Humanities & Social Sciences Communications

ARTICLE

https://doi.org/10.1057/s41599-023-01756-1 OPEN

Co-management for sustainable development and conservation in Sanjiangyuan National Park and the surrounding Tibetan nomadic pastoralist areas

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The Qinghai-Tibet Plateau plays an essential role in national to regional ecological security, biodiversity conservation, and sustaining livelihood. An array of natural resource management, environmental conservation, and ecological restoration projects have been trialed and implemented in recent years in the vast Sanjiangyuan region of the central Qinghai-Tibet Plateau, aiming especially to ensure socio-ecologically appropriate and sustainable development of animal husbandry in the alpine grasslands. Novel approaches in China have included the introduction of more collaborative approaches in protected area management and the development and formal establishment of a new multi-purpose national park system. Many milestones have been achieved. However, such developments are driven largely by national and global goals and very little has been heard to date directly from the people most affected: those residing within the protected landscapes, i.e. the community stakeholders themselves. This empirical, perceptions-based study aims to partially fill this gap, drawing on the results of focus group discussions with community representatives supplemented by key informant interviews and a targeted review of the literature, to provide synthesized feedback and priority recommendations for improving "community co-management" collaborations for the joint benefit of Tibetan herders and protected areas. The mixed-method approach employed in this study was based on a conceptual model derived from Elinor Ostrom's social–ecological systems framework, calibrated to local residents' self-assessments of their household well-being. Results highlight how the most recent configuration of China's national park model (i.e., its form and the approaches it utilizes) is generally deemed successful by community stakeholders, albeit with some notable perceived limitations mainly relating to a sense of lack of fairness and inclusiveness in the "one household, one post" co-management mechanism. The paper closes with discussion and recommendations around fundamental issues of equity, empowerment, and gender, finally pointing to the significance and, ultimately, the need to move even beyond co-management per se and to adopt a model of inclusive governance for conservation wherein joint deliberations and decision-making amongst diverse stakeholders are prioritized over the simple implementation of externally developed programs and management plans.

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Introduction

The Qinghai-Tibet Plateau (or Tibetan Plateau) is the most extensive high-altitude region in the world (Yao et al., 2011; Zhou et al., 2021). Animal husbandry is a major livelihood and 'pillar industry' in the agricultural sector (Yang et al., 2019) that is essential for local herders as well as farmers who depend on mixed agricultural practices to survive in alpine regions. As such, animal husbandry (herding) is a critical component for the sustainable development of Tibetan areas (Shang et al., 2018). The Qinghai-Tibet Plateau has 1.28 million km^2 of alpine grassland (about half of the land area of the entire Plateau) that is grazed by 13 million yak and nearly 50 million Tibetan sheep. Situated in an ecologically fragile high-altitude zone, the plateau ecosystems face the dual pressures of global climate change, which is occurring more rapidly in mountain regions of the world (Adler and Wester, 2022), and the cumulative effect of all human activities directly impacting land, water, and other natural resources.

Although nomadic pastoralism has been practiced on the Tibetan Plateau for millennia (as early as 8800 years before present; Foggin, 2021), since the 1950s animal husbandry has grown particularly rapidly, with human population and livestock numbers both increasing dramatically. In light of the relatively low average carrying capacity of alpine grasslands due to limited productivity and unpredictable severe weather events, the imbalance between supply and demand of natural grassland (forage) for livestock generally translates into limited production efficiency and low operational benefits for herders, at least when assessed in strictly economic terms (Long et al., 2008, 1999). Such apparent inefficiencies, however, are lessened when risk aversion perspectives, long-term production reliability, and social–ecological resilience (e.g., with enhanced social cohesion) are also taken into account (Roe et al., 1998; Gonbuzeren et al., 2018; Colding and Barthel, 2019; Li et al., 2022). Whatever the core causal factors, serious degradation of the alpine grassland ecosystem is observed in many parts of the Qinghai-Tibet Plateau, manifesting, inter alia, as a decline of grassland productivity that in turn leads to further intensification of the imbalance and significantly affecting the sustainable development of the alpine region (Li et al., 2021). It must be noted, though, that across most of the Tibetan plateau, the grassland systems do not follow the traditional equilibrium theory, but instead—as with most arid and semi-arid rangelands globally—these lands more closely follow non-equilibrium dynamics (also known as the state-and-transition model) (Ellis and Swift, 1988) whereby bouts of overgrazing may lead to irreversible ecological changes.

For the Tibetan grasslands, there clearly is a need for fresh perspectives on ecosystem dynamics and pastoral development (Wang et al., 2018) and, furthermore, there is also a need to reconsider grassland policy measures that (inadvertently) are based on equilibrium theory. Evidence is now mounting that rather than primarily influenced by a single factor, stocking rates, degradation of Tibetan grasslands is more likely caused by a combination of factors that include privatization, sedentarization, and climate change. Traditional forms of pastoralism have exerted relatively little influence in terms of grassland degradation (Cao et al., 2019).

The geographic focus of this paper is the Sanjiangyuan region (in English, "Three Rivers' Source Region," referring to the vast headwaters of the Yangtze, Yellow, and Mekong Rivers), which lies in the center of the Qinghai-Tibet Plateau (Fang, 2013). This region has a sensitive and fragile ecological environment (Liu et al., 2016): once the alpine grassland vegetation is degraded, it is difficult to restore back to ecological health (Sheng et al., 2019).

In total, 22 ecological restoration programs have been implemented since the initiation of the Western China Development Strategy in 2000 with the aim to protect the fragile ecology of the Tibetan plateau and to ensure the sustainable delivery and use (direct and indirect) of the plateau's many ecological services (Sheng et al., 2019). These programs sought to reduce land degradation, alleviate rural poverty, and stimulate economic development, and they have purportedly brought dramatic social and ecological improvements to the region (Ting et al., 2021). Studies highlight, for example, that ecological restoration policies have contributed to improvements of ecosystem services for the whole region, especially through mitigation of grassland degradation in protected areas (as noted by net primary production (NPP) increase by 45%, grassland biomass increase by nearly 25%, and runoff, provision of water resources to downstream regions, and improving water quality; Qinghai Provincial Government Office, 2021); though some caution is still urged, as such correlations do not actually imply causality and there are many complex, interrelated factors that are always at play simultaneously.

Additionally, most regional assessments conducted over the past couple of decades have been undertaken within the framework of the natural sciences, mostly focusing on ecological trends. Fewer studies have focused on regional socioeconomic and development impacts or on social sciences related to the aforementioned environmental policies and restoration programs. Notably, recent research has shown that although China's grassland management policies may have generally improved ecosystem conditions, in some instances they have also brought about negative impacts on pastoralist livelihoods, animal husbandry, and pastoral society, and even the conditions of some grassland regions (Gongbuzeren et al., 2018). Yet, whatever the policy and/or research processes that are followed and challenges encountered, learning from experience and channeling key lessons into future development programs and actions are of paramount value.

