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LETTER

Collaborative conservation for snow leopards: Lessons learned from successful community-based interventions

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Abstract

Collaborative conservation interventions based on engagement with local communities are increasingly common, especially for large carnivores that negatively impact people's livelihoods and well-being. However, evaluating the effectiveness of large-scale community-based conservation interventions is rarely done, making it problematic to assess or justify their impact. In our study focused on snow leopards (*Panthera uncia*) in five countries, we show that bespoke and well-implemented community-based and conflict management intervention efforts can lead to more sustainable conservation outcomes. Collaborative interventions, spread over about 88,000 km^2 of snow leopard habitat, reduced livestock depredation and disease and associated economic costs. Additionally, they generated conservation-linked livelihoods and enhanced community decision-

making, leading to more positive behavioral intent toward snow leopards and improved communities' cooperation, economic security, and confidence. Our results provide lessons learned and recommendations for practitioners and governments to alleviate conflicts and foster coexistence with snow leopards and large carnivores more broadly. These include prioritizing locally led tailored solutions based on the PARTNERS principles, recognizing local community rights in conservation decision-making, and recognizing the role of social norms in ensuring accountability.

KEYWORDS
CBC, conflict, conservation, evaluation, Himalaya, local communities, *Panthera uncia*

1 | INTRODUCTION

Biodiversity conservation efforts typically include establishing protected areas, implementing and enforcing conservation laws and policies, providing financial incentives, and supporting community-based conservation (CBC) programs. In CBCs, "community members or a community–based organization are involved in efforts to protect or conserve the lands and environment they live on or nearby through the highest levels of participation" (Horwich & Lyon, 2007, p. 376). CBC interventions are increasingly common, especially in the global South (Adams & Hulme, 2001; Galvin et al., 2018; Sachs et al., 2009). Resources for CBC are often limited, in part because of their small scale (Horwich & Lyon, 2007), but also because their effectiveness is rarely evaluated robustly (Ferrero & Pattanayak, 2006; Kleiman et al., 2000; Sutherland et al., 2004; Pullin & Knight, 2001; Stem et al., 2005), with evaluations limited in scale and scope (Brooks et al., 2013) or based on modeling predictors of success (Fariss et al., 2023).

Human–wildlife conflicts represent a major challenge for conservation (IUCN, 2023; Redpath et al., 2013). Large carnivores are often central in such conflicts, whether it is wolves across the northern hemisphere (e.g., Salvatori et al., 2020), tigers in Asia (e.g., Miller et al. et al., 2015), lions in Africa (e.g., Blackburn et al., 2016), or jaguars in South America (e.g., de Souza et al., 2018). These are complex problems involving impacts of carnivores on livestock, livelihoods, well-being, and even human lives (Van Eeden et al., 2018). Outcomes of such conflicts can include retaliatory killing of carnivores, exacerbating social conflicts between those suffering the costs and those seeking to protect wildlife (Dickman, 2010; Redpath et al., 2013). A large body of work has focused on developing CBC interventions to address the negative impacts of these conflicts (Branco et al., 2020; Redpath et al., 2015; Redpath et al., 2017; Western et al., 2015), but there remains a lack of rigorous scientific evidence as to their effectiveness (Eklund et al., 2017), especially over large geographic areas and different cultural contexts, and in terms of different types of outcomes (Brooks et al., 2013).

The wide-ranging mountain habitat of snow leopards (*Panthera uncia*) is used by people who depend on livestock. Snow leopards kill livestock and may suffer from consequent retaliatory killing (Mishra et al., 2003; Shehzad et al., 2012; Suryawanshi et al., 2017). As part of the work of the Snow Leopard Trust and its partner organizations, interventions are designed, implemented, and monitored with the active participation and decision-making of community members. In 2017, this included 232 communities engaged in protecting snow leopards over 88,000 km^2 of habitat (Figure 1).

In this paper, we address research and practice gaps around CBC in the context of a human–wildlife conflict by examining the effectiveness of CBC interventions on the reduced likelihood of communities killing snow leopards in retaliation of livestock losses (see Figure 2 for our theory of change).

