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Challenges for Governing Mountains Sustainably: Insights From a Global Survey

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Governance is increasingly recognized as key to sustainability and human wellbeing in mountain social-ecological systems (MtSES). Mountains present particular challenges for effective governance related to their

geographic complexities, status as commons, susceptibility to environmental change, and impacts of external political and socioeconomic processes. This study reports on the results of a global survey of local mountain governance. It explored a range of known governance challenges to discover which are most prevalent and whether relative strength of local governance helps to mitigate these challenges. The study analyzed 75 survey

responses across 5 continents from researchers and practitioners who work on mountain governance. Major challenges for governance included contradictory policies, poverty, and the presence of valuable nonrenewable natural resources. Compared with sites with stronger local governance, those with weaker arrangements reported significantly greater prevalence of certain challenges, such as corruption. Yet many challenges did not differ significantly by strength of local governance, implicating external factors instead. This finding points to a need to improve governance across levels to support MtSES sustainability.

Keywords: governance; mountain sustainability; challenges; commons; global survey.

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Introduction

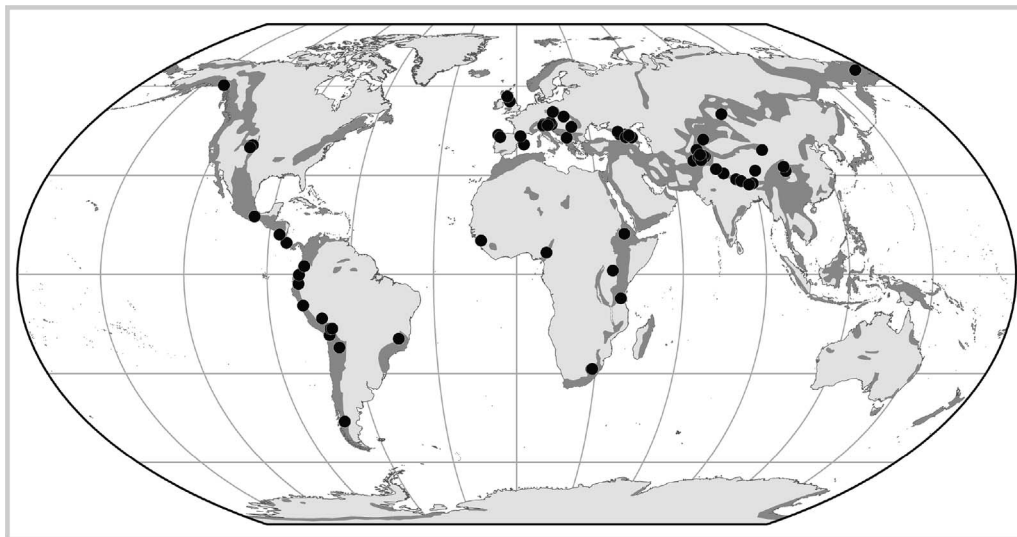
Mountain social-ecological systems (MtSES) are highly vulnerable to global environmental changes and disaster risk (Kohler et al 2010) yet provide key ecosystem services on which most humans depend (Köhner and Ohsawa 2005). Achieving sustainability constitutes a major challenge for the future wellbeing of MtSES and all who depend upon them. Effective governance is increasingly recognized as a critical dimension for conserving natural resources, moving toward sustainability, and bettering people's lives (Baumgärtner et al 2010; Mutekwa and Gambiza 2016; Adler et al 2020; Nguyen et al 2020). Yet mountains are often subject to governance shortcomings that perpetuate problems or exacerbate unsustainable processes. Although several studies have explored challenges for MtSES sustainability (eg Gardner and Dekens 2007; Alessa et al 2018; Grêt-Regamey et al 2019; Klein, Tucker, Nolin, et al 2019; Payne et al 2020), to our knowledge, there has yet to be a global empirical assessment of governance challenges. This study is an initial effort to address this gap by collecting comparable data from mountain researchers and practitioners worldwide who have local-level knowledge of MtSES governance issues. As part of

an ongoing study of mountain governance, we aim to identify major challenges for governance of MtSES and examine the prevalence of governance arrangements relevant to sustainability. We ask the following: What are the major challenges for sustainable local governance of MtSES? How do governance arrangements shape the severity of challenges experienced across sites? We focus on political-structural and socioeconomic challenges that tend to be systemic across levels of governance, as well as challenges experienced primarily as local concerns. Many of these challenges are interrelated with environmental problems within and across levels of governance.

Theoretical contexts and concepts

Governance refers to the processes by which the norms, rules, and strategies that interact to shape behavior are crafted, applied, interpreted, and revised (McGinnis 2011). Governance extends beyond government to include informal and formal arrangements. Formal governance entails institutionalized ways of organizing society and producing collective goods and services through authoritative rules (Draude et al 2012; Koehler et al 2017).

FIGURE 1 Global map of site locations. Black dots indicate sites; those in close proximity appear as single or overlapped dots. (Map by Ricardo J. Garnica-Peña)



Informal governance operates through unwritten rules, webs of power and relationships, and decision-making processes that operate outside official channels (Helmke and Levitsky 2004; Christiansen and Neuhold 2012).

