed-methodological approach emphasizes a combination of "diverse ways of thinking, knowing, and valuing" (Greene and Caracelli 2003: 93) and rejects the notion that one paradigm is better than another, which has been a fundamental barrier to interdisciplinarity (Brown et al 2015). The inclusion of constructivist and critical approaches, along with their associated methodologies, in mountain observation will lead to more engagement with values and power dynamics than typically found in traditional positivist science. This is essential for addressing questions of what to sustain and develop in mountain social–ecological systems and how to diversify the voices and perspectives included in observations. An integrated, eclectic toolbox of methods will help assess multiple conditions, actions, and their implications, along with locally relevant values, meanings, and experiences to help facilitate dialogue, collaboration, and complex decision-making.

The previously outlined framework can be operationalized using methods that draw on the 3 paradigms outlined earlier—positivist, constructivist, and critical—to represent the human dimensions of mountain systems. These can be thought of as different layers of the same research effort (Figure 2). Just as an interdisciplinary effort brings multiple researchers together, this framework requires a community of researchers who accept that science can be done by integrating different epistemologies and ontologies to collectively observe social systems in mountains.

The positivist layer organizes bundles of indicators and theory-driven formulae to measure wellbeing, vulnerability, environmental degradation, and environmental stewardship at different scales across space and over time. Premised on the assumption that there are observable realities in the social world that can be measured quantitatively, this provides a data-driven picture of what is happening where. An example of a conceptual framework and associated structural variables for assessing governance in varying action situations is the social–ecological systems framework (Ostrom 2009) and its elaboration into the institutional analysis and development framework (Ostrom 2011). However, the quantification and classification of structural information is less helpful in explaining why patterns and processes are occurring when and where they are found and risks overgeneralization and blind spots, leading to omission of important locally relevant variables in environmental observatory models (Freudenburg 1996).

The constructivist layer incorporates values, meanings, experiences, and motivations across diverse perspectives within mountain social systems. This research assumes social meanings and motivations are constructed in context. By emphasizing the voices, lived experiences, and motivations of individuals, social groups, and institutions within mountain landscapes, engaged and participatory research builds a mosaic of contextual perspectives, shedding light on contested or shared interpretations of

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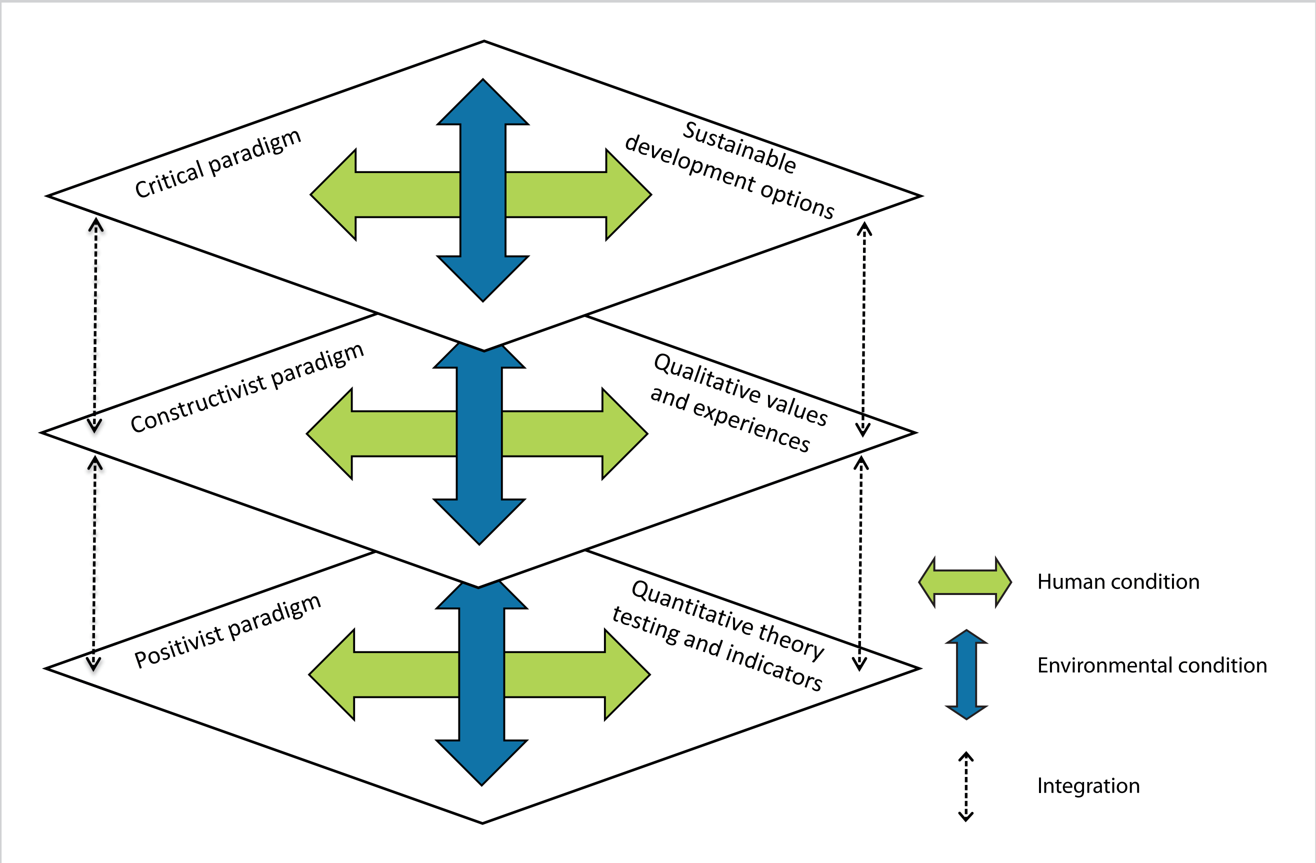
FIGURE 2 Multiparadigmatic framework for observing the human dimensions of mountain development.