2 | METHODS

We used long-term data monitoring of key indicators from China, Kyrgyzstan, India, Mongolia, and Pakistan (see Figure 2) to examine the effectiveness of the four interventions collaboratively designed and implemented with local communities, adapted to community needs: reducing the numbers of livestock lost to depredation by collaboratively building or reinforcing livestock corrals against predators (henceforth referred to as "predator-resistant corrals"; Samelius et al., 2021) (see Appendix S2 for examples of predator-resistant corrals), reducing

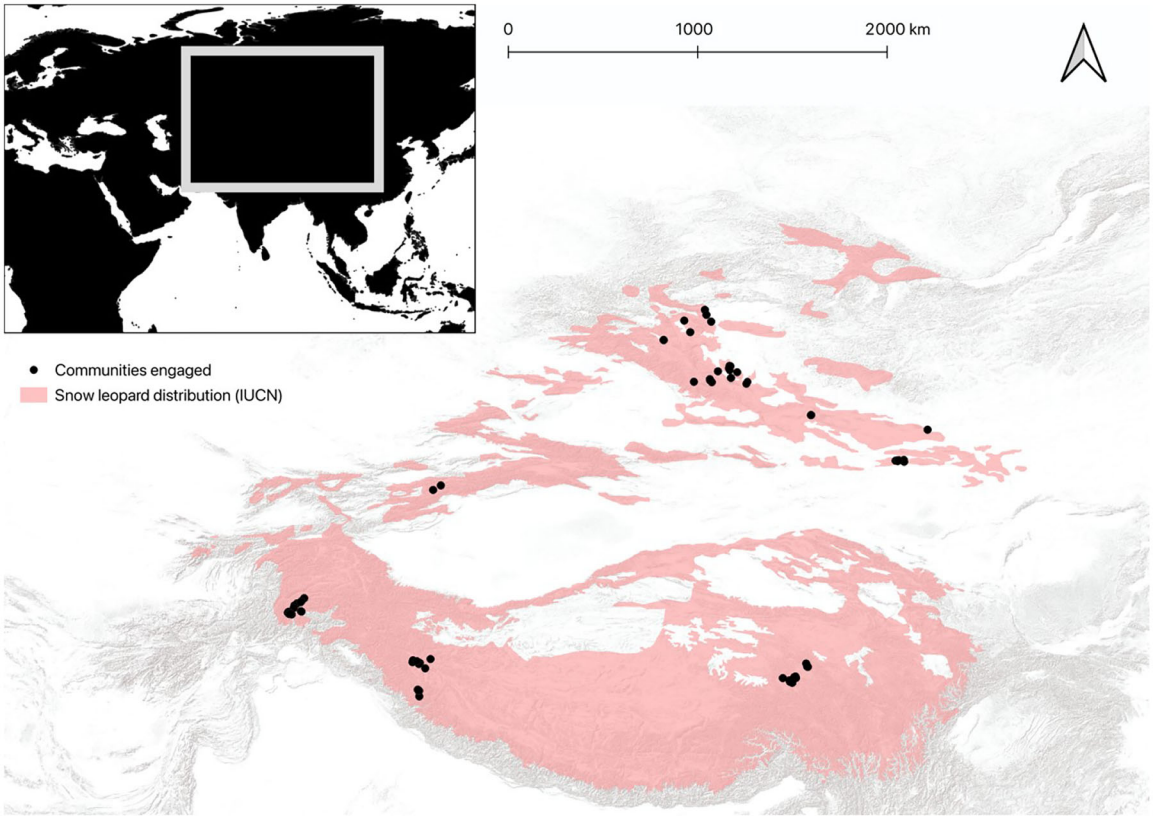

FIGURE 1 Map showing location of community-based conservation interventions in five countries: Spiti Valley in India (32° N; 78° E), Tost in South Gobi, Mongolia (43° N; 101° E), Altai in Mongolia (48° N; 92° E), Hindu Kush-Pamir in Pakistan (36° N; 71° E), Central Tien Shan Mountains in Kyrgyzstan (42° N; 80° E), and Sanjiangyuan in China (31°–36° N, 89°–102° E). Pink areas highlight snow leopard range, and circles represent the communities where interventions were implemented. Communities are defined as "a hamlet or village, a collection of individuals or households who identify themselves as a group, live in the same area, and share systems of local resource use, traditions, and governance" (Mishra et al., 2017, p. 3). These communities together are engaged in protecting snow leopards over 150,000 km^2 of snow leopard habitat.

TABLE 1 Year in which intervention programs started in each intervention country.

