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Conservation Ecology of the Critically Endangered Baluchi Asiatic Black Bear in Iran

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Abstract: This study evaluates conservation gaps of the critically endangered Baluchi Asiatic Black Bear (*Ursus thibetanus gedrosianus*) in Iran. The project encompassed habitat and conflict assessment, diet analysis, and local community engagement over 16 months. In addition to community-based activities conducted in southern Iran and key locations within the species' range, previous research on this subspecies over the past two decades was reviewed to identify conservation priorities and knowledge gaps. Observations from fieldwork, including camera trapping and indirect evidence, provide preliminary insights into activity patterns and possible movement pathways; however, they are based on limited, non-systematic data and should be interpreted with caution. Mineral extraction activities, particularly chromium mining, were identified as significant threats, with several operations located within or near core habitat areas. Community participation and awareness in areas surrounding critical habitats appear to play an important role in conservation efforts, highlighting the need to strengthen local capacity and support sustainable livelihoods. While habitat restoration and water availability are widely recognized in the literature as important factors in arid ecosystems, their effects on habitat connectivity and human–bear conflict were not directly assessed in this study. Overall, the results provide indicative ecological and socio-economic insights and highlight the potential value of community-based conservation approaches in arid environments while emphasizing the need for more rigorous quantitative and long-term studies.

Keywords: Activity pattern, dietary analysis, human-larg carnivores conflicts, Hormozgan province, Iran.

İran'da Kritik Derecede Tehlike Altındaki Beluçistan Asya kara (Siyah) Ayısının Koruma Ekolojisi

Öz: Bu çalışma, Beluçistan Asya kara (Siyah) Ayı'sının (*Ursus thibetanus gedrosianus*) İran'daki koruma açıklarını değerlendirmektedir. Araştırma, 16 ay süresince habitat ve insan-yaban hayatı çatışması değerlendirmeleri, beslenme analizi ve yerel topluluk katılımını kapsamaktadır. Türün yayılış alanı içerisindeki önemli bölgeler ile güney İran'da yürütülen topluluk temelli faaliyetlere ek olarak bu alttür üzerine son yirmi yılda gerçekleştirilen çalışmalar incelenerek koruma öncelikleri ve bilgi boşlukları belirlenmiştir. Arazi çalışmaları kapsamında elde edilen gözlemler, kamera tuzakları ve dolaylı bulgular aracılığıyla türün aktivite örüntüleri ve olası hareket yollarına ilişkin ön bulgular sunmaktadır; ancak bu veriler sınırlı ve sistematik olmayan örneklemeye dayandığından dikkatli yorumlanmalıdır. Özellikle krom madenciliği olmak üzere mineral çıkarım faaliyetleri, çekirdek habitat alanlarının içinde veya yakınında konumlanan işletmeler, önemli tehditler arasında belirlenmiştir. Kritik habitatların çevresindeki alanlarda yerel toplulukların katılımı ve farkındalığı, koruma çabalarında önemli bir rol oynamakta olup yerel kapasitenin güçlendirilmesi ve sürdürülebilir geçim kaynaklarının desteklenmesi gerekliliğini ortaya koymaktadır. Kurak ekosistemlerde habitat restorasyonu ve su varlığının önemi literatürde yaygın olarak vurgulanmakla birlikte, bu faktörlerin habitat bağlantılılığı ve insan-ayı çatışması üzerindeki etkileri bu çalışmada doğrudan değerlendirilmemiştir. Sonuç olarak, elde edilen bulgular, ekolojik ve sosyo-ekonomik açıdan gösterge niteliğinde bilgiler sunmakta ve kurak ortamlarda topluluk temelli koruma yaklaşımlarının potansiyel değerini ortaya koyarken daha kapsamlı nicel ve uzun dönemli çalışmalara duyulan ihtiyacı vurgulamaktadır.

Anahtar kelimeler: Aktivite modeli, beslenme analizi, insan-büyük etobur çatışmaları, Hormozgan, İran.

