PROJECT REPORT

Project title:
Studying negative impacts of free-ranging dogs on native threatened wild mammals to develop effective mitigation framework in the Indian trans-Himalaya

PRINCIPAL INVESTIGATOR:
RASHMI SINGH RANA

nature conservation foundation

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Acknowledgments

I extend my deepest gratitude to the funding bodies, The Rufford Foundation and The Habitat Trust, whose financial support enabled us to pursue this critical conservation project in the trans-Himalayan landscape. I am also immensely grateful to my supervisors, Dr. Yash Veer Bhatnagar and Dr. Kulbhushansingh Suryawanshi, for their unwavering guidance and support throughout the project. Additionally, the NCF accounts team deserves special recognition and thanks for accepting and efficiently managing the RSG funds.

The success of this project wouldn't have been possible without the invaluable contributions of our field assistant, Mr. Vikram Katoch, and our dedicated research interns, Mr. Bhaskar Panwar and Mr. Neeraj Bisht. Their enthusiasm and hard work were instrumental during the extensive six-month data collection process.

Our deepest appreciation goes out to our respondents and community members who generously shared their time and invaluable knowledge during our surveys. The insights of local stakeholders, including forest officers and staff of the Lahaul Forest Division, further enriched our understanding of the conservation challenges in Lahaul.

Last but not least, I am deeply grateful to my family and friends for their constant support, especially during my prolonged absences in remote areas for this project. This project would not have been the same without their love and encouragement.

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Executive summary

Impacts of free-ranging dogs on wildlife have been recognised as an urgent conservation threat in shared rangelands. The aim of this study was to fill a lacuna of information by assessing establishing the nature, extent as well as drivers of negative interactions between FRDs and wild mammals across the trans-Himalayan Lahaul landscape. Furthermore, consultations from other Himalayan landscapes like Spiti and Ladakh were taken to develop a dog-threat mitigation action plan for the study landscape of Lahaul through multi-sectoral convergence.

Socio-ecological community surveys, dog population assessment surveys, as well as garbage assessment surveys were finally conducted in 52 villages across Lahaul. To gather representative data the surveyed villages were selected following a stratified sampling approach based on indicators like sub-valley, bank (of main Chandrabhaga river), village population size and village livestock holding.

Our community surveys involved Focus Group Discussions, Key-informant interviews and participatory digital mapping exercises. These surveys revealed that 83% of the sampled villages reported negative dog-wildlife interactions. The most noted ones were that of FRDs chasing and hunting wild canids like Himalayan red fox, followed by Asiatic ibex, Himalayan musk deer and marmots. One observed instance each of FRDs killing a snow leopard, and injuring a brown bear was also reported. FRDs were also reported to attack and predate on livestock such as sheep and calves of cattle. Based on these community observations, certain clusters were seen to have significant levels of negative dog-wildlife and dog-livestock interactions (Map 4 & 6). These clusters are formed around villages in Upper Pattan, parts of Tinan, Gahr as well as Tindi sub-valleys.

Dog population assessment was conducted in the 52 sampled villages as well as 4 additional habitations (army camps, markets and tourist hubs) using a combination of line-transect distance sampling and sight-resight sampling methods. A total of 494 km of transect length was walked to determine an estimated density of 70 dogs per km sq. (95% CI 40 to 100 dogs/km sq.). The overall abundance for is 780 dogs across the surveyed locations. The Lincoln-Peterson index estimated the total population size, N, for dogs for Lahaul to be 883 with a detection probability of 0.65.

Generalised linear modelling was done to tease out factors that potentially drive negative dog-wildlife interactions as well as village dog abundances. Potential predicting factors were dog village abundance, village population, village livestock holding, distance to nearest garbage site, garbage site extent, distance to nearest market, and market type. The modelling efforts indicated that bigger villages with a garbage site in close vicinity reported higher dog-wildlife interactions. It is likely that attract more dogs possibly due to higher food provisioning opportunities, thereby leading to higher negative dog-wildlife interactions. Moreover, village dog abundance was higher in bigger, more populated villages with an open dumping garbage site. While villages with larger livestock holding had lesser dog abundances which may be because such villages may actively dissuade dog presence as part of their livestock guarding practices.

Based on our results and consultations, a dog-threat mitigation actions framework was developed for Lahaul landscape (Figure 15). The framework relies on a four-fold foundation that need active and concerted implementation: 1) Directed action plans, 2) Action committee, 3) Cross-departmental convergence, and 4) Community partnerships. Following this framework, active measures need to be concerted in 4 target zones (Map 9.) where a dog-oriented action plan and a garbage-oriented action plan, as detailed in the report, need to be implemented through stakeholder collaborations. The need for systematic monitoring and evaluation of efforts is a critical part of the framework to endure sustained adaptability and efficiency of the proposed mitigation strategy.

Introduction

Free-ranging dogs (FRDs) have been receiving global recognition for the potential and realised threat they pose to wildlife populations, particularly in natural areas and sensitive ecosystems. While dogs are often seen as beloved companions, their presence and interactions with wild animals can have far-reaching negative consequences. The uncontrolled or unmonitored growth of the FRD population in ecologically sensitive regions has emerged as a pressing conservation concern. Unowned and owned dogs, roaming freely without human supervision, may impact the delicate balance of the ecosystem, endangering the very wildlife that defines a region's unique biodiversity (Hughes et al. 2013).

In the vast trans-Himalayan rangelands, the boundaries between human-occupied spaces and so-called wild or natural areas blur, creating a seamless interface between the domesticated and the wild life. The burgeoning FRD population is spilling over from its original haunts and venturing deeper into the heart of remote forests and pastures. This expansion overlaps with the habitats of native threatened wild mammals, creating a perilous situation for these vulnerable species. The increasing overlap between FRDs and threatened wildlife has led to documented instances of negative interactions. One of the most direct and alarming impacts of dogs on wildlife is predation. Dogs, with their natural predatory instincts and hunting prowess, can actively prey on a wide range of wild animals, including small mammals, reptiles, birds, and even larger species like deer and foxes (Home et al., 2018). This predation can have a devastating effect on vulnerable wildlife populations, especially those already facing other threats such as habitat loss.

For instance, FRDs have been observed preying on Himalayan musk deer, a critically endangered species. Additionally, there have been reports of dogs chasing and harassing Himalayan wolves, another threatened species. These documented cases, along with anecdotal evidence and photographic captures of dog-killed musk deer, highlight the urgent need for a systematic study to comprehensively document these harmful interactions in the study landscape of Lahaul. There have also been numerous reports of the negative impacts of the uncontrolled FRD populations on threatened fauna of the cold desert landscape of Ladakh. There are multiple photographic and videographic records of packs of FRDs harassing and chasing the endangered snow leopard, Himalayan brown bear, lynx, black-necked cranes and Kiang (Tibetan wild ass). The Forest department of Ladakh has confirmed FRDs to be bigger threats to wildlife than hunting or retaliatory killing (Gandhi, 2019). Such research is crucial to understanding the full extent of the threat posed by FRDs to threatened wildlife in the region and to develop effective mitigation strategies.

Image 1. A lone wolf (maybe male) surrounded by a pack of dogs near a village in Lahaul in January 2022. The blue arrow is pointed towards the wolf that descended closer to the village. Picture credits: Shiv Kumar and Amir Jaspa.

Beyond direct predation, dogs can also indirectly harm wildlife through disturbance and harassment. The presence of dogs can cause stress and disruption to wildlife behaviour, forcing them to abandon feeding and nesting sites, and expending valuable energy on avoidance and escape. This chronic disturbance can negatively impact wildlife reproduction, survival rates, and overall fitness (Smith et al., 2009). Ghoshal et al. (2017) undertook a study to identify and assess various conservation threats to snow leopard and its prey species in trans-Himalayan regions, including Lahaul. Their study highlighted that in Lahaul the threat of depredation of wildlife by free-ranging dogs was the third biggest threat (following illegal wildlife hunting and trade by migratory herders, and prey reduction due to competition by migratory livestock). Another study by the same group of authors (Ghoshal et al., 2016) also noted frequent interactions between free-ranging dogs and the Himalayan red fox in the trans-Himalayan region of Spiti. The study indicated that the density of free-ranging dogs in the region impacted the occurrence of red fox.

Furthermore, dogs can transmit diseases to wild animals, potentially introducing pathogens to which wildlife populations have no immunity. Diseases like parvovirus, distemper, and rabies can spread from dogs to wild carnivores, causing significant mortality and population declines (Belsare et al., 2014). There is established evidence of considerable pathogen load in FRDs for transmissive diseases like Canine Parvovirus, Canine Distemper Virus (CDV) and Canine Adenovirus in 100%, 54% and 66%, respectively, of sampled FRDs (n=97 dogs from 6 villages in Spiti) (Home et al., 2022). Another study from Nepal found high prevalence of CDV in 70% of sampled dogs (n=68) (Ng et al., 2019). Both studies raise urgent need to address the high risk of disease spillover from dogs overlapping with wild mammals and carnivores, thereby, hindering the fitness and survival of the wildlife.

Moreover, the introduction of stray or feral dogs into natural areas can lead to hybridization with wild canids. This hybridization can blur genetic lines and threaten the integrity of wild canid populations, disrupting their ecological role and potentially reducing their genetic diversity. There are also reports of wolf-dog hybrids from Ladakh, locally named '*khibshank*' in Ladakhi, that locals believe can be distinguished by their physical traits such as 'aggressive behaviour, and longer tails and ears' (Bhura, 2021). A group of scholars (Hennelly et al., 2015) from the adjacent region of Spiti have documented incidents of FRDs intermingling with Himalayan wolf. Most critically, they have photographed and published an image (Image 2 below) of a male FRD in a mating position with a female wolf. The scholars could not comment on the outcome of the observed mating behaviour between these wild and domestic species, but literature reports multiple cases of successful hybrid offspring of the two, thereby inducing genetic dilution which threatens genetic integrity and survival of the population of the wild canids (Pilot et al., 2018; Salvatori et al., 2020).

Image 2. Female Himalayan wolf and male feral dog in mating position in Lahaul-Spiti. (Picture credit: Lauren Hennelly, 2015)

Aims and Objectives

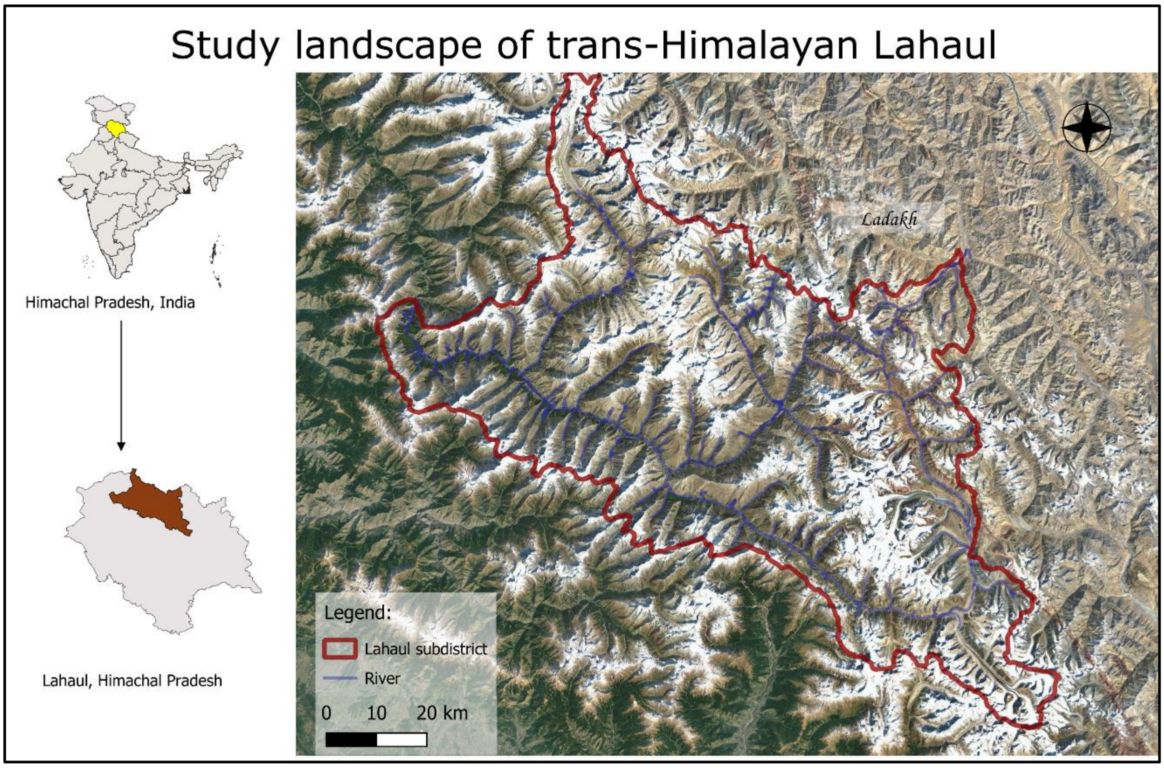
Globally, free-ranging dogs (FRDs) have been recognised as an imminent conservation threat to native wildlife. Yet this recognition and evaluation is lacking from Indian trans-Himalaya due to lack of targeted studies. To address this, we aim to establish the level of conservation threats posed by FRDs on threatened native wildlife, and to subsequently urge conservationists and government to include FRDs as part of wildlife conservation action plans. The following objectives will help reach the stated aim:

1. To determine the nature and extent of negative impacts of free-ranging dogs (FRDs) with native wildlife through community knowledge.
2. To identify the key drivers of the negative interactions of free-ranging dogs (FRDs) and native wildlife.
3. To facilitate institutional convergence to implement the suggested mitigation action framework to reduce negative impacts of free-ranging dogs (FRDs) on wild animals in Lahaul.

Study area

Lahaul is a subdivision of the Lahaul & Spiti district, Himachal Pradesh, part of the cold desert zone of the Indian Himalaya (Lat:32°22.517’N – 32° 48.564’N, Long:76°25.017’E – 77°16.636’E). Lahaul landscape is a transition zone between the greater Himalaya and trans-Himalaya zone, characterised by both steep and undulating terrain, snow-covered peaks ranging till 6400 metres asl, and harsh climate. The Lahaul valley is enclosed by the main Himalayan Zanskar range from the north, the Pir Panjal range on south and the Kunzum range on the east. At an average elevation of 4717 m asl, this cold desert region receives heavy snowfall of about 200-400 cm, with temperature dipping down to -16 degree Celsius. The barricading mountain ranges allow scanty precipitation in the form of rainfall, regionally varying between 100-700 mm.

The dry temperate to alpine climate allows poor vegetation growth, with patches of Juniper (*Juniperus spp.)*, blue pine (*Pinus wallichiana*), fir (*Abies pindrow*), spruce (*Picea smithiana*) cedar (*Cedrus deodara*), birch (*Betula utilis*) and Rhododendron (*Rhododendron spp.)* [16, 17]. The rich faunal biodiversity includes large mammals like snow leopard (*Panthera uncia*), Himalayan wolf (*Canis lupus chanco*), Himalayan brown bear (*Ursus arctos isabellinus*), Himalayan black bear (*Ursus* thibetanus), red fox (*Vulpes Vulpes*), musk deer (*Moschus leucogaster*), blue sheep (*Pseudois nayaur*) and Asiatic ibex (*Capra sibirica*).

