OPINION

Climate change and human–wildlife conflicts in the Indian Himalayan biodiversity hotspot

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Human–wildlife conflict[1,2] is a conservation challenge facing scientists and policy-makers worldwide[3,4], with an increasing demand for holistic resolution strategies[5]. Conflict with wild animals has the potential to negatively affect the livelihood and well-being of communities[3,6–9], and revengeful killing of the animals to safeguard personal interests[6,10,11]. This is a worrying development, especially for threatened wild species if deemed as 'conflict species'[3,6,9,12], as it can greatly hinder their protection and conservation[5,13], especially in developing countries.

It is important to note that not all human–wildlife interactions give rise to negative experiences, and that humans and wildlife have historically adapted to each other's presence in many instantces[14]. However, increasing human population and rapid urbanization[3,15] in many areas has fragmented the home ranges of numerous wild animals[12], especially large carnivores[16]. It is thus not surprising that there is a 'breach of man-made boundaries' by these animals[14], resulting in a dynamic tussle for resource use and the likelihood of increased encounters (often negative) with humans[4,12,16]. Nonetheless, it is also important to point out that some rural areas in India are seeing declines in human population due to urban migration and this may be expected to decrease such conflicts. Additionally, although fragmentation by urbanization does occur, it could be argued that agriculture, commercial plantations, infrastructure (e.g. roads and dams) and industries (e.g. mining) are more serious threats for habitats.

The Indian Himalayan biodiversity hotspot harbours numerous endemic species, and is home to over 50 million people[17]. Local communities here are dependent on agriculture and animal husbandry, and also depend on adjoining forests for resources and livelihoods[17]. The region is affected by anthropogenic stressors[10], including numerous existing and proposed hydropower projects[18], and the construction of roads through animal corridors continues to degrade the natural habitat[19]. The changing climatic variables too continue to have a socio-ecological impact on the region[10]. It is therefore not surprising that the Indian Himalaya is facing human–wildlife conflicts[20]. Over the last few decades (1994–2016), field studies conducted by the authors and an extensive on-line search of peer-reviewed published and grey literature (using Google Scholar and Google search engines for the time period 1994–2016, and keywords such as 'human–wildlife conflict', 'human–wildlife interactions', 'Indian Himalaya', and 'Indian Himalayan region'; resulting in 114 regional relevant publications which were downloaded, read in full, and included in the analysis) has revealed numerous wild animals which have a negative impact on the well-being of local communities (Table 1).

Our data reveal that a major barrier in understanding the vulnerability, resilience and adaptive abilities of communities to human–wildlife conflict is the lack of consideration given to conflicts, which are often complex and deep-rooted local events, governed by attitudes and behaviour of people and underlying social tensions[3]. There are social and cultural perceptions, and religious beliefs of local people towards conflict species[3], which demand a holistic approach to any conflict[3,16,21]. It is essential to progress beyond perceiving a threat to conflict species alone[16,22]. Obtaining information on the food and habitat availability of conflict species[16], their historical habitat range[23], and fragmentation of available habitat[24,25] is essential in understanding human–wildlife encounters[24,25]; however, a multidisciplinary strategy based on communication, trust[25], and involvement of local stakeholders could go a long way in conflict resolution[21,24,26–28].

Presently, there is a need to understand the impacts of conflict on the existing vulnerabilities of communities[21] due to the current and projected climate change in the Indian Himalayan region[29]; and the resulting attitude and behaviour towards the conflict species[30]. Any conflict could increase this vulnerability, lessen opportunities for adaptation, and reduce support for species management[3].

For their implementation and long-term success, conflict resolution strategies[12,31,32] need to be supported by scientific[2] and legislative provisions benefiting local communities and conflict species[3,10,26,28], along with an opportunity to bring about a positive shift in human behaviour[31]. Targeted education and awareness programmes[10] and communication[33] with communities could provide them with site- and species-specific information, gender-specific skills to make informed decisions[34], and develop a level of tolerance towards conflict species[22]. Print and electronic media can play an important role here[2]. Also, local communities need to be active participants and partners in the entire process of human–wildlife conflict resolution. Further, giving voice to and empowering local people, addressing vulnerabilities and human needs, and designing locally appropriate measures with local participation will go a long way in this endeavour.

The socio-ecological impacts of conflict should be assessed across multiple habitats[6,12] based on field data collected over spatial and temporal scales to gain knowledge about the patterns of conflict and movements of conflict species[35]. Understanding the habitat continuity, food availability and population structure of conflict species could further assist in formulating resolution strategies[36] amidst the changing climatic variables in the region. The attitude and perception of people to conflict species needs to be monitored, which can change over time[37]. Additionally, the effects of conflicts on the wildlife (i.e. numbers killed, culled), and area of habitat loss also need to be carefully looked into.

The current compensatory mechanisms need to be strengthened, become more transparent, and provide locally acceptable incentives and opportunities for communities[38] and conflict species[6,9,39]. Alternatively, approaches such as insurance (which is different conceptually and practically from the current compensation mechanism) need to be looked into for local communities. When relying on species distribution models for conflict

Table 1. Conflict species, their IUCN Red List status, dominant interactions with local communities, and previous proposed actions

Conflict species	IUCN Red List status	Human–wildlife interactions	Previous proposed actions
Arunachal macaque (*Macaca munzala*)	Endangered	1, 2	a
Asiatic black bear (*Ursus thibetanus*)	Vulnerable	1–4	b–e
Dhole (*Cuon alpinus*)	Endangered	2, 4	e
Tiger (*Panthera tigris*)	Endangered	2–4	b–d
Himalayan brown bear (*Ursus arctos*)	Least Concern	3	d
Hanuman langur (*Semnopithecus entellus*)	Least Concern	1, 5	f
Wild boar (*Sus scrofa*)	Least Concern	1, 2, 5	b
Asian elephant (*Elephas maximus*)	Endangered	1–3, 5, 6	f–h
Common leopard (*Panthera pardus*)	Near Threatened	3–5	b–e
Rhesus macaque (*Macaca mulatta*)	Least Concern	1, 5	f
Snow leopard (*Uncia uncia*)	Endangered	2, 4	b, e, i, j

(Key I: 1, Cause damage to agricultural crops; 2, Results in targeting/retaliatory killing of species; 3, Result in human casualties; 4, Predate on livestock; 5, Cause bodily harm to local people; 6, Decreased well-being of communities.)
(Key II: a, Address well-being of communities; b, Strengthen crop and livestock protection; c, Monitor high-conflict zones; d, Scientific estimation range and habitat of species; e, Spread education and awareness among locals; f, Develop a comprehensive management plan involving local stakeholders; g, Understand behavioural response of species; h, Protect animal corridors; i, Provide economic incentives for locals; j, Develop a comprehensive compensation mechanism.)

species, various uncertainties should be addressed using long-term field data[1] before making assumptions relating to their population growth, movement or behavioural pattern[40]. The 'one model fits all' approach using charismatic[37] species should be avoided[41]. Above all, managing this interdisciplinary relationship[42] through local stakeholder involvement[1,4] could be the decisive factor for the well-being of vulnerable communities, and the protection and conservation of threatened species in the region.

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