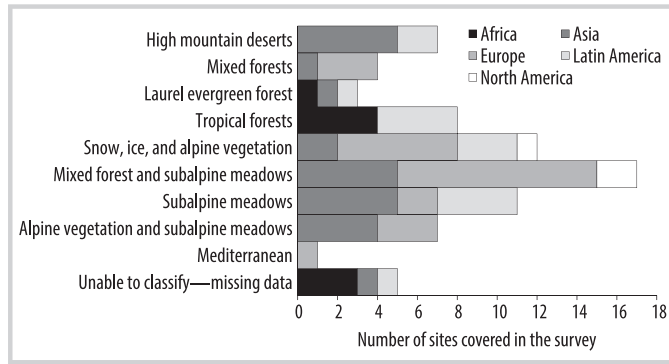
Drawing on the Brundtland Commission, we define sustainability as the ability to meet “the needs of the present without compromising the ability of future generations to meet their own needs” (Brundtland 1987: 41). We define sustainable governance as governing purposefully to achieve sustainability. Such governance requires institutional arrangements designed to support healthy social–ecological systems, equitable economic arrangements, and inclusive societies while avoiding degradation of natural resources (cf Seyle and King 2014). Governing MtSES sustainably encounters numerous challenges, partly because of widely held perceptions that they are commons free of restrictions, as exemplified by statements such as “Mountains belong to everyone.” Yet the term “commons” encompasses multiple definitions that often ignore understandings of mountain peoples (Debarbieux and Price 2012). Here we focus on commons as common-pool resource (CPR) systems, because this definition highlights governance: CPR systems are subtractable (depletable), and access is open to all unless appropriate institutional arrangements exist to manage access and control extraction rates (Ostrom 2005). A large literature recognizes that vulnerabilities of CPR systems to overexploitation pose serious governance challenges (eg McCay and Acheson 1987; Bromley 1992; McKean 2000). Yet researchers have identified facilitating conditions and principles associated with long-enduring, ostensibly sustainable, CPR governance (Wade 1988; Ostrom 1990; McKean 1992; Agrawal 2002; Ostrom 2009). Synthesizing these sources, particularly Ostrom (1990), reveals that principles associated with effective CPR governance include (1) clear property rights (communal, private, public, or a combination), (2) participation by a majority of local stakeholders in decision-making, (3) accessible conflict mediation, (4) rules that fit the local situation, (5) monitoring accountable to local stakeholders, (6) a degree of local autonomy, (7) graduated sanctions, and (8) coordination across levels of government. These principles have been

supported in numerous studies exploring community-based governance of natural resources (Cox et al 2010; Oyerinde 2019), and they merit consideration in assessing sustainable governance more broadly (Seyle and King 2014). We adopted these principles as indicators of effective local governance for sustainability. By focusing on principles associated with governance from the perspective of local experiences, this approach partly overcomes the imposition of external definitions on mountain peoples.

MtSES pose a particular set of conundrums for sustainable governance. As discussed by Klein, Tucker, Nolin, et al (2019), many MtSES are (1) resource rich yet income poor, (2) subject to inappropriate policies developed by outsiders, (3) remote but vulnerable to global change processes, (4) experiencing destabilizing migration fluxes, (5) attractive to varied actors with contrasting goals, and (6) often lacking in detailed data. These conundrums complicate local governance for many mountain peoples. Relative remoteness, for example, often entails marginalization and inadequate access to infrastructure (eg health care, education, communications, and transportation) even as it may allow local autonomy. As emphasized here, local governance encompasses formal and informal arrangements at the level of communities, municipalities, or other primary political levels. Depending on national definitions, local governance may include higher political levels, as in the case of China. All levels of governance interact, sometimes in unpredictable and highly diverse ways. The survey recognized that governance outcomes may relate to social action within local, subnational, transnational, or international institutional frameworks other than the state (Krasner and Risse 2014).

Methods

The study team developed an online survey to collect data on local and regional mountain governance around the world. Although they have certain limitations, online surveys have proven to be a useful data collection method, especially in reaching groups with specific characteristics (Alessi and Martin 2010; Bernard 2018). The survey was aimed at

FIGURE 2 Major biomes by continental area.

mountain researchers with knowledge of governance in local study sites, following other online surveys directed at self-identified experts (eg Ryan et al 2014; Hanspach et al 2017; Klein, Tucker, Nolin, et al 2019; Steger et al 2021). The survey addressed a range of known governance challenges for MtSES. Here we analyze socioeconomic pressures, local concerns for governance, and political-structural dimensions (defined as constellations of institutions that regulate the vertical distribution of power and its functional organization on the ground). The questions included multiple choice, Likert scale, and narrative responses and covered geographic, livelihood, and biophysical factors, as well as governance challenges. Respondents were asked to assess local governance using the Ostrom principles, discussed earlier, as indicators. The survey protocol can be viewed in Appendix S1 (*Supplemental material*, <https://doi.org/10.1659/MRD-JOURNAL-D-20-00080.1.S1>). Survey respondents were instructed to apply their own site's understandings of local governance and to distinguish local, regional, national, and international levels of governance for certain questions.

The survey was entered in Jot Survey with versions in English, French, Chinese, Russian, and Spanish. From

February–May 2019, the survey was distributed through the Mountain Research Initiative (MRI) newsletter and listservs of the Mountain Partnership, the Mountain Institute, the Mountain Sentinels network, and collaborators' institutional and professional networks. Collaborators directly contacted colleagues and practitioners whose expertise and fieldwork encompassed mountain governance.