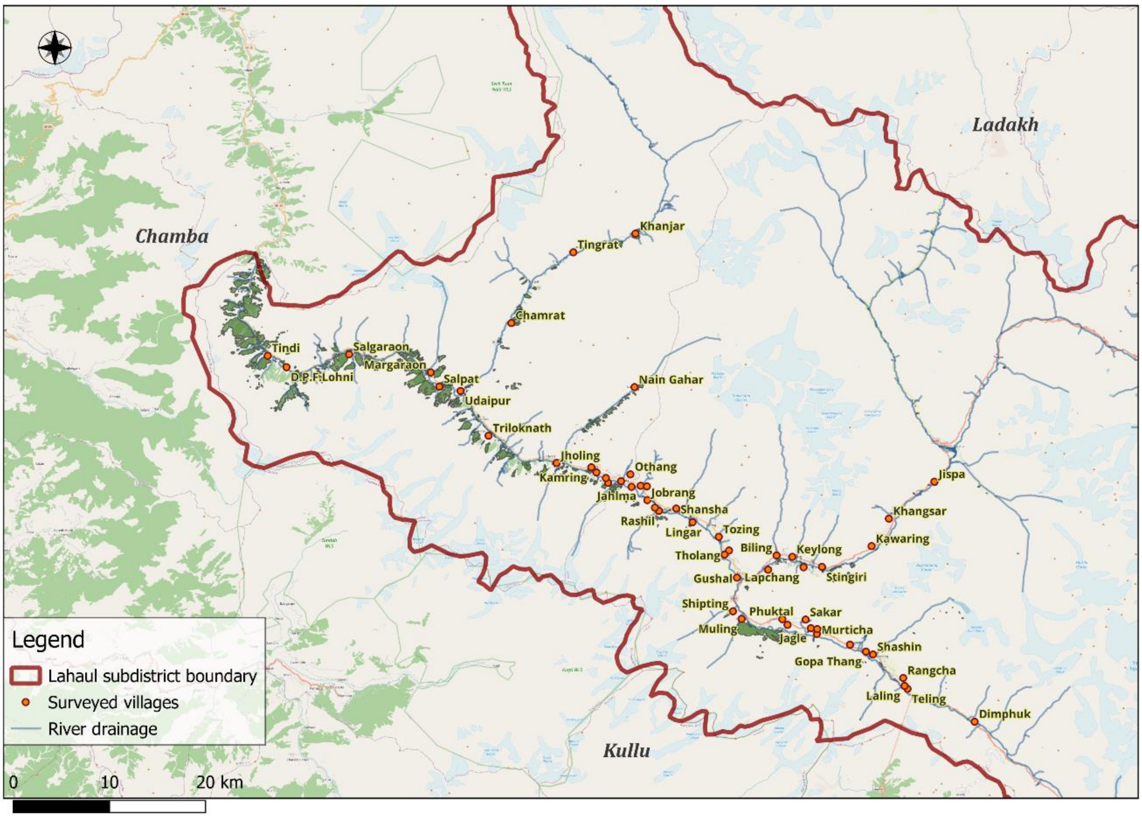


Map 1. The study landscape of trans-Himalayan Lahaul, Lahaul & Spiti district in the Indian state of Himachal Pradesh.

Methods & Activities

1. Village selection

The study landscape of Lahaul has a total of 198 villages. To conduct a representative assessment of Lahaul valley, a stratified sampling method was used to select 50 villages based on strata like sub-valley, bank (of main Chandrabhaga river), village population size and village livestock holding (Map **2**). The automated selection was done using the Random Selection tool on QGIS 3.30.



Map 2. Selected sample of villages for surveying across the study landscape of Lahaul

2. Community surveys to assess nature and extent of dog-wildlife interactions

We conducted a total of 55 Focus Group Discussions (FGDs) and 5 Key-Informant (KI) interviews (Mukherjee et al. 2017) to gather relevant data for 52 villages. We also interviewed 7 forest guards and informal conversations with 2 personnels from army camps. Active oral consent was taken before the discussions and interviews. Respondents were informed about the nature, goal and themes involved the survey, as well as the right to withdraw consent at any time during the survey. Anonymity of respondents was also assured during our introduction.

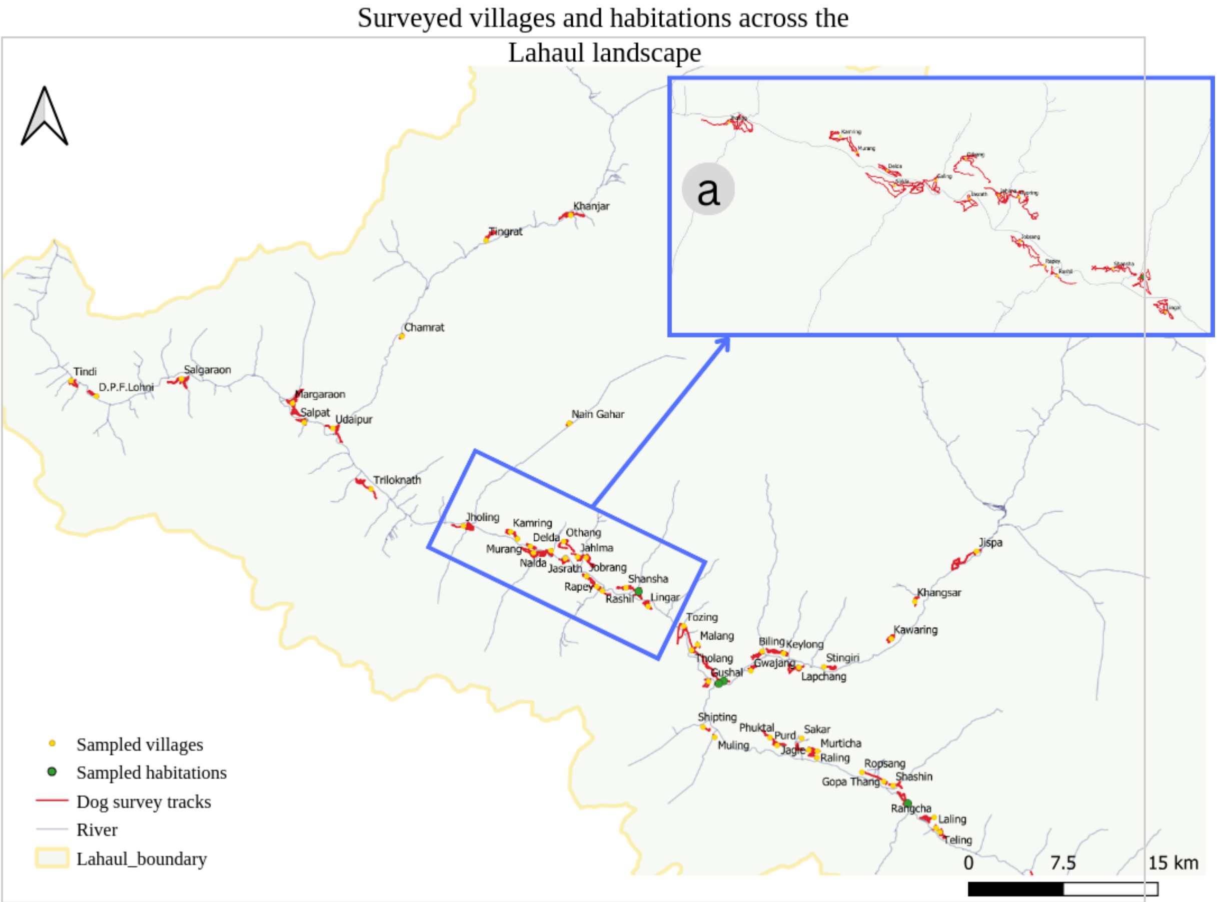
FGDs and KI interviews were conducted following a semi-structured questionnaire covering themes pertaining to village free-ranging dogs, owned dogs, dog-wildlife interactions, dog-livestock interactions, dog disease and mortality, behaviour, tolerance and attitudes towards dogs, mitigation practices and limitations. A participatory digital mapping exercise was conducted during FGDs and KI interviews to mark locations of dog-wildlife interactions and dog presence in wild habitats.

Image 3. Conducting Focus Group Discussions and participatory digital mapping as part of community surveys in Lahaul.

3. Dog population assessment surveys to determine abundance and density estimates

Dog population assessment surveys were conducted in 52 villages and 4 habitations which included market spots, tourist spots and GREF camp, making it a total of 56 locations (Map **3**). These surveys employed a combination of distance sampling method following a line-transect and sight-resight method. Each village or location was surveyed on two consecutive days by the same team of at least 2 surveyors and around the same time of the day. The line transect routes were not predefined due to the uncertainty of the terrain, but we mostly followed village trails and roads. Line transects walked were recorded on the mobile application OSMand. The distance for each sighted dog during the line transect was measured using a Gogogo laser rangefinder 1200 Yards. One surveyor was responsible for clicking pictures for

IDing the sighted dogs as well as measuring the distance of the dog from the line. The second surveyor was responsible for recording data such as Image ID, measured distance, dog sex, age-class, coat pattern, coat colour, coat condition, physical health and GPS coordinates. This data was collected on the KOBOCollect mobile application. The same was repeated on the second day of survey for resighting dogs, with an additional information about whether the detected dog was a new sighting or a resight from previous day's suvey.



Map 3. Villages and habitations surveyed for dog population assessment. A total transect length of 494 km was walked in 56 locations.

In addition to the 56 locations, we also repeated these two-day surveys in 4 locations in the late evenings to compare temporal change. In total we conducted 60 two-day surveys (120 transects lines) and walked a total transect length of 494.07 km.

Analysis for estimation of dog abundance and density was done using the package Rdistance in R environment (R Core Development Team), and the total population size (N) was estimated using the Lincoln-Peterson Index:

$$N = \frac{n1 * n2}{m}$$

Where, n1 = number of dogs sighted on Day 1; n2 = number of sighted on Day 2; and m = number of dogs re-sighted on Day 2.

Image 4. Dog population assessment survey. a) Survey team collecting data on sighted free-ranging dogs; b) free-ranging dogs observed through the laser rangefinder; c) & d) a male adult dog sighted in survey 1 and re-sighted in survey 2, respectively.

4. Garbage site assessment surveys to examine the type and extent of garbage disposal

A preliminary garbage site assessment was done around all villages and on opportunistic encounters across the study landscape. For each garbage disposal site, details like GPS coordinates, location name, dimensions of garbage (if calculation was possible), type of waste in the garbage site (wet, dry, electronic), the extent of spread of the garbage, along with a picture of the garbage site were recorded in the KOBOCollect mobile application.

It was not possible to record dimensions of garbage disposal sites that covered the entire face of the mountain and extended deep into the valley slopes and streams.

Image 5. Garbage assessment survey: a) and b) are examples of an open hillslope disposal type of garbage dumping, where the discarded contents cover the sloping face of the hills and eventually reach the river or stream; c) example of an open disposal type of garbage dumping usually found around villages; d) example of garbage dumpster found in and around big villages, however the dumpsters are often overfilled and garbage is dumped around the dumpster attracting free-ranging dogs.

5. Drivers of dog-wildlife interactions and dog abundance in villages

To ascertain about factors that influence or drive dog-wildlife interactions and dog abundance in villages, both these response variables were modelled as a function of a list of predictors that have been noted in several studies. For the analysis, GLM modelling was performed in R environment (R Core Development Team) to tease out the role and direction of influence that factors such as village size, livestock holding, distance to garbage site, type of garbage, distance to market or tourist hub have on both the responses of interest. Significantly correlated factors were not used in the same model structure.

6. Consultation and facilitation meetings with stakeholders in the study and allied landscapes to develop effective dog threat mitigation framework for Indian trans-Himalaya

Post data analyses, results for the dog surveys and extent of dog-wildlife as well as dog-livestock interactions were shared with Animal Husbandry department, District Forest Department, Tourism department, District Administration and local NGO groups leaders like

YDA Garsha, as well as Panchayat Pradhans of villages with high dog abundance and related problems.

For consultation and critical feedback, cross-learning visits were done in neighbouring region of Spiti and Ladakh as both these landscapes have similar threat from dogs to wildlife and conservation efforts. In Ladakh, meetings were held with the Animal Husbandry department's Director, Technical Officer and veterinary surgeon. Consultations and feedback meetings were held with the head of the garbage Unit at 14 Corps Leh as well as with the Dy Commandment Vet of the Veterinary branch of the ITBP HQ in Ladakh. In Spiti, meetings were held with the Additional Dy Commissioner, ADM, Veterinary surgeon in-charge of Animal Husbandry dept, Chief Medical Officer, and women-led SHG called Mentok SHG that feed dogs in winters.

Learnings from all the visits and interventions used in all landscapes have helped address gaps to develop a mitigation action framework for Lahaul in the context of the growing conservation threat that dogs pose to wildlife and livestock.

Results

1 Nature and extent of dog-wildlife interactions

1.1 Types of negative dog-wildlife interactions

Interactions observed by communities between free-ranging dogs and wild animals were predominantly negative in nature. About 83% (n=52 villages) of villages noted negative behaviour of FRDs with wild animals in the last five years, particularly behaviours such as chasing, harassing, and hunting. Few instances of behaviours such as barking and co-eating on food resources were also observed. The communities reported a total of 154 independent sightings or observations of negative interactions between dogs and wild animals. The most observed interaction was that of dogs chasing wild animals.

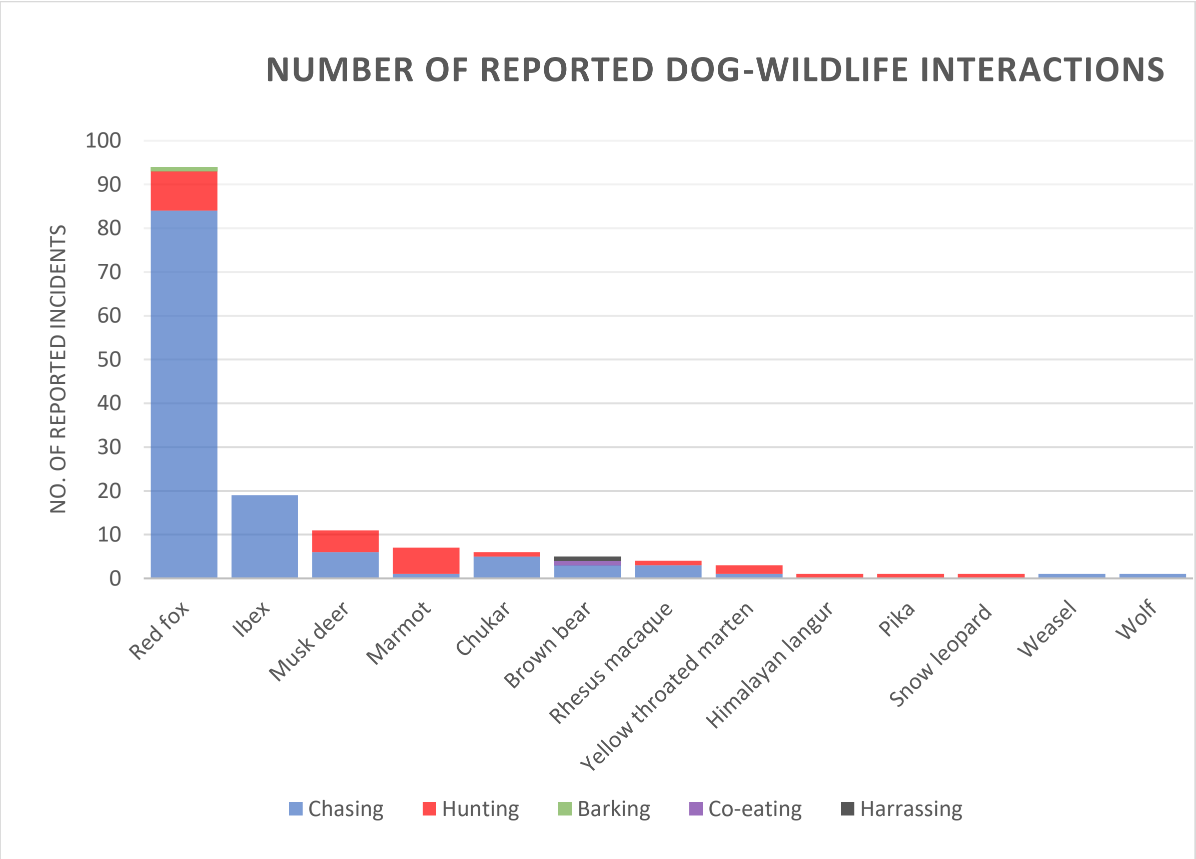


Figure 1. Number and nature of reported incidents of independently observed dog-wildlife interactions including free-ranging dogs chasing, hunting, barking, co-eating and harassing wild animals.

