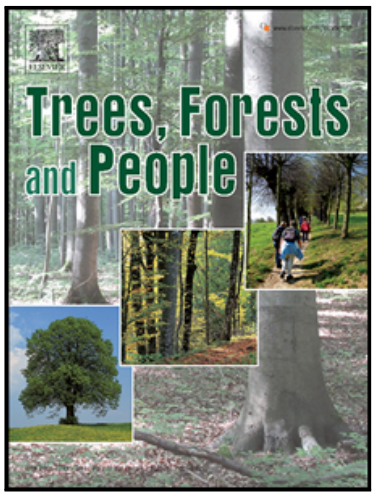

Enhancing human-tiger coexistence in forest corridors of Nepal through a socio-ecological approach to conservation

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PII: S2666-7193(23)00034-1
DOI: https://doi.org/10.1016/j.tfp.2023.100402
Reference: TFP 100402

To appear in: *Trees, Forests and People*

Received date: 22 May 2023
Revised date: 4 June 2023
Accepted date: 6 June 2023

Please cite this article as: Basant Sharma , Dinesh Neupane , Enhancing human-tiger coexistence in forest corridors of Nepal through a socio-ecological approach to conservation, *Trees, Forests and People* (2023), doi: https://doi.org/10.1016/j.tfp.2023.100402

Highlights

- Despite the recent growth in the tiger population and negative interactions, people still hold a positive attitude towards Bengal tigers.
- However, people's tolerance to tigers reduced due to increase in population and frequent negative interactions.
- A high level of tolerance was associated with infrequent visitation to the forest, young and educated individuals, families benefitting from tourism, and those with no hostile interactions with tigers.

Enhancing human-tiger coexistence in forest corridors of Nepal through a socio-ecological approach to conservation

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Abstract

Forest corridors in lowlands of Nepal provide connectivity for endangered Bengal tigers (*Panthera tigris tigris*) between Nepal and India. In recent years, both Bengal tiger and human populations in these areas have increased, leading to greater potential for conflict. Although people's attitudes and behaviors towards Bengal tigers have been relatively positive, increased tiger attacks are likely to negatively impact human perceptions of risks. We investigated current views of people living in four different communities of the Khata Corridor of Nepal and inferred how their opinions of Bengal tigers varied based on multiple locality-specific effects. We conducted in-person household surveys (N = 177) using a systematic random sampling design and semi-structured questionnaires. In general, people had positive attitudes towards Bengal tigers but also believed expanding populations in the region were responsible for greater conflict.

There was a consensus opinion that Bengal tiger abundances should remain constant or be reduced in the next 10 years, indicating potential for reduced acceptance. However, individual's attitude and tolerance for Bengal tigers varied based on structure of local human settlements. Our finding suggest individuals living in communities lacking formal education, with more frequent visitation to forest habitats, higher intensity of hostile interactions, and no benefits from tourism had lower levels of tolerance. Greater tolerance for Bengal tigers was conversely most associated with opposite settlement demographics. Coexistence between humans and Bengal tigers may be enhanced by working towards equal opportunities for eco-tourism among settlements, and public reporting of research findings to counter opinions that are not supported by data.

Keywords: Eco-tourism, human-tiger conflict, *Panthera tigris tigris*, wildlife economy, wildlife tolerance

Introduction

Human-wildlife conflict generally occurs where human and wildlife space-use overlaps resulting in damage of wildlife habitats and/or human resources, loss of livelihoods, and direct threats to life including killing and injuries to wildlife, people, and livestock (Mekonen, 2020; Nyhus, 2016). The main drivers of global human-wildlife conflict include expanding human settlements that encroach on wildlife habitats and increasing movement of wildlife into human settlements (Doak et al. 2014; Fonseca et al. 2021). The goal of present-day conservation biology is to alleviate conflict and develop coexistence strategies between humans and wildlife populations (Redpath et al., 2013). Maintaining successful, long-term coexistence is challenging, however, as complex social and ecological interactions between humans and wildlife are not well understood (Carter and Linnell, 2016). Incorporating community attitudes and tolerance levels towards wildlife in any coexistence strategy, and understating how these vary across socio-

ecological and landscape-level contexts, can likely enhance successful coexistence efforts (Pooley et al. 2020). Such efforts must consider spiritual views and norms, current attitudes, and to what degree people practice acceptance (do not act) or intolerance (negative actions) towards species to inform appropriate conflict-mitigation practices (Rissman and Gillon, 2017; Young et al., 2016).