The survey responses were compiled in Microsoft Excel (Redmond, WA, USA). The data were cleaned and checked through 4 steps: (1) localization of the mountain ranges and sites using survey information and Google Earth (Mountain View, CA, USA); (2) translation of non-English surveys into English; (3) cleaning, standardization, and coding of key text responses; and (4) creation of a SPSS (Armonk, NY, USA) database. Using SPSS, descriptive statistics were run to understand the distributions of geographic, biophysical, and socioeconomic characteristics of the cases. To identify major challenges for governance across the sample, SPSS frequencies were run to sum the Likert scale ranks for each challenge in the categories of political-structural challenges, socioeconomic challenges, and local concerns for governance. For the first 2 categories, respondents were instructed to use their own judgment. For local concerns, the survey asked respondents to indicate residents' perspectives. Higher total sums of Likert scale ranks (where higher ranks indicated greater severity of a challenge) indicated the top challenges.

To gauge the effectiveness of local governance, the survey asked respondents to rank the strength of the Ostrom principles on a Likert scale of 0 to 4 (absent, low, somewhat low, somewhat high, and high). To identify patterns in the relative strength of the governance principles across sites, we ran a hierarchical cluster analysis using Ward's method (Ward 1963) with the R statistical program (Vienna, Austria; Venables et al 2021). This method minimizes within-cluster variance to find coherent groupings according to shared features. The results point to strengths of governance principles within resulting clusters and allow comparative

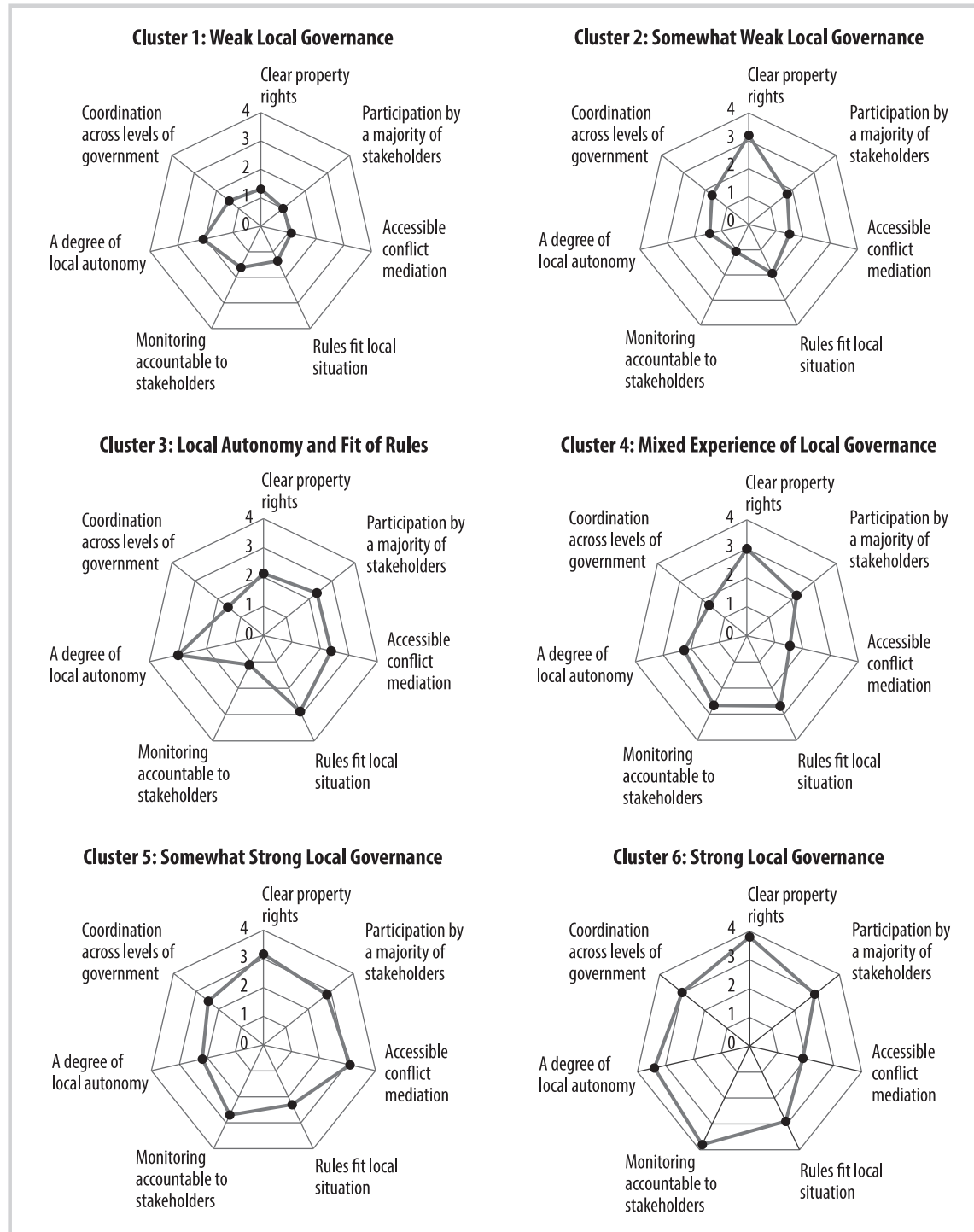
TABLE 1 Strength of governance principles by cluster.