As seen in Figure 1, the highest number of reported negative interactions of dogs was with the Himalayan red fox, followed by ungulates like Asiatic ibex, Himalayan musk deer and marmot. Wild threatened mammals like Himalayan brown bear, snow leopard, and Himalayan wolf were also reported to experience negative interactions with FRDs. A few negative encounters were also reported between FRDs and other wildlife including chukar partridge, rhesus macaque, Himalayan langur, pika, yellow-throated marten and weasel.

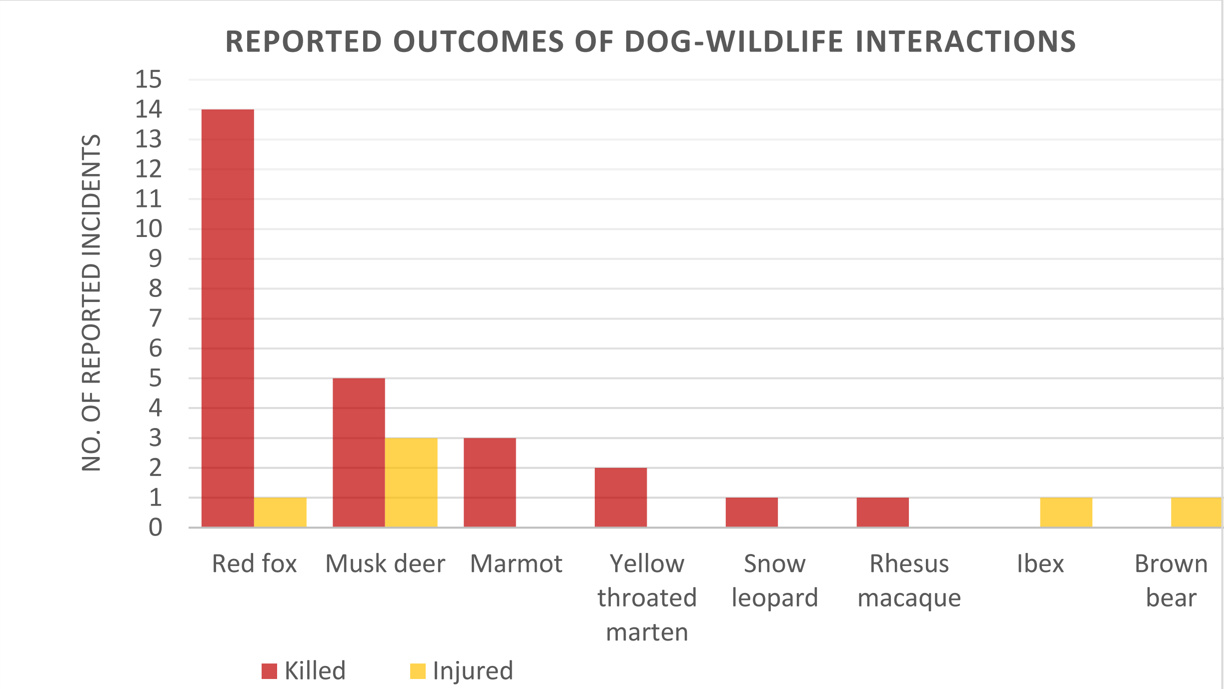
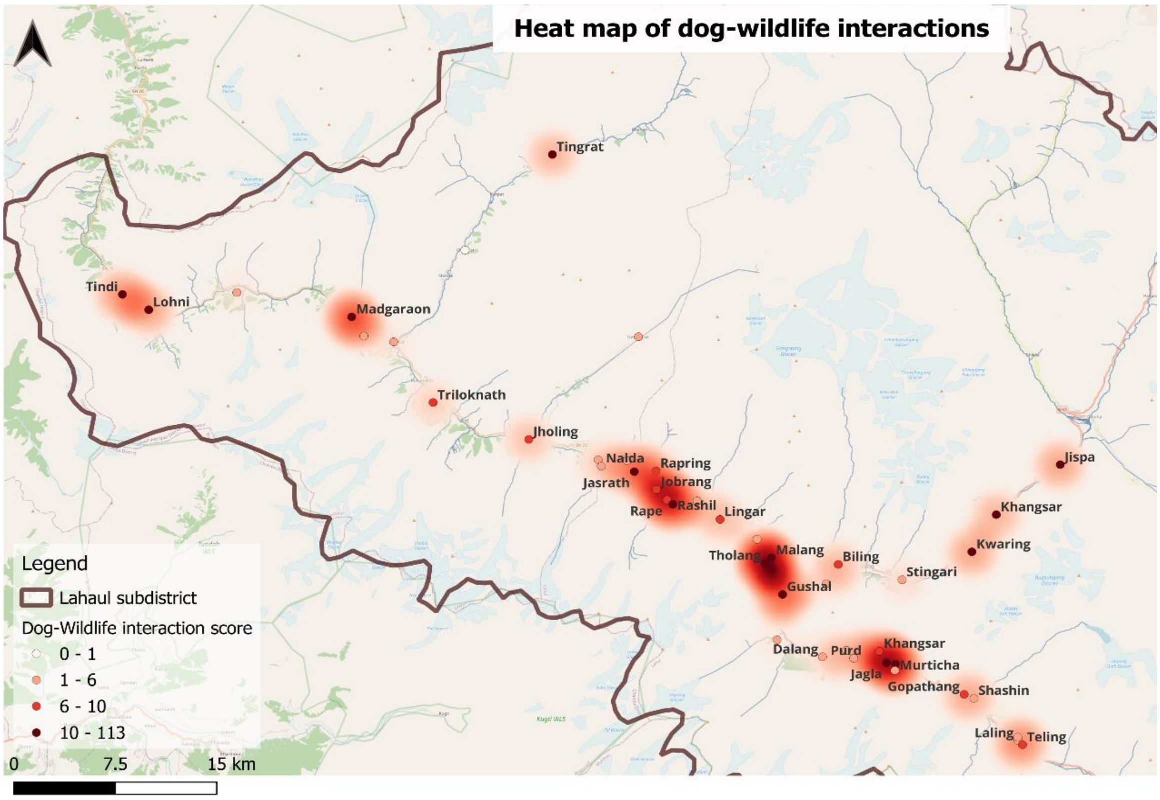


Figure 2. Number of independently observed outcomes of free-ranging dogs either killing or injuring wild animals.

Moreover, respondents from some villages observed direct negative outcomes in which the wild animal was either killed or injured as a result of the encounter with FRDs (Figure 2). A total of 26 reported attacks were seen to have resulted in killing of the wild animal involved, while 6 attacks resulted in the wild animal being injured. The highest number of dog-killing were reported for red fox (53.8%) followed by musk deer (19.2%), marmot (11.5%) and yellow-throated marten (7.6%), while a single incident of killing was reported for the snow leopard and rhesus macaque. In the sighted dog attacks on wildlife, highest number of reported injuries was observed for musk deer (50%), followed by a single observation of injury in the case of red fox, ibex and brown bear each.

1.2 Dog-related threat levels for wildlife

Each reported interaction between dogs and wild animals was given a score based on the type of interaction. An interaction involving a wild animal being hunted was given the highest score of 4, interactions resulting in an injury to the wild animal was given a score of 3, while a chasing and barking-only type of interactions were scored 2 and 1, respectively. Each interaction type was multiplied by the number of wild animals reported to be involved in the given interaction. These scores were added for each surveyed village to get a cumulative dog-wildlife interaction score for that village. This calculated score takes into account the nature as well as the frequency of reported negative interactions between dogs and wild animals. The heatmap for the dog-wildlife interaction scores for Lahaul (Map 4) highlights regions and villages with higher levels of sighted dog-wildlife interactions. These areas highlighted in dark red and the 29 villages labelled are where wildlife of Lahaul experiences significant direct threats from free-ranging dogs.



Map 4. Heat map of intensity of reported dog-wildlife interactions based on scores given to the nature and frequency of independently observed interactions. The labelled villages (29 in number) are where wildlife of Lahaul experiences significant direct threats from free-ranging dogs.

1.3 Seasonality of dog-wildlife interactions

As indicated in Figure 3, for wild animals such as red fox, ibex, musk deer snow leopard and yellow-throated marten a significant majority of interactions with dogs (70%, 94%, 77.8%, 100% and 100%, respectively) were noted in winter months. This could be because all these wild mammals, with the exception of red fox, descend closer to the villages in the winter months, making such interactions easier to observe. Although red foxes come closer to villages even during summer months, it may be easier for respondents to observe red fox-dog interactions in the less busy winter months. For hibernating mammals like the brown bear 66.6% of the interactions were observed in summer months, while a few (33.3%) were observed in the early winter months when the bears enter a biological stage of hyperphagy and come closer to the village in search of high-calorie food before winter denning. Troops of primates like rhesus macaque descend to lower altitudes regions outside of the study landscape which is likely why most macaque-dog interactions would be observed in summer (66.6%) and only few incidents (33.3%) reported for winter months. All incidents of marmot-dog interactions were observed in summer months when villagers visit the higher pasture areas for livestock grazing.

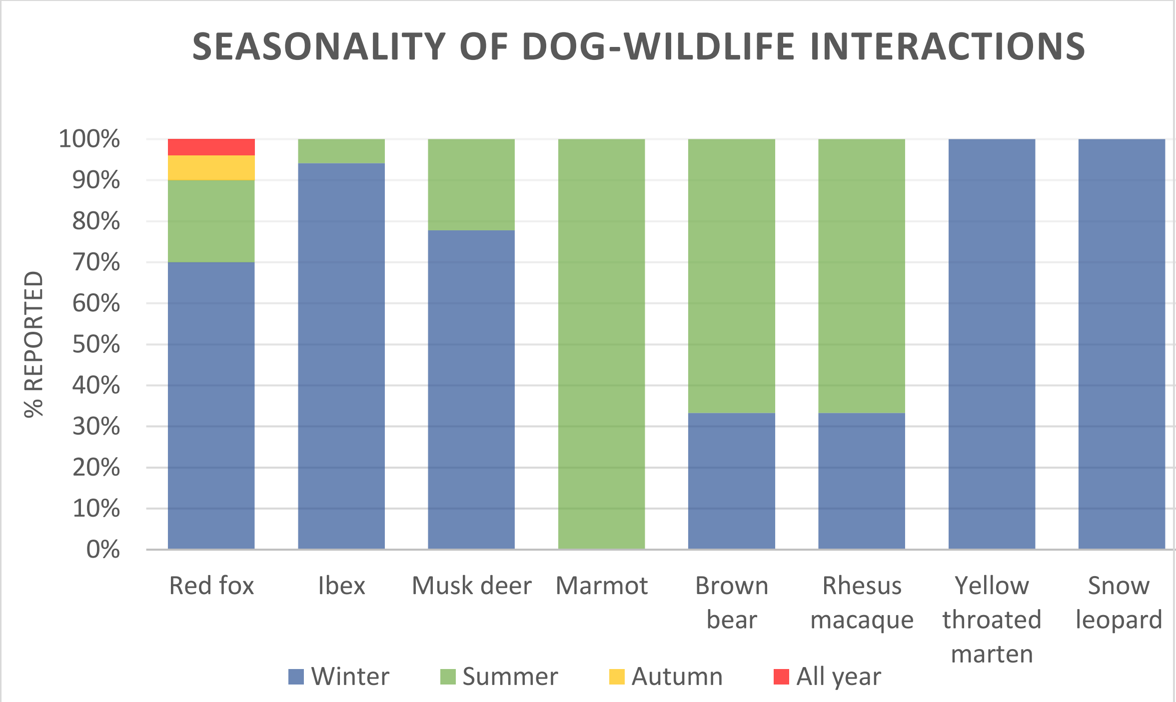


Figure 3. Seasonality of independently observed dog interactions with wild mammals.

1.4 Perception of dog behaviour towards wildlife

Respondents were asked about their perception about the anticipated or expected behaviour of FRDs towards the wild animals that visit their villages (Figure **4**). For ungulates like ibex, musk deer, or tahr, a majority of respondents (53%) believed that dogs would only chase ungulates upon sighting, 18% believed that dogs would even hunt or kill ungulates, while 10% were of the belief that they would only bark at ungulates. A large majority of respondents (68%) felt that dogs would chase canids like red fox and Himalayan wolf, while 16% believed that the wild canids would be hunted by dogs. Interestingly, a small proportion of respondents (2%) believed that dogs would socialise with canids like wolves or be attacked by wolves (2%). Over half of the respondents (53%) perceived that dogs would do nothing upon sighting a snow leopard, while 16% believed that snow leopard would be chased by dogs, and 11% thought that dogs would only bark at snow leopard. Similarly, for bears, 53% respondents believed that dogs would only bark at bears upon sighting, while only 22% felt that dogs would chase after bears, and an even smaller number of respondents (11%) thought that the dogs would not interact with bears.