Human coexistence with carnivores is complicated given that many carnivores are species of conservation concern, and which play key ecological roles in maintenance of prey-predator relationships (Kuijper et al., 2016). Indeed, the most common conflicts reported for carnivores include livestock depredation, fear through perceived threat, and actual attacks on humans resulting in serious injury or loss of life (Lamb et al., 2020). Despite inherent conflict with carnivores, recent studies report positive human-carnivore relationships reflecting social and cultural factors associated with coexistence. For example, in Tibet, Buddhist monasteries protect snow leopards (*Panthera uncia*) and their habitats because of their cultural values, even given periodic livestock depredation (Liu et al., 2011).

Bengal tigers (*Panthera tigris tigris*) occur in Nepal in central Himalaya and are a persistent focus of human-wildlife conflict in the region. Bengal tigers are considered globally endangered (Goodrich et al., 2021). In Nepal, they are distributed through forests of western and central lowlands with occasional sightings above 3100 m from the eastern Ilam to western Dadeldhura districts (Bista et al., 2021; Smith et al., 1998; WWF, 2021). The contemporary range of Bengal tigers includes areas affected by both rapid human expansions and significant habitat fragmentation (Bhattarai et al., 2017; Wikramanayake et al., 2004). Recognizing Bengal tigers were a keystone species throughout their range, an extensive recovery program was initiated by the government of Nepal in the early 1970s (DNPWC, 2022). The goal was to

integrate communities living around the edges of Bengal tiger habitats with conservation efforts by promoting sustainable ecotourism (Ghimire, 2022; Karki et al., 2011; Wikramanayake et al., 2010). Concurrent with increasing Bengal tiger populations, human-tiger conflict in Nepal increased based on number of attacks on humans and livestock (Mandal, 2021; Pokharel, 2022; Rauniyar, 2021). This provides a challenge for the Nepal government, international agencies, and local communities actively involved in conservation to identify what threshold of Bengal tiger abundances can be sustained while balancing acceptable levels of conflict. How best to co-exist with Bengal tigers has now emerged as a leading concern for future conservation in Nepal and throughout its range.

Social-ecological studies of conflict with Bengal tigers in Nepal are underrepresented in the related literature. Most studies are based on either tiger attack patterns and how livelihoods are impacted by such attacks (Acharya et al., 2017; Bhattarai et al., 2019; Bhattarai and Fischer, 2014; Dhungana et al., 2018, 2018, 2016; Gurung et al., 2008; Lamichhane et al., 2018, 2017; Ruda et al., 2018; Shahi et al., 2021; Sijapati et al., 2021; Silwal et al., 2017) or on ecological modelling including conflict as a model parameter (Faisal et al., 2023; Kanagaraj et al., 2011; Karki et al., 2015; Thapa et al., 2017). These studies provide possible solutions for reducing human encounters with tigers, prioritizing compensation schemes (or relief funds), and enforcement of several conflict mitigating measures (such as restricting human access to forests). However, human dimensions of conflict, which is crucial to enforce suitable policies for conservation while also improving human interests, has received little attention. A few studies addressed anthropological aspects of conflict through in-person surveys; in general, reporting positive attitude towards Bengal tigers, especially in Chitwan and Bardiya National Park, two prime areas in Nepal for high Bengal tiger densities (Bhattarai and Fischer, 2014; Carter et al.,

