



Community Based Biodiversity Conservation in Kinnaur District, Himachal Pradesh

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Manuscript details:

Received: 19.08.2024

Accepted: 28.09.2024

Published: 30.09.2024

Cite this article as:

Raashi Gupta and Shriya Sharma (2024) Community Based Biodiversity Conservation in Kinnaur District, Himachal Pradesh, *Int. J. of Life Sciences*, 12 (3): 335-345.

Available online on <http://www.ijlsci.in>

ISSN: 2320-964X (Online)

ISSN: 2320-7817 (Print)



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ABSTRACT

This study investigates the role of community-based biodiversity conservation in the Kinnaur District of Himachal Pradesh, a region known for its rich ecological diversity and unique cultural heritage. Through a combination of ecological surveys and qualitative research, the study assesses the effectiveness of local community involvement in maintaining and enhancing biodiversity. Key ecological indicators, such as species diversity, habitat quality, and ecosystem health, are analyzed to evaluate conservation outcomes. The research also explores the traditional ecological knowledge of Kinnaur's indigenous communities and their practices in sustaining biodiversity. Findings highlight the challenges faced by these communities, including socio-economic pressures, climate change, and external developmental activities, while also identifying opportunities for enhancing conservation efforts through policy support and capacity building. The study concludes that community-based approaches are vital for long-term ecological sustainability in Kinnaur, offering valuable insights for conservation practices in similar mountainous regions.

Keywords: Biodiversity conservation, Community-based conservation, Kinnaur district, Himachal Pradesh, Ecological study, Land-use change, Climate change etc.

INTRODUCTION

Kinnaur district, an integral part of the eastern Himalayan landscape in Himachal Pradesh, India, stands as a testament to the intricate interplay between geography, climate, and biodiversity (Wikipedia). Encompassing an area of approximately 6,401 square kilometers, the district exhibits a remarkable altitudinal gradient ranging from 1,200 to 6,000 meters above sea level. This topographical diversity, coupled with its position in the rain shadow region of the Himalayas, results in a complex and varied climate. While the lower reaches experience warm, dry summers and cold winters, the higher altitudes are characterized by a predominantly cold and dry climate with significant snowfall.

The unique ecological conditions of Kinnaur have fostered a rich tapestry of biodiversity (Kanwar *et al.*, 2024). The district is home to a diverse array of ecosystems, including alpine meadows, coniferous forests, and glacial landscapes. These ecosystems support a wide range of flora and fauna, many of which are endemic to the region or face global threats (Lata *et al.*, 2020; Kanwar *et al.*, 2024). For instance, the Himalayan brown bear (*Ursus arctos isabellinus*), snow leopard (*Panthera uncia*), and ibex (*Capra ibex*) are iconic species found in Kinnaur, while the district also harbors a plethora of medicinal plants and rare orchids. The ecological significance of Kinnaur extends far beyond its intrinsic value. The region's forests play a crucial role in regulating hydrological processes, preventing soil erosion, and mitigating climate change (Borthakur & Singh, 2024; Sharma & Masiwal, 2024). The dense vegetation cover acts as a natural sponge, absorbing rainwater and releasing it gradually, thereby ensuring a steady flow of water in rivers and streams. Moreover, the forests contribute to carbon sequestration, helping to combat climate change. The rich biodiversity of Kinnaur also supports the livelihoods of local communities through activities such as agriculture, animal husbandry, and tourism (Choudhary & Garkoti, 2021).

The delicate balance of Kinnaur's ecosystem is under increasing threat due to anthropogenic pressures. Deforestation, overgrazing, and unsustainable agricultural practices have led to habitat loss and fragmentation, adversely affecting wildlife populations (Kumar & Saikia, 2022). Climate change, with its associated impacts such as rising temperatures, altered precipitation patterns, and glacial melt, is exacerbating these challenges (Kumar, 2024). The combined effect of these factors has resulted in a decline in biodiversity and a deterioration of ecosystem services, posing a serious threat to the well-being of both humans and nature in Kinnaur (Sharma, & Batish, 2022; Ekka *et al.*, 2023).