The main significance of this paper lies in its contributions to the further development of the current approach used by the government of China (i.e., the development of a national park system) in ways that are both fair and inclusive of local communities; since, based on global experience, failure here would likely lead to failure also in attaining the desired longer-term conservation outcomes. The paper reviews plans and progress to date in the development of China's first national park, particularly shedding light on how conservation programs can be made fairer and more inclusive through co-management approaches. Specifically, in this paper we consider observations and perceptions about this conservation model—as begun in Sanjiangyuan National Park—based on information gathered through focus group research and direct observations, further supplemented by a review of relevant academic literature.

Background

Major geographies. The Qinghai-Tibet Plateau encompasses around one-fourth of China's total land area and provides many benefits, nationally and globally, especially in terms of the ecosystem services deriving from the headwaters of the many major Asian rivers originating on the plateau (Foggin, 2018; Kreutzmann, 2016; Squires and Lu, 2017). Around 3 billion people rely on the life-giving water resources of these great rivers and their watersheds. The Tibetan plateau itself is often called the 'third pole' of the world because of its extensive area and very high elevation (Yao et al., 2012). Even more strikingly, the plateau's simple presence and land cover (including seasonal snow

cover) affect global climate systems, e.g. through surface heating and other atmospheric processes impacting the Asian monsoon (Chen et al., 2021; Lu et al., 2018; Ma et al., 2017).

The Qinghai-Tibet Plateau also is a region that is populated by unique and diverse wildlife (Foggin, 2012; Schaller, 1998; Stokstad, 2020; Zhao et al., 2020) as well as by Tibetan pastoralists whose livestock have long provided for their basic necessities and well-being (Foggin, 2021; Gruschke, 2012). Overall, the Tibetan plateau thus constitutes one of the world's most extensive integrated social–ecological systems (Cong et al., 2015; Gongbuzeren et al., 2018).

The Sanjiangyuan region—constituting the headwaters of the Yangtze (*Changjiang*), Yellow (*Huanghe*), and Mekong (*Lancangjiang*) Rivers—is located in the heart of the Qinghai-Tibet Plateau (Foggin, 2008; Shao et al., 2013). It covers an area of 363,000 km^2, or about half of Qinghai Province (Du, 2012). Because of the great ecological significance of the area's biodiversity and its important water regulatory functions for the entire country and globally (Stokstad, 2020), around half of the Sanjiangyuan region (153,000 km^2) was designated as a national nature reserve in 2000 (Sheehy et al., 2006; Li et al., 2020), an area equivalent to England and Wales combined. Most of this vast area (123,100 km^2) was recently reclassified as a national park—the most recent step in a series of significant policy changes (and novel policies) seeking to reverse decades of unsustainable development decisions and actions that have greatly degraded numerous ecosystems including grasslands, lakes, and glaciers across northwest China (Wu et al., 2020; Xinhua, 2018; Shang et al., 2018). The Sanjiangyuan National Park is comprised of three contiguous sections that respectively encompass the headwaters of the Mekong River in the south (adjacent to Tibet Autonomous Region), the Yangtze River in the south-central and western parts, and the Yellow River in the north-eastern part of the national park.

In parallel with these institutional changes over the past 20 years, in similar ways as other parts of the Tibetan plateau and more broadly across all the high mountainous areas of Central Asia, the Sanjiangyuan region and its main pastoralist inhabitants remain vulnerable to a wide array of interrelated environmental, economic and sociopolitical factors. Many of these factors originate far outside the plateau area, yet greatly impact the environment and local people's lives and well-being—this is Globalization 101, operating in myriad and complex ways beyond simple market integration. Both national environmental policies and global climate change, for example, affect local mountain communities; the latter through the shrinking of glaciers as well as with a changing seasonality and intensity of precipitation, thereby impacting pastoralist livelihoods.

Evolving policy context. In order to understand the background and evolving contexts of the Sanjiangyuan region in terms of its socioeconomic systems and development paradigms, we reviewed 13 government development policies in China since 1994 with special reference to the Sanjiangyuan region as well as to pertinent environmental hazards (Table S3). This information mainly comes from the relevant official websites pertaining to the Sanjiangyuan area, supplemented by academic literature. As seen in Table S3, the recent shift to a national park model better embraces co-management approaches, as compared to stricter command-and-control tendencies in nature reserves. This also is consistent with China's national ecological compensation policy (Hu et al., 2019) and the further refining of the Chinese concept of Ecological Civilization (*shengtai wenming*) (Ma and Wei, 2021). Ecological Civilization has now even been written into China's official constitution as the guiding ideological framework for the country's environmental policies, laws, and education, and it is increasingly being presented not only as a response to environmental degradation in China but also as the country's proposed vision for our global future (Hansen et al., 2018).

Given the many known benefits of local engagement in pasture management and conservation—benefits for both people and nature—a critical question arises, How can more community-centered approaches in conservation be integrated into China's nationally-endorsed plans and approaches? Local communities remain the longest-standing custodians of the environment, and it is increasingly recognized that communities are best placed to contribute to broadly desired conservation outcomes. In light of this, a system of rangers or wardens from local communities has been trialed in the Sanjiangyuan region (Foggin, 2018; Yan et al., 2017). The development of Sanjiangyuan National Park over its 5-year trial phase built on earlier experiences initiated under the nature reserve model, when community co-management approaches and other forms of positive engagement with local people first emerged. The "one village, one post" (*yicun yidian*) collaborative conservation project was launched in 2006 by the nature reserve together with the NGO Plateau Perspectives and was developed over several years collaboratively with local Tibetan pastoralist communities. The "one village, one post" project (or rather, approach) was subsequently scaled-up under the GEF-supported UNDP Qinghai Biodiversity Conservation Project (2013–18). This larger project, endorsed at the highest levels, enabled the further strengthening of the earlier co-management venture, helping embed community-centric approaches into protected area legislation and practice at the provincial level (Foggin, 2005, 2018).

The "one village, one post" project that centered on community co-management in the nature reserve arose from a strategic conservation planning meeting held in Yushu town, Qinghai province, in 2005 (Foggin, 2005) where the conceptual model was presented, discussed, and broadly agreed, leading to the launch, in 2006, of a trial project including communities and nature reserve authorities (see https://plateauperspectives.org/collaborative-management/). The selected focal wildlife species around which collaborative efforts were organized was the snow leopard (Foggin, 2018; https://plateauperspectives.org/snowleopard/) and the geographic focus was Suojia district (or township, *xiang*), which constituted the largest core zone of the reserve as well as where long-term community development had been advanced already for several years by Plateau Perspectives together with local government, pastoralist communities, and nascent grass-roots civil society. This particular area also was where good snow leopard habitat and community conservation areas were both to be found (Foggin, 2008, 2012, 2014, 2018). In addition, first-hand trial implementation of co-management was strengthened with the participation of nature reserve authorities along with local community and government representatives in several study tours focused on co-management, organized and led by Plateau Perspectives, to mountain national parks in Western Canada (2010, together with Parks Canada), Mongolia (2008), Sichuan and Yunnan in China (2011) and Nepal (2012) (https://plateauperspectives.org/study-tours/). This early development of co-management was embedded in the Yangtze Headwaters Sustainable Development Project, led by Plateau Perspectives and supported financially by the Government of Norway and several smaller complementary development initiatives. Many of the experiences from the trial project were later taken up directly by the Sanjiangyuan National Nature Reserve—and by extension, in due course, by the Sanjiangyuan National Park.