Country	Predator-resistant corrals	Handicraft programs	Livestock vaccination	Livestock insurance
China				2015
India	2011	2013		2002
Kyrgyzstan		2003		
Mongolia	2015	2000		2009
Pakistan	2014	2003	2003	2003

Note: The programs initiated in the mentioned years have been active continuously since their inception, operating each year thereafter.

losses of livestock to disease through vaccination (Nawaz et al., 2016), helping people cope with livestock losses through insurance (Mishra et al., 2003), and linking pro-conservation behavior with handicrafts-based livelihood enhancement (Agvaantseren et al., 2016; Young et al., 2021) (Figure 3).

All programs were established at least 3 years prior to the evaluation in 2017 (see Table 1).

Two questionnaires (Appendix S1) were developed, translated, piloted, and implemented in 2017–2018. The first questionnaire focused on corrals, while the second questionnaire addressed other interventions. Specifically, the first questionnaire focused on households with corrals in Mongolia, Pakistan, and India (corrals were not adapted in Kyrgyzstan and China). It gathered information on the type of corral used (predator-resistant or

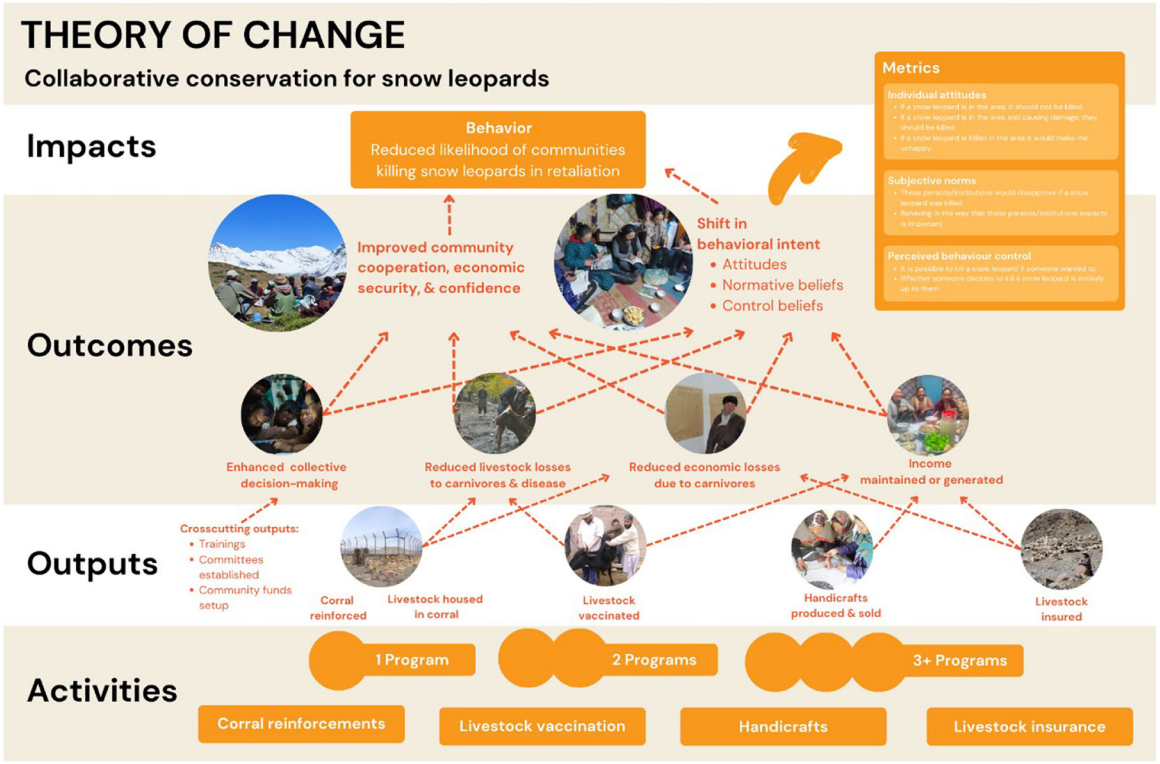

FIGURE 2 Theory of change for collaborative conservation of snow leopards in high Asia. This diagram provides a comprehensive representation of the interrelationships among key activities, outputs, outcomes, and impacts associated with the collaborative conservation approach for snow leopards. The figure highlights the four primary community-based programs, namely, predator-resistant corrals, livestock vaccination, handicrafts, and livestock insurance, which were implemented either as standalone initiatives or in combination (two to three programs) within each community. The measurement of behavioral intent is illustrated in the top right corner box, emphasizing the specific questions asked during the household survey.