1. Introduction

The Asiatic black bear (*Ursus thibetanus* subsp. *gedrosianus* Blanford, 1877), classified as Critically Endangered in Iran, faces multiple and interacting conservation challenges including habitat loss, climate change, and increasing human–bear conflicts. The Baluchi subspecies has a restricted and fragmented distribution, primarily confined to southeastern Iran and adjacent regions of Pakistan, representing the westernmost and one of the most isolated populations of the species (Yusefi et al., 2020). In Iran, its occurrence is largely limited to arid and semi-arid mountainous landscapes in provinces such as Hormozgan, Kerman, and Sistan and Baluchestan, where populations are small, patchily distributed, and increasingly vulnerable to environmental and anthropogenic pressures. This restricted range, combined with climate-induced drought and habitat fragmentation, limits both dispersal and access to natural food resources.

Previous studies have highlighted the importance of habitat connectivity and landscape structure for the persistence of these fragmented populations. For example, Almasieh et al. (2016) identified key habitat cores and

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corridors in southeastern Iran, emphasizing the role of connectivity in maintaining viable populations. In Hormozgan Province, the species relies heavily on both cultivated and wild fruits, particularly date palms (*Phoenix dactylifera*), which increases its exposure to human-dominated landscapes and associated risks (Ghadirian & Pishvaei, 2014). Other studies have documented severe fragmentation of bear populations into small, isolated patches, underscoring the need for integrated conservation strategies that combine habitat management with community engagement (Ahmadzadeh et al., 2008). Recent landscape-level analyses have further demonstrated the influence of environmental variables, such as humidity, on habitat suitability and connectivity, revealing spatial heterogeneity across regions such as Bahr Asman and Zaryab in Kerman Province (Ruholamininejad et al., 2022). In addition, phylogeographic research has shown that the Baluchi subspecies represents a distinct and highly vulnerable lineage, with remaining populations largely confined to areas near the Iran–Pakistan border (Yusefi et al., 2020). Beyond its conservation status, the Asiatic black bear plays an important ecological role in arid and semi-arid ecosystems. In southeastern Iran, the species contributes to seed dispersal, particularly of date palm and other plant species such as *Nannorrhops ritchiana*, *Ziziphus* spp., and *Moringa peregrina* (Sayedi et al., 2022). These interactions highlight the species' functional importance in maintaining vegetation dynamics and ecosystem processes, especially in environments with limited plant regeneration capacity.

Despite these advances, significant knowledge gaps remain regarding the integration of ecological observations with socio-economic dynamics and community-based conservation practices. Climate change is expected to further alter habitat suitability and distribution patterns, increasing the urgency for adaptive and locally grounded conservation strategies (Farashi & Erfani, 2018). Similarly, the application of multi-criteria approaches for habitat modelling and conservation prioritization has been recognized as important but remains limited in practice (Rahdari et al., 2017). In this context, the present study aims to provide descriptive insights into the activity patterns, diet composition, and key conservation challenges of the Baluchi Asiatic black bear while also examining ongoing community-based conservation efforts. Rather than testing formal ecological hypotheses, the study focuses on identifying practical conservation gaps and highlighting opportunities for integrating ecological knowledge with local stakeholder engagement in arid landscapes.

2. Material and Method

The project was conducted over 16 months (December 2023–April 2025) in the Rudan area where habitat fragmentation is pronounced. The study followed an applied, community-based conservation approach aiming to integrate ecological observations with stakeholder engagement rather than to test formal ecological hypotheses. To support this approach, three face-to-face workshops and a series of village-level meetings were organized that involved 68 participants from seven villages including residents, representatives of government agencies, NGOs, local businesses, and researchers. Participants were selected using a purposive sampling strategy to ensure the inclusion of both conflict-affected households and community members without direct conflict experience, thereby capturing a range of perspectives. Stakeholder roles and responsibilities were explored using a structured roles-matrix framework. Participatory facilitation methods, including World Café, Fishbowl, and Pro-Action Café formats, were used to guide structured group discussions on conservation challenges and potential solutions.

The project adopted a co-management framework from design to dissemination, combining local knowledge with scientific information within a theory-of-change approach. Interdisciplinary input from sociologists and economists supported community engagement and ensured representation across gender and age groups. To reduce recall and reporting bias, discussions of threats and conflicts were limited to events occurring within the previous 12 months. Information was cross-checked among participants where possible and contributions were recorded anonymously during plenary sessions. Awareness of ecological and socio-economic values of ecosystem services was promoted through training sessions, field excursions, camera-trapping demonstrations, and species-identification activities as well as community events such as local festivals and competitions. In parallel, the project encouraged local stakeholders, including businesses and authorities, to incorporate biodiversity information into decision-making processes, linking conservation activities with local livelihood opportunities (Fig. 1).