2014; Carter and Allendorf, 2016; Dhungana et al., 2022). However, attitudes towards Bengal tigers varied based on several socio-economic parameters associated with communities including education, religion, occupation, age, sex, forest use, livestock herd size, and past-experiences. Individuals with no formal education, lower religious caste, farmers involved with daily agricultural work, older age groups, females, frequent forest visitation, small livestock size, and those who were previous victims of Bengal tiger encounters were less positive (Carter et al., 2014). In general, local people were willing to tolerate some degree of livestock loss but were highly intolerant to attacks on humans (Bhattarai and Fischer 2014). In a recent comparative study between Bengal tigers and common leopards, two carnivores sharing similar habitats in the lowlands of Nepal, people viewed Bengal tigers and their conservation much more favorably than leopards even though leopards, have not been involved in killing humans (Dhungana et al. 2022). The majority of existing studies are also focused on Chitwan National Park and only handful of research efforts have been focused elsewhere, for instance in Bardiya National Park and the associated Khata Corridor.

The Khata Corridor is the primary transitory route for wildlife crossings between Bardiya National Park in Nepal and Katarniyaghat Wildlife Santuary in India (Fig. 1). This region has experienced exponential growth of resident Bengal tiger populations within just 13 years, with a ~600% increase between 2009 (18 individuals) to 2022 (125 individuals) (DNPWC, 2022). Settlements in Khata Corridor are located at varying distance from Bardiya National Park with differences in livelihood status, economic benefit received from tiger-led tourism, conflict intensity and ability to cope with tigers. Individuals living on the periphery of forests are generally socially marginalized, financially poor, and have greater dependency on forest resources. Frequent forest visitation is often the only option to fulfill needs for food and

resources, including harvesting of grass, fruit, firewood, litter and building materials, and livestock grazing, even though restrictions on forest access should prevent these activities. As a consequence, increasing tiger densities in the region has potential to affect human well-being (Wegge et al., 2018). Reducing conflict between communities and Bengal tigers will require updated understanding of perspectives with regard to local people's attitudes and beliefs.

The goal of this study was to gather contemporary evidence for a) individuals' current views of ongoing human-tiger conflict in the region, b) current attitudes, and c) tolerance towards Bengal tigers as Bengal tigers demographics change through time. We generated data on socio-economic conditions of households through personal interviews across multiple communities and assessed how such factors affect perceptions, attitudes and tolerance levels towards Bengal tigers. Our results provide potential solutions towards coexistence through improved management strategies for Bengal tigers across their range that prioritize people's concerns through understanding the current socio-ecological context in Nepal.

Methods

Study area

Khata Corridor covers approximately 90 km^2, of which ~65 km^2 is either National Forest or Community Forest (both in and outside of the buffer-zone area of Bardiya National Park) or open-shrub forest mixed with grassland. Settlements with cultivating agricultural lands comprise ~25% of this area. Khata was legally classified as a wildlife corridor in 2010 when Nepal declared it as a 'forest under protection'. Alongside Bengal tigers, Asian elephants (*Elephas maximus*), greater one-horned rhinoceros (*Rhinoceros unicornis*), common leopard (*Panthera pardus ficusa*), barking deer (*Muntiacus muntjac*), and spotted deer (*Axis axis*) use Khata

Corridor as a connection between India and Nepal. We conducted our study in four settlements of Khata Corridor; Thakurdwara (28.447N, 81.247E), Neulapur (28.444N, 81.303E), Dalla (28.412N, 81.233E), and Pattharbhuji (28.390N, 81.221E) (Fig. 1). Hindu people dominate settlements with mixed caste groups compromising indigenous Tharu people, Brahmin-Chhetri, Magar and Dalit. In general, both Thakurdwara and Dalla benefit from ecotourism as they have established income-generating activities through homestays, hotels and shops, whereas Pattharbhuji and Neulapur have no tourism benefits.