traditional corrals), the number and type of livestock corralled, and livestock losses to predators in the last year. The second questionnaire gathered information on age, education, income, participation in interventions, the number of small (goat, sheep) and large (horse, camel, yak, donkey) livestock owned, livestock losses, the effectiveness of specific interventions (perceived effect on income, livestock health, confidence, cooperation, etc.), and information on attitudes, subjective norms, and perceived behavioral control (see Figure 2 for the variables used) based on the theory of planned behavior (TPB) (St John et al., 2010). TPB is used by social psychologists to understand human behavior (Ajzen, 1985) and is based on the premise that the more positive a persons' attitude, subjective norms, and perceived behavioral controls, the higher the likelihood of them enacting the behavior in question (in our case, stopping retaliatory killing of snow leopards) (St John et al., 2010). Questionnaires were developed in close collaboration with country programs following the theory of change expected (Figure 2).

Our aim was to compare responses from households within communities with one or more interventions with responses from households in control communities without any interventions. The selected control communities had similar demographic and economic characteristics within the snow leopard distribution. For both surveys, we used a modified systematic sampling approach to ensure spatial representation of households across the communities and minimize bias related to their locations. We note that some socioeconomic differences may have existed between communities with interventions and those without, given that many, if not most, communities are influenced by site-specific conditions and past conservation history. The sample included 57 communities across five countries. Within each community, respondents were selected from 10 households participating in no conservation intervention, 10 in one intervention, and 10 in two or more interventions. Gender balance was a goal. Key informants, such as the village head, provided information on households' participation in interventions and suggested which households to target to ensure geographical representation, given limited updated maps or information on community distribution, especially for seminomadic communities.

The survey data from both questionnaires were entered into an application (https://www.fulcrumapp.com) and

FIGURE 3 Visual documentation of collaborative conservation programs implemented across five countries: India, Mongolia, Pakistan, Kyrgyzstan, and China. The funding for these conservation programs came from multiple sources listed above and in the acknowledgments section. Designs were locally adapted with inputs from community members. The Non Governmental Organisations (NGO) provided the funding for materials, while community members donated their time and collected locally available materials (such as stones and sand for construction). For handicrafts, the NGO organized trainings of various kinds. Trainers traveled to field sites, and, at other times, participants traveled to central places where trainings were imparted. For vaccines, participants were supported to travel to and receive training in vaccination and basic animal health care at a veterinary university. We continue to visit the predator-resistant corrals and help repair them collaboratively when needed. The partnerships with communities are long term, and do not end as a project comes to an end. The oldest partnerships are more than 25 years now. Each community is different, and there are changes over time. The process and decisions on engagement take place at multiple levels. (i) The focal communities are within the snow leopard landscapes we prioritize for conservation. (ii) Focal communities are located in or close to prime snow leopard habitat. (iii) Our approach involves a long period of communication and trust-building with identified communities before any interventions are started. This can take from a few months to several years. One

(Continues)

FIGURE 3 (Continued)
exception is when we respond to emergency situations (e.g., a snow leopard is trapped, or there is catastrophic livestock mortality), in which case, we jumpstart the relationship with emergency interventions such as predator-resistant corral building or reinforcement or initiating a livestock insurance program. Refer to PARTNERS principles for more details on the approach and process.

TABLE 2 Summary of communities and households (HH) surveyed per country, including those engaged in community-based conservation of snow leopards and "control" HH not engaged in conservation efforts.

Country	Number of communities surveyed	Number of HH interviewed	Number of interventions at interviewed HH		
			0	1	2+
China	6	89	41	29	19
India	15	248	91	116	41
Kyrgyzstan	3	35	15	20	0
Mongolia	11	98	49	41	8
Pakistan	22	353	184	126	43
Total	57	823	380	332	111

Note: The table includes the number of community-based conservation interventions that each surveyed household was involved in (predator-resistant corrals, handicrafts, insurance, and livestock vaccination).

uploaded into a shared cloud. Numbers of questionnaires collected are summarized in Table 2.