Figure 1. A part of awareness is increasing about the Asiatic Black Bear status in Iran

To identify broader conservation gaps, a structured literature review was conducted using Google Scholar, Scopus, Web of Science, and national databases. Searches included keywords such as "black bear", "black bear Iran", and equivalent terms in Persian. Relevant studies published in both English and Persian over the past two decades were compiled and reviewed to contextualize the field findings.

Field data collection included camera trapping and recording of indirect signs to document species presence, activity patterns, and habitat use. Five camera traps were deployed across four seasons at locations selected based on prior evidence of bear activity (e.g., tracks, trails, and proximity to potential den sites). Cameras were placed opportunistically rather than through a systematic sampling design and therefore results are interpreted as descriptive rather than representative of the wider population. In addition to camera trap records, indirect evidence such as tracks, scat, and damage to agricultural areas was recorded to support presence data. With the assistance of local communities, potential den sites were identified and examined to assess their structure and use. Observations focused on determining whether bears utilized natural cavities or excavated dens; however, these observations were limited in number and are presented as exploratory.

2.1. Diet Analysis

During the project fieldwork at the Rudan area from the end of 2023 to April 2025, 63 scat samples were collected. Collected samples were weighed using a digital balance (to the nearest 0.1 gr), placed in separate zipped plastic bags, labeled with unique codes, and stored in a portable -20° °C fridge until processing at the lab. Scat samples were dried out using an oven and weighed with an accuracy of 0.01 g afterwards. The collected scat samples were then diluted to a volume of 300 ml, soaked for three days, washed with distilled water, and passed through 0.5 mm sieves. The remaining samples were dried using paper towels and then weighed and analyzed for food items. Dietary content was identified to the finest taxonomic resolution possible using standard macroscopic and microscopic methods. Dietary indices were used to describe patterns of diet composition across seasons. No formal statistical tests were conducted to evaluate seasonal differences and results are interpreted descriptively. Food items have been identified using identifiable parts of prey, such as hair, bone, skin pieces, feathers, and partially digested plant materials like fruits, seeds, and twigs. To better identify undigested prey items, reference plant and insect materials were collected from the area of the scat collection.

Scat samples were then analyzed using the frequency of occurrence (FO) to determine each prey item's consumption rate and importance (Breuer, 2005; Klare et al., 2011). This index is calculated by dividing the number of observations of prey (n_i) by the total number of Scats (N) multiplied by 100 (Eq. 1) (Klare et al., 2011). Although this method leads to useful and practical information, it may produce biased results by giving higher importance to small prey when the consumed preys have different body sizes (Sharbafi et al., 2016). The percentage of occurrence (PO) was measured by adding the number of observations obtained from species I (c_i) to the total observations I.

Eq. 1- $$Fo_i = 100\, n_i \,/\, N$$

Eq. 2- $$Po_i = 100\, c_i \,/\, C$$

The relative volume (RV) percentage was used to provide a comparative estimate of the volumetric contribution of different dietary items. RV was assessed using both graduated cylinder and graph paper methods following Klare et al. (2011). The use of two approaches aimed to increase measurement reliability and minimize potential bias associated with each method. Both methods provided consistent estimates and final RV values were derived based on averaged or cross-validated measurements rather than as separate analytical comparisons.

Eq. 3. $$Rv_i = 100\, n \,/\, N$$

The standardized Levins and Shannon–Wiener indices were used to estimate trophic niche breadth of the Asiatic black bear population (Krebs, 1998; Krebs, 1999). The Shannon-Wiener index provided a non-dimensional measure of diversity and results biased toward rare and less-consumed species. Eq. 4 shows the Shannon–Wiener index (H), where pj is the proportion of prey item j in the diet. This unstandardized index is not bounded between 0 and 1; instead, its maximum depends on the number of dietary categories included (Krebs, 1998).