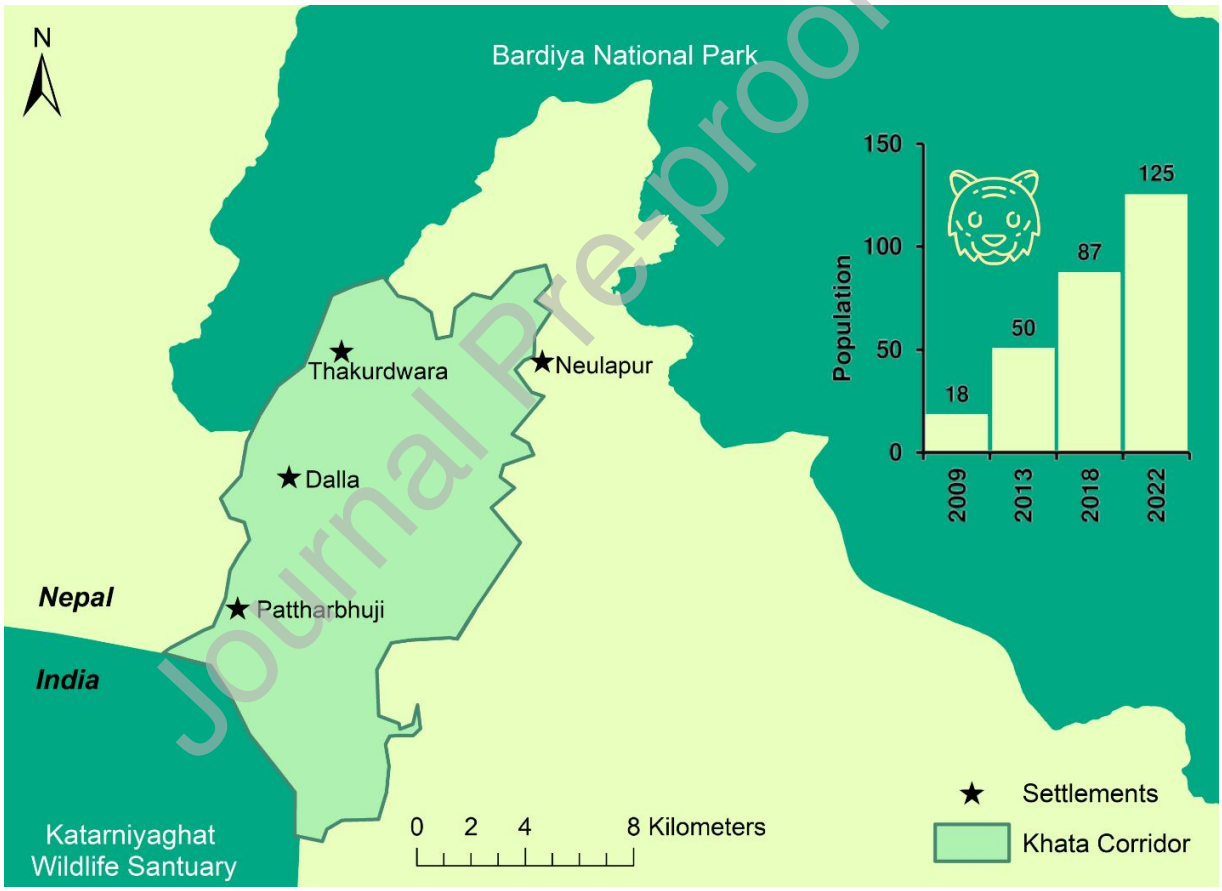

Figure 1. Map of study area representing the Khata Corridor, with four different settlements selected for household surveys alongside population of Bengal tigers in Bardiya National Park during National Tiger Census in 2009, 2013, 2018 and 2022 as documented by Department of National Park and Wildlife Conservation, Nepal. Thakurdwara is located in the northern end of

the corridor directly connected to Bardiya National Park whereas Pattharbhuji is located in the southern end of the corridor, and is only partially in the vicinity of both national forest and community forest, but is connected to the Katarniyaghat Wildlife Santuary in India. Neulapur is also at the northern end but not directly connected with Bardiya National Park. The location of Neulapur is however within a buffer-zone area and connected to a community forest that in turn links to Bardiya National Park. Dalla is located in between Thakurdwara and Pattharbhuji settlement, separated by agricultural lands and scattered human settlements with Thakurdwara but by forest with Pattharbhuji. All settlement are within the buffer zone of Bardiya National Park except Pattharbhuji.