2.1 | Analysis

We used Poisson generalized mixed-effects models using the package lme4 in R (Bates et al., 2007) to compare livestock holding and livestock predation across corral types (traditional corrals and predator-resistant corrals) and across herders participating in the livestock insurance programs. For the analysis of corral types, we used "communities" as random effect and "corral type" as fixed effect. Since no livestock were killed in any of the predator-resistant corrals, we randomly added "1" to a randomly chosen predator-resistant corral: the Poisson model could not be fitted in the situation where all counts in one of the groups are zero, and randomly adding a count of one to the group containing all zero counts provides a simple, if conservative, way of adjusting for this (which could underestimate the difference between the corral types, but should not overestimate it). For the analysis of the insurance program, we used "Country" and "Community" (nested in Country) as random effects and participation in the program as fixed effects. We used generalized mixed-effects models to compare livestock holdings and livestock death due to diseases across people participating in the livestock vaccination program in Pakistan. We used "Community" as a random effect and participation in the vaccination program as the fixed effect. We used Poisson distribution for all the generalized mixed-effects models.

To measure behavioral intent, we excluded data from Mongolia due to inconsistencies related to one of the social norm questions. We fitted mixed ordered regression models for ordinal responses using the "clmm" function in the "ordinal" R package (Christensen, 2018; R Development Core Team, 2008). These models fit cumulative link mixed models with one or more random effects via the Laplace approximation or quadrature methods, thereby accommodating random effects such as those needed to account for country- and community-level indices in the questionnaire data structure. The response "intention to kill a snow leopard" was assumed to have an ordered categorical structure, ranging from 3 (*a snow leopard should be killed*) to 15 (*a snow leopard should not be killed*). Gender and age were entered as categorical factors, with age split into three categories (<30, 30–50, and 50+ years). Perceived behavior control scores ranged from 2 (*a person feels unable to kill a snow leopard*) to 10 (*a person feels able to kill a snow leopard*) and were entered in the models as a categorical factor, with all levels compared to the lowest. Finally, social norms scores ranged from −10 (*the opinion leaders would disapprove if a snow leopard was killed*) to 10 (*the opinion leaders would approve if a snow leopard is killed*). Given the large number of categories (21), this variable was entered into models as a numeric integer and treated as a continuous effect. To compare alternative models with different random effect structures, we used likelihood ratio tests to evaluate support in the data.

The final model included main effects for the TPB as well as effects for gender and age of respondents. The model also included random effects for country and community. The importance of including the two random

effects was demonstrated using a likelihood ratio test comparing models with (m2) and without (m1) random effects for both country and community (m1: Log likelihood −1124.9; m2: Log likelihood −1109.6; Chi-squared test *p*-value: <0.001). Similarly, a likelihood ratio test demonstrated better support for a model containing both random effects (m2) over only including an effect for country (m3) (m3: Log likelihood −1112.0; m2: Log likelihood −1109.6; Chi-squared *p*-value: 0.03).

The models used (Poisson generalized mixed-effects models for count data, and mixed ordered regression models for ordinal data) were selected because the distributional assumptions made by these models are appropriate for these forms of data. The Poisson model allows variation to scale with the mean, as we would expect to be the case for count data, while the ordered regression model allows the categories in the ordinal data to correspond to unevenly spaced values of a numeric variable (so avoiding the difficulties associated with treating ordinal data as if they were continuous). In both cases, the use of mixed models permits the inclusion of random effects, which allows the hierarchical structure of the data (community within country) to be accounted for within the analyses, reducing the risk of pseudoreplication. The hierarchical structures assumed by these models are still necessarily relatively simple, with country and community assumed to be the dominant levels of variation; therefore, model assumptions may fail if, for example, there is substantial local spatial dependence or variation over time. The ordered regression models also make an assumption of proportional odds, which may fail if the underlying relationships vary depending on the ordinal class. Note that a lack of a significant result should not be interpreted as evidence against an effect, as nonsignificant effects can also arise due to a lack of statistical power, particularly when sample sizes are low.

3 | RESULTS

3.1 | Corral reinforcement

A total of 107 predator-resistant corrals were implemented across India, Mongolia, and Pakistan (Appendix 2). We interviewed representatives from 139 households from 22 communities, including households with these predator-resistant corrals ($n = 65$) and those with unchanged traditional corrals ($n = 123$). Households reported housing 8426 livestock across both types of corrals (99% of which were the smaller bodied goats and sheep). In 25 different instances, 248 small-bodied livestock were killed by snow leopards or wolves in traditional corrals, a statistically significant finding, while no animals were killed in predator-resistant corrals (Table 3). Although 36 large-bodied livestock were killed in two instances in the traditional corrals and none were killed in the predator-resistant corrals, the difference was not statistically significant (Table 3). Livestock holding was similar across both corral types (Table 3).