Since the beginning of the trial phase of Sanjiangyuan National Park in 2015, implementation of the even finer-scale "one household, one post" policy (*yihu yigang*)—also known as the

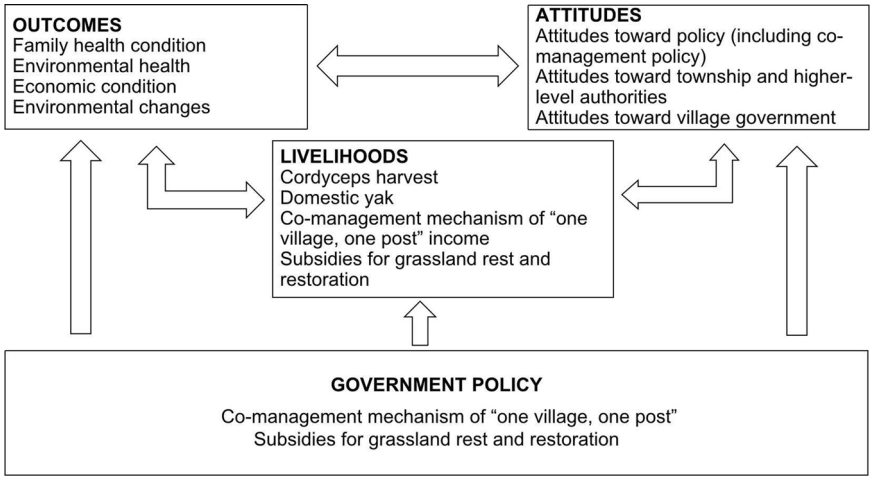

Fig. 1 Framework for household-level surveys. Not all of the indicators listed in the framework will be available in all household surveys. This analytical framework is meant to be indicative of the types of information available and suggestive of possible analyses.

national park's community warden program—has enhanced the income of 17,211 herders, gradually improving their living standards. These 'posts' are the equivalent of 'ranger stations'—but instead of being government-built and administered posts, i.e. physical buildings from which monitoring activities are carried out, the so-called 'household posts' are the material location of each and every household resident in the national park. These are official government 'posts' in terms of their physical reality and location (i.e., residents' homes), but they also remain 'public' inasmuch as they are run by members of the public (i.e., local herders) with specific but clearly stipulated conservation related responsibilities overseen by a selected individual per household. As each household has someone paid by the national park to provide agreed services (cf. ecological compensation), each household thus serves multiple conservation functions including, inter alia, wildlife and ecological monitoring, anti-poaching patrols, and broader community outreach.

Methods

Conceptual framework and 4 main research hypotheses. In the past several decades, numerous scholars have used the Social–Ecological Systems (SES) framework to guide the study of the inherent complexity of policy analysis in dynamic, multi-scalar systems. So far, however, few studies have used the SES framework to consider the fairness and equity of government programs in regard to their impacts and perceived benefits both within and near protected areas—including both their governance and management (see Borrini-Feyerabend et al., 2014; Worboys et al., 2015). Policy analysis in this study mainly adopts the approach of 'horizontal policy analysis', recognizing especially the interrelated ways in which horizontal perspectives (i.e., across sectors and interests) can help address complex or so-called 'wicked' societal problems such as climate change and gender inequality (Endl, 2017; Sjöö and Callerstig, 2020). Horizontal integration—rather than following purely vertical assessments and top-down hierarchies—can better shed light on realms of coherence between sectoral goals and can help develop solutions for the mitigation of particular problems such as those found at the intersection of the establishment of national parks and the multiple discrete needs of local people and communities, encompassing both a healthy environment as well as socioeconomic and other development aspirations.

Here we follow a specific version of the SES model as displayed in Fig. 1 depicting many of the heterogenous interactions between policy, livelihoods, attitudes, and outcomes in the Sanjiangyuan context. Policies define the context or parameters for the current livelihood strategies of resident households in the national park, shaping local people's attitudes toward the government and influencing environmental and human well-being outcomes. Current policies affecting the Sanjiangyuan region include the *yihu yigang* or "one household, one post" co-management model for national park operations, grassland subsidies aiming to reduce livestock pressure on the grassland, and earthquake recovery funds (this followed a large magnitude 6.9 earthquake that devastated Jiegu town, the capital of Yushu Tibetan Autonomous Prefecture, Qinghai Province on 14 August 2010) (Liu et al., 2011)); with these policies recognized as exogenously determined by the central and provincial government and national park authorities in China. To a large extent, local livelihoods are circumscribed by policies such as these, which therefore also affect environmental and social outcomes alongside their influence on public attitudes.

Three policy variables, in particular, appear to have a large impact on the households that continue to live within the Sanjiangyuan National Park area: payments for ecological guards (community wardens), grassland subsidies (requiring people to temporarily move away from the grassland), and the recent arrival (resettlement) of families from the Yushu area following the devastating earthquake. Some households also have received support to help them move to other towns, and/or have received compensation for damages caused by wildlife to their houses, livestock, or people (cf. human–wildlife conflict) (Li, 2019). Households may respond to such interventions in various ways, but always their attitudes and often their livelihood strategies are influenced by the implementation of these policies.

Key informant interviews and household interviews revealed that the two livelihood strategies most reliant on the environment are livestock grazing and harvesting *Cordyceps sinensis*, known as *chongcao* in Chinese and "caterpillar fungus" in English. Other contributors to the households' economic situations include national park payments to local community wardens under the *yihu yigang* co-management model and grassland subsidies to households for not grazing livestock for a set period of time. The latter at least theoretically aims to allow for some recovery of grasslands that (are assumed to) have been previously overgrazed.

Finally, outcomes are expressed in terms of households' economic well-being, health, and wealth, as well as the overall state of the local environment and associated trends.

Table 1 Focus group sampling (4 geographic areas × 3 types of participants = 12 focus groups).