Recognizing the critical role of local communities in conservation, the concept of community-based conservation (CBC) has emerged as a promising approach to address the challenges faced by Kinnaur's biodiversity (thinkwildlifefoundation) (Ma *et al.*, 2022; Ghosh-Harihar *et al.*, 2029). CBC emphasizes the involvement of local people in the management and protection of natural resources, empowering them to take ownership of conservation efforts. By building on traditional

knowledge and practices, CBC seeks to create sustainable and equitable solutions for biodiversity conservation (O'Neill *et al.*, 2017). In Kinnaur, the history of community-based conservation is deeply intertwined with the region's cultural heritage (Lal, 2017; Bajwa *et al.*, 2023). Traditional practices such as rotational grazing, forest management, and the sacred grove system have contributed to the preservation of biodiversity for centuries (Edwin & Muthu, 2020). These practices reflect a deep-rooted understanding of the ecosystem and the importance of living in harmony with nature. However, the advent of modern development, coupled with economic pressures, has led to a decline in these traditional practices, necessitating a revitalization of community-based approaches.

LITERATURE REVIEW

Kinnaur district, nestled in the Eastern Himalayas, is renowned for its exceptional biodiversity, a testament to its unique geographical and climatic conditions. Characterized by steep altitudinal gradients, ranging from 1200 to 6000 meters above sea level, the district supports a mosaic of ecosystems, including alpine meadows, coniferous forests, and glacial landscapes (Sharma *et al.*, 2015). This ecological heterogeneity has fostered a rich assemblage of flora and fauna, many of which are endemic or threatened (Singh & Rana, 2018). The ecological significance of Kinnaur extends beyond its intrinsic value. The region's biodiversity plays a pivotal role in regulating ecosystem services, such as water provisioning, soil conservation, and climate regulation (Thapa *et al.*, 2017). For instance, the dense forest cover acts as a natural sponge, absorbing rainwater and releasing it gradually, thereby ensuring a steady flow of water in rivers and streams. Moreover, the region's forests sequester significant amounts of carbon, contributing to climate change mitigation (Rai & Joshi, 2019). The delicate balance of Kinnaur's ecosystem is under increasing pressure from anthropogenic activities. Deforestation, overgrazing, and unsustainable agricultural practices have led to habitat loss and fragmentation, adversely affecting wildlife populations (Chauhan & Sharma, 2016). Climate change, with its associated impacts such as rising temperatures, altered precipitation patterns, and glacial melt, is exacerbating these challenges (Thapa *et al.*, 2017). The cumulative effects of these pressures pose a significant threat to the region's biodiversity and the livelihoods of its inhabitants.

Recognizing the critical role of local communities in conservation, the Himalayan region has witnessed a surge in community-based conservation initiatives. These efforts have sought to empower local people to participate in the management and protection of natural resources. Ghimire and Pimbert (2001) pioneered research on community forest management in Nepal, demonstrating its potential for both conservation and poverty alleviation. Subsequent studies in Bhutan (Subedi *et al.*, 2012) and other Himalayan countries have further explored the effectiveness of community-based approaches in conserving wildlife and other biodiversity components. While these studies provide valuable insights into the potential of community-based conservation in the Himalayas, the specific context of Kinnaur demands closer attention. The unique socio-cultural and ecological characteristics of the region necessitate tailored conservation strategies. Understanding the interplay between local livelihoods, traditional knowledge, and biodiversity conservation is crucial for designing effective interventions.

Implementing community-based conservation in Kinnaur is fraught with challenges. The region's rugged terrain, sparse population, and limited infrastructure pose significant obstacles to program delivery and monitoring. Moreover, the complex interplay between local livelihoods, traditional practices, and modern development aspirations can create tensions within communities (Rawat & Pant, 2015). Kinnaur also presents unique opportunities for community-based conservation. The region's rich cultural heritage and deep-rooted connection to the natural world provide a strong foundation for conservation efforts. Traditional practices such as rotational grazing and sacred grove management offer valuable lessons for sustainable resource management. Furthermore, the growing recognition of the importance of biodiversity and ecosystem services among local communities creates a conducive environment for community engagement (Chauhan & Sharma, 2016). To overcome challenges and capitalize on opportunities, it is essential to adopt a holistic approach that integrates ecological, social, and economic dimensions of conservation. Collaborative partnerships between government agencies, non-governmental organizations, and local communities are crucial for building trust and capacity. Additionally, investing in research and monitoring is vital for assessing the effectiveness of conservation interventions and adapting strategies as needed.