Governance principles ^{a)}	Local governance type					
	Cluster 1: weak (N = 14)	Cluster 2: somewhat weak (N = 17)	Cluster 3: local autonomy and fit of rules (N = 9)	Cluster 4: mixed experience (N = 13)	Cluster 5: somewhat strong (N = 12)	Cluster 6: strong (N = 10)
Clear property rights	1.3	3.2	2.1	3.0	3.2	3.8
Participation by a majority of stakeholders	1.0	1.8	2.3	2.2	2.8	2.9
Accessible conflict mediation	1.1	1.5	2.4	1.6	3.1	1.9
Rules fit local situation	1.4	1.9	2.9	2.7	2.3	2.9
Monitoring accountable to stakeholders	1.6	1.1	1.1	2.7	2.7	3.8
A degree of local autonomy	2.1	1.4	3.0	2.3	2.2	3.4
Coordination across levels of government	1.4	1.7	1.6	1.7	2.5	3.0
Mean of all principles ^{b)}	1.4	1.8	2.2	2.3	2.7	3.1

^{a)} Adapted from original Ostrom design principles for long-enduring CPR regimes (Ostrom 1990) and related sources (Wade 1988; McKean 1992; Agrawal 2002), with language to facilitate accessible terminology for survey translation and interpretation across diverse languages, contexts, and cultures. This analysis included 7 of the 8 Ostrom principles. The missing principle (graduated sanctions) was included in the survey, but more than one third of the responses were "Don't know" or blank; therefore, it was dropped from the cluster analysis.

^{b)} Likert scale ranks for principles: absent = 0, low = 1, somewhat low = 2, somewhat high = 3, high = 4.

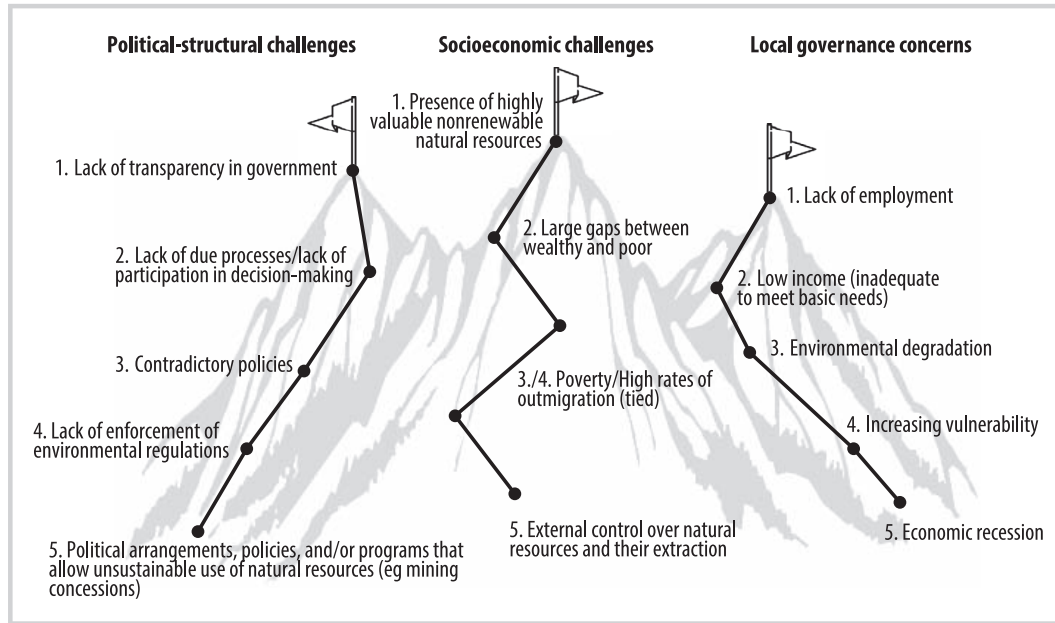
FIGURE 3 Radiographs of governance clusters.



analysis across them (cf Landau and Chis Ster 2010). For each cluster, we examined the means and medians of each principle. Then, using the Likert scale data that ranked challenges, we ran Kruskal-Wallis H tests (Smalheiser 2017) using SPSS to examine whether the prevalence of governance challenges varied across the governance clusters. Where the data fulfilled the assumption of similar distributions, pairwise statistics were conducted to discover which pairs of clusters were significant.

Results and discussion

The survey received 80 responses; 5 surveys had to be excluded because of missing data. There were 49 responses in English. The other surveys were returned in Russian (12), Spanish (11), Chinese (2), and French (1). Most respondents (63%) reported affiliations with universities, institutes, or organizations in the same area or country as their research

FIGURE 4 Major challenges for mountain governance.

sites (Appendix S2, *Supplemental material*, <https://doi.org/10.1659/MRD-JOURNAL-D-20-00080.1.S1>).

Geographic, biophysical, and socioeconomic characteristics

The surveys represented 5 continental areas (Africa, Asia, Europe, Latin America, and North America), 39 countries and 1 disputed region, and 36 mountain ranges, including specific peaks (eg Mount Elgon). Based on the survey data and Google Earth, we mapped the approximate location of the sites (Figure 1). Many sites encompass a wide elevational range (up to 7300 m between minimum and maximum elevations) and a diverse combination of biome types (Figure 2). Predominant biomes were identified based on survey descriptions and definitions drawn from Richter (2001). Mixed forests and subalpine meadows occurred most frequently (17 sites). The mean maximum elevation was 3489 m; 1 Himalayan site reported a maximum elevation of 8000

m. The growing season averaged 6 months (ranging 2 to 12 months), with a mean minimum temperature of 10°C and a mean high temperature of 23°C. Neither biomes nor continental areas had significant association with the types of challenges reported across sites.