	Townships (communities) covered by the co-management mechanism	Townships (communities) not covered by the co-management mechanism
Mekong River Source Area (Zaduo County)	Zhaqing, Chadan (x male, female, and gov/NP FGs)	Sulu, Jieduo, Sahuteng (x male, female, and gov/NP FGs)
Yellow River Source Area (Maduo County)	Zhalinghu, Huanghe, Machali (x male, female, and gov/NP FGs)	Huashixia (x male, female, and gov/NP FGs)

Environmental change is assessed in this study according to residents' perceptions of ecological conditions, especially in relation to the perceived impacts of governmental policies. Local attitudes may also change as a result of policies and programs, including national park operations, e.g. in regard to roles and perceived effectiveness of government administrations and village-level committees and their governance (cf. local participation in decision-making).

Based on the conceptual model illustrated in Fig. 1, in this study we specifically have hypothesized the following relationships between policy, livelihood, outcomes, and attitudes:

H1. There are two-way (mutual) relationships between local households' livelihoods and environmental and development outcomes;

H2. Government policies (such as adopting the co-management model in the Sanjiangyuan National Park, in particular, its "ecological compensation" payments to community wardens) are positively correlated with local residents' livelihoods and associated choices/actions;

H3: Residents' attitudes towards government policies and approaches are positively correlated with their personal level of engagement (participation) in associated activities.

H4. Demographic characteristics of households account for the majority of the heterogeneous (multi-directional) interactions between livelihood, outcome, policy, and attitude.

Procedures and sampling design. This study employed a two-phase mixed methods design. In the first phase of our work, we adopted a cross-sectional survey approach (Cohen et al., 2017), largely following the survey development path suggested by Rosier (1997). In the second phase, more qualitatively oriented focus groups and interviews were used as a way to triangulate and supplement the initial survey findings, with special attention given to better understanding concerns that emerged from earlier work regarding perceived fairness (or lack thereof) in the implementation of the co-management model (Morgan, 1997).

The main data for Phase 1 were obtained through a household survey. First, semi-structured interviews were conducted with the local managers of the Mekong River Headwaters National Park to elicit feedback about the social–ecological transformational aspects of the co-management policy. Second, a pilot household questionnaire was developed based on the SES framework, previous interview results, and consultations with experts (following Ajzen, 2006). A total of 10 questionnaires were administered in the pilot survey and the resulting data were used to select reliable and valid items to improve the quality of the final questionnaire in terms of internal consistency and discriminant validity. The final version of the household questionnaire comprised four parts: family composition, economic and natural conditions, national government compensation and support programs, and local awareness of environmental changes and government policies. Four-point Likert scales were used to elicit and record respondents' attitudes and questionnaire outcomes. The formal survey was conducted by the senior author and a Tibetan–Chinese translator in July–August 2018 with face-to-face interviews in the participants' houses (the government translator played only a translation role). A stratified sampling approach was used to identify the respondents for the survey based largely on household conditions and practical feasibility, with four research areas selected from amongst the 19 administrative villages distributed across Zaduo County (*xian*), namely the main village of Zhaqing district (*xiang*), Gesang district, Angsai district, and the new environmental resettlement district. Ninety-nine (99) local families were interviewed during the limited survey time. Information was provided by the head of each of the households visited. We stratified the sampling to ensure the representation of different types of households and household heads (e.g., by age and gender). Responses from the 99 households interviewed were recorded both by hand and with an audio recorder. After transcribing all responses to datasheets, it was found that all households had complete response sets; all were therefore kept as the study group.

Primary data for Phase 2 were obtained through focus group interviews, seeking mainly to ascertain local perspectives on government policies. A total of 12 focus group discussions were conducted, with a total of 219 participants. We used focus groups because these are an effective way to collect a large amount of data on a particular issue, information that may be little known but, once highlighted, can be used to identify key topics for further exploration (Morgan, 1997). A pilot focus group was first conducted in the headwaters of the Yellow River in July 2018 to explore the focus group members' concerns with the policies that had been implemented in the area and to determine whether the focus group method could be effective for collecting data for the project. The formal 12 focus group studies were conducted in July 2020 at 4 sites (Table 1). In each of the sites, we convened three focus groups: one with male residents only, one with female residents only, and one with representatives of local government administrations and national park management agencies. All of the participants in this study voluntarily provided their prior and informed written consent to participate in the discussions. Each focus group consisted of between 5 and 20 people, with an average of 12 participants, and the group discussions lasted between 90 and 120 minutes. Due to the special situation around Covid-19, we could not provide refreshments to the participants. The broad open-ended questions that guided the focus group interviews and ensuing discussions are provided in Box 1.

Focus group transcripts were used for comparative analysis. The main points of inter-group comparison are as follows: distinguishing between river basins (i.e., Yellow River versus Mekong River sources areas, or headwaters); gender; location (inside versus outside the National Park); and main stakeholder category (government versus local residents). See Table S2 in the supplementary information for the main results of the comparative analysis.

Basis of the modeling in this study. Local residents' home areas (villages) were organized and named differently before and after the Yushu earthquake. Village codes were given to each

Box 1

Questions for focus group survey

(a) Please describe the recent history of the co-management system.
(b) What are the different ways in which people are affected by the co-management system?
(c) Who is most positively affected by the co-management system in this area, and why?
(d) Who is most negatively affected by the co-management system in this area, and why?
(e) What has been done, or could be done, to improve the situation of people who have been negatively affected?

household interviewed based on the village's names as formally designated and recognized after the earthquake. Ordered categorical variables were created for Economic Condition and Family Physical Condition, from 'worst' to 'best' based on descriptions provided by household members. Four categories were thus recorded and a four-point scale was used to evaluate residents' responses: −1, 0, +1 and +2, roughly translated in narrative language as Poor (*buhao*), Fair (*yiban*), Good (*haikeyi*), Very Good (*bijiaohao*). The following areas of inquiry also were categorized in degrees, from negative to positive (as above) based on the household respondents' classifications: several types of environmental concerns and ecological conditions; the perceived quality of air, water, and soil; changing health and other socio-economic conditions of households; perceptions of changes in approaches to environmental protection (government policies); awareness of compensation opportunities, including payments to community wardens and grasslands subsidies; environmental protection actions taken; and support for national policies and for village committees and the mechanisms they use for implementing the national policies.

Reliability and validity tests. Regarding reliability, we used R to check the option distribution of variables one by one, without deleting any data, but re-encoding some extreme values to ensure that neither is data lost nor is any extreme single value unduly affecting results. The extreme values and options with fewer choices were then combined to achieve dimensionality reduction for multivariate statistical analysis. Regarding validity, we analyzed the distribution of each option with the distribution of residuals and regrouped some degree-dependent variables using the distribution and selection range.

All categorical responses recorded were double-checked by a certified Tibetan–Chinese translator to ensure that the corresponding levels were correctly transcribed. Due to their high correlations, the mean awareness of air, water, and soil quality and of health condition changes was understood to represent households' awareness of environmental changes and health condition changes, respectively. Finally, factor variables that can be used for multivariate logistic and multiple linear regression analysis were obtained for subsequent steps in the overall analysis; the optimized measurement model fits well.