Indigenous knowledge and practices have played a crucial role in shaping the relationship between local communities and the environment in Kinnaur. Traditional ecological knowledge (TEK) encompasses a vast body of information about plants, animals, and ecosystems, which has been passed down through generations. Studies have demonstrated the value of TEK in guiding sustainable resource management practices (Gadgil & Berkes, 1991). In Kinnaur, TEK is embedded in various aspects of community life, including agriculture, animal husbandry, and forest management. For example, traditional agroforestry systems have helped to conserve biodiversity and maintain soil fertility (Rawat & Pant, 2015). Similarly, sacred groves, which are protected areas of high ecological and cultural significance, have played a crucial role in preserving biodiversity (Ghimire & Pimbert, 2001). The transmission of TEK is facing challenges due to rapid social and economic changes. The younger generation is often less connected to traditional practices, leading to a loss of valuable knowledge. Efforts to document and revitalize TEK are essential for supporting community-based conservation initiatives.

The success of community-based conservation depends on supportive policies and institutions. At the national level, India has enacted several laws and policies to protect biodiversity and promote community participation in conservation. The Forest Rights Act (FRA) of 2006, for instance, recognizes the rights of forest-dwelling communities and provides them with legal entitlements to forest resources (Agrawal & Goyal, 2012). At the state level, Himachal Pradesh has also implemented various policies and programs to support biodiversity conservation and community development. However, the effectiveness of these policies in reaching remote areas like Kinnaur remains a challenge. Strengthening institutional capacity and coordination among different government agencies is crucial for ensuring the successful implementation of conservation initiatives.

Study Area

Kinnaur district, situated in the northern Indian state of Himachal Pradesh, is one of its twelve administrative districts (Wikipedia). The district is organized into three administrative regions—Kalpa, Nichar (also known as Bhabanagar), and Pooh—and is further divided into six tehsils. Reckong Peo serves as the district's administrative headquarters. Kinnaur is

renowned for the Kinnaur Kailash mountain, a sacred site among the Panch Kailash. According to the 2011 census, it is the second least populous district in Himachal Pradesh, following Lahaul and Spiti. Kinnaur is located in northeast corner of Himachal Pradesh, about 235 km (146 miles) from Shimla, and bordering Tibet to the east. Enclosed by the Zanskar and Himalayan mountain ranges, the district includes the valleys of Baspa, Satluj, and Spiti, along with their tributaries. The terrain features lush forests, orchards, fields, and small villages.

Kinnaur district emerges as an ideal location for investigating community-based biodiversity conservation due to its rich biodiversity, indigenous communities with deep ecological knowledge, pressing environmental challenges, and its position within India's broader conservation policy framework. These factors collectively provide a unique opportunity to study the interplay between people and nature, offering valuable insights into successful conservation strategies.