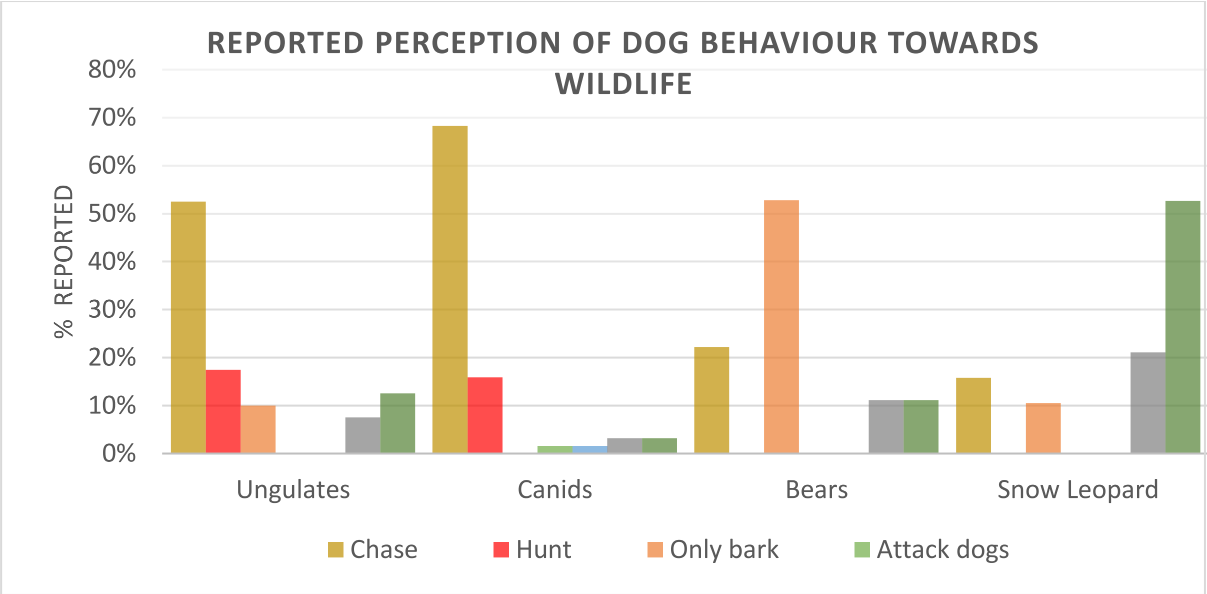
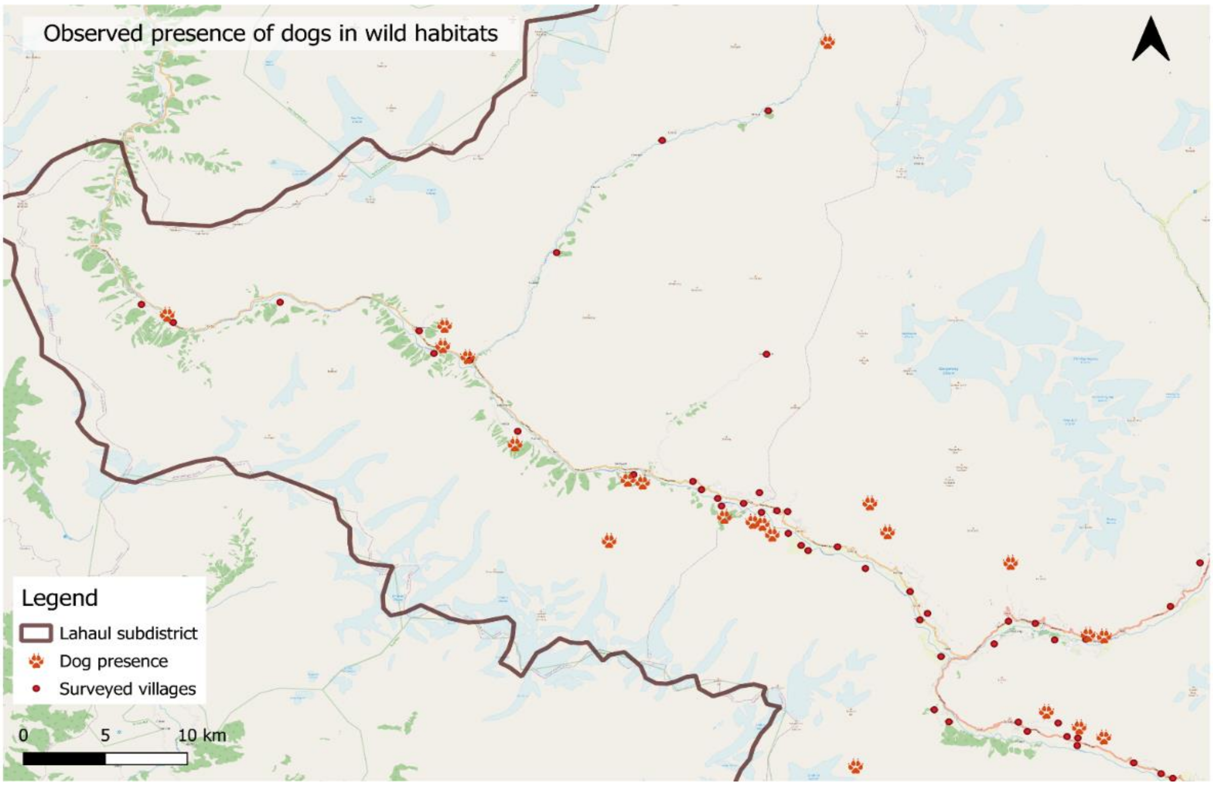


Figure 4. Perception of respondents about potential dog behaviour towards wild mammals if encountered.

1.5 Presence of free-ranging dogs in wild habitats

Respondents from 52 villages were asked if they had observed dogs in wild habitats away from villages or human habitations. A significant majority of 71% of the respondents reported to have sighted dog packs in wild habitats like pasturelands and distant forest areas (Map 5). In almost all the reported sightings the dogs were seen in packs of over 5-6.



Map 5. Locations marked where free-ranging dogs were observed either individually or in packs in wild spaces away from villages or habitations. This map is based on the participatory digital mapping exercise.

1.6 Dog-wildlife interaction observed by project team

During our surveys, we also observed a pack of four dogs chasing a herd of ibex (Image 6 & 7). The ibex managed to escape in this observed instance by running towards steep cliffs. The same pack of dogs were also seen feeding on an ibex head before this observed chasing. One female dog has been photographed to be following an ibex by other observers (Image 8).

Image 6. This is a screengrab from a video of dogs chasing after a herd of ibex. The red outlined boxes are zoomed in frames of the picture. © Rashmi Singh Rana

Image 7. This is another screengrab from a video of the same observed incident of a pack of dogs chasing a herd of ibex. The red outlined boxes are zoomed in frames of the picture © Rashmi Singh Rana

Image 8. The same female dog photographed at different occasions. In the picture on the left, the project team observed it eating a male ibex's head. The red outlined box is a zoomed in image. In the picture on the right, the same female dog was observed to be behind and above in close proximity to a male ibex. Even in this incident, the same dog(pack) was reported to following and chasing the ibex herd. © Rashmi Singh Rana and Amir Jaspa

2 Nature and extent of dog-livestock interactions

2.1 Types of negative dog-livestock interactions

Most of the surveyed villages (82%) reported attacks on their livestock by free-ranging dogs (Figure **5**). A total of 163 independent incidents of dog attacks on livestock were reported to have occurred in the last five years. Majority of these attacks were reported to be on small-bodied livestock like sheep and goat (63.1%), followed by calves of cattle (22.6%), cattle like cows and dzomos/churi (female cow-yak hybrids) (9.8%). A few instances of dog attacks were also made on horses (3%) and donkeys (1.2%). In these dog attacks, a total of 511 livestock heads were killed by dogs, while 45 sustained injuries in the last five years.

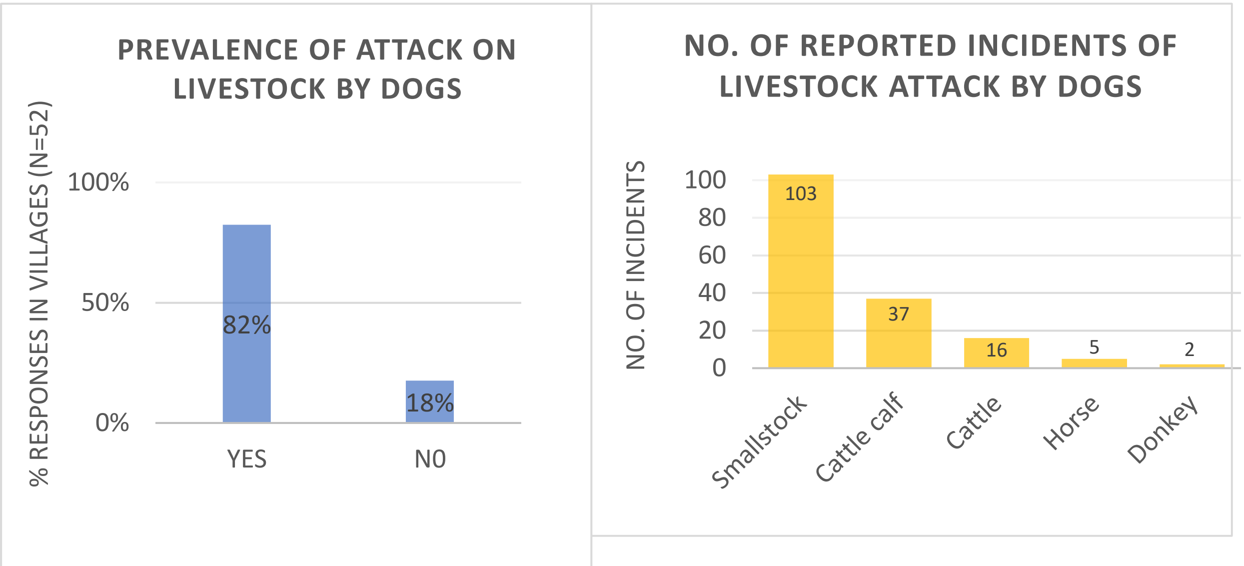
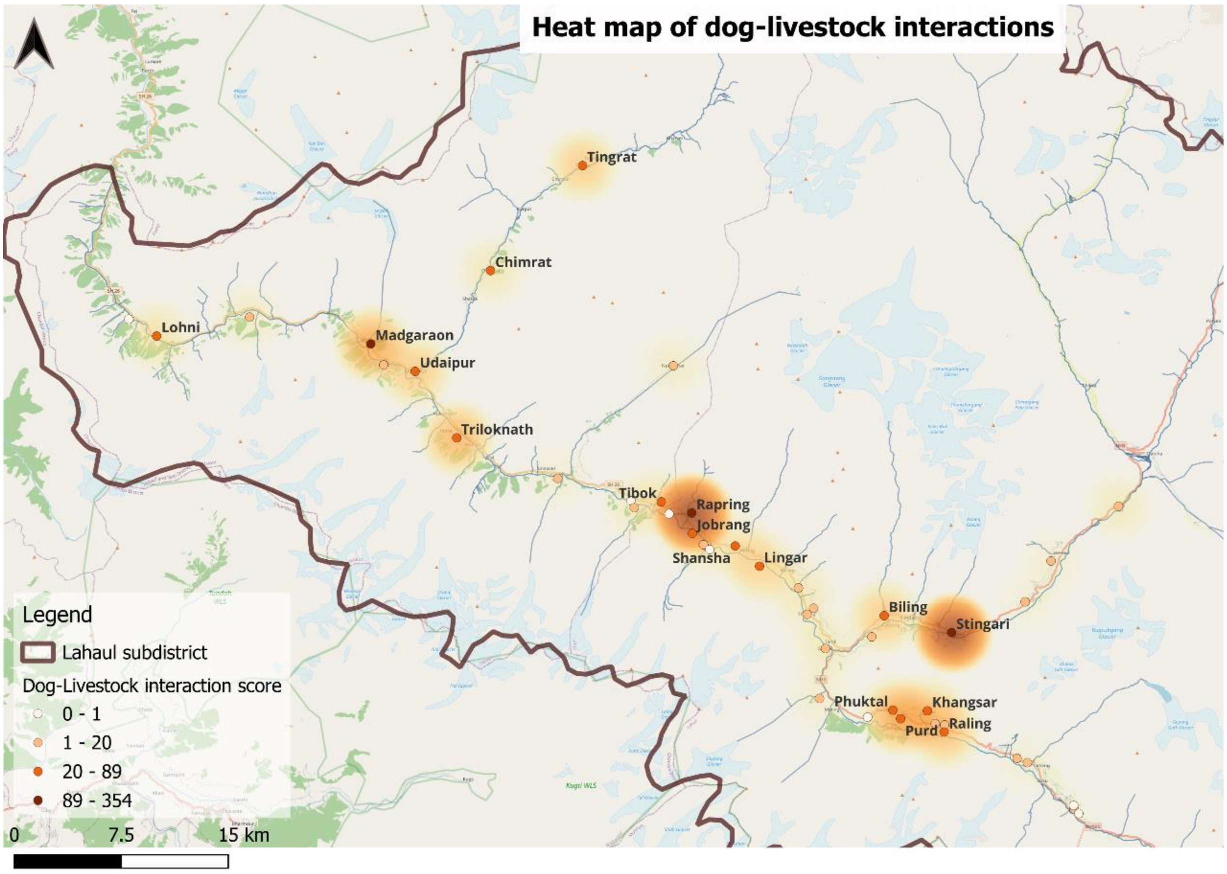


Figure 5. Reported prevalence and incidents of free-ranging dogs attacking on different livestock types.

2.2 Dog-livestock predation

Villages were categorised on the basis of reported dog-livestock interactions. Interactions involving killing or consumption of livestock by dogs was given a score of 3, while interactions resulting in only injury of livestock was scored 2, and those with only dog chasing livestock were given a score of 1. Each interaction type was multiplied by the number of livestock reported to be involved in the given interaction. These scores were added for each surveyed village to get a cumulative dog-livestock interaction score for that village. The heatmap for the dog-livestock interaction scores for Lahaul (Map **6**) highlights regions and villages with higher levels of dog-livestock interactions. These areas highlighted in dark orange and the 17 villages labelled are where dog predation on livestock was most reported.



Map 6. Heat map of intensity of reported dog-livestock interactions based on scores given to the nature and frequency of independently observed interactions. The labelled villages (17 in number) are those with significant level of threat to livestock from free-ranging dogs.

2.3 Monetary losses due to livestock attacks by dogs

A staggering loss of Rs. 34, 83, 525 (~ 33,000 GBP) was incurred by pastoralists due to attacks on their livestock by dogs in the last five years. Small-bodied livestock like sheep (and goat) comprised of a major chunk of this loss (61.7%), which was followed by cattle calf (29.4%), horses (6.4%), and cattle (4.7%). The monetary losses for livestock were calculated by using the average rates of two different years (2015 & 2020) as provided by the Animal Husbandry Department in Lahaul.

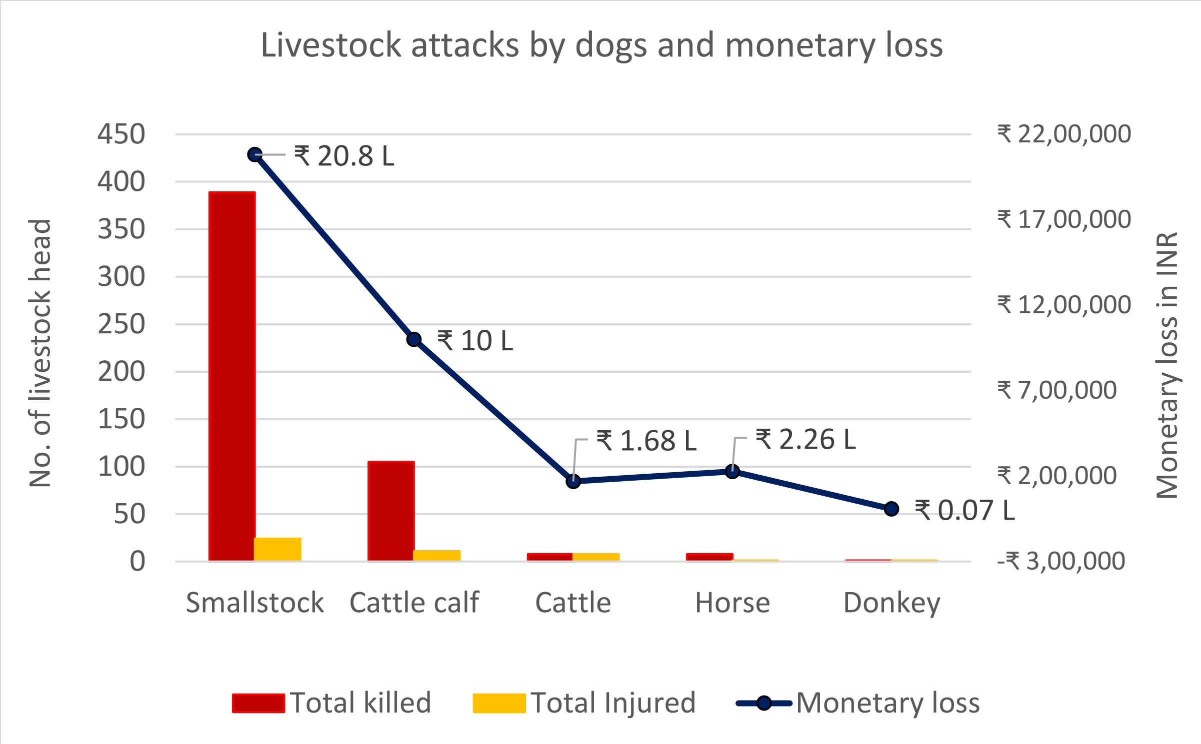


Figure 6. Reported number of livestock attacks and outcomes of deaths and injuries in the last five years. The monetary loss calculated is based on the number of reported livestock killed by dogs. Source of average livestock rates were calculated from the rates given by Animal Husbandry department.

2.4 Location and seasonality livestock depredation

For the small-bodied livestock like sheep and goat exactly half of the reported interactions with dogs occurred in pasturelands while the sheep were grazing in summer months, while the other half occurred near village premises especially during autumn and winter months when dogs have lesser sources of food available. Most of the dog attacks on large-bodied livestock like cattle (including calves) were reported to take place near village premises (90%), when the cattle were left outside for unattended grazing during autumn and winter months.