Multiple logistic regression fitting and hypothesis testing. All variables were coded in R 3.5.1 for modeling. The mean values and standard deviations are shown in Table S1. Of the total number of complete questionnaires obtained, 98.6% had complete data for the variables used in the present analysis. To retain the maximum number of cases, a hot-deck imputation algorithm was used to make up the missing data. In the process of fitting multiple logistic regression models, multiple indices were used to assess model fitness, and a model was considered suitable for analysis only when it achieved the recommended Goodness-of-Fit (GOF) measures (Smith and Rose, 1995). Only when all of these conditions were achieved was the hypothetical model deemed suitable for analyzing the actual survey data.

Table 2 Ordered logistic regression results for economic condition, family physical condition, and health conditions of households.

	Model 1	Model 2	Model 3	Model 4
Age		−0.0255 (0.0103)*	−0.037 (0.018)*	
Gender	−2.48 (0.92)**	−1.87 (0.0129)*		
HH mem	0.0405 (0.105)			
Yak	0.0284* (0.0148)		−0.00536 (0.01645)	
Subsidies		−0.0000698 (0.0001564)		
EcoGuard		−0.604 (0.401)	−0.264 (0.522)	−0.131 (0.465)
Gesang Township			1.41 (0.87)	2.29 (1.07)*
AWSH perception			1.80 (0.79)*	
EcoCon				−0.00683 (0.2688)
Sample size (*n*)	99	99	99	99

**, and * denote statistical significance at the 5%, and 10% levels, respectively.

Results and discussion

The hypotheses' test results are shown in Tables 2 and Table 3. For Model 1 (based on Hypothesis 1, or H1), Gender and NumCordyceps (amount of *chongcao* collected) are significant explanatory variables while NumHouseMember (number of household members) and NumCattle (number of yak) are not significant. For Model 2 (based on H2), Age and Gender are significant explanatory variables, while the other three variables are not significant. Older members and female members of the households have worse family physical conditions than younger and male household members. In regard to Model 3 (based on H3), Age and MeanPerceptionAWSH (mean perception of quality of air, water, soil, and health conditions) are significant, while the other three variables are not significant. Additionally, older household members have more negative attitudes toward government policies, and households with higher mean perceptions of the quality of air, water, soil, and health conditions have more positive attitudes toward government policies. For Model 4 (based on H4), EcoGuard (whether or not a household includes a community warden) and EcoCon (household economic conditions) have no relationship with attitudes toward village policies. Finally, for their parts, Models 5–8 tested the effects of different types of variables on the households' perceptions of air, water, soil, and health conditions. The results show that only three variables have a significant effect on MeanPerceptionAWSH, namely age, amount of *chongcao* harvested, and sense of satisfaction with local government affairs.

On the basis of the above findings, the fourth hypothesis (H4) was fully adopted; H1 and H3 were only partially adopted based on the relationship between household economy and livelihood (but the relationship with environmental health, and likewise the relationship with EcoGuard, Subsidy, and Attitude were not

Table 3 Linear regression results for households' mean perception of air, water, soil, and health conditions (the dependent variable is MeanPerceptionAWSH in all models).

	Model 5	Model 6	Model 7	Model 8
Gender	0.015(0.134)			
Age	0.000566**			
	(0.000215)			
Gesang Township	0.0413			
	(0.0781)			
Cordyceps		−0.0000528*		
		(0.00003287)		
Yak		−0.00122		
		(0.00214)		
Subsidies			0.0000034	
			(0.00001042)	
Ecoguards (wardens)			−2.49	
			(6.45)	
Government policies				0.113
				(0.053)*
Village concerns				0.026
				(0.051)
Sample size (*n*)	99	99	99	99

**, and * denote statistical significance at the 5%, and 10% levels, respectively.

significant); and H2 was rejected for lack of any statistically significant relationships.

Implementation of the community warden program (community co-management). The Sanjiangyuan National Park has a strong "workforce" (*shengtai guanhuyuan*) of community wardens. The wardens not only serve as environmental and wildlife monitors but also as protectors who detect infractions and serve as liaisons between the National Park and the wider communities of which they are a part. However, the term '*shengtai guanhuyuan*' that permeates much of China's view of national parks is itself still somewhat oppositional, in that it implies that national parks need to be guarded from people who otherwise would contravene regulations and harm the environment. Yet there is positive movement, too, such as through the continuing development of 'co-management' approaches, which are more participatory and inclusive in nature—even if not to the extent observed in some other circumstances worldwide (Brooks et al., 2013).

During the course of our focus group interviews conducted in July 2020, almost all residents expressed that they believe the establishment of the national park has had a substantial positive impact on the environment and on their lives. It is felt that the application of the "one household, one post" ecological management system has transformed residents from being simply users of the grassland to re-establishing them as guardians of the grassland. It appears that local residents feel well qualified for this job, and they also express a sense of satisfaction in accomplishing the agreed duties. Significantly, living standards have reportedly improved, as also has environmental quality in the national park. However, household survey data collected in July and August 2018 showed that income sources related to government conservation policies ("one household, one post") were not correlated with respondents' economic status, family health, or satisfaction with the government. In our investigation, some respondents repeatedly mentioned that their life was not as happy as before. One explanation would be that this is due to the transition period in developing the National Park systems, particularly inasmuch as the "one household, one post" system is not yet fully established and operationalized. Another explanation could be that residents in the ecological resettlement area have not found moving from pastures to urban areas to be suitable to their needs, whether in terms of material well-being, socio-cultural aspirations and/or attachment (sense of identity), or otherwise. For their part, the environmental payments through the "one household, one post" management system are forms of "extrinsic" motivation. Yet people have strong "intrinsic" motivations as well, things that they do because of their own values or because it brings them real enjoyment. Some intrinsic motivations may be related to culture and tradition. While both forms of motivation can and often do occur simultaneously, in some situations, extrinsic forms of motivation can actually "crowd out" intrinsic motivating factors (Kaczan and Swallow, 2019). Judging from the feedback received through focus groups in 2020, intrinsic motivations have become stronger since 2018, but we still must proceed cautiously and consider these issues carefully in future policy design processes. Our findings support the results from studies in South Asia (Soliku and Schraml, 2020), where, to combat the continuous deterioration of forest resources, community co-management has been introduced as a permanent approach to integrating local communities in forest management processes by utilizing the capacities and comparative advantages of various social actors. This approach seeks to enhance both forest health and local livelihoods by offering local communities the responsibility to manage forest resources alongside the opportunity to enjoy benefits derived from them (De Pourcq et al., 2016). Co-management approaches are widely considered to be a successful natural resources conservation technique to address anthropogenic disturbances in many regions of the world, such as Nepal, Honduras, Ethiopia, and Malawi (see Nagendra et al., 2004; Takahashi and Todo, 2012; Niraula et al., 2013; Chinangwa et al., 2017).