3.2 | Livestock insurance

Sixty-six communities involving approximately 1400 households engaged in livestock insurance programs in Mongolia, Pakistan, India, and China. We interviewed representatives of 61 households from 10 communities participating in the community-run livestock insurance programs. Households reported insuring both small (goats, sheep) and large livestock (horse, camel, yak, donkey). These households had insured 90% of their livestock. Out of the 61 household respondents, 80% felt more economically secure (i.e., confident in their financial stability and ability to recover from losses) as a result of the insurance program, and 67% reported increased cooperation within the community due to the program. Predation of both large- and small-bodied livestock was similar irrespective of whether people participated in the insurance program or not (Table 3). Livestock holding of both small- and large-bodied livestock was significantly higher for people who were part of the insurance programs (Table 3).

3.3 | Livestock vaccination

In Pakistan, 170 communities involving over 20,000 households were engaged in the snow leopard friendly livestock vaccination program. Of those, we interviewed 161 households across 15 communities. Ninety-six percent reported the vaccination program was effective or very effective in keeping their livestock healthy. The majority of household respondents agreed that they could keep (57%), sell (54%), or slaughter (52%) more livestock as a result of the vaccination program. The majority of the respondents (61%) reported increased cooperation within the community due to the program. Household respondents reported owning more and losing less large-bodied livestock to disease compared to nonparticipating households ($n = 193$; Table 3). There was no difference in small-bodied livestock ownership or mortality to disease between participating and nonparticipating households (Table 3).

3.4 | Handicrafts

A total of 473 households (56 Kyrgyzstan, 84 Pakistan, 276 Mongolia, 57 India) were engaged in the

TABLE 3 Coefficients of Poisson generalized mixed-effects models and corresponding *p*-values testing the effects of the predator-resistant corral reinforcement, livestock insurance, and livestock vaccination for conservation programs in China, India, Kyrgyzstan, Mongolia, and Pakistan designed to reduce small-bodied (goat and sheep) and large-bodied (horse, camel, yak, donkey) livestock losses to carnivores or disease.

Conservation program	Small-bodied livestock killed by carnivores or diseases[e] (coefficient; *p*-value)	Large-bodied livestock killed by carnivores or diseases[e] (coefficient; *p*-value)	Model structure
Corral reinforcement[a]	3.88 (0.0002)	−1.73 (0.45)	Fixed effect: Corral type (predator-resistant corrals vs. traditional corrals); Random effect: Community; Family: Poisson
Livestock insurance[b,c]	0.008 (0.96)	0.20 (0.18)	Fixed effect: Participation in insurance program; Random effect: Country/community; Family: Poisson
Livestock vaccination[d]	−0.08 (0.81)	−1.63 (<0.005)	Fixed effect: Participation in vaccination program; Random effect: Community; Family: Poisson

Note: The *p*-values were interpreted at alpha of 0.004 (adjusted for 12 multiple comparisons including the six presented in Appendix S3).

[a]The predator-resistant corral reinforcement program was implemented in India, Mongolia, and Pakistan.

[b]We do not have data on livestock holding from Mongolia.

[c]Livestock insurance program was implemented in China, India, Mongolia, and Pakistan

[d]Vaccination program was implemented only in Pakistan

[e]For predator-resistant corrals and insurance, we compare mortality due to predation by carnivores, and for vaccination program, we compare mortality due to diseases.

TABLE 4 Average earnings for households from local communities in conservation-linked handicrafts program per household per year in Pakistan, Mongolia, Kyrgyzstan, and India (all figures in USD).

	Average earning per household/year		
	Year 1	Year 2	Year 3
Pakistan	39	13	15
Mongolia	145	110	112
Kyrgyzstan	74	171	97
India	15	35	21

conservation-linked handicrafts program during the study period. In addition to producing and selling handicrafts, participants refrained from hunting in the surrounding areas, aligning with the program's conservation principles. This connection defines the program as "conservation linked." The program generated a livelihood contribution ranging between $15 and $171 per household per year (Table 4). The handicraft products generated between $38,587 and $47,214 per year, which was distributed back to the participant households. Additionally, participants received bonuses for their compliance with conservation measures, which included refraining from hunting snow leopards in the area. Bonuses for conservation compliance distributed back to participants amounted to $9062–$10,046 each year (Agvaantseren et al., 2016; Agvantseren et al., 2016; Alexander et al., 2022). We interviewed 73 household respondents participating in the handicrafts program. Eighty-four percent agreed that household income had increased as a result of the program; 85% reported that they felt more confident since joining the scheme; and 74% felt that the scheme had led to increased cooperation within the community.