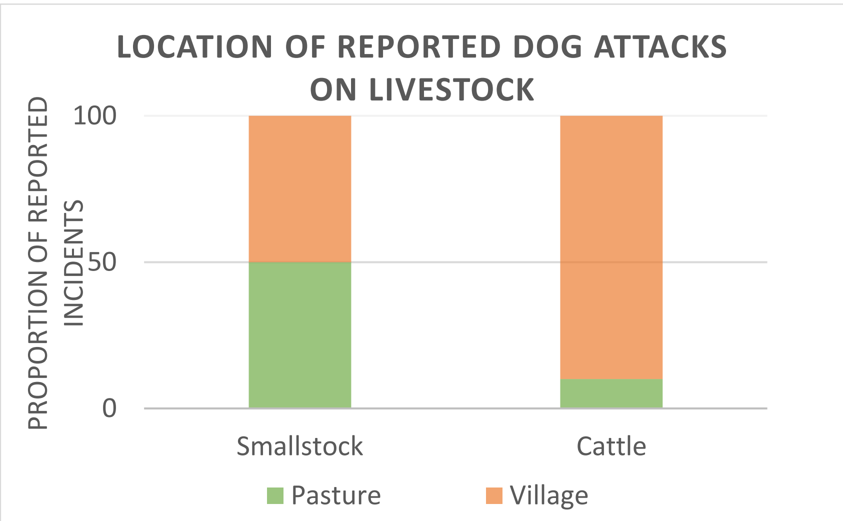


Figure 7. Location of reported dog attacks on livestock in the last five years.

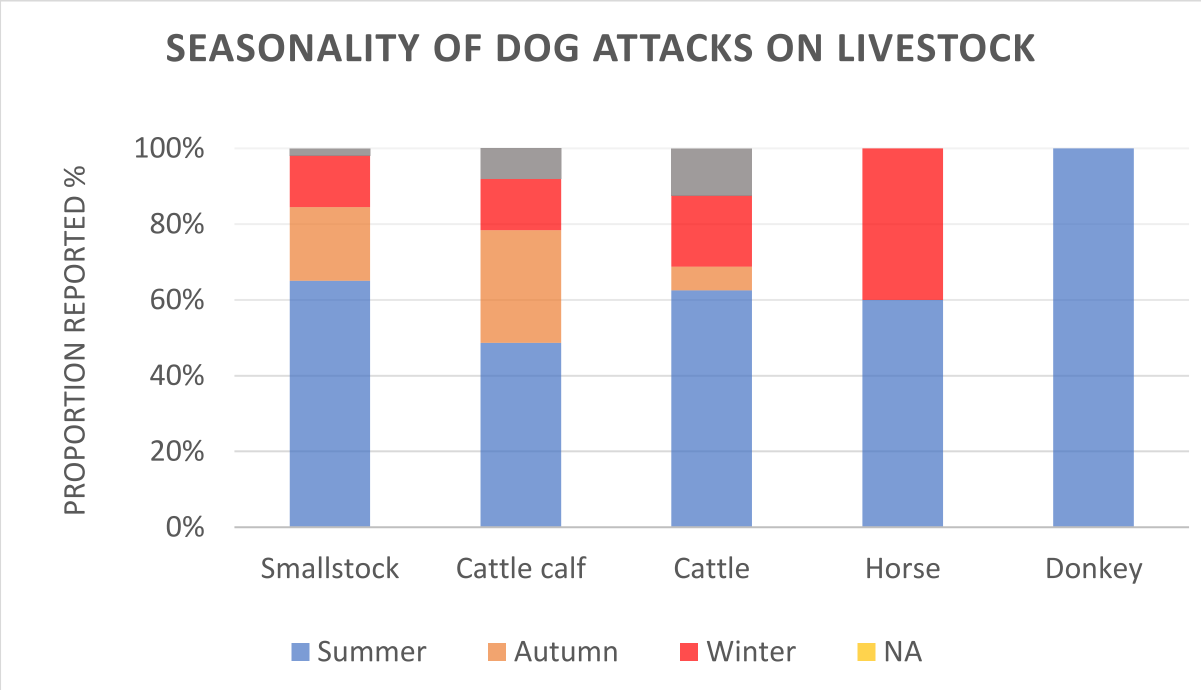


Figure 8. Seasonality of reported dog attacks on livestock in the last five years.

2.6 Trend of dog attacks on livestock

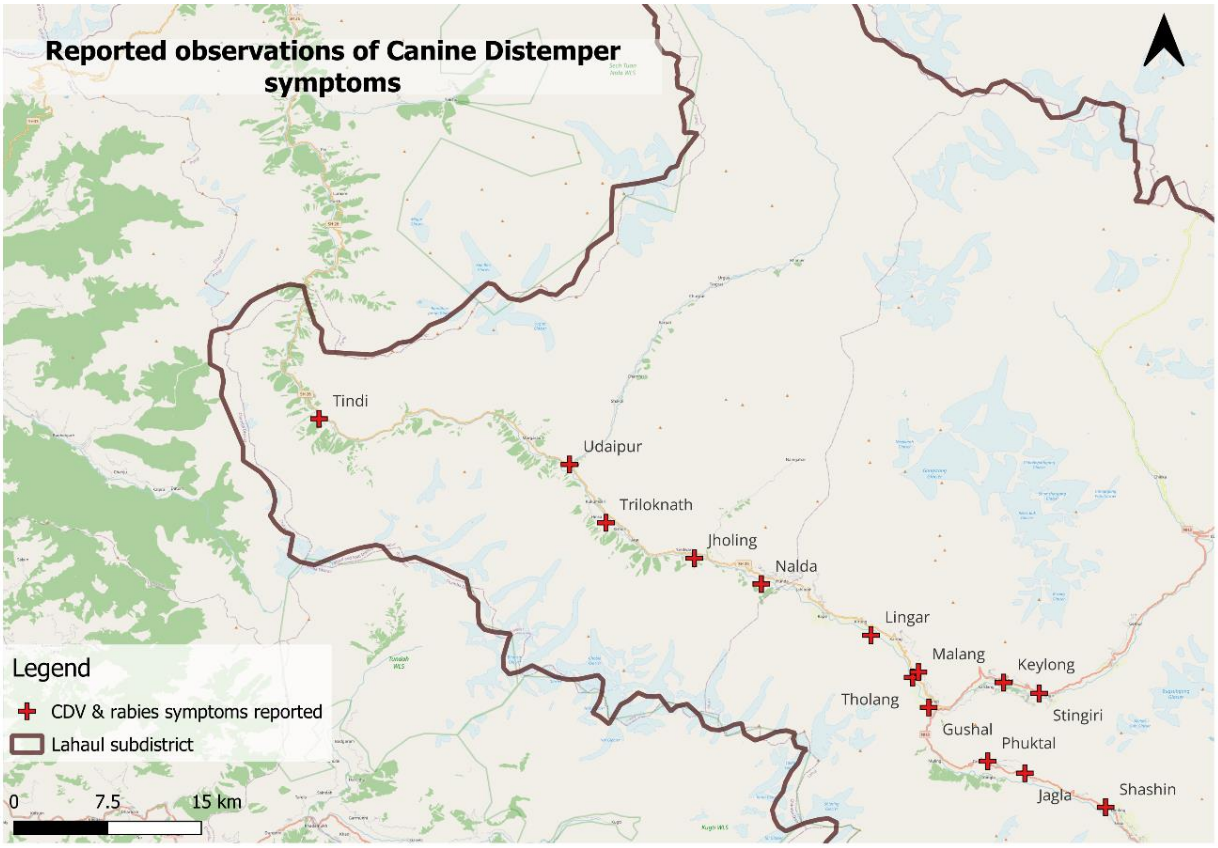
A majority of 47% of villages noted an increasing trend of dog attacks on livestock, while 28% felt that there was a decreasing trend, and 26% noted no change. The villagers that's reported an increasing trend attributed the reasons to increasing dog population in and around villages, lack of food resources for dogs around villages as well as poor herding practices. Villages that observed a deceasing trend also reported a significant reduction in livestock holding in their villages in recent years which was why dog attacks had become less common than before.

3 Diseases in dogs

3.1 Status of disease-related mortality in dogs

Only 21% of the villages reported death of dogs in the last five years due to disease, while most villages (79%) did not observe disease-related deaths in dogs. However, an outbreak of canine distemper for observed in villages like Keylong and Stingari last year (2022) where countless dogs (adults and young ones) died. Many of these dogs were collectively buried last year in the month of October. This was the first case of a CDV outbreak in dogs in Lahaul.

From the surveyed villages, 11 villages reported observations of symptoms of Canine Distemper Disease in dogs which included coughing, sneezing, nasal discharge, eye redness, twitching or jerking and seizures. And 4 villages reported symptoms of rabies such as foaming or excessive salivating in dogs. These villages have potential to be sources of disease outbreak and subsequent transmission to wild animals like red fox, wolf and snow leopard (Map **7**).



Map 7. Villages where symptoms of Canine Distemper disease were observed by respondents. There was an outbreak of CDV disease and mortality in FRDs in Keylong and Stingiri in September-October 2022. This was the first of its kind of disease outbreak in dogs in Lahaul.

We have also observed a few dog adults that have survived the CDV outbreak but yet display physical symptoms of twitching, jerking, lower body weakness which are due to the neurological effects of CDV disease (Image **9**).

Image 9. Observed disease in free-rangong dogs. a) Dog with skin disease; b) Dog with jerking and twitching symptoms as remnants of Canine Distemper disease.

3.2 Status of dog vaccination

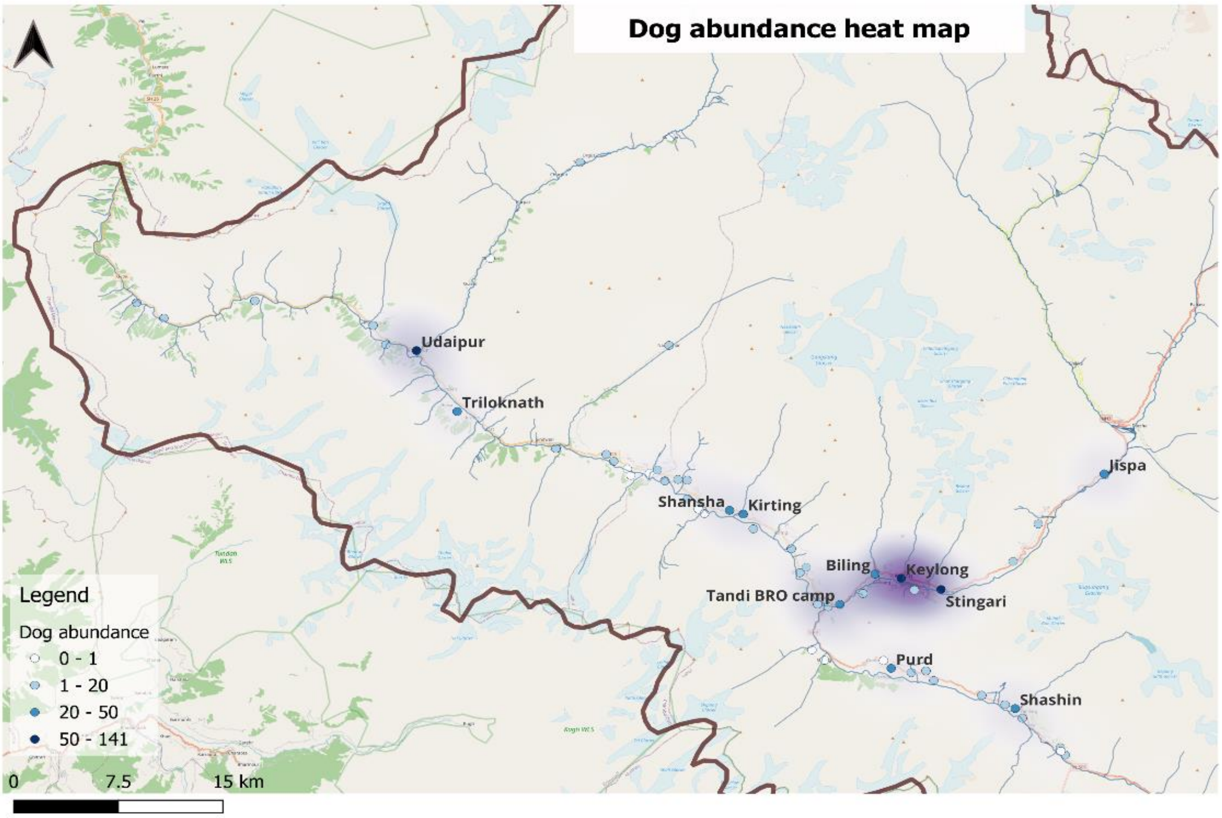
Although the sub-district level Animal Husbandry department keeps only the anti-rabies vaccines for dogs, these vaccines are administered only to pet dogs brought by owners. The department does not keep any other vaccine for dogs to protect against contagious diseases such as Canine Distemper or Canine Parvovirus. Out of the 52 surveyed villages 86% or 45 villages had some pet dogs. Some of the pet dogs had restricted movement within the household, but most pet dogs were free-roaming and without restriction, especially throughout winter months. Out of these 45 villages that kept pet dogs about 71% of households reported to vaccinate their dogs against rabies, while the remaining did not vaccinate their pet canids.

4 Status of dog population estimates across Lahaul

4.1 Dog density, abundance and total population size

Through our dog population surveys in 52 villages and 4 habitations including BRO & GREF camps, tourist and market hubs the density of dogs for Lahaul is estimated as 70 dogs per km sq. (95% CI 40 dogs to 100 dogs/km sq). The overall abundance for is 780 dogs across the surveyed locations. The Map 8 shows the heat map for dog abundance across Lahaul with area highlighted blue indicating higher dog abundance. Three villages namely, Keylong, Udaipur and Stingari had highest dog abundance ranging from 68 to 141, and villages like Jispa, Triloknath, Tandi BRO camp, Shashin, Shansha, Kirting, Biling and Purd had relatively moderate dog abundance ranging from 21 to 50. Using the abundance estimate, the human to dog ratio in Lahaul is estimated as 1:13, or 1 dog for every 13 humans. Village-wise list of dog abundance and sex-wise counts can be found in Appendix Table A.

The Lincoln-Peterson index estimated the total population size, N, for dogs for Lahaul to be 883 with a detection probability of 0.65.



Map 8. Heat map of relative dog abundance estimates in surveyed villages and habitations. Labelled villages have the highest dog (relative) abundance.

4.2 Dog age-class and sex class counts

Our dog population assessment indicates (Figure **9 & 10**) that 43% of sighted dogs were male and 40% of sighting were of female dogs. However, in 17% of the sightings the sex of the sog could not be determined owing to the fact that the dogs sighted were either puppies whose sex could not be ascertained from a distance, or the dog moved away before its sex could be ascertained or captured photographically. Adult dogs comprised 63% of our sightings, followed by pups being sighted on 20% of the occasions, while subadults and old dogs were sighted the least (14% and 3 % of occasions respectively).

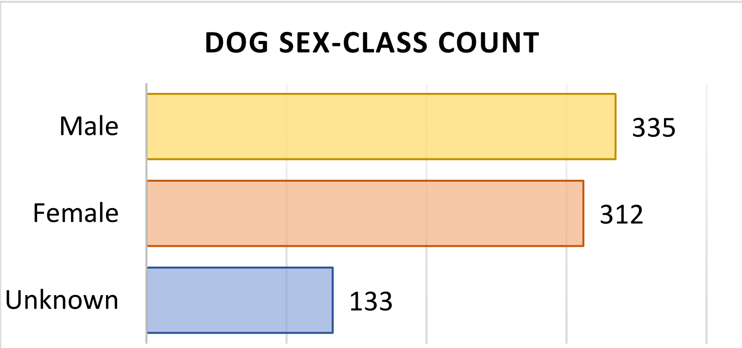


Figure 9. Dog sex classification as counted in dog population assessment.