The Shannon-Wiener index tends to overestimate rare species. To avoid this bias, Levin's index (L) was calculated. This index measures the uniform distribution of various prey items in the species' diet and is not sensitive to rare prey species (Krebs, 1999). Eqs. 5 and 6 represent the simple and the standardized (Ls) Levin's index. The basic Levin's index (L) is not bounded between 0 and 1, whereas the standardized form (Ls) ranges between 0 and 1 (Krebs, 1999).

Eq. 4- $$H = -\sum pi\ (\ln pi)$$

Eq. 5- $$L = 1/ \sum pi2$$

Eq. 6- $$Ls = (L - 1)/(n-1)$$

2.2 Activity Pattern Analysis

The temporal activity patterns were investigated using data from five positioned camera traps (36 photos) within the study area and also photo events collected by other researchers (15 photos). Camera trap events were compiled from a text file that recorded the timing of independent images of species. Time values were converted from standard time format to radians, allowing for a suitable application of circular statistics (Naderi et al., 2021). The activity profile was categorized based on the extracted timestamps. Statistical analyses were performed using the R programming language (R Core Team, 2022) with the circular package employed to facilitate a rigorous evaluation of activity overlap. In the study area, five cameras were deployed at different stations with a distance of more than 5 km between each station. Circular statistics were used to explore whether activity times differed from a uniform distribution. For each dataset (our cameras and the combined dataset including external photos), Rayleigh's test of uniformity was applied using the circular package in R. When appropriate, Watson's U^2 test was also used to compare activity distributions between seasons. Given the modest sample size and non-random placement of camera traps, these tests are interpreted as descriptive support for observed activity patterns rather than as definitive inference. In addition, Rayleigh's test assumes unimodal clustering and alternative approaches such as Rao's spacing test may provide a more robust assessment where this assumption is not met.

2.3. Threats Analysis

Semi-structured questionnaires were designed to collect data on the main threats to the species and to evaluate people's awareness about the species in the study area. In face-to-face interviews, we collected data on the attitude of local people to black bears, the status of human-black bear conflict, the extent of crop damage and livestock damage caused by the species, and the socioeconomic status of the nearby communities. Since the number of residents at the village was small, I tried to contact most of the people personally, especially those who suffered from bear damage to their property. Both open- and closed-ended questions have been included in the questionnaires to obtain information about human-bear conflicts and interactions in the study area. All targeted farmers and local villagers were selected randomly to avoid any bias in data collection. Descriptive statistics and the Pearson chi-square test were used for the analysis of the collected data. Responses to closed questions were summarized with descriptive statistics (proportions and 95% confidence intervals). Pearson's chi-square tests were used to explore associations between categorical variables (e.g. respondent occupation, gender, history of crop damage, and attitudes toward bears). Given the small, non-random sample, these tests are interpreted cautiously and are used to indicate possible patterns rather than to draw population-level inferences.

3. Results

Over one year, 1,900 camera trap nights detected approximately 51 photo events from Asiatic Black bears in Hormozgan Province. Activity time analysis indicated that the species prefers to be active at sunset and sunrise, and less activity is observed during the day (Fig. 2). Rayleigh tests confirmed that bear activity times were significantly clustered around crepuscular periods ($Z = 4.3$ $p < 0.05$) rather than uniformly distributed across the day. Confidence intervals for the circular mean overlapped between seasons; thus, we do not claim strong seasonal shifts in activity. The presence of activity signs during the winter period provides preliminary evidence that some individuals may remain active during this time. I also recorded and measured four active dens, indicating that all of the recorded dens are natural cavities under the rocks. No excavated dens have been recorded during the study period. One case of an attack on humans and one accidental mortality was also been recorded. After collecting accessible published papers in various national and international databases, 13 scientific papers have been recorded, focusing on the species in Iran.

This study involved the participation of more than 60 local volunteers, with ten families engaged in producing handmade crafts as part of the community-based component. Survey responses suggested an increase in local awareness of bear ecology compared to baseline perceptions and a decrease in reported conflicts was observed during the project period. Children from primary and secondary schools participated more actively than adults.