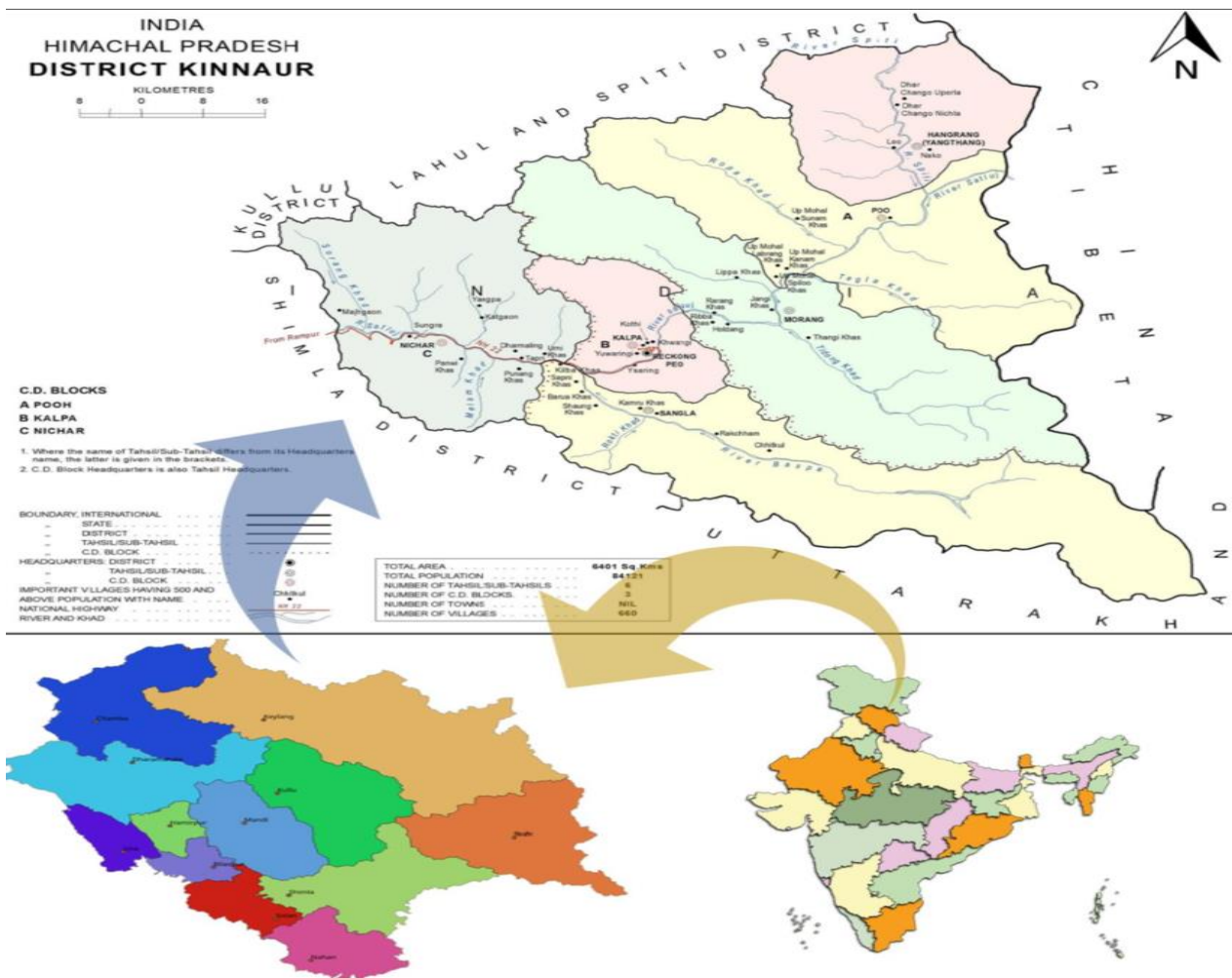


Figure 1: Map of study site

Ecological Profile of Kinnaur

Kinnaur, a mountainous district in Himachal Pradesh, India, is renowned for its exceptional biodiversity. Situated within the Eastern Himalayas, the region encompasses a diverse range of altitudes, from the lower valleys to the snow-capped peaks, creating a mosaic of ecosystems (Sharma & Rawat, 2010). The alpine meadows of Kinnaur, characterized by their low

temperatures and short growing seasons, support a unique assemblage of flora and fauna (Singh & Rawal, 2015). Endemic species like the *Saussurea gossypiphora* and *Pedicularis roylei* thrive in these harsh conditions (Gupta & Sharma, 2012). The region's coniferous forests, predominantly composed of *Pinus wallichiana* and *Abies pindrow*, harbor a rich diversity of birds, including the endangered Western Tragopan