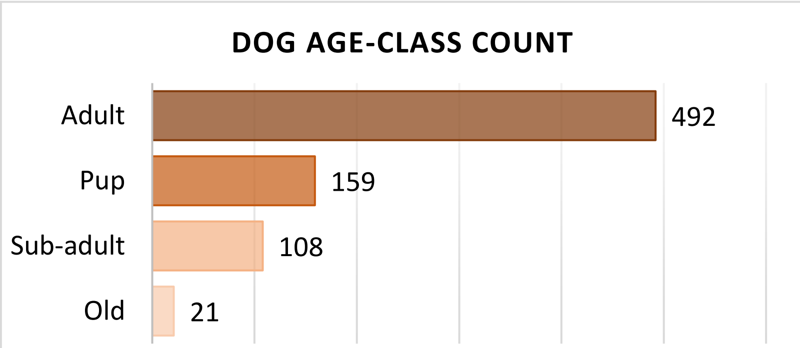


Figure 10. Dog age classification as counted in dog population assessment.

5 Preliminary garbage site survey assessment across Lahaul

5.1 Type and extent of garbage disposal sites and disposal methods

We surveyed a total of 105 garbage disposal sites around our survey villages. About 68.5% of the sites composed of both dry and wet waste, and only 28% of the sites consisted of only dry waste. Electronic waste like batteries and electric bulbs was also present in 20% of the garbage sites (Figure **11**).

Over half of the surveyed garbage sites (53%) were large-scale Open hillslope dumping type where the entire garbage is disposed of into and along a large water stream called *nallah* which then joins the main river Chandrabhaga. Open dumping was recorded for 31% of the disposal sites, and 16% of the sites surveyed were large garbage dumpsters that were overfilled and surrounded by garbage in near vicinity (Figure **12**).

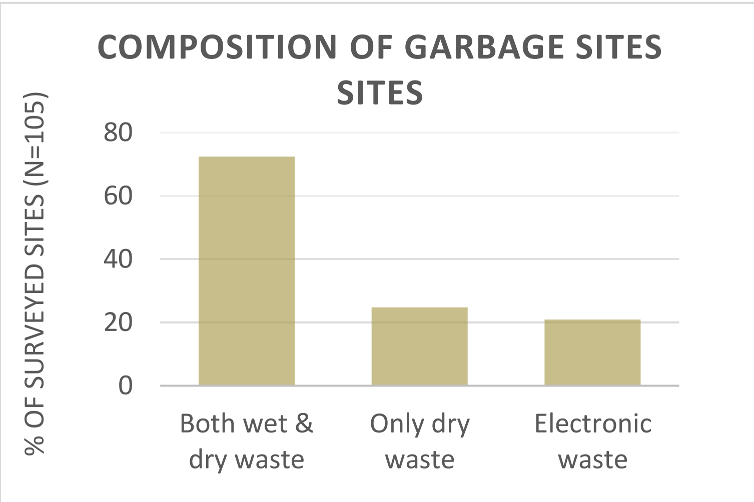


Figure 11. Composition of garbage disposal sites surveyed categorised into wet waste, dry waste and electronic waste.

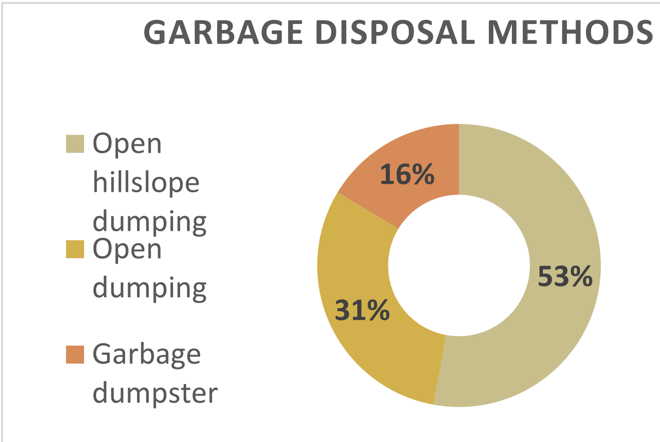


Figure 12. Garbage extent based on the type of disposal or dumping methods: Open hillslope dumping is largescale dumping across the face of hills directed towards water streams or river; Open dumping is a medium-scale dumping spaces created within village premises; garbage dumpster is multiple fine-scale dumping near big villages for garbage collection.

6 Drivers of dog-wildlife interactions

The list of predictor variables that have been noted in other studies to influence increased interactions between dogs and wildlife are listed in Table 1 below.

Table 1. List of predictor variables used to ascertain drivers of dog-wildlife interactions as well as factors associated with relative dog abundance in villages.

Predictor variables	*Type & Source*	*Influence*
Dog village abundance	Estimated using sight-resight surveys	Higher dog abundance may increase instances of dog-wildlife interactions
Village population	From Govt. Census records	Higher village population may attract higher number of dogs and increase the instances of dog-wildlife interactions
Village livestock holding	From Govt. Census records	Higher livestock holding may attract higher number of dogs and increase the instances of dog-wildlife interactions
Distance to nearest garbage site	Calculated using QGIS 3.30 Vector Analysis tool 'Distance to nearest hub'	Vicinity of garbage sources may attract higher number of dogs and increase the instances of dog-wildlife interactions
Garbage site extent	Classified into 3 based on type of garbage disposal methods: Garbage dumpster, Open dumping and Open hillslope dumping	Type of garbage disposal methods may influence dog abundance and increase the instances of dog-wildlife interactions
Distance to nearest market	Calculated using QGIS 3.30 Vector Analysis tool 'Distance to nearest hub'	Vicinity of market hubs may influence dog abundance and increase the instances of dog-wildlife interactions
Market type	Classified into 2 types: Market hub or tourist hub	Type of market hub may influence dog abundance and increase the instances of dog-wildlife interactions

Our response variable was the dog-wildlife interaction score which takes into account the nature and frequency of reported negative interactions between dogs and wild animals. The best performing model, selected through Information-criterion theory, i.e., model with lowest AIC value, indicates that dog-wildlife interaction increases with increase in the village population size (β=0.007, SE=0.004), and on the other hand decreases as the distance from the nearest garbage point increases (β= -0.27, SE= 0.60). This means that bigger villages with a garbage site in close vicinity attract more dogs possibly due to higher food provisioning opportunities, thereby leading to higher negative dog-wildlife interactions.

7 Drivers of dog population abundance in villages

The same list of predictors as listed in Table 1 above were used to ascertain drivers for dog population abundance in and around surveyed villages.

The modelling efforts lead to two models with comparable performance (AICC <2). The first model indicates that village population size (β=0.11, SE=0.007) and distance to nearest garbage site (β=0.49, SE=0.87) and open dumping-type garbage site (β=0.79, SE=4.31) have a positive influence on village dog abundance, while village livestock holding (β=-0.03, SE=0.003) and an open hillslope dumping-type garbage site (β=-6.04, SE=3.83) have a negative influence on the response variable. The second closely related model indicates that, in addition to the above-mentioned predictors, distance to nearest market has a negative influence on dog abundance (β= -0.10, SE=0.28).

To summarise, this indicates that bigger villages with open dumping sites, even if the sites are distant, will attract more dogs due to higher food provisioning opportunities, thereby increasing dog abundances. And villages with larger livestock holding may dissuade dogs from being present in the villages as villagers would be more vigilant and active in removing dogs from villages in order to prevent livestock predation. Moreover, villages with an open hillslope dumping-type garbage site may not be preferred by dogs as such dumping sites typically have dry waste such as packaging material that are not palatable for dogs or any animal.

8 Communities' mitigation practices and limitations

In order to avoid problems or losses due to free-ranging dogs, a majority of villages reported that they shoo away and most of the times with the aid of sticks and stones (66%). If the dogs become too problematic villages admitted to taking to measures such as poisoning dogs (4%) or killing dogs with sticks and stones (1%). To prevent further problem due to dogs, people also reported to relocating dogs away from the village (4%) to towns like Keylong and Udaipur or to markets or tourist hubs with surplus food availability. A small portion of villages took to curbing dog feeding (1%). To prevent livestock predation villages either ensure guarded or attended grazing (6%), or restrict the movement of their livestock (4%) especially in winters. Eight villages reported to not having dog problems and therefore, did not actively engage in any mitigation measures (12%) (Figure 13).

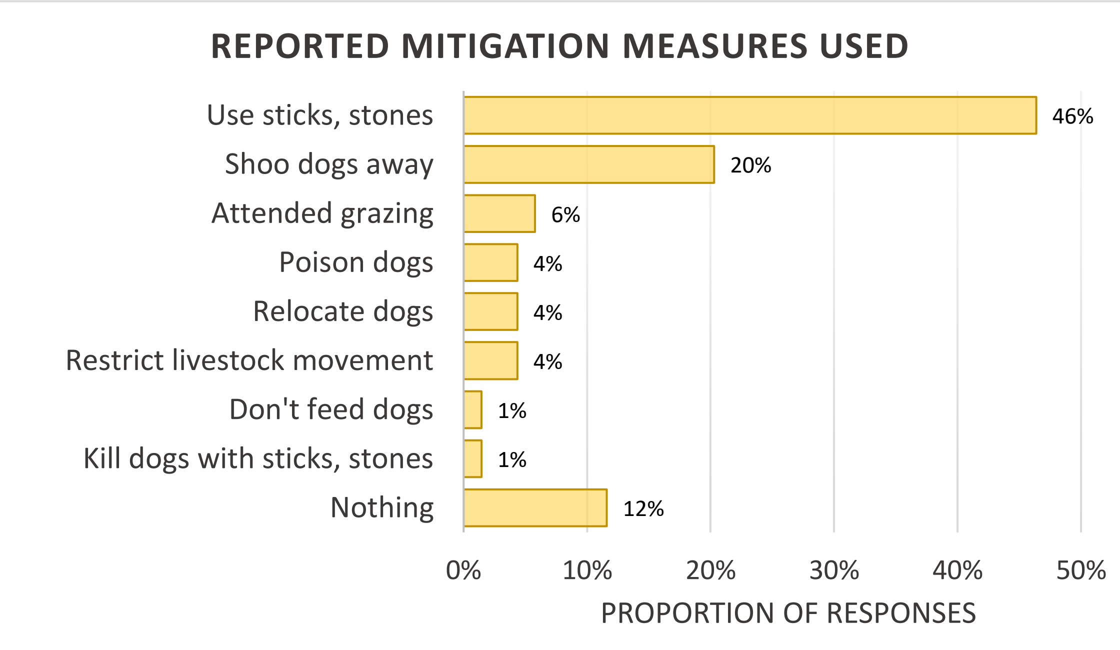


Figure 13. Mitigation measures employed by villages to manage problems or losses associated with free-ranging dogs, especially pertaining to dog attacks on livestock and human safety.

Over half of villages felt that sterilisation programmes for dogs (56%) would be an efficient method for controlling the increasing dog population, while 11 % of responses felt poisoning and removing dogs would be a more successful measure. Some responses were in support for relocating dogs (10%), or culling dogs (7%) or culling only problem dogs (1%). Some villagers believed that creating a dog sanctuary (6%) for dogs would be a useful alternative, and some were of the opinion that curbing dog feeding (5%) or undertaking controlled feeding (1%) would be good practices. Few responses were in support of practicing garbage management (1%) and promoting dog adoption (1%) (Figure 14).

Although sterilisation received the maximum support from villages, it was acknowledged that catching dogs would be a challenge and a limitation for effectively controlling FRD population. Nonetheless the villagers expressed support for ABC programmes by promising to take out time to cooperate with the ABC team or the Animal Husbandry department in such initiatives. The villagers also vocalised their willingness to extend support for post-dog operative care and feeding the dogs.

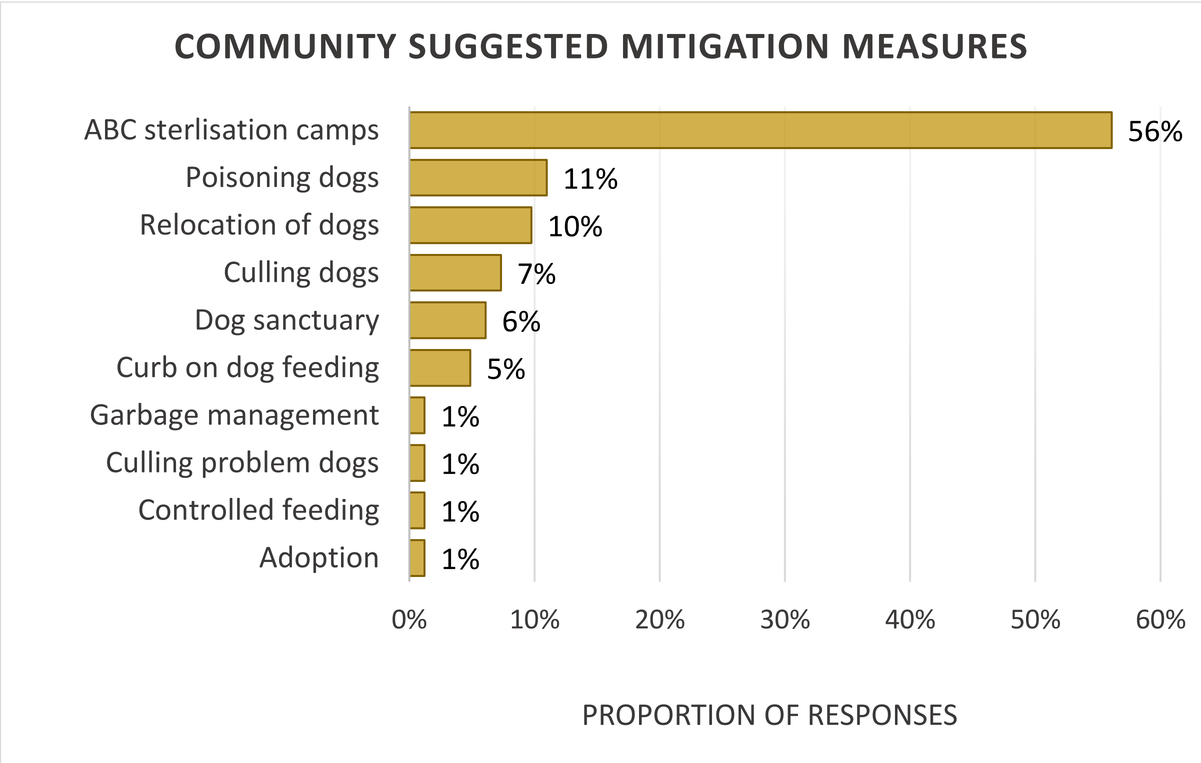


Figure 14. Mitigation measures suggested and perceived by respondents as most effective for dog population management during Focus Group Discussions.

9 On-going challenges w.r.t address dog population and dog movement

There is consensus that fertility control or sterilisation method through ABC camps for humanely controlling dog population is perceived as the best method by several studies as well as stakeholders in the landscape. Despite being widely implemented there have been many limitations for the successful outcomes in most case-studies. Even more challenging in mountainous terrain are logistical and technical limitations.

- Challenges for dog catching include dogs escaping away from villages and disappearing into the difficult to access mountain areas, frightened dogs barking and alerting other dogs to escape and hide; managing fear and stress level of dogs caught and caged before sterilisation.
- Then there are challenges pertaining to maintaining ambient temperature in the recovery room for post-operative recovery and care of sterilised dogs.
- Another known issue for dog catching is lack of local community support.
- Potential stigma associated with the label of a 'dog catcher'.
- Establishing well-functioning operation theatre camps as well as space for pre- and post-operative setup is a significant roadblock due to lack of infrastructure in remote locations.
- Lack of staff or veterinary surgeons to perform surgeries on dogs in a targeted approach at the subdistrict Animal Husbandry Department.
- Lack of clarity about the role and mandate of the Animal Husbandry department. It is common belief among communities that Animal Husbandry should be responsible for conducting dog sterilisation camps, however, it is less known that even Panchayats can take over this role to initiate the need for such camps.