vulnerability, wellbeing, and environmental actions from degradation to stewardship. The Mountain Voices oral history project (Panos Oral Testimony Programme n.d.) is an international application of a constructivist approach to mountain development and associated vulnerabilities. While useful for capturing the deep meanings held in places (Geertz 2000), representation across societies and spaces can be difficult. The risk of overreliance on this type of information alone is relativism or limited application beyond a given location, though this can be overcome to an extent through meta-analytical, comparative research. Integrating positivist and constructivist approaches will help to triangulate findings from different vantage points for deeper understanding.

The critical layer reveals unequal distributions of environmental costs and benefits, with a view to changing social order or improving socioenvironmental conditions (Robbins 2011). Social science that empirically reveals power relationships and factors enabling or constraining actions can help to identify steps that could be taken to implement change in systems that may improve conditions within mountain communities, landscapes, and regions. This type of social science inquiry requires thinking about what perspectives are present or absent in negotiations and decision-making and the potential options for and implications of actions based on complex power dynamics and inequalities (Scoones 1999).

Together, these 3 approaches form a multiparadigmatic and multimethod framework for assessing the human dimensions of mountain landscapes and linking mountain observatories in a global network. The framework shares similarities with the social impact assessment (SIA) approach (Vanclay et al 2015) and the driver pressure state impact response (DPSIR) framework (EEA 1999). While the SIA approach seeks to document multidimensional attributes, it is most often used for the evaluation of impacts associated with a particular development action (Esteves et al 2012), rather than the broader environmental actions and conditions that are the focus of mountain observatories. However, the SIA's well-developed community-profiling techniques, which assess local needs and aspirations, as well as key social issues, are valuable both as indicators and as community engagement methods and could be readily incorporated in mountain observatory efforts (Esteves et al 2012).

Designed to describe the origins and consequences of environmental problems, the DPSIR framework emphasizes stable indicators associated with environmental drivers, pressures, states, impacts, and responses but may be insufficient to capture trends over time or the power dynamics that often subjugate the interests and knowledge of local stakeholders (Carr et al 2007). Svarstad et al (2008) showed that the DPSIR framework is incompatible with various value orientations and perpetuates a barrier to greater stakeholder participation, which is necessary for robust assessments and observations of landscape conditions and dynamics. The framework outlined in this paper may combine well with the DPSIR framework to expand the range of considerations and perspectives incorporated into mountain observatories.

To fully achieve sustainable development goals, the perspectives and knowledge of nonscientific actors in mountain landscapes must also be integrated into mountain observatories (Kläy et al 2015). Participatory and engaged methods often incorporated by constructivist and critical social scientists help to incorporate more local, indigenous, or situated knowledge (Irwin 2001). As revealed by the survey of participants in the Perth III mountain conference (Gleeson et al 2016), the mountain research community appears to be well connected to societal partners: of more than 300 participants, nearly half (45%) rated their connection as 4 or 5 on a 5-point scale (1 = little interaction; 5 = abundant interaction). The transdisciplinary focus was higher for social scientists (68%) than for biophysical scientists (36%). These data suggest that social science members of the mountain research community can help expand engagement with knowledge holders beyond the scientific community (Gleeson et al 2016).

Conclusion

By organizing the GNOMO initiative for the pursuit of sustainable mountain development, the mountain research community has committed not only to interdisciplinary science but also to "actionable science" that informs decision-making, improves policies, and serves society (Palmer 2012). Such commitment requires breaking down paradigmatic differences not only between the social and the natural sciences but also within the social sciences. Furthermore, innovative participatory engagement methods are needed to reach beyond scientific perspectives to most fully observe mountain systems.

The framework highlighted in this paper suggests that the divergent paradigms within the social sciences can be embraced within a network of mountain observatories. This does not mean that each scientist must endeavor to put each paradigm into practice. Instead, by supporting research and observatory networks and committing to constructive dialogue among scientists, practitioners, decision-makers, and other stakeholders (Brown et al 2015), deeper integrative understanding is possible. Admittedly, this transparadigmatic reorientation of the GNOMO effort will require a philosophical shift by an international and multidisciplinary group of researchers. But there is precedent in other international research communities, such as the Millennium Ecosystem Assessment, the Earth System Science Partnership, and Future Earth (Mooney et al 2013). I hope we will seize this opportunity to build on these examples to create a more holistic and robust global network of mountain observatories by adopting an inclusive approach across and beyond sciences.

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