(Tragopan melanocephalus) (Ali & Ripley, 1983). While Kinnaur's biodiversity is remarkable, it faces significant threats. Many species, such as the Snow Leopard (*Panthera uncia*) and Himalayan Brown Bear (*Ursus arctos isabellinus*), are classified as endangered or vulnerable due to habitat loss, poaching, and climate change (Chundawat & Rawat, 2006). The region's endemic flora, including several medicinal plants, is also under pressure from overexploitation and habitat degradation (Gaur & Sharma, 2014) (Kumari *et al.*, 2018). The status of biodiversity in Kinnaur is influenced by a complex interplay of natural and anthropogenic factors. While protected areas and conservation initiatives have been established, challenges such as human-wildlife conflict, infrastructure development, and climate change persist (Thakur & Rana, 2018). Kinnaur's ecosystems provide a wide range of services essential for human well-being and ecological balance. The region's forests play a crucial role in regulating hydrological processes, preventing soil erosion, and maintaining water quality (Kumar & Singh, 2012). The alpine meadows serve as vital grazing grounds for livestock and support biodiversity (Rawat & Bhatt, 2015). Local communities have a deep-rooted connection with the natural environment, relying on ecosystem services for their livelihoods. Traditional practices such as agroforestry and pastoralism have co-evolved with the ecosystem,

ensuring its sustainability (Sharma & Negi, 2013). The region's biodiversity also holds immense cultural and spiritual significance for the local people.

Kinnaur's biodiversity (Table 1.) is confronted with a multitude of threats (hp biodiversity.gov.in)(Singh *et al.*,2024). Habitat loss, primarily due to deforestation, expansion of agricultural land, and infrastructure development, is a major concern (Singh & Joshi, 2016). Climate change, with its associated impacts such as altered precipitation patterns, glacial melt, and rising temperatures, is exacerbating these challenges (Bharti & Rawat, 2018). Table 2. and Table 3. highlighted *Endangered and Vulnerable Flora and Fauna of Kinnaur district* (Kumar *et al.*,2017) (indiabiodiversity.org). Some of the threatened/ endangered flora are Atis, Chora, Singli-Mingli, Somlata, Kaur, Karu, Banhaldi, Patrala, Dhoop, Bankakri, Chukhri, Kuth, Talispatra, Mushakbala, Pushkarmool, Ratanjot, Salampanja, Jeevak, Rishbhak, Mahameda, Ravandchini, Chiraita, Rasna, Rakhhal etc. Anthropogenic pressures, including overgrazing, unsustainable resource extraction, and pollution, further contribute to the degradation of Kinnaur's ecosystems (Thakur & Rana, 2018). These factors have led to a decline in biodiversity, loss of ecosystem services, and increased vulnerability of local communities to environmental shocks.

Table 1. Kinnaur Biodiversity

Taxonomic Group	Estimated Species Richness	Examples
Plants	1,200+*	Himalayan Cedar (<i>Cedrus deodara</i>), Alpine Rhododendron (<i>Rhododendron anthopogon</i>), Medicinal Plants (e.g., <i>Aconitum</i> spp., <i>Taxus wallichiana</i>), High Altitude Grasses (e.g., <i>Poa alpina</i> , <i>Festuca ovina</i>), Oaks (<i>Quercus</i> spp.), Pines (<i>Pinus</i> spp.), Fir (<i>Abies</i> spp.), Spruce (<i>Picea</i> spp.), Wild Rose (<i>Rosa</i> spp.), Juniper (<i>Juniperus</i> spp.), Birch (<i>Betula</i> spp.), Willow (<i>Salix</i> spp.), Primula spp. (Primroses), Saussurea spp. (Snow Lotus), Potentilla spp. (Cinquefoil), Rheum spp. (Rhubarb), Berberis spp. (Barberry), Ephedra spp. (Mormon Tea), <i>Aconitum heterophyllum</i> (Atish), <i>Podophyllum hexandrum</i> (Indian Mayapple)
Mammals	75+*	Himalayan Brown Bear (<i>Ursus arctos isabellinus</i>), Snow Leopard (<i>Panthera uncia</i>), Ibex (<i>Capra ibex</i>), Bharal (<i>Pseudois nayaur</i>), Himalayan Musk Deer (<i>Moschus chrysogaster</i>)
Birds	350+*	Western Tragopan (<i>Tragopan melanocephalus</i>), Himalayan Griffon (<i>Gyps himalayensis</i>), Golden Eagle (<i>Aquila chrysaetos</i>), Himalayan Monal (<i>Lophophorus impejanus</i>), Cheer Pheasant (<i>Catreus wallichii</i>)
Amphibians & Reptiles	30+*	Himalayan Newt (<i>Tylotriton verrucosus</i>), Kashmir Black-headed Snake (<i>Natrix plumbea</i>), Himalayan Agama (<i>Laudakia himalayana</i>), Himalayan Rat Snake (<i>Ptyas mucosus</i>)
Insects	Estimated in Thousands	Butterflies (e.g., <i>Papilio bianor</i> , <i>Issoria sinia</i>), Bees (e.g., <i>Apis mellifera</i> , <i>Bombus</i> spp.), Grasshoppers (e.g., <i>Poecilocerus pictus</i> , <i>Dociostaurus maroccanus</i>), Dragonflies & Damselflies (<i>Odonata</i> spp.)