The research sites presented a mix of livelihoods. Respondents could choose up to 3 primary economic activities for each site. Of the sites, 77% depended on agricultural activities, pastoral activities, or a combination (crop production, livestock husbandry, and pastoralism), often in conjunction with logging, tourism, or residential services (second homes and rentals). Seven sites reported mining, and another 7 reported non-timber product harvesting in combination with other activities. One site reported trophy hunting.

Cluster analysis of governance principles

The cluster analysis identified 6 significantly distinct groupings representing combinations of strengths and weaknesses in the Ostrom governance principles discussed earlier (Figure 3; Table 1). The within-group similarity of the clusters is significant ($P = 0.001$) as is the between-group dissimilarity ($P = 0.001$). The clusters consist of a fairly proportional number of cases. They do not reveal distinctive patterns in biomes or composition of economic livelihoods. All clusters have cases from at least 4 of the 5 continental areas (Africa, Asia, Europe, Latin America, and North America) represented in the sample.

- **Cluster 1** (weak local governance) includes sites from Asia, Africa, Europe, and Latin America, representing 10 countries. The Caucasus and the Andes are each represented by 3 cases. The elevation range covers 3500 m, varying from mixed forests and subalpine meadows to high mountain deserts and permanent snow. Nine sites depend on agropastoral activities in combination with other activities, such as tourism or residential services. Two are primarily pastoral, and 1 site has mining. One site with a

FIGURE 5 Village of Khoy, Chechen Republic. (Photo by Alexey Gunya)

TABLE 2 Political–structural challenges for governance: medians of Likert scales and significant differences across clusters (Kruskal–Wallis *H* test).

Governance challenge ^{a)}	Local governance cluster, med (<i>n</i>)						Kruskal–Wallis <i>H</i> test statistic (df = 5)	Asymptotic significance (*significant) ^{b)}
	Cluster 1: weak (<i>N</i> = 14)	Cluster 2: somewhat weak (<i>N</i> = 17)	Cluster 3: local autonomy and fit of rules (<i>N</i> = 9)	Cluster 4: mixed experience (<i>N</i> = 13)	Cluster 5: somewhat strong (<i>N</i> = 12)	Cluster 6: strong (<i>N</i> = 10)		
Corruption	3.00[^] (10)	2.00 (13)	2.50[†] (8)	0.50 (8)	2.00 (9)	0.00^{^†} (9)	18.704	0.002*
Laws applied inconsistently	3.00^{^†} (12)	1.00 (15)	3.00^{o*} (8)	0.00^{†o} (12)	2.00 (11)	0.00^{^†} (10)	21.161	0.001*
Lack of due process/lack of participation in decision-making ^{c)}	3.00 (13)	2.00 (15)	2.00 (9)	1.00 (12)	1.00 (11)	1.00 (9)	6.628	0.250
Contradictory policies ^{c)}	2.00 (12)	3.00 (15)	2.00 (7)	1.50 (12)	1.50 (12)	1.00 (10)	5.312	0.379
Impunity for powerful individuals	2.00^{^†} (13)	1.50 (16)	1.00 (9)	0.00[†] (12)	1.00 (12)	0.00[^] (10)	18.223	0.003*
Policies/programs exacerbate social inequities	2.00[^] (11)	1.50 (14)	1.00 (7)	1.00 (12)	1.00 (11)	0.50[^] (10)	11.125	0.049*
Policies/programs allow unsustainable natural resource use ^{c)}	2.00 (10)	1.00 (15)	2.00 (9)	0.50 (12)	2.00 (12)	1.00 (10)	4.451	0.486
Lack of enforcement of environmental regulations ^{c)}	1.00 (11)	2.00 (17)	2.00 (9)	2.00 (11)	2.00 (12)	0.00 (10)	8.381	0.136
Lack of transparency in government ^{c)}	2.00[^] (13)	2.00 (15)	2.50 (8)	3.00[†] (11)	1.00 (11)	0.00^{^†} (9)	16.059	0.007*

Note: med (*n*), median value and *n* of observations; significantly different pairs of medians are indicated in bold with matching superscript symbols ([^], [†], ^o, and [†]).
^{a)} Likert scale ranks: not an issue at any level of governance = 0, one level = 1, two levels = 2, three levels = 3, four levels = 4 (local, regional, national, and international levels of governance).
^{b)} With Bonferroni correction for ties.
^{c)} One of the top 5 challenges across the sample.

protected area relies solely on tourism (Czech Republic). Relative to the other clusters, these cases were weak on all dimensions associated with effective governance (Figure 4; Table 1).

- **Cluster 2** (somewhat weak local governance) encompasses all continental areas except North America and is the largest cluster, with 17 sites. These sites present diverse biomes and the greatest range in elevation, spanning 8000 m. All but 1 of the sites depend on agropastoral livelihoods, and 4 sites include mining, more than any other cluster. Although these sites have strong property rights, other principles of effective governance ranked very low to somewhat low.
- **Cluster 3** (local autonomy and fit of rules) is the smallest cluster with 9 sites, of which 4 represent the Andes. The biomes range from montane tropical forests to subalpine meadows to snow, ice, and alpine vegetation. Seven of the sites depend on tourism in combination with agropastoralism, but 1 site in Chile depends solely on tourism because of it is a national protected area. These sites are characterized by strong local autonomy and rules appropriate for the local situation, but other principles appear relatively weak.
- **Cluster 4** (mixed experience of local governance) presents a concentration of cases from Asia (53.8% of cluster) but has at least 1 case from each continental area in the

sample. The sites encompass a range of 5300 m in elevation, varying from mixed deciduous forests to alpine meadows to permanent snowpack. A varied mix of agropastoral pursuits with tourism or logging typifies most sites. These sites report clear property rights as the strongest principles of effective governance, but other principles are low to intermediate in strength.