3.5 | Behavioral intent

Of the 824 household interviews, 552 complete responses were used for the analysis of the behavioral intent toward snow leopards. These responses covered 54 different communities in four countries (China: 73; India: 169; Kyrgyzstan: 25; Pakistan: 247). Of the respondents, 233 were involved in no conservation intervention, 245 in one

TABLE 5 Results for effects of theory of planned behavior (TPB) on local community respondents' intentions to kill snow leopards in four countries.

	Estimate	*SE*	*z*-value	*p*-value
Gender (male)	0.889	0.188	4.742	<0.001*
Age (<30)	0.689	0.248	2.772	0.0056*
Age (30–50)	0.295	0.191	1.540	0.123
Social norms	−0.069	0.017	−4.192	<0.001*
1 scheme	0.432	0.197	2.192	0.028*
2+ schemes	0.501	0.299	1.675	0.094
Perceived behavioral control [10]	−1.070	0.332	−3.225	0.0013*
Perceived behavioral control [9]	−0.786	0.351	−2.239	0.025*
Perceived behavioral control [8]	−0.563	0.509	−1.106	0.269
Perceived behavioral control [7]	−0.253	0.429	−0.589	0.556
Perceived behavioral control [6]	0.101	0.241	0.420	0.674
Perceived behavioral control [5]	−0.409	0.349	−1.172	0.241
Perceived behavioral control [4]	−0.184	0.328	−0.562	0.574
Perceived behavioral control [3]	−0.427	0.349	−1.225	0.220
Random effect	Variance	*SD*		
Community	0.1185	0.3442		
Country	0.00	0.00		

Note: Since killing snow leopards is illegal and is therefore hard to measure, TPB provides a way to understand potential behavior by quantifying attitudes, norms, and behavioral intent. * means significant at the P⟨0.05 level

intervention, and 74 in two or more interventions. In general, male respondents reported significantly lower intentions to kill snow leopards than did females (estimate = 0.889, $SE = 0.188$, $z = 4.742$, $p < 0.001$). Younger respondents (age <30) reported significantly lower intention to kill snow leopards than did older respondents (age 50+) (estimate = 0.689, $SE = 0.248$, $z = 2.772$, $p = 0.0056$), and there was a tendency for respondents from the middle age category (age 30–50) to have lower intentions to kill snow leopards compared to the oldest respondents (age 50+), but this was not a significant effect (estimate = 0.295, $SE = 0.191$, $z = 1.540$, $p = 0.123$) (Table 5). Respondents who thought their opinion leaders would approve if a snow leopard were killed were likely to have significantly greater intentions to kill snow leopards (estimate = −0.069, $SE = 0.017$, $z = -4.192$, $p = 0.001$). Respondents with higher perceived behavioral control (indicating the person felt relatively able to kill a snow leopard) reported significantly higher intentions to kill snow leopards compared to respondents with the lower perceived behavioral control. This was true for the two highest score categories (*Perceived behavioral control [10]*: estimate = −1.032, $SE = 0.322$, $z = -3.205$, $p = 0.001$; *Perceived behavioral control [9]*: estimate = −0.907, $SE = 0.355$, $z = -2.555$, $p = 0.011$) (Table 5).

Respondents involved in at least one conservation intervention reported significantly lower intentions to kill snow leopards than those not involved in any intervention (estimate = 0.432, $SE = 0.197$, $z = 2.192$, $p = 0.028$). Respondents involved in two or more interventions similarly reported lower intentions to kill snow leopards compared to those not involved in any intervention (estimate = 0.501, $SE = 0.299$, $z = 1.675$, $p = 0.094$), but this effect was not significant, likely due to the lower number of respondents involved in two or more interventions (74/552).

4 | DISCUSSION

The relative effectiveness of CBC approaches, especially in situations where human–wildlife conflicts occur, is debated, and there have been calls for further research on the effectiveness of these approaches (Redpath et al., 2017; López-Bao et al., 2017). Overall, our findings suggest that a collaborative, large-scale community-based approach is effective in terms of direct outcomes, such as reducing losses of penned livestock to predators, reducing livestock mortality from disease, and providing women with an additional source of income. In terms of the more indirect effects, interventions also help generate cooperation, economic security, and confidence (see also Young et al., 2021), and respondents participating in one or more conservation interventions have significantly lower intentions to kill snow leopards than those not participating.