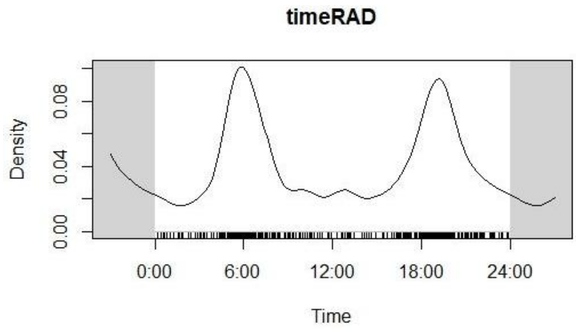

Figure 2. Black bear activity pattern based on the camera trap events

Field observations indicated increased bear detections in areas where habitat restoration and community-based activities were implemented; however, no formal spatial or connectivity analyses were conducted and thus no conclusions can be drawn regarding changes in habitat connectivity. Similarly, the use of native vegetation was observed to provide potential food resources and shelter. However, habitat quality was not quantitatively measured in this study and these observations should be interpreted cautiously. A reduction in reported conflicts was observed during the project period; yet, no standardized or statistical analysis was conducted to evaluate changes over time or to assess relationships with specific interventions such as water provisioning or habitat management. Therefore, these patterns should be considered indicative rather than causally supported.

The community-based livelihood component appeared to support local engagement and increased ecological awareness was observed among participants. Maintaining long-term habitat management and sustained stakeholder engagement remain key challenges. Overall, the findings highlight the potential value of combining ecological and socio-economic approaches in conservation programs in arid environments while emphasizing the need for more rigorous quantitative and long-term assessments.

3.1. Dietary Findings

This study identified that items in the processed scats can be classified as fruits, such as various members of *P. dactylifera, Nannorrhops ritchiana, Ziziphus sp. Pistacia atlantica, Ficus carica, Morus alba, Moringa peregrina.* Based on the food items frequency analysis, 86 percent of the scat contents were plant materials and 12 percent animal remains such as birds' feathers, small mammals' teeth, and two percent of various insects, especially ants and beetles. The width of the trophic niche showed limited variation across seasons based on descriptive indices. The highest values were observed during the summer period ($B = 1.32$) followed by a gradual decrease during fall ($B = 1.10$) and lower values in autumn ($B = 1.02$). However, no formal statistical comparisons were conducted to evaluate seasonal differences. This reduction in width coincided with a decrease in the availability of several fall season food sources leading bears to intensively focus on two or three high-calorie nutrition sources such as *P. dactylifera, Nannorrhops ritchiana, Ziziphus* sp. *Pistacia atlantica*. Overall, Levin's index remained relatively low, primarily due to the dominance of specific food items during each seasonal period. Despite the diversity of food items consumed, each season had its predominant foods, constituting the majority of the diet, consequently lowering the index values. Levin's index remained relatively low, reflecting the dominance of particular food items within each seasonal period. Although a variety of food items was recorded, each season was characterized by a few predominant components that contributed most to the diet, resulting in lower niche breadth values. The Shannon index also varied across seasons with higher values observed during late spring and summer ($H' = 2.11$) and lower values during early spring and late fall ($H' = 1.21$). However, these values are presented descriptively and no statistical analyses or measures of uncertainty were applied to evaluate seasonal differences; therefore, these patterns should be interpreted cautiously. The bear's food range showed variation across seasons based on descriptive indices with lower overlap between summer and spring–fall periods (Pianka's index $\alpha = 0.28$) compared to spring–summer ($\alpha = 0.61$). These values indicate potential seasonal shifts in diet composition; however, no inferential statistical tests were applied to assess the significance of these differences. Diets in the spring and fall periods showed relatively low overlap ($\alpha = 0.31$) suggesting differences in diet composition; however, these observations are descriptive and were not tested statistically.