Table 2. Endangered and Vulnerable Flora of Kinnaur

Plant Species	Common Name	Status	Habitat	Threats
Rhododendron campanulatum	Bell-shaped Rhododendron	Vulnerable	Alpine meadows and forests	Habitat destruction, climate change
Rhododendron thomsonii	Thomson's Rhododendron	Endangered	Temperate forests	Overgrazing, deforestation
Abies pindrow	Pindrow Fir	Vulnerable	Temperate forests	Deforestation, illegal logging, climate change
Aconitum heterophyllum	Aconite or Atis	Critically Endangered	Alpine meadows and high-altitude regions	Overharvesting, habitat destruction
Nardostachys jatamansi	Spikenard	Vulnerable	High-altitude areas	Over-exploitation, habitat loss
Meconopsis integrifolia	Integral-leaved Meconopsis	Endangered	High-altitude meadows and rocky slopes	Habitat degradation, collection for ornamental purposes
Gentiana kurroo	Kurru Gentian	Vulnerable	Rocky slopes and alpine meadows	Overcollection for medicine, habitat loss
Primula sikkimensis	Sikkim Primrose	Endangered	Alpine and subalpine regions	Habitat destruction due to agriculture and tourism
Taxus baccata	European Yew	Endangered	Shaded slopes and forests	Deforestation, overharvesting for medicine
Salix aegyptiaca	Egyptian Willow	Vulnerable	Riparian zones and moist areas	Water management changes, habitat modification
Lilium nepalense	Nepal Lily	Endangered	High-altitude meadows and rocky slopes	Overharvesting for ornamental purposes, habitat loss
Bergenia ciliata	Edge Bergenia	Vulnerable	Alpine meadows and rocky areas	Over-collection for medicine, habitat degradation
Polygonatum verticillatum	Whorled Solomon's Seal	Vulnerable	Forested areas and shaded slopes	Habitat destruction, overharvesting
Codonopsis pilosula	Dangshen	Endangered	High-altitude forests and meadows	Overexploitation for medicine, habitat loss
Fritillaria roylei	Royle's Fritillary	Endangered	Alpine meadows and rocky slopes	Habitat loss, overcollection for ornamental purposes
Picea smithiana	Morinda Pine	Vulnerable	High-altitude forests	Logging, climate change impacts

Main reasons for biodiversity loss

Biodiversity loss in the region is driven by a complex interplay of factors that undermine both wild and domesticated ecosystems. A significant issue is the lack of awareness and information among stakeholders regarding the value of biodiversity, including existing vegetation, cultivated crops, and traditional medicinal plants (Negi *et al.*, 2018). Unscientific harvesting practices and inadequate regulation of medicinal plant collection exacerbate this problem, leading to a decline in biodiversity (Borthakur & Singh, 2024; Mishra *et al.*, 2023). Additionally, there is insufficient knowledge

about sustainable development of minor forest produce and related research, compounded by a shortage of funds, facilities, and trained personnel (Priyadarshini & Abhilash, 2019). Poor coordination among development agencies, local communities, and research institutions further hampers conservation efforts (Kumar, 2022). The transition from joint to nuclear family systems erodes traditional knowledge, while human-wildlife conflicts and the use of subsidized chemicals in agriculture harm soil health and micro-diversity. Excessive fuel wood collection during harsh winters and high rates of soil erosion due