While the interventions had a positive overall positive effect on snow leopard conservation, enhancing

behavioral intent, community cooperation, economic security, and confidence, it is important to acknowledge that the relationship between behavioral intent and actual behavior change, as well as its direct influence on snow leopard viability, remains uncertain. The Snow Leopard Trust implements long-term camera trapping in specific sites where CBC programs are present to monitor snow leopard populations and populations remain stable (Davletbakov et al., 2016; Sharma et al., 2014, 2021). However, determining the direct effect remains challenging. Participants who chose to engage in interventions may have already possessed lower intentions to kill snow leopards, which could influence the observed effects. Without preintervention data, causal inferences should be made cautiously.

We also acknowledge the limitations inherent in self-reported data and perceptions of intervention effects, including biases and the potential influence of being selected as a recipient of an intervention. Additionally, the performance of CBCs relative to other forms of protection is still an area that requires further investigation.

Our results do provide lessons learned and recommendations for conservation practitioners and governments, including a need to focus on locally led tailored solutions, recognizing local community rights in conservation decision-making, and acknowledging the role of social norms in ensuring accountability.

The first is the need to develop and promote locally led tailored solutions. The effectiveness of future community-based approaches depends upon conservationists understanding the societies they work with, their traditions, value orientations, and their institutions (Baral, 2012; Brooks et al., 2013; Brooks, 2017; Waylen et al., 2010; Nilsson et al., 2016; Van Eeden et al., 2018). As such, interventions in this paper varied across the snow leopard range, considering specific threats and the distinct needs of communities and various socioeconomic groups within them. Multiple interventions were used to address these needs, resulting in lower intention to harm snow leopards among participants participating in two or more interventions. Notably, our CBC programs have continued to expand in 2022, incorporating up to six interventions in certain communities, and reflecting an even greater diversity of programs (e.g., beekeeping and tourism). These interventions were developed based on long-term relationships with communities, following the PARTNERS principles approach (Mishra et al., 2017; Young et al., 2016). We recommend conservationists adopt the PARTNERS principles in the future for effective and morally defensible conservation programs (Camino et al., 2023).

The second is the need for local ownership and engagement with community organizations and decision-making institutions—as emphasized in the recent Kunming–Montreal Global Biodiversity Framework. The CBC programs discussed in this paper promoted collective decision-making by establishing local committees and locally led governance structures to oversee program implementation and monitoring (Alexander et al., 2021, 2022; Mishra et al., 2016). Our findings indicate that this approach positively influenced intracommunity cooperation toward conservation. In light of this, policy recommendations could focus on strengthening legal rights to land and natural resource use, bolstering the capacity of local institutions, and supporting local enterprises to develop contextually appropriate solutions (Mishra et al., 2023).

Finally, our case study underlined the presence and strength of social norms around conservation, which gave weight to the views of other members of the community (St John et al., 2010). The social costs of killing snow leopards were evident, as this was reported to lead to negative reactions from community leaders, religious institutions (e.g., monasteries), law enforcement, and other community members. Attention to these wider social norms and such informal accountability are not always in place in CBC programs. The loss of support to a CBC program by influential institutions or members of the community represents another example of the crucial role of trust and accountability in the long-term success of CBC initiatives (Balint & Mashinya, 2006; Baral & Stern, 2011; Davis and Goldman, 2019; Young et al., 2016).

To conclude, the overarching objective of the interventions described in this paper is to foster resilience in coexisting with snow leopards. However, it is crucial to acknowledge that this resilience occurs in a dynamic context (Carter & Linnell, 2023). For example, climate change poses challenges to this coexistence. Therefore, it becomes imperative to expand efforts and support communities not only in addressing direct threats to carnivores but also in addressing a wide range of potential challenges. Building resilience against these future changes through respectful, tailored, and long-term interventions should be a key consideration moving forward.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data generated and analyzed during this study are stored in the shapefile format, along with associated data in tabular form, on the Global Snow Leopard Ecosystem Protection Program GIS repository. This repository is openly accessible through the following link: https://snowleopard.maps.arcgis.com/home/gallery.html. Please note that all GIS coordinates for China only represent a generic point in the country and do not point to specific survey locations due to legal restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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