10 On-going challenges and impacts w.r.t garbage disposal and management

Although villages in Lahaul are fairly active in segregating wet waste from dry waste, to use the wet waste as livestock or cattle feed, this practice is slowly becoming absent in due to the decline in livestock holding and cattle feed needs. Leftovers of meat and bones, especially with increased consumption during winter months, are left outside the house for free-ranging dogs which serves as a resourceful attractant. Additionally, deceased cattle are thrown in the open which serves as another attractant for dogs and wildlife like red fox and brown bears creating a direct resource competition between dogs and the wild.

Furthermore, in market areas, waste is typically mixed and discarded into dustbins that are later dumped onto hillslopes near water streams. The practice of waste segregation is yet to be practiced despite the presence of the green wet garbage and the blue dry garbage bins mounted at some locations.

Lack of active waste management is also partly due to the irregular service of waste collection facilities in Lahaul. Most often the waste just remains dumped and collected in community garbage dumpsters and are not removed for months, leading to an accumulation of garbage all around the dumpsters. These overspilled garbage points also serve as attractants for scavengers like dogs and wildlife like red fox.

Even with up-and-coming tourist spots and the resultant food waste generated, there is no intervention or measure such as a waste management plant or incinerator to decompose the significant amount of food waste. This unlimited food waste serves as a major point of food subsidy for dogs and increases the carrying capacity of the habitat thereby, enabling more frequent puppy litter production and survival.

Dog threat mitigation action framework for Lahaul

An effective mitigation framework should be able to address the roadblocks and limitations that hinder implementation of management efforts to address the issues w.r.t negative impacts of free-ranging dogs. Informed by a comprehensive literature review of dog population control practices and their effectiveness in mitigating impacts on wildlife and livestock, coupled with stakeholder consultations in Lahaul, Spiti, and Ladakh, a mitigation action framework is proposed which is specifically tailored to address the escalating dog-induced challenges in Lahaul. This framework will serve as a crucial component of an integrated landscape management plan for the region.

A four-fold foundation for the dog threat mitigation action framework in Lahaul landscape is proposed (Figure **15**):

1) **Directed action plans**
    - includes a set of actionable points to achieve predefined outcomes aligning with identified problems such as unmonitored dog population growth (Dog-oriented action plan) and indiscriminate garbage disposal practices (Garbage-oriented action plan). These two actions plans have been elaborated in the next section.
    - a system to monitor and evaluate progress towards desired impact or outcomes using a set of defined indicators.
    - focus on improving understanding about local dog population dynamics and interactions as well as behaviour ecology.
    - flexibility to adapt with improved learnings and understanding.
2) **Action committee**
    - Formalisation of a dedicated group or committee comprising of member stakeholders (such as Forest dept, Animal Husbandry dept, District Panchayat Office, Block Development Office, Tourism department and local NGO groups like YDA Garsha) to oversee working of the Directed Action Plans in Lahaul.
    - This committee can be the same as that is proposed to be institutionalised under the Integrated Landscape Management Plan for Lahaul, an initiative taken by the Lahaul forest division, Himachal Pradesh Forest Department.
3) **Cross-departmental convergence**
    - An integration of this framework into the district's administrative functioning should allow for opportunities for departments to committedly collaborate and sustain the dog threat mitigation action framework.
4) **Community partnerships**
    - Ensure community participation through equal partnerships and engagements in co-designing and leading the implementation of Directed Action Plans.
    - This is required to foster community ownership and collective decision-making and implementation of mitigation measures or strategies.

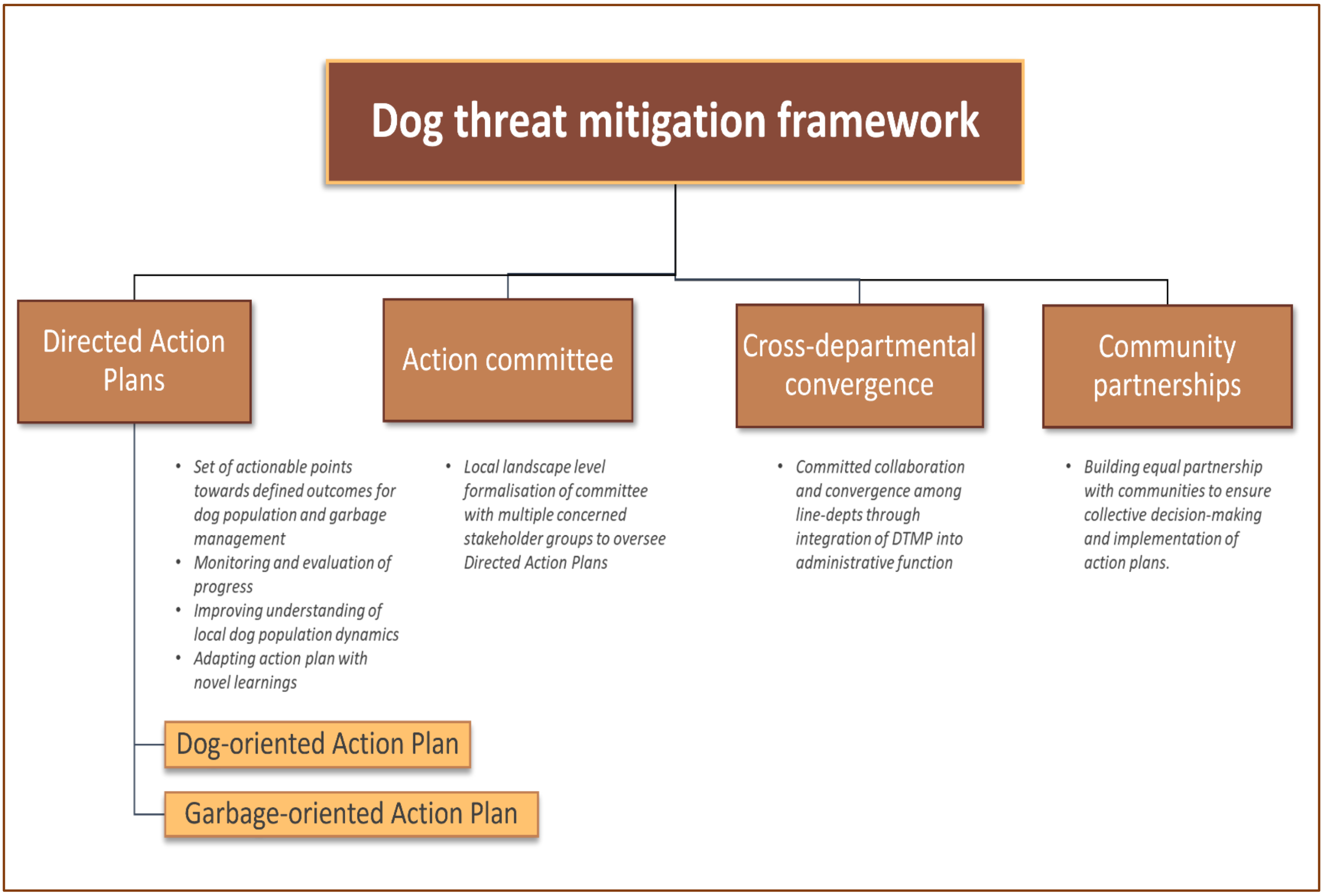
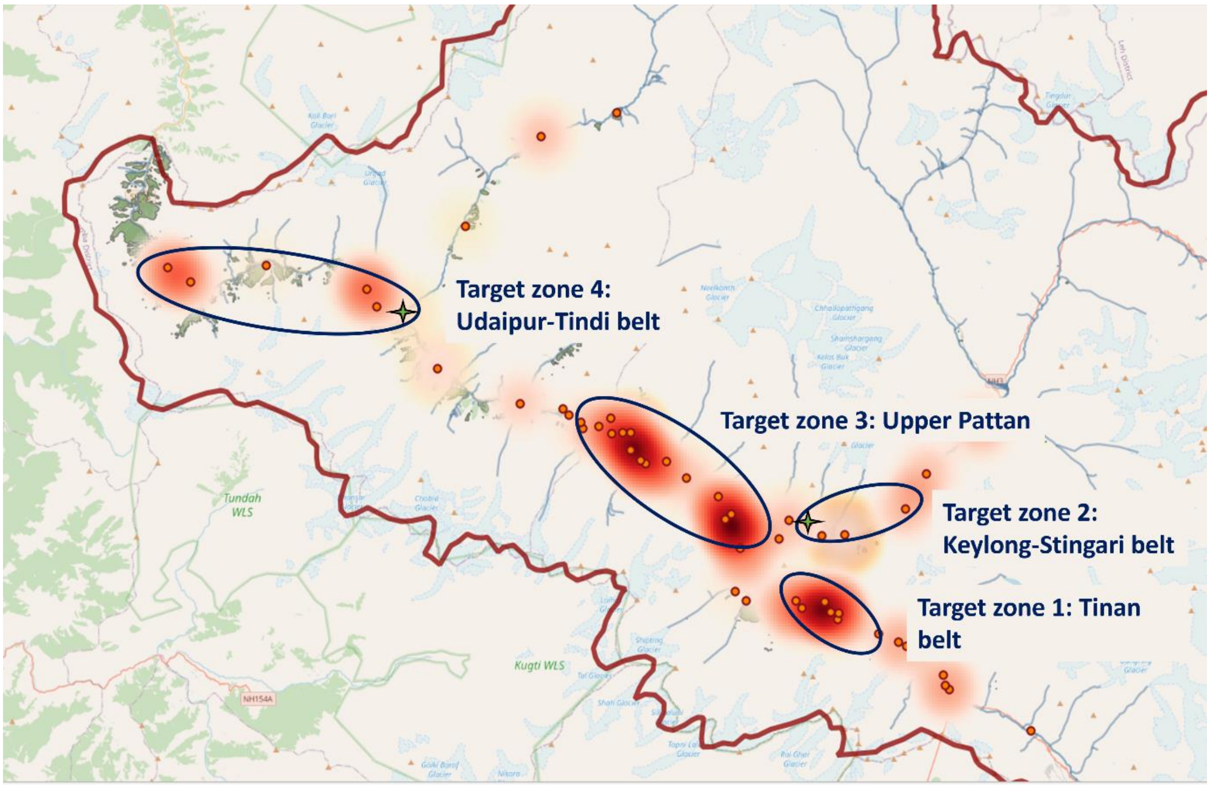


Figure 15. A proposed four-fold foundation for the dog threat mitigation action framework for Lahaul.

The dog threat mitigation action framework and the action plans should be initiated in dedicated and concerted phases targeting areas with highest reported dog impacts. Four target zones have been identified to begin implementation of intervention as seen in Map **9**: upper Pattan belt, Tinan belt, Keylong to Stingari region of Gahr belt and the Udaipur to Tindi belt. The Directed Action Plan for each of the target zone would include multi-faceted yet directed measures as part of the Dog-oriented Action Plan and a Garbage-oriented Action Plan detailed below.



Map 9. Four target zones identified with high relative dog abundances and significant negative dog-wildlife-interactions reported. These target zones should have concerted efforts to address the problems arising from escalating dog population.

A. DOG-ORIENTED ACTION PLAN

Large-scale targeted sterilisation camps have shown desired outputs in many case studies in India. However, dog sterilisation and vaccination camps face limitations that require significant financial, logistical and HR support. Accounting for and overcoming the anticipated challenges for dog ABC and vaccination camps will increase the success rate of such interventions in controlling the ever-growing dog population.

i. To make dog catching easier, the Animal Husbandry department can procure oral sedation medicines that are available and safe for dogs on the day of sterilisation camp. Authorised personnel and volunteers can be given the duty to feed only approved short-term sedation drugs mixed in some food for dogs to eat. These feeders should monitor the dog activity of the dogs fed to notice signs of sedation. These sedated and semi-sedated dogs can then be taken to the pre-operative care theatre.

ii. To address the potential of rabies and disease outbreaks, additional measures of administering oral rabies vaccines (ORVs) can be actioned in these target zones. These ORVs may also be mixed or hidden in food items specifically kept for dogs. Many ORVs used widely in US and other countries come encased within a palatable bait. Rabitec is an example of an ORV that is licensed to vaccinate red foxes and racoon dogs in European Union. ORVs are also used to vaccinate Ethiopian wolves to prevent dog-transmitted rabies outbreak.

iii. In areas where sterilisation camps cannot be held due to unsuitable weather and temperature conditions, community dog feeders can partner with Animal Husbandry department to administer animal birth control pills to unneutered female dogs during months of oestrus, typically in March-April and Sept-October.

iv. Volunteers from communities can be referred to as ‘animal handlers’ to avoid the stigma associated with label of a ‘dog catcher’. Volunteers or animal handlers can be given incentives for safely catching and bringing dogs to the sterilisation camps. There can be a system designed to offer points to the dog handler per dog caught, and these points can be exchanged for accessing subsidies from the Animal Husbandry department on livestock feed and related products.

v. Since Panchayat can play a key role in initiating and cooperating with ABC camps, these local government bodies along with existing *mahila mandal* can partner with relevant dept to execute these camps and garner active support from community members for the same.

vi. Village Panchayat ghar (offices) and *mahila mandal* community centre buildings have traditional heating system known as *bukhari* as well as modern heaters to maintain ambient temperature. These infrastructure and setups can be used as operation theatres and pre/post operative care rooms during ABC camps.

vii. Responsible dog ownership should be mandated to ensure monitoring of dog movement into wild spaces away from villages. Responsible pet ownership should mandate completion of all vaccinations, especially vaccines for Canine Distemper Virus and Canine Parvo Virus.

viii. Ensuring controlled feeding of free-ranging dogs. Providing excessive food to dogs accelerates their fertility, reproductive capacity and survival. Controlled or limited feeding may allow for a natural state of carrying capacity for dog survival.

ix. Strict ban on poisoning with fine and punishment. Poisoned carcasses or dogs died of poisoning have grave consequences as cascading effect on scavengers like red fox, wolf, bear, raptors mountain weasel, ermine.

x. Awareness and education camps should be held by Animal Husbandry dept in collaboration with local NGOs or groups in these 4 target zones to explain the above-mentioned action points. These awareness camps can be made part of the regular *gram sabha* meetings held in villages of these zones.

xi. Shortage of staff or veterinary surgeons employed with the Animal Husbandry dept can be addressed by hiring qualified vet surgeons from private practices and paying them competitive daily wages through joint inter-departmental funds.

xii. ABC camps should be conducted a minimum of twice a year before onset of dog breeding or heat cycle, and a maximum of thrice a year.

xiii. Mandatory inclusion of systematic Monitoring and Evaluation of impacts using suitable indicators. For instance, to measure the impact of dog-oriented plan in controlling dog populations, some indicators can be used, such as percentage of sterilised dogs, percentage of pup to adult ratio in sub-population or relative abundance of dogs.

xiv. Ensure regular, systematic and efficient surveys in high density villages a minimum of twice or thrice a year, right before ABC camps in a given year.

xv. Surveys must include rapid health monitoring of dogs to keep a check on potential zoonotic disease risk.