Conversely, households living outside the national park boundaries do not benefit from this system of co-management to the same extent. Notably, the "one household, one post" co-management system has not been extended equally to all households outside the national park, only to those living in close vicinity of the park. Secondly, there are fewer environmental projects outside of the national park, such as wildlife monitoring and grassland restoration. Although local government has taken some measures to reduce the gap between people living inside and outside of park boundaries, such as in skills training, more

could be done for people and communities living beyond the park's boundaries. Yet, we should still recall that due to stricter ecological protection measures inside the national park as well as the presence of wildlife, residents within the park do also incur additional costs as well as diminishing some opportunities (e.g., inability to benefit from tourism, weaker infrastructure), which is the reason the authorities deem the differentiated approach to be justified. Broadly speaking, though, local residents recommend that people who live outside the park should also benefit from the "one household, one post" policy—and in this way, even extending in practice if not legally the bounds of de facto conserved areas—but with possibility for this to be at a reduced monthly salary of 1400–1800 CNY (approx. 220–280 USD) per month.

Physical and social well-being of marginalized groups. In focus group interviews, women generally indicated that they felt that more attention should be given to their welfare. Our model results equally show that households' economic status varies on the basis of gender, with EcoCon (economic condition) of female-led households being significantly lower than that of households led by men. Gender is also an important explanatory variable for Model 2, in which respondents' assessments of their family health status were less positive for households that are headed by women. While improvements in health and income have occurred in recent years, more research is still needed to better understand the full expression and meaning of ill-health and of multi-dimensional poverty in this context (Yoeli-Tlalim, 2010; Ma et al., 2022).

Findings of this study in the Sanjiangyuan region broadly support results observed elsewhere. For example, Afriyie et al. (2022) report that men were more satisfied with PAs' policies and governance than women. This could be the result of the division of responsibilities, duties, and experience at the household or even at community levels, with greater involvement of men in outdoor activities such as clearing fields and farming. Studies in other areas of the world have also observed lower well-being amongst women in PAs (Bitanyi et al., 2012). Furthermore, in many countries, there is unequal access to formal education as well as a lack of participation (whether by opportunity or by choice) in decision-making processes by women in PAs in regard to the use of natural resources, including management and conservation, which eventually leads to negative attitudes toward PAs (Allendorf et al., 2006).

Highlighting the varied benefits of gender-responsive approaches in program implementation for households and for communities as a whole (e.g., for nutrition, climate adaptation, or social harmony; Deering et al., 2019) could contribute to reducing various forms of inequality in both access to and control of resources. Regardless of any government policies specifically targeting marginalized groups, the goals of social–ecological transformation policies should consider the welfare of such groups, e.g. considering women and elderly people. The present analysis shows that even in the study's target group, there are sometimes subtle hierarchies. For example, in the Sanjiangyuan National Park, if a man in any given household felt that he needed employment, it is more likely that he would take up that household's allocated ecological guard position rather than one of the household's female members. While such a situation may not be the direct result of the co-management policy, arising instead from pre-existing social norms, to date this has not been proactively countered through the new program. In short, some of the target groups within the focal area appear to still be marginalized and further steps may be needed in the Sanjiangyuan National Park to redress such marginalization.

Environment quality—conditions and trends. Elderly people reported in the focus groups that the environment has not returned to the quality they recall from the 1960s and 1970s. Our model results also confirm that age has a significant impact on MeanPerceptionAWSH, with older people holding more negative attitudes toward government policies. While it is broadly accepted that socio-demographic and cultural contexts usually influence people's perceptions and attitudes about the environment (Bennett, 2016), the effect of age per se on perceptions and attitudes toward PAs has been inconsistent and may be site specific. For instance, in some developing countries older people are often both less educated and less likely to support PAs (Mehta and Heinen, 2001), whereas in Ethiopia older people in areas surrounding PAs held more positive attitudes toward the national parks than the younger generation, possibly because their longer and direct experience of the negative effects of biodiversity loss has helped them to appreciate more of the vital roles of PAs in wildlife conservation (Tessema et al., 2007).

Elderly residents who were born in more challenging socio-economic times also reported that their lives have seen tremendous changes and they generally perceive the national park policies as being a form of social assistance—relative to their prior deprivations, which current policies are now addressing at least in part. On the other hand, they reported that current environmental quality is not as good as what they experienced when they were young. In the past, Tibetan herders used oil lamps for lighting and there were no batteries or coal for heating, thus there was barely any environmental pollution. Few plastic products were present until the early 1990s. There also were no notable problems with small burrowing mammals, which in more recent times have become very abundant and whose presence correlates with degraded land (Smith and Foggin, 1999). Overall, in their youth, between 20,000 and 30,000 *mu* (1333–2000 ha) of grassland provided enough pasture for 1500–1600 Tibetan sheep, but now the same area can support only 500–600 sheep. Many respondents thus feel that environmental quality has decreased in more recent times, including from 2000 to 2016, which was perceived as a somewhat difficult period. However, from 2016 to the present (since the launch of the national park pilot phase), environmental quality is reported to have greatly improved; though still not as good as in the more distant past. Young residents also have reported that environmental quality has improved significantly over the past decade.

With all such recorded statements, however, while there may be a correlation between observed states (or conditions, situations), we must not immediately imply causality when and/or where none can be properly attributed. For example, the most serious grassland degradation in the Sanjiangyuan area basically took shape around the mid-1970s and continued until the mid-1990s, and no sharp increase in grassland degradation has occurred since then (Liu et al., 2008). One of the most likely contributing factors to this was reduced pressure on the grassland system due to the occurrence of a major snowstorm in 1985 that caused great losses to livestock and wildlife. Around the same time, there was also a period of aridification with rapid extension of sand dunes and numerous losses of streams and lakes through the 1980s and 1990s and even into the early 2000s. Such natural occurrences could therefore be behind the more recently noted observations of improved grassland conditions; with the positive changes noted since 2016 simply being a 'recovery' from abnormal (or statistical 'outlier') situations, which are not themselves representative of longer-term baselines or averages. Over longer timeframes, conflicts between people and nature in the Sanjiangyuan region have in fact gradually increased—just as everywhere around the world—most likely due to increasing

anthropogenic activities (e.g., new access and market demands) as well as global climatic changes.