3.2. Main Threats

Chromium mining and sand harvesting were identified as key potential threats based on field observations and stakeholder interviews. Several mining operations were observed within or near areas used by bears, suggesting possible disturbance to habitat use; however, no quantitative spatial or statistical analyses were conducted to assess their impact. Local communities reported increased bear presence in rural gardens and farms, which may be associated with changes in habitat conditions, although this relationship was not formally tested. Interviews with local residents and conservations with authorities also indicated that recent severe drought may represent an additional pressure on the species, potentially affecting the availability of natural food and water resources. Climate-related changes in precipitation patterns were reported to be associated with reductions in wild fruit production and prey availability; however, these observations are based on local knowledge and were not quantitatively assessed in this study. Descriptively, households that had experienced crop damage reported more negative attitudes toward bears than households without recent damage. However, chi-square tests did not detect statistically significant differences at the 0.05 level, likely reflecting the limited sample size.

4. Discussion

The findings of this study highlight the critical conservation needs of the critically endangered Asiatic Black Bear (*Ursus thibetanus gedrosianus*) in Iran by emphasizing habitat connectivity, community involvement, and threats from human activities. Observations from this study indicated increased bear detections in the areas where habitat restoration and water-related interventions were implemented. However, no spatial analyses or movement-based assessments were conducted to evaluate habitat connectivity and therefore no conclusions can be drawn regarding changes in connectivity at the landscape scale. Connectivity is inherently a spatial property that requires dedicated modeling approaches, which were beyond the scope of this study. As a result, the observed patterns should be interpreted as preliminary and indicative rather than as evidence of improved connectivity. Future research incorporating spatial modeling and long-term monitoring would be necessary to evaluate the effects of habitat restoration and resource availability on connectivity and movement patterns of the species (Almasieh et al., 2016; Ghadirian et al., 2017). The identification of the key habitat cores and corridors in previous studies (e.g., Almasieh et al. 2016) illustrates the fragmented nature of the population's distribution, underscoring the urgent need for effective landscape connectivity to prevent further genetic isolation and decline consistent with global studies (McRae et al., 2008).

Camera trapping revealed active use of natural caves and den sites, with three sites providing insight into key activity patterns. The high activity during dawn and dusk, with peak occurrences during crepuscular hours, corroborates previous findings (Hwang & Garsheliset, 2007) that this species is predominantly nocturnal, likely as an adaptive response to reduce human conflicts. The conservation implication is that protection measures should consider these activity patterns with rangers and local authorities prioritizing monitoring and protection during these critical periods. The natural dens located under rocks and within caves are vital refuges, supporting earlier research that emphasizes the importance of these microhabitats for survival (Ghadirian et al., 2017). The study's observations suggest that these dens, especially in rugged mountainous terrain, are crucial for breeding and shelter and their protection should be integrated into conservation planning, echoing the importance of microhabitat conservation highlighted in other regional studies (Ahmadzadeh et al., 2008).

Diet analysis confirmed the key role of cultivated and wild fruits, especially date palms (*Phoenix dactylifera*), which contributed overwhelmingly to the bears' diet—up to 94.8% frequency in scat samples. These findings are consistent with prior ecological studies in southeastern Iran (Sayedi et al., 2022), which demonstrated the bears' dependence on date palms during summer and autumn. The high seed germination rate observed (average 12.6 seeds per scat) indicates an effective seed dispersal role, emphasizing the bear's ecological function as a keystone species promoting forest regeneration in arid environments (Rogers & Applegate, 1983; Willson & Gende, 2004). As other studies indicate, the dispersal of other species, such as *Nannorrhops ritchiana*, *Ziziphus* sp., and *Moringa peregrina*, further supports the concept that this species maintains vital ecological relationships critical to ecosystem stability (Valido & Nogales, 1994; Campos & Ojeda, 1997).

The threats identified—particularly habitat degradation near mineral mines such as chromium—and the ongoing drought exacerbate the challenges faced by the population. The proximity of mining activities to core habitats, notably in areas like Bahr Aseman and Zaryab, has contributed to habitat destruction and fragmentation, driving the bears toward agricultural areas where conflicts with farmers and herders are frequent. These findings reinforce earlier assessments (Fahimi et al., 2010; Ghadirian & Pishvaei, 2014) that emphasize habitat loss and human-wildlife conflict as primary threats. The drought's impact on water sources, prey availability, and vegetation cover further reduces habitat quality that aligns with previous climate impact predictions for similar arid ecosystems (Farashi & Erfani, 2018; Ripple et al., 2014).