- **Cluster 5** (somewhat strong local governance) has a balanced mix of sites and diverse biomes across Latin America, Europe, Asia, and Africa. These sites present intermediate to high strength of all governance principles. All but 1 of the sites pursue varying agropastoral activities, often in combination with logging or tourism. The exception is a Slovakian national park dominated by tourism.
- **Cluster 6** (strong local governance) has the strongest representation from the Global North, particularly Europe (60% of cluster cases) and North America, and is the only cluster that does not have sites from Africa. Its biomes include mixed forests, subalpine meadows, and snow, ice, and alpine vegetation. All but 1 of the sites note tourism as a major activity, usually with agropastoral activities. At first glance, the regional composition of this cluster seems to imply that the resources and governments of the Global North benefit local governance. However, most cases from Europe are spread across the other clusters, including weak local governance.

TABLE 3 Socioeconomic challenges and local concerns for governance: medians of Likert scales and significant differences across clusters (Kruskal–Wallis *H* test).

Challenge	Local governance cluster, med (<i>n</i>)							Kruskal–Wallis <i>H</i> test statistic (df = 5)	Asymptotic significance (*significant) ^{a)}
	Cluster 1: weak (<i>N</i> = 14)	Cluster 2: somewhat weak (<i>N</i> = 17)	Cluster 3: local autonomy and fit of rules (<i>N</i> = 9)	Cluster 4: mixed experience (<i>N</i> = 13)	Cluster 5: somewhat strong (<i>N</i> = 12)	Cluster 6: strong (<i>N</i> = 10)			
Socioeconomic challenges ^{b)}									
Presence of highly valuable nonrenewable natural resources ^{c)}	3.00 (13)	3.00 (18)	3.00 (9)	3.00 (13)	3.00 (10)	3.50 (10)	1.686	0.891	
Large gaps between wealthy and poor ^{c)}	4.00 (11)	3.00 (17)	3.00 (8)	2.00 (13)	2.00 (12)	2.00 (10)	9.018	0.108	
Poverty ^{c)}	3.50[^] (12)	3.00 (17)	3.00 (9)	2.00 (13)	3.00 (11)	1.00[^] (9)	14.713	0.012*	
High outmigration ^{c)}	3.50 (12)	2.00 (17)	3.00 (9)	2.00 (13)	2.00 (12)	1.50 (10)	6.029	0.303	
External control over natural resources ^{c)}	2.00 (13)	2.00 (15)	3.00 (9)	2.00 (13)	3.00 (12)	2.00 (10)	4.058	0.541	
Local concerns for governance ^{d)}									
Lack of employment ^{c)}	4.00 (14)	4.00 (17)	3.00 (9)	3.00 (13)	4.00 (11)	2.00 (10)	17.671	0.003*	
Low income ^{c)}	4.00 (14)	3.00 (17)	3.00 (9)	3.00 (13)	4.00 (11)	2.00 (10)	7.577	0.181	
Environmental degradation ^{c)}	2.00 (12)	2.00 (17)	2.00 (9)	3.00 (13)	2.00 (11)	3.00 (10)	1.218	0.943	
Increasing vulnerability to hazards ^{c)}	2.00 (12)	3.00 (17)	3.00 (9)	2.00 (13)	2.00 (11)	2.50 (10)	2.682	0.749	
Economic recession ^{c)}	3.00 (13)	3.00 (17)	2.00 (9)	3.00 (12)	3.00 (9)	3.00 (10)	4.441	0.488	
Change in access to land/resources	3.00[^] (13)	3.00[†] (17)	1.00[†] (9)	2.00 (13)	2.00 (11)	1.00[^] (10)	17.262	0.004*	
Problems with local government	2.00 (14)	3.00[^] (17)	2.00 (9)	2.00 (13)	2.00 (10)	1.00[^] (10)	11.092	0.050*	
Inadequate educational opportunities	3.00[^] (14)	3.00[†] (17)	3.00[°] (9)	3.00[†] (13)	3.00^{&} (10)	0.00^{^†°†&} (10)	18.030	0.003*	
Lack of credit	2.00 (13)	2.00 (16)	1.00 (7)	3.00[^] (12)	2.00 (10)	0.50[^] (10)	13.176	0.022*	

Note: med (*n*), median value and *n* of responses; significantly different pairs of medians are indicated in bold with matching superscript symbols ([^], [†], [°], [†], and [&]).

^{a)} With Bonferroni correction for ties.

^{b)} Likert scale ranks: absent = 0, low = 1, somewhat low = 2, somewhat high = 3, high = 4.

^{c)} One of the top 5 challenges across the sample for the indicated category of governance challenge.

^{d)} Likert scale ranks: not a concern = 0, minor = 1, somewhat minor = 2, somewhat major = 3, major = 4.

Major challenges for governance

The survey covered a range of governance challenges. Looking at the sample as a whole, the top political–structural challenge was lack of transparency in government, followed by lack of due process (Figure 4). The top socioeconomic challenge emerged as the presence of highly valuable nonrenewable natural resources. Given that only 7 sites reported mining as a major economic activity, this finding indicates that valuable nonrenewable resources pose problems even when they are not a major economic activity. A related top socioeconomic challenge is external control

over natural resources and their extraction. In the category of local governance concerns, 3 of the top 5 challenges relate directly to economic insecurity, and environmental degradation and increasing vulnerability point to precarity for social–ecological wellbeing.