Recommendations for enhancing inclusive governance in China's national park system

Enhancing partnerships beyond PA boundaries—mainstreaming equity at regional level. China's first national park has not yet adequately addressed the issue of (perceived lack of) "fairness." For example, due to historical reasons, three districts (Geladandong, Dangqu, Yoguzonglie) in the Yangtze River headwaters are still involved in on-going provincial-level administrative divisions, leading to poor integration across management agencies under different prefectures. Some residents are included within the scope of the national park, thus benefiting from the "one household, one post" community warden project and other poverty alleviation programs and now with high expectations and preferences for future policies; by and large, they actively support the development of the national park. Some other residents in the same region, however, are not included in the national park (as with 12 villages in Qumalai County in the source area of the Yangtze River and 8 villages in Maduo County in the source area of the Yellow River), subjecting them to policies and opportunities/constraints very different from those enjoyed by the residents inside the national park. In order to better coordinate the development of national parks and their surrounding areas, for both conservation and social purposes, it is recommended to broaden the application of socially beneficial conservation programs in China's PAs—such as the "one household, one post" mechanism—and to bring these also into surrounding areas, beyond the PAs' boundaries narrowly defined. The scope of expansion of PA approaches beyond its boundaries per se should be delineated according to standard principles of integrated ecosystem management, for the protection and sustainable use of regional social–ecological landscapes. Towns and communities that fall within the expanded area will need to follow the national park's regulations on ecological protection, in the same way as residents inside the park, and they equally will enjoy benefits from the financial, technical, and talent support programs organized by the national park. Formation of a polycentric "national park—township (*xiang*)—village (*cun*)" system of integrated governance and development planning (and operations) would assist in the provision of additional buffer space for national parks, and hence their effective protection, through increasing virtual space for multi-stakeholder dialogs, awareness raising, and capacity development.

Empowering local communities. In China as elsewhere, all things "local" are likely to be at risk as countries seek approaches for balancing local needs and interests versus regional, national and global scale needs and interests. In many instances, there are a wide array of complex challenges associated with serving the needs of the majority while simultaneously prioritizing the interests, and rights, of local stakeholders. Many overlapping issues also are recognized as "wicked problems" (*sensu* Rittel and Webber, 1973), problems "that cannot be adequately solved using the rational-comprehensive planning model [and generally] characterized by a lack of consensus and clarity in their definition and potential solutions" (Akami et al., 2016). These same authors continue, "Wicked problems, just as social-ecological systems, exhibit the attributes of complex adaptive systems, such as emergence, scale-sensitivity, heterogeneity, surprise, and path-dependence." Indeed, according to Ritchey (2013), wicked problems are "messy [and] devious, and they fight back when you try to deal with them." But whether we consider environmental degradation or challenges of poverty from a perspective of "complexity" or "wickedness" (i.e., intractability), the development of solutions in local contexts (cf. decentralization, or more accurately the contextualization and localization of solutions) shows substantial promise for overcoming many current complex challenges, with benefits to be derived across multiple scales (Gardner, 2011; Peters, 2017). This study lends further support to such an approach. At the same time, it should be noted that decentralized governance is not seen here as an end in itself, but rather a means to create more open (inclusive), responsive (adaptive), and effective systems of governance for the sustainable use and conservation of natural resources, through more representative community decision-making approaches as offered, for example, in co-management mechanisms.

The value of localization is being realized in many places around the world. While longer-term cyclical (on-going) projects and their outcomes are often produced at the national level, the majority of countries are so diverse that we need to look back to more local levels and local contexts, including regional levels such as provinces and all the way down to the most "local," which manifests mostly at community levels and often is synonymous with people's sense of identity, cultural preferences, along with their ethics and norms of behavior (Foggin et al., 2021). Further, we do not want to lose what local communities have acquired over generations, their traditional ecological knowledge (Ma et al., 2020; Bridgewater and Rotherham, 2019; Frainer et al., 2020). Based on the understanding that access to and use of biodiversity is critical for human livelihoods and well-being, especially for Indigenous peoples and local communities (IPLCs) whose livelihoods, traditions, cultures, and worldviews are highly dependent on the natural environment and relevant for nature conservation and who see themselves as an intrinsic part of nature rather than distinct or independent of it, the involvement of local communities—better still, their leadership in the design and implementation of conservation solutions—is essential. Biodiversity maintained in a healthy state, neither destroyed nor degraded, is now also recognized by the United Nations and its member states as the foundation of a wide range of human rights (UNEP, 2022).

In practice, the empowerment of people and communities means allowing for some transfer of rights and authority to more local levels, promoting discussion and contextualized decision-making. Empowering local people is more conducive to long-term conservation and broader sustainability (Salerno et al., 2021). The following issues should therefore be considered in multi-stakeholder dialogues with more space to hear local voices: (i) regional natural resource endowment and socio-economic development, both within and beyond the national park; (ii) relevant policies and regulations (current and potential, at different geographic scales) that could help expand the scope of effective co-management in protected areas; (iii) local governance institutions (formal and informal/traditional) that can strengthen participation and local engagement in decision-making; (iv) the presence of different forms of civil society, including sectoral associations and community- or interest-based cooperatives that could aid in cross-regional exchanges and dialogues; (v) capacity development; and (vi) local sense of identities and pride in traditional culture. It is important to hear local voices not only in regard to local matters but also valuing them for the contributions they can make to complex or wicked problems at regional and higher levels.

Empowering women. Gender equality is both a practical issue and an ethical issue. China's engagement with gender and the empowerment of women has for a long time been associated mainly with the work carried out by the Women's Federation, nationally and across all administrative levels. However,

measuring empowerment in this way is simply too narrow. Realistic labor options are needed for women, as well as spaces and opportunities for them to express themselves, to be heard, and to enact their own decisions. In regard to employability, building on skills and knowledge that many women already possess must be the cornerstone for strengthening and enabling their involvement in society. As women are empowered, they bring many benefits to development and environmental protection (Duflo, 2012). We therefore recommend that a social impact assessment disaggregated by gender be conducted in regard to both current operations and future plans for the National Park, out of which special opportunities for women will be highlighted and remedial actions outlined where necessary. Minimally, considering the many different ways that women contribute to society—not only through their families but in many direct ways through diverse social institutions—it is no longer viable to consider the Women's Federation as the sole or primary mechanism for engaging with gender-related issues; as full and valued members of society, gender dimension must always be entirely mainstreamed in all development sectors, interest groups, as well as critical dialogues pertaining to assessments of current conditions and all planning for the future. As a department of government, the Women's Federation has a role to play. In particular, it has the responsibility to communicate particular types of information and government policies and to ensure that various requirements are met; but in this it acts as an executive branch in a top-down manner (while also contributing in important ways to enhancing women's capabilities through training opportunities), not itself coming from a local grassroots perspective. Endogenous views that can contribute to development and conservation come from multiple sources, from all human groupings including formal, informal, and natural associations—each of these also to be viewed through the lens of gender—moving us beyond the limited reach of single "blueprint" approaches developed from afar.

Developing and strengthening co-management by moving towards more inclusive governance. Different stakeholder groups often take note of different problems or identify different causes and drivers of change, and thus different solutions are considered by each to be most appropriate. While the complexity arising from such a diversity of ideas and opinions may seem problematic, this diversity is in fact a very important, even essential element of nature conservation when viewed from a rights-based perspective —which also is a core approach and purpose of this study, bringing new voices to bear on conservation planning and implementation in China's first national park.