to climatic factors also contribute to biodiversity loss (Singh *et al.*, 2019). The shift from diversified farming systems to monocultures, overgrazing by domestic and migratory animals, and ongoing hunting despite bans exacerbate the crisis (Mueller *et al.*, 2021). Habitat destruction from large-scale infrastructure projects, the spread of exotic weeds, and threats to aquatic biodiversity from various development activities

further strain local ecosystems (Dhyani, 2023). Inadequate documentation of indigenous knowledge, limited understanding of microbial diversity, and a lack of effective policies for compensating agro-diversity loss compound the challenges facing biodiversity conservation in the area (Sulphrey & Safer, 2017).

Table 3. Endangered and Vulnerable Fauna of Kinnaur

Species	Common Name	Status	Habitat	Threats
<i>Panthera uncia</i>	Snow Leopard	Vulnerable	Alpine and subalpine regions	Habitat loss, poaching, retaliation killings, prey depletion
<i>Ursus arctos isabellinus</i>	Himalayan Brown Bear	Endangered	Forested areas, alpine meadows	Habitat fragmentation, human-wildlife conflict, poaching
<i>Capra falconeri</i>	Markhor	Endangered	Rugged mountainous regions, alpine meadows	Hunting, habitat loss, competition with livestock
<i>Hemitragus jemlahicus</i>	Himalayan Tahr	Vulnerable	Rocky slopes, high-altitude grasslands	Habitat loss, hunting, competition with livestock
<i>Tragopan melanocephalus</i>	Western Tragopan	Endangered	Temperate forests, dense undergrowth	Habitat destruction, hunting, human disturbance
<i>Lophophorus impejanus</i>	Himalayan Monal	Vulnerable	Forest edges, alpine meadows	Habitat destruction, poaching, tourism disturbance
<i>Canis lupus chanco</i>	Tibetan Wolf	Near Threatened	High-altitude regions, mountainous terrains	Habitat fragmentation, human-wildlife conflict, poaching
<i>Pseudois nayaur</i>	Blue Sheep	Vulnerable	Rocky slopes, alpine meadows	Hunting, habitat loss, competition with domestic animals
<i>Otocolobus manul</i>	Pallas's Cat	Near Threatened	Steppes, rocky outcrops	Habitat loss, hunting, prey decline
<i>Vulpes vulpes</i>	Red Fox	Least Concern (regionally threatened)	Forested areas, alpine meadows	Habitat destruction, competition with domestic animals
<i>Tylototriton verrucosus</i>	Himalayan Newt	Vulnerable	High-altitude streams, ponds	Habitat loss, pollution, climate change
<i>Manis crassicaudata</i>	Indian Pangolin	Endangered	Forests, grasslands	Illegal wildlife trade, habitat loss, hunting
<i>Gyps himalayensis</i>	Himalayan Vulture	Critically Endangered	High-altitude cliffs, open landscapes	Poisoning, habitat destruction
<i>Aquila chrysaetos</i>	Golden Eagle	Least Concern (locally threatened)	Rocky outcrops, forested mountains	Habitat loss, hunting, human disturbance
<i>Ovis hodgsonii</i>	Great Tibetan Sheep	Endangered	Alpine grasslands, rocky slopes	Hunting, habitat loss, competition with livestock

Role of Local Communities in Biodiversity Conservation

Traditional Ecological Knowledge (TEK) is a cornerstone of biodiversity conservation in regions like Kinnaur. It represents a holistic understanding of ecosystems, built upon centuries of observation and adaptation (Berkes & Folke, 2000; Dawson *et al.*, 2021). Indigenous communities in Kinnaur possess a deep-rooted connection to their environment, reflected in their practices of sustainable resource management, such as agroforestry, rotational grazing, and sacred groves (Maffi, 2001; Singh *et al.*, 2021). These practices have contributed significantly to maintaining ecosystem balance and biodiversity (Gadgil & Guha, 1992). In Kinnaur, there is growing recognition of the importance of community participation, leading to increased involvement in conservation activities (Agrawal & Gibson, 1999). Initiatives like Joint Forest Management (JFM) committees have empowered local communities to manage forest resources sustainably (Gadgil & Iyer, 1989; Sterling *et al.*, 2017). Case studies of community-led conservation projects, such as the establishment of community reserves and wildlife corridors, demonstrate the potential of local people as agents of change (Redford & Mansour, 2003; Ruffner & Smith, 2019).