Political–structural challenges

Hypothetically, it would be expected that the cases with stronger governance should have fewer problems or better success in addressing them than sites with weaker

TABLE 4 Characteristics of North Caucasus sites.

Region	Cluster	Elevation range (m)	Major biomes (additional biomes)	Primary livelihoods
Republic of Dagestan	Cluster 1: weak local governance	1500–4000	Snow, ice, and alpine vegetation and shrubs (mountain steppe, montane forest, subalpine meadows)	Livestock grazing, agricultural crops
Churtakh village, Republic of Dagestan	Cluster 1: weak local governance	2000–3000	Alpine vegetation and shrubs and subalpine meadows (mountain-meadow steppe)	Livestock grazing, agricultural crops
Kezenoy-Am area, Chechen Republic	Cluster 2: somewhat weak local governance	1800–3000	Alpine vegetation and shrubs and subalpine meadows (montane forest)	Tourism, livestock grazing
Khoy village, Chechen Republic	Cluster 4: mixed experience of local governance	1800–2500	Mixed forest (mountain-meadow steppe, subalpine meadows)	Livestock grazing, agricultural crops
Upper Balkaria, Kabardino-Balkaria Republic	Cluster 2: somewhat weak local governance	1000–4000	Mixed forest and subalpine meadows (mountain steppe, snow, ice, and alpine vegetation and shrubs)	Livestock grazing, agricultural crops
Elbrus area, Kabardino-Balkaria Republic	Cluster 3: local autonomy and fit of rules	1500–5642	Snow, ice, and alpine vegetation and shrubs (mixed forest and subalpine meadows, mountain steppe)	Tourism, livestock grazing
Uchkulan village, Karachay-Cherkessia Republic	Cluster 1: weak local governance	1500–3500	Mixed forest and subalpine meadows (mountain steppe, alpine meadows)	Livestock grazing, agricultural crops
Karachay-Cherkessia Republic	Cluster 5: somewhat strong local governance	700–4000	Snow, ice, and alpine vegetation and shrubs (mountain steppe, montane forest, subalpine meadows)	Tourism, agricultural crops, livestock grazing
Republic of North Ossetia-Alania	Cluster 4: mixed experience of local governance	700–3000	Snow, ice, and alpine vegetation and shrubs (mountain steppe, montane forest, subalpine meadows)	Agricultural crops, livestock grazing, residential–tourism combined

governance. However, it is difficult to ascertain whether governance challenges in a certain locale relate to internal or external conditions, processes, or policies. Kruskal–Wallis H tests were run on all governance challenges, confirming that significant differences exist between clusters for certain governance challenges (Table 2). Corruption emerged as significantly different across the clusters. The other challenges with significant differences appear to be related to corruption, including lack of transparency, inconsistent application of laws, and impunity for powerful individuals. These are particularly present in cluster 1 (weak local governance). It is striking that cluster 6 (strong local governance) reported a low or no incidence of corruption and did not reveal issues with lack of transparency or impunity. The survey also asked whether anything was being done to address major governance challenges. Most sites in clusters 5 and 6 (stronger local governance) indicated good, partial, or slow progress, whereas sites in clusters 1, 2, and 3 (weaker local governance) usually indicated little or no progress in addressing major governance challenges.

Socioeconomic dimensions

Poverty—among the top 5 socioeconomic challenges for governance—proved significantly different across the

clusters. The cluster of weak local governance showed poverty as a somewhat major to major challenge for governance, whereas the strong local governance cluster held poverty as a minor issue (Table 3). Similarly, when survey respondents were asked how well the overall governance system worked for socioeconomic sustainability, cases with weak governance often answered “poorly,” and this differed significantly from the cases with strong local governance (asymptotic significance of 0.009). The other major socioeconomic issues identified as creating challenges for governance, such as high rates of outmigration or the presence of valuable nonrenewable natural resources, did not differ significantly across clusters. The lack of significant differences may be related to the prevalence and complexities of these challenges. For example, highly valuable nonrenewable resources pose a double-edged sword for communities eager for economic returns (employment, royalties, improved infrastructure, etc). Yet mountain communities, regardless of local governance strength, have little power to prevent the toxic contamination typically associated with mining concessions. Thus, certain challenges appear widespread, linked to external pressures, and resistant to remedies available to local governance.

BOX 1: North Caucasus study sites: an example of variable local governance among neighboring sites

The 75 survey cases included 9 representing the Russian Federation's North Caucasus, which cover all clusters except cluster 6: strong local governance (Table 4). These cases reveal that within a region, governance can vary greatly. Competition over tourism is one factor shaping local governance. The Elbrus area of Kabardino-Balkaria, distinct for its local autonomy and fit of rules, attracts tourists to Mt. Elbrus, particularly for skiing, and federal development programs have invested in infrastructure. Access to local resources, especially land, is regulated by local actors (private organizations and local government). The municipality of Elbrus appears to be a rare case where local actors have maintained legal control over its resources despite attempts by external actors to take over land, tourism, and infrastructure. This success has relied on a secure, relatively autonomous local government able to work through legal strategies and informal networks in this ongoing struggle (Koehler et al 2020). By contrast, neighboring Upper Balkaria, with somewhat weak local governance, lacks tourism and experiences economic stress. In Karachay-Cherkessia, historical factors have generally fostered somewhat strong local governance, but certain areas like Uchkulan village have weak local governance and scant access to resources. In Khoy village (Chechen Republic), with mixed experience of local governance, top-down bureaucracy constrains local initiatives while hindering entrepreneurship and resolution of land ownership problems. This discourages people who would like to return to their native village. Overall, these sites identify centralization and top-down pressures as the main challenges. Problem-solving efforts advance slowly.