The main purpose of this study is not so much to suggest any fundamental change to China's governance model for PAs, but to objectively analyze the current state of PA governance through a review of the Sanjiangyuan National Park, in particular, 'hearing' previously little heard local voices. Although China has applied a management model that now collaborates more closely than before with local communities (in the form of "one household, one post" co-management in Sanjiangyuan National Park), most actual decision-making (i.e., governance *sensu* Borrini-Feyerabend et al., 2014) in China's PAs is still dominated by top-down habits, further accentuated by the continued 'belief' in the unquestioned efficacy of rational-comprehensive planning theory "with its roots in economic assumptions about human behavior (Brooks, 2003) and positivist assumptions about science (Dalton 1986) [often leading to exclusive] application of the scientific method to decision-making" (Akamani et al., 2016). This theory holds the (erroneous) view that planners can be "value-neutral technicians" who undertake purely objective analyses of planning problems. However, such approaches do not work well—if at all—with complex or wicked problems. Accordingly, a rethinking of problems from the perspective of a social-ecological systems framework creates new opportunities for development, in particular through "adaptive governance" that includes "the pursuit of adaptive and integrated goals, utilization of diverse sources of knowledge, reliance on a polycentric institutional structure, and an analytic-deliberation decision-making process that is informed by communicative action theory" (see Bates et al., 2009; Dietz et al., 2003; Folke et al., 2005; cited in Akamani et al., 2016). Most significantly, as begun here in this study—and made possible through the co-management model that is already being trialed in the Sanjiangyuan National Park—it is essential to recognize and listen to local voices, with their local perspectives; as mutual understanding across stakeholder groups, integrating multiple ways of knowing, and co-creating solutions are all necessary for developing viable models of regional conservation and development (De Vos et al., 2022; Relva and Jung, 2021).

The explorations undertaken to date in China's development of its new national park system have been extremely valuable and are largely on-track; the country is following good governance experience and wisdom accumulated globally, coming with generally open and inclusive attitudes. The bottom-line is that for governance processes to be fair and equitable, that is, for decision-making processes to reflect the needs, interests, and suggestions of all core stakeholders (cf. rights holders, especially marginalized groups including women and local communities), safe spaces that are both welcoming and accessible must be created for them, places and contexts where genuine dialogues and fruitful creative thinking may take place. It is possible that non-government organizations and other elements of civil society also may participate in such processes, enabling and empowering local stakeholders that up to now have generally been marginalized or otherwise have kept relatively silent in matters of planning and decision-making.

With the development of China's economy and society, including the country's integrated development orientation under the umbrella of ecological civilization, the PA system that is being developed to rescue human and non-human beneficiaries from worsening environmental problems is becoming more prominent by the day. Promoting the construction of China's PA system in a systematic, scientific way has become one of the key issues the country wishes to urgently address, and this is being achieved now most notably through the establishment of the national park system (He et al., 2018). Due to the complexity of China's environmental issues, however, the process of creating good governance systems is a complex and long-term process. Thus, even if Sanjiangyuan National Park does not immediately prove to be perfectly aligned with all of its desired goals, any trend towards greater inclusivity in conservation planning and governance as well as management should be favorably viewed, as it speaks to China's attitude to strengthen community partnerships.

Conclusions

Conservationists broadly recognize that protected areas (PAs) have limited prospects to achieve conservation aims without the involvement and support of local people. This paper has assessed the Sanjiangyuan region in China's Qinghai Province, a vast high-altitude area that is of great national and global significance for watershed, biodiversity, and sociocultural conservation. A critical review of policy documents and the scholarly literature has further clarified the recent history and current practices of integrated resource management, environmental conservation and community development in the predominantly pastoral Sanjiangyuan region, culminating now in the "one household, one post" co-

management mechanism adopted by China's first national park. Thousands of Tibetan women and men from local communities are involved as wardens, helping to monitor the environment and wildlife and to protect the ecological health of the Qinghai-Tibet Plateau. Implementation of this community-oriented mechanism in the pastoralist social-ecological system has massive implications both for ecosystems and for the well-being of many local communities in the Sanjiangyuan region. Bringing new empirical observations and perceptions-based interviews and focus groups to the discussion, our results indicate that the benefits and challenges of China's newest and largest national park project remain unevenly distributed. We conclude that the potentially transformative co-management model is simultaneously generating meaningful improvements for the natural environment and for local people's livelihoods and socioeconomic development, but it has also been found that this promising conservation model could be adjusted and improved further to benefit all residents in the Sanjiangyuan region through fair, equitable, and inclusive transformations.

Data availability

Our specific datasets generated in this study are not publicly available, as they are part of the authors' ongoing research. These data are available from the corresponding authors upon reasonable request.

Received: 25 July 2022; Accepted: 17 May 2023;
Published online: 16 June 2023

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Acknowledgements

We wish to extend our gratitude to all of our colleagues, family, and friends for supporting us during this research. We also thank the Sanjiangyuan National Park administration and all field staff for their helpful contributions to the study, including sharing informational material with the study participants. We also acknowledge all the participants as well as other local community members who shared with us their knowledge and perspectives during field investigations. The support of Plateau Perspectives and of the Institute of Asian Research in the School of Public Policy and Global Affairs, University of British Columbia toward the development of this research paper is also gratefully acknowledged. Our work was supported by the Second Tibetan Plateau Scientific Expedition and Research of MOST of China (2019QZKK0401); The Strategic Priority Research Program of the Chinese Academy of Sciences (No. XDA20020302); Sanjiangyuan National Park Joint Research Project of CAS and Qinghai Province (No. LHZX-2020-05).

Author contributions

Conceptualization: TM and BS; Data curation: TM; Formal analysis: TM, JMF and BS; Funding acquisition: LSZ; Investigation: TM; Methodology: TM and BS; Project administration: TM; Supervision: LSZ, BS and WGS; Validation: BS and JMF; Writing—original draft, TM; Writing—review & editing, TM, BS and JMF.

Competing interests
The authors declare no competing interests.

Ethical approval
The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki, especially the basic principles of respect for individuals, their right to make informed decisions, and recognition of vulnerable groups. It also was carried out according to guidance from the Science Ethics Committee of the Chinese Academy of Sciences, whereby the need to obtain formal ethical approval for the study is not applicable as participation in the focus group sessions and household interviews was entirely voluntary.

Informed consent
Informed consent was obtained from all participants at the outset of each focus group meeting and household interview. On each occasion, the study and its purposes were introduced and explained, and the intended uses of all information gathered were explained. Every participant was free to decide individually whether to participate or not.

Additional information
Supplementary information The online version contains supplementary material available at https://doi.org/10.1057/s41599-023-01756-1.

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