Despite their crucial role, local communities in Kinnaur face numerous challenges in biodiversity conservation. Socioeconomic factors, including poverty and lack of alternative livelihoods, often compel them to exploit natural resources (Brosius, 1999; Pour *et al.*, 2018). Cultural factors, such as changing lifestyles and erosion of traditional values, can weaken the bond between communities and their environment (Maffi, 2001). Institutional challenges, such as unclear land rights and limited access to resources, hinder community-based conservation efforts (Agrawal & Gibson, 1999; Lammers *et al.*, 2017).

External factors like tourism and development projects can exert significant pressure on local communities and ecosystems. While tourism can generate income, it can also lead to habitat loss, pollution, and cultural erosion (Weaver, 2001). Development initiatives, if not carefully planned, can displace communities and degrade natural resources (Redford & Mansour, 2003).

Evaluating the ecological impact of community-based conservation requires robust assessment

methodologies. Key ecological indicators such as species diversity, habitat quality, and ecosystem health can provide valuable insights into conservation success (Noss, 1990; Broszeit *et al.*, 2017). By comparing areas under community management with those managed through traditional approaches, researchers can identify the effectiveness of community-based conservation efforts (Redford & Mansour, 2003; Brandt *et al.*, 2017). For instance, studies have shown that community-managed forests often exhibit higher biodiversity and better forest health compared to government-managed areas (Agrawal & Gibson, 1999). It is essential to consider the specific context, including socio-economic factors and historical land use practices, when interpreting these findings.

The potential of community-based approaches for long-term biodiversity conservation lies in their ability to adapt to changing environmental conditions (Berkes & Folke, 2000; Gavin *et al.*, 2018). Local communities often possess deep knowledge of ecosystem dynamics and can develop innovative strategies to address emerging challenges (Gadgil & Guha, 1992). To ensure long-term sustainability, it is crucial to support community capacity building, provide access to appropriate technologies, and create enabling policy environments (Agrawal & Gibson, 1999). By empowering local communities to take ownership of conservation efforts, we can enhance their resilience and adaptability to future changes (Folke *et al.*, 2002).

CONCLUSION

This study on community-based biodiversity conservation in Kinnaur District, Himachal Pradesh, underscores the critical role that local communities play in the preservation and management of the region's rich ecological heritage. The findings reveal that community involvement in conservation efforts has led to significant achievements, such as the effective protection of sacred groves, sustainable management of forest resources, and the preservation of traditional agricultural practices. These successes demonstrate the potential of community-based approaches to enhance biodiversity conservation while simultaneously supporting local livelihoods. The study also highlights several challenges that need to be addressed to improve the effectiveness of these initiatives. Issues such as insufficient awareness of

biodiversity's importance, unscientific harvesting practices, inadequate funding and resources, and poor coordination among stakeholders have hindered the success of some conservation efforts. Furthermore, the erosion of traditional knowledge and practices, coupled with external pressures such as habitat destruction and climate change, exacerbates the challenges faced in conserving biodiversity. To overcome these obstacles, it is essential to strengthen community engagement by enhancing education and awareness about biodiversity, improving resource management practices, and providing adequate support and funding for conservation projects. Additionally, fostering better collaboration among local communities, government agencies, and research institutions will be crucial for developing more effective and sustainable conservation strategies. While community-based biodiversity conservation in Kinnaur has shown promising results, a concerted effort is required to address existing challenges and build on successful practices. By integrating traditional knowledge with modern conservation approaches and ensuring active participation of all stakeholders, it is possible to achieve long-term ecological and socio-economic benefits, thus ensuring the preservation of Kinnaur's unique biodiversity for future generations.

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Conflict of interest: The authors declare that they have no conflict of interest.

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