Various factors must be examined to explain the diversity of governance in the North Caucasus. Core difficulties have been its geographic and sociocultural diversity. Another factor relates to the political contradictions between the local institutions and the formal federal setup with its highly centralized executive political power. Although the state is overtly present in all municipalities, institutional penetration varies greatly and relates to local ability and willingness to follow state rules and implement its policies. During the Soviet period, the state developed a complex web of interdependent relations with municipalities, leading to arrangements combining formal and informal rules. These hybrid arrangements largely determined local communities' ability to access resources like tourism and influenced the formation of local elites (Koehler and Zürcher 2003). Today, North Caucasus municipalities are heterogeneous, with diverse institutions aiming to ensure that governance works for local people (Gunya et al 2019). The heterogeneity rarely results from transparent and formalized local procedures; rather, it results from varied and often antagonistic relationships between the state and the communities. The state strongly affects whether local governance works or fails, but it is enacted via informal patron–client relations and moderated by the ways local communities confront, manipulate, or avoid state interference (Koehler et al 2017).

Local governance concerns

Local concerns tended to echo political–structural and socioeconomic challenges. At the local level, concerns related to livelihoods, wellbeing, and human capital emerge as major issues. Lack of employment, problems with local government, inadequate access to education, and changes in access to land and natural resources comprise major concerns for sites experiencing weaker local governance but are of significantly less concern for sites in the strong local governance cluster (Table 3). These findings resonate with recent studies indicating an association between strong local governance and economic sustainability (Moreno-Pires and Fidélis 2012; Ojha et al 2019). Stable access to employment, educational opportunities, and land and natural resources contributes to economic sustainability. In light of the issues identified in Klein, Tucker, Nolin, et al (2019), mountains appear vulnerable to high rates of migration and lack income despite valuable resources. Stronger local governance appears to be able to ameliorate some of these, whereas weak local governance lacks arrangements that can help protect local people from stressors. Although it might be expected that regions would have similar patterns in strength or weakness of local governance, our study shows that within a given region, localities in relatively close proximity can vary in strength of local governance. This implies that despite national political structures that impose top-down pressures, location-specific factors shape local-level governance. Unique historical experiences, particular kinds of natural resources, or varying interactions with external actors may create opportunities or exacerbate

challenges for local governance, as found for Caucasus sites (Figure 5; Table 4; Box 1).

Commonalities, contrasts, and challenges across clusters

Most governance challenges considered in this survey did not emerge as significantly different across the clusters (Appendix S3, *Supplemental material*, <https://doi.org/10.1659/MRD-JOURNAL-D-20-00080.1.S1>). Even sites with somewhat strong to strong local governance experienced challenges similar to those of sites with weaker governance. As an example, no cluster was immune from local concerns over economic recession or low income. Insufficient access to health care was nearly a top 5 challenge and appeared as a major concern for certain sites in every cluster. Although the severity of most challenges was ranked slightly lower in clusters with stronger governance, a plurality of sites ranked the top 5 political–structural and socioeconomic challenges as somewhat high or high concerns in most clusters. As indicated by Klein, Tucker, Nolin, et al (2019), many MtSES face a set of conundrums reflecting geographic, political, and socioeconomic marginalization yet offer features that draw outside attention. A key example is that of valuable nonrenewable resources, which are more often extracted to benefit powerful outside actors than to benefit local people. Such conundrums exceed the capacity of local governance to address concerns alone. Therefore, resolving the major conundrums facing MtSES requires cross-level coordination, development of partnerships, and participatory processes in which mountain peoples and communities have a strong

voice (Björstig 2017; Wymann von Dach et al 2017; Klein, Tucker, Steger, et al 2019).

Conclusions

This analysis points to the great diversity of challenges confronting governance for sustainability across mountain sites. Given the vast diversity of MtSES, this study sample is too small to draw generalizable conclusions. Nonetheless, to our knowledge, it offers the first set of comparable data on local governance challenges for MtSES sustainability from around the world. Further research is needed, but these findings provide initial insights. The results mirror other studies in showing that local governance varies with local contexts, despite top-down governments and external pressures (eg Schermer et al 2016). The Caucasus cases illustrate this finding clearly (Gunya et al 2019). Thus, pathways toward sustainability for MtSES need to fit local contexts, as well as the range of external conditions that affect local opportunities and vulnerabilities. Strong local governance can make constructive differences in the wellbeing of local residents, but mechanisms to strengthen MtSES governance remain elusive. No one-size-fits-all approach can resolve the myriad governance challenges faced by MtSES (cf Ostrom 2007) or mitigate systemic political and socioeconomic arrangements that tend to disadvantage certain mountain peoples and drive environmental degradation. Therefore, efforts to improve local governance and MtSES sustainability would benefit from approaches that fit local contexts while building equitable and creative collaborations among diverse, supportive actors within and beyond mountain communities.

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Supplemental material

APPENDIX S1 Survey protocol.

APPENDIX S2 List of sites by key descriptors and respondent affiliation.

APPENDIX S3 Kruskal–Wallis *H* test results by cluster for political–structural challenges, socioeconomic challenges, and local governance concerns.

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