B. GARBAGE-ORIENTED ACTION PLAN

i. *Mandatory up-scaling of existing waste segregation:*
Villages are quite efficient at segregating wet food waste from the dry waste. The local administration and the Tourism department can up-scale this practice and mandate all registered hotels and homestays to compulsorily have segregated waste dustbins for tourists and tenants.

ii. *Integrating dry waste segregation for safe and efficient waste management:*
SADA (Special Area Development Authority) has been given the lead to address the growing garbage disposal issues in Lahaul. Pushing this initiative forward, segregation activities should include segregating dry waste into plastic, glass, and electronic for environmentally safe management of dry waste. The segregation should be at the level of households, hotels and homestays.

iii. *Installation of Organic Waste Charring (OWC) machines:*
OWC units can be established in select locations like BRO or GREF camps that have surplus food waste generated throughout the years. In Ladakh, Ecosage Enviro, Himalayan Waste Management Company engineered and tested OWC for the climate of Ladakh. It was observed that the semi-automatic OWC functioned well in the high altitude, low atmospheric temperature of Ladakh winters. The machine works on the principles of pressure and heat to dehydrate the food waste into biocompost. The OWC machine processes the waste overnight or in 12-14 hours' time, and therefore, the wet waste can be processed on a daily basis. The machine also has an odour management system to manage food waste smell. The OWC machine capacity ranges from 50 kgs volume to up 1000 kgs.
The Ecosage team completed the installation of the machine and also provided on-site training to the client (at army camp) with the operation, handling and troubleshooting in the function of the OWC.
The machine worked well in the ambient temperature of -5 to -10 degree Celsius inside the cookhouse. The machine does not require any bacterial or enzyme inputs. No pipe burst even at low temperatures. No leakage was reported during operation. Condensation was observed but it was addressed and removed through the pipe without any blocking or freezing, by maintaining a warm temperature for the out-going water.
However, no testing results have been reported to assess the biocompost quality for the purpose of soil enriching. Nonetheless, the generated biocompost can be taken to the market to be sold by establishing market-linkages at the local level.

iv. *Installation of community biodigester units:*
Wet kitchen and food waste coming from market and tourist hubs like Keylong and Udaipur can be collected to be processed in a community-led biodigester unit. The manure generated from the community biodigester plant can be sold at minimal prices

to household contributing to the supply of segregated wet waste. The price can be ascertained after cost-benefit analysis to run the expenses of running such a plant. The manure can be used be used in agricultural fields.

v. *Installation of CCTV cameras around the existing hillslopes garbage dumping points:*
To dissuade and monitor the restriction on garbage dumping along hillslopes and water streams, night-vision CCTV cameras can be installed to keep a watch and fine individuals or groups that break established norms. Action can be taken for suspicious activities.

vi. *Awareness and education camps:*
Workshops on best practices for waste management and disposal should be made a mandatory part of village-level gram sabha meetings, where the above-mentioned points must be re-iterated.

The escalating negative impacts of free-ranging dogs on wildlife and livestock populations in Lahaul necessitate immediate and decisive action. The proposed dog threat mitigation framework offers a comprehensive and tailored solution to address this critical conservation issue. By implementing this framework in active collaboration and partnerships with local communities and multi-sectoral convergence, we can safeguard the region's precious wildlife and livestock populations and ensure a more harmonious coexistence between humans and nature in the Himalaya.

References

1. Belsare, A. V., & Gompper, M. E. (2015). A model-based approach for investigation and mitigation of disease spillover risks to wildlife: Dogs, foxes and canine distemper in central India. Ecological Modelling, 296, 102–112. https://doi.org/10.1016/j.ecolmodel.2014.10.031
2. Bhatnagar, Y.V., Nagpal, T., Rana, R.S., Chugh, K., Gokhale, A., Jalihal, S. (2022). State of Human-Wildlife Conflicts in the Lahaul Landscape in Himachal Pradesh. Nature Conservation Foundation, Mysore, Report submitted to the HCL Foundation, Noida, India.
3. Bhura. Khee highlights the worrying trend of stray dogs attack in Ladakh. (2021, November 10). The Week. https://www.theweek.in/leisure/society/2021/11/10/khee-highlights-the-worrying-trend-of-stray-dog-attacks-in-ladakh.html
4. Contardo, Juan, et al. 2021. 'Environmental Factors Regulate Occupancy of Free-Ranging Dogs on a Sub-Antarctic Island, Chile'. Biological Invasions 23(3):677–91.
5. Ersmark, Erik, et al. 2016. 'From the Past to the Present: Wolf Phylogeography and Demographic History Based on the Mitochondrial Control Region'. Frontiers in Ecology and Evolution 4.
6. Fischer, Jason D., et al. 2012. 'Urbanization and the Predation Paradox: The Role of Trophic Dynamics in Structuring Vertebrate Communities'. BioScience 62(9):809–18.
7. Gandhi. In Ladakh, the snow leopard has a new foe-feral dogs. (2019, July 05). The Hindu. https://www.thehindu.com/sci-tech/energy-and-environment/in-ladakh-the-snow-leopard-has-a-new-foe-feral-dogs/article28294567.ece
8. Ghoshal, A., Bhatnagar, Y., Mishra, C., & Suryawanshi, K. (2016). Response of the red fox to expansion of human habitation in the Trans-Himalayan mountains. European Journal of Wildlife Research, 62, 131–136. https://doi.org/10.1007/s10344-015-0967-8
9. Ghoshal, A., Bhatnagar, Y. V., Pandav, B., Sharma, K., Mishra, C., Raghunath, R., & Suryawanshi, K. R. (2017). Assessing changes in distribution of the Endangered snow leopard Panthera uncia and its wild prey over 2 decades in the Indian Himalaya through interview-based occupancy surveys. Oryx, 53(4), 620–632. https://doi.org/10.1017/S0030605317001107
10. Ghoshal, Abhishek, et al. 2016. 'Response of the Red Fox to Expansion of Human Habitation in the Trans-Himalayan Mountains'. European Journal of Wildlife Research 62:131–36.
11. Goswami, Varun, M., et al. 2007. 'Application of Photographic Capture–Recapture Modelling to Estimate Demographic Parameters for Male Asian Elephants'. Animal Conservation 10:391–99.
12. Hennelly, Lauren, et al. 2015. 'Himalayan Wolf and Feral Dog Displaying Mating Behaviour in Spiti Valley, India, and Potential Conservation Threats from Sympatric Feral Dogs'. Canid Biology & Conservation 18 (7):27–30.
13. Hennelly, Lauren, et al. 2021. 'Ancient Divergence of Indian and Tibetan Wolves Revealed by Recombination-aware Phylogenomics'. Molecular Ecology mec.16127.
14. Home, C., Bhatnagar, Y. V., & Vanak, A. T. (2018). Canine Conundrum: Domestic dogs as an invasive species and their impacts on wildlife in India. Animal Conservation, 21(4), 275–282. https://doi.org/10.1111/acv.12389
15. Home, Chandrima, et al. 2022. 'Serosurvey of Viral Pathogens in Free-Ranging Dog Populations in the High Altitude Trans-Himalayan Region'. Journal of Threatened Taxa 14(5).
16. Hughes, Joelene, et al. 2013. 'A Review of the Interactions between Free-Roaming Domestic Dogs and Wildlife'. Biological Conservation 157:341–51.

17. Joshi, BheemDutt, et al. 2020. 'Revisiting the Woolly Wolf (Canis Lupus Chanco) Phylogeny in Himalaya: Addressing Taxonomy, Spatial Extent and Distribution of an Ancient Lineage in Asia'. PLOS ONE 15(4):e0231621.
18. Kumar, V., Sharief, A., Dutta, R., Mukherjee, T., Joshi, B. D., Thakur, M., Chandra, K., Adhikari, B. S., & Sharma, L. K. (2022). Living with a large predator: Assessing the root causes of Human–brown bear conflict and their spatial patterns in Lahaul valley, Himachal Pradesh. Ecology and Evolution, 12(7). https://doi.org/10.1002/ece3.9120
19. Meunier, N. V., et al. 2019. 'A Comparison of Population Estimation Techniques for Individually Unidentifiable Free-Roaming Dogs'. BMC Veterinary Research 15(1):190.
20. Mcclintock, Brett, et al. 2014. 'Mark-Resight Abundance Estimation under Incomplete Identification of Marked Individuals'. Methods in Ecology and Evolution 5:1294–1304.
21. Mcclintock, Brett. 2015. 'Multimark: An R Package for Analysis of Capture-Recapture Data Consisting of Multiple "Noninvasive" Marks'. Ecology and Evolution 5:4920–31.
22. McDonald, Trent., Carlisle, Jason., and McDonald, Aidan. (2023). Rdistance: Distance-Sampling Analyses for Density and Abundance Estimation. R package version 3.0.0. https://CRAN.R-project.org/package=Rdistance
23. Miller, David L., et al. 2019. 'Distance Sampling in R'. Journal of Statistical Software 89(1).
24. Mishra, C. 2016. The Partners Principles for Community-Based Conservation. Seattle, WA: Snow Leopard Trust.
25. Ng, Debby, et al. 2019. 'Canine Distemper in Nepal's Annapurna Conservation Area – Implications of Dog Husbandry and Human Behaviour for Wildlife Disease' edited by C. Lebarbenchon. PLOS ONE 14(12):e0220874.
26. O.Nyumba, et al. 2018. 'The Use of Focus Group Discussion Methodology: Insights from Two Decades of Application in Conservation' edited by D. Geneletti. Methods in Ecology and Evolution 9(1):20–32.
27. Pilot, M., Greco, C., vonHoldt, B. M., Randi, E., Jędrzejewski, W., Sidorovich, V. E., Konopiński, M. K., Ostrander, E. A., & Wayne, R. K. (2018). Widespread, long-term admixture between grey wolves and domestic dogs across Eurasia and its implications for the conservation status of hybrids. Evolutionary Applications, 11(5), 662–680. https://doi.org/10.1111/eva.12595
28. Punjabi, et al. 2012. 'Using Natural Marks to Estimate Free-Ranging Dog Canis Familiaris Abundance in a Mark-Resight Framework in Suburban Mumbai, India'. Tropical Conservation Science 5(4):510–20.
29. Silva-Rodríguez, et al. 2012. 'Domestic Dogs Shape the Landscape-Scale Distribution of a Threatened Forest Ungulate'. Biological Conservation 150(1):103–10.
30. Singh, A. 2010. 'Conservation prioritization of habitats and forest communities in the Lahaul valley of proposed cold desert biosphere reserve, North Western Himalaya, India'. Applied Ecology and Environmental Research 8(2):101–17.
31. Singh, G. S., et al. 1997. 'Changing Traditional Land Use Patterns in the Great Himalayas: A Case Study of Lahaul Valley'. Journal of Environmental Systems 25(2):195–211.
32. Salvatori, V., Donfrancesco, V., Trouwborst, A., Boitani, L., Linnell, J. D. C., Alvares, F., Åkesson, M., Balys, V., Blanco, J. C., Chiriac, S., Cirovic, D., Groff, C., Guinot-Ghestem, M., Huber, D., Kojola, I., Kusak, J., Kutal, M., Iliopulos, Y., Ionescu, O., … Ciucci, P. (2020). European agreements for nature conservation need to explicitly address wolf-dog hybridisation. Biological Conservation, 248, 108525. https://doi.org/10.1016/j.biocon.2020.108525
33. Sharief, A., Joshi, B. D., Kumar, V., Kumar, M., Dutta, R., Sharma, C. M., Thapa, A., Rana, H. S., Mukherjee, T., Singh, A., Thakur, M., Sharma, L. K., & Chandra, K. (2020). Identifying Himalayan brown bear (Ursus arctos isabellinus) conservation areas in Lahaul Valley, Himachal Pradesh. Global Ecology and Conservation, 21, e00900. https://doi.org/10.1016/j.gecco.2019.e00900

34. Sharma, R. K., Rana, R.S., Sripal, R., Nagpal, T., & Rajendran, T. Gupta, A. (2020). Human-Wildlife Conflict Management Strategy in Pangi, Lahaul and Kinnaur Landscapes, Himachal Pradesh (A SECURE Himalaya study). WWF-India.
35. Smith, K. F., Acevedo-Whitehouse, K., & Pedersen, A. B. (2009). The role of infectious diseases in biological conservation. *Animal Conservation*, *12*(1), 1–12. https://doi.org/10.1111/j.1469-1795.2008.00228.x
36. Suryawanshi, K. R., Bhatnagar, Y. V., Redpath, S., & Mishra, C. (2013). People, predators and perceptions: Patterns of livestock depredation by snow leopards and wolves. Journal of Applied Ecology, 50(3), 550–560. https://doi.org/10.1111/1365-2664.12061
37. Vanak, Abi Tamim, et al. 2009. 'Dogs Canis Familiaris as Carnivores: Their Role and Function in Intraguild Competition'. Mammal Review 39(4):265–83.
38. Vitekere, Kasereka, et al. 2021. 'Threats to Site Occupation of Carnivores: A Spatiotemporal Encroachment of Non-Native Species on the Native Carnivore Community in A Human-Dominated Protected Area'. Zoological Studies 60.
39. Werhahn, Geraldine, et al. 2017. 'Phylogenetic Evidence for the Ancient Himalayan Wolf: Towards a Clarification of Its Taxonomic Status Based on Genetic Sampling from Western Nepal'. Royal Society Open Science 4(6):170186.
40. Young, Juliette C., et al. 2018. 'A Methodological Guide to Using and Reporting on Interviews in Conservation Science Research'. Methods in Ecology and Evolution 9(1):10–19.

Annexure

Table A. List of surveyed villages and habitations in Lahaul with sex-class, age-class details and relative abundance of sighted dogs.

S.no	Village/Habitation name	Sex class			Age-class				Total
		Female	**Male**	**Unknown**	**Adult**	**Pup**	**Sub-adult**	**Old**	
1	Keylong	54	46	41	77	35	27	2	**141**
2	Udaipur	41	29	6	53	8	12	3	**76**
3	Stingari	33	30	5	32	21	15		**68**
4	Tandi BRO	15	17	13	25	17	3		**45**
5	Jispa	20	16	7	31	5	7		**43**
6	Triloknath	15	16	4	27		6	2	**35**
7	Kirting	8	11	8	11	13	3		**27**
8	Purd	7	8	9	8	9	5	2	**24**
9	Biling	6	6	9	11	10			**21**
10	Shashin	10	7	4	14	5	1	1	**21**
11	Gushal	13	7		16	3	1		**20**
12	Tandi Bridge	10	6	2	17		1		**18**
13	Shansha	3	7	7	9	2	5	1	**17**
14	Tholang	3	9	4	8	7	1		**16**
15	Tindi	5	9	0	10	2	0	2	**14**
16	Sissu Nursary	5	8		10			3	**13**
17	Jahalma	6	7		8		5		**13**
18	Teling	2	3	6	6	5			**11**
19	Salgaraon	4	6	1	8	1	2		**11**
10	Margaraon	3	8		9	1	1		**11**
21	Lohni	5	3	1	7		2		**9**
22	Gopathang	3	5	1	8			1	**9**
23	Rapring	4	4	1	3	5	1		**9**
24	Sakar-Khangsar	3	5		3	1	3	1	**8**
25	Jagla-Murticha	3	3	1	4	1	2		**7**
26	Kawaring	4	2		5	1			**6**
27	Kamring	1	5		5	1			**6**
28	Tingrat	1	5		6				**6**
29	Malang	3	3		6				**6**
30	Salpat	2	4		4		2		**6**
31	Tozing	1	3	1	4	1			**5**
32	Khangsar	1	4		3		1	1	**5**
33	Othang-Tibok	2	3		4		1		**5**
34	Nain Gahar		5		4			1	**5**
35	Rangcha	3	2		4		1		**5**
36	Dimphuk	1	3	1	4			1	**5**
37	Murang	1	2	1	4				**4**
38	Lingar	1	3		4				**4**

39	Gwajang	2	1		2	1			**3**
40	Lapchang		3		3				**3**
41	Jholing	2	1		2	1			**3**
42	Jasrath	1	2		3				**3**
43	Ropsang	1	2		3				**3**
44	Raling		2		1	1			**2**
45	Jobrang		2		2				**2**
46	Muling	1			1				**1**
47	Nalda	1				1			**1**
48	Khanjar	1				1			**1**
49	Galing		1		1				**1**
50	Laling	1			1				**1**
51	Chimrat		1		1				**1**
	Grand Total	**312**	**335**	**133**	**492**	**159**	**108**	**21**	**780**