Previous studies of habitat models, especially under future climate scenarios (notably RCP 8.5), predict a significant reduction in suitable areas, predominantly in low-altitude zones and along landscape bottlenecks such as passes and plains. These zones, identified by circuit theory analysis, are critical corridors where movement and gene flow are most vulnerable. The potential for habitat corridor collapse, as shown by decreased current flow and increased resistance in the models, threatens the long-term viability of these small populations. Similar patterns of habitat constriction have been documented in other small or isolated bear populations worldwide (McRae et al., 2008; Kadariya et al., 2018) emphasizing that maintaining landscape connectivity is essential for adaptive resilience.

Furthermore, the importance of local community engagement is highlighted through the social component of the study. Community participation in habitat management, education, and conflict mitigation, particularly through livelihood initiatives, was observed during the project and is consistent with approaches reported in previous studies (Fahimi et al., 2011; Ghadirian et al., 2017). While these activities may support conservation efforts, their ecological and socio-economic impacts were not quantitatively evaluated in this study. Increasing awareness of the ecological role of the bear, particularly its contribution to seed dispersal, may contribute to improved attitudes toward the species and reduced conflict as suggested in the broader literature. Similarly, livelihood initiatives such as sustainable use of natural resources and ecotourism have the potential to align local economic interests with conservation goals; however, their effectiveness was not formally assessed here.

Participatory approaches are widely recognized as valuable in human–wildlife conflict mitigation but, in the present study, these outcomes should be interpreted as indicative observations rather than measured conservation success. Future research incorporating quantitative monitoring and long-term evaluation would be necessary to assess the effectiveness of these approaches. In addition to the community engagement, habitat management recommendations advocate for the protection and restoration of water sources which are vital for the bear's survival in arid environments. As highlighted in previous studies (Ghadirian & Pishvaei, 2014; Ruholamininejad et al., 2022) and based on observation and interviews with locals and conservation agencies, the availability of water during dry seasons directly influences the distribution and activity patterns of the species. By restoring dried-out existing water sources and safeguarding their natural flow, it is possible to improve habitat quality and support connectivity across fragmented landscapes which is critical given the predicted habitat declines under future climate change scenarios. The author also knows that the statistical power was limited by the small number of camera-trap events and the non-random, exploratory nature of our questionnaire sample. Therefore, the circular and chi-square tests should be viewed as supporting descriptive patterns rather than as definitive hypothesis tests.

Overall, the study results affirm that an integrated conservation strategy—combining habitat restoration, landscape connectivity, socio-economic incentives, and community participation—is essential for the effective and sustainable protection of the Baluchi black bear. Implementing these measures will not only contribute to stabilizing and increasing the local populations but also enhance the ecological integrity of the broader ecosystem, as documented in similar successful cases of community-based conservation worldwide (Fahimi et al., 2011; Ghadirian et al., 2017). Enhanced local awareness, shared responsibilities, and adaptive management frameworks will be the key to overcome ongoing threats and to ensure the long-term survival of this critically endangered subspecies. The observations from this study suggest that mining activities and drought may play an important role in shaping habitat use and human–bear interactions in the region. However, these relationships were not quantitatively assessed and further spatial and statistical analyses are needed to evaluate their impact. Similarly, the community-based conservation approach implemented in this project may contribute to improved local engagement and awareness; however, its effectiveness in enhancing conservation outcomes was not formally measured. Future studies should incorporate long-term monitoring and quantitative indicators to assess the effectiveness of such approaches.

Limitations and future work

This study has several limitations that should be considered when interpreting the results. The number of camera-trap events was relatively low and cameras were placed opportunistically rather than through a statistically designed sampling scheme which restricts inference about habitat selection, movement patterns, and activity differences among areas. Questionnaire data were also based on a small, non-random sample of households and thus the social findings should be viewed as illustrative rather than representative of all communities in the region. Statistical analyses, therefore, have limited power and are used primarily to support descriptive patterns, not to test formal hypotheses. In addition, the fieldwork covered only a portion of the subspecies' range and no new spatial connectivity or climate-change models were developed as a result of this project. Future work should expand camera-trap and interview sampling to a broader area, use systematic survey designs and stronger statistical frameworks, and explicitly integrate new field data into connectivity and climate-impact models to assess population viability and conservation options more rigorously.

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