Household survey

All four settlements included a total of 1720 households of which 177 households (~10% of households within each settlement) were selected for in-person surveys considering 95% confidence interval and 7% margin of error. To determine starting point for the survey, we chose a random number between one and sampling interval (10) then surveyed every n^{th} household from the starting point following systematic-random sampling. In most cases, every 10^{th} household was chosen but if such household was empty or had no willing or eligible participants, then the 9^{th} position household was interviewed. Household surveys were conducted in December 2021 and consisted of semi-structured questionnaires presented to any household member >18 years old. We initiated each survey by greeting the household member(s), summarizing the project, and requesting their willingness to participate. We collected information on individuals' demography (i.e., age, gender), socio-economic conditions (i.e., occupation, monthly family income, number of livestock in possession, frequency of forest visitation), and past experience with Bengal tigers (i.e., have they economically benefitted from

tiger-led tourism, have family members or livestock been attacked or killed by Bengal tigers in the past five years). We then collected anecdotal responses on several survey questions that could measure individuals' views, attitudes, and tolerance levels towards Bengal tigers. Such as, we asked how Bengal tiger densities in the forest and incidences of tiger attacks on humans and livestock have changed in comparison to the past 10 years (5-point Likert scale, 1 = highly decreased, 2 = decreased, 3 = same, 4 = increased, and5 = highly increased) or whether increases in Bengal tiger populations led to greater human-tiger conflict in the region (yes or no). To quantify individuals' attitudes, we asked if they enjoyed having Bengal tigers in nearby forests (yes or no) or whether Bengal tigers should be conserved although sometimes they cause human fear and potentially lethal attacks on humans and livestock (yes or no). We measured individuals' tolerance level towards Bengal tigers as their preference on coexisting with larger populations in nearby forests in the next 10 years compared to current populations occurring in nearby forests. We chose a ten-year period because it is a duration that generally corresponds to generation change in Bengal tiger populations (Carter et al., 2014). Responses on future tiger preferences was ordinal; less, same, or more Bengal tigers compared to current population estimates from National Tiger Census 2022 (DNPWC, 2022).

Statistical analysis

We used chi-square, goodness-of-fit tests to assess differences in individuals' current views on conflict with Bengal tigers. Specifically, we investigated statistical differences ($p \leq 0.05$) in responses to a) change in tiger density in the nearby forest, and b) change in incidences of tiger attacks in comparison to the past 10 years. However, as no respondents chose "highly decreased" or "decreased", these were removed from the test. We also performed chi-square tests of independences to assess if an increase in tiger populations was considered to increase conflict

in the region, across multiple variables (Table 1). Chi-square tests of independences were again used to assess whether people's attitude (response on enjoying having Bengal tigers) and tolerance level (response on future tiger preferences) were significantly associated with the socio-economic characteristics (Table 1). As there was significant association between individuals tolerance with multiple variables, we used ordinal regression tests to determine the most significant contributors and how that could affect acceptance with Bengal tigers (for prior two cases no regression tests were followed). However, preliminary analyses revealed some independent variables were also highly associated with each other, for example, a) location of human settlement was correlated with respondent's age ($\chi^2 = 31.45, df = 6, p = 0.000$), forest visitation pattern ($\chi^2 = 140.75, df = 9, p = 0.000$), benefit received from tourism ($\chi^2 = 16.62, df = 3, p = 0.001$), and victim status ($\chi^2 = 74.66, df = 3, p = 0.000$), and b) education status was correlated with monthly family income ($\chi^2 = 5.03, df = 1, p = 0.025$). In these cases, we used a representative variable based on lowest AICc values in single-effect models. For example, the model with settlements and education had lowest AICc compared to other competing models therefore, these were considered for ordinal regression alongside an extra variable (i.e. occupation) that was not associated with any other predictor variables (Table 2). We built more ordinal regression models including null model (model without variable) trying different combinations between these variables. All models were built in R studio (R Studio Team, 2022) using "MASS" package (Venables and Ripley, 2002). Models with ΔAICc value < 2 were considered as best competing models, while also considering a single best model for explanation identified based on low AICc value and high AICc weight (ω) (Table 2).

Table 1. List of variables used for chi-square test of independence. Analysis was performed between each of response variable (views, attitude and tolerance) and the same set of predictor variables to check significant association.

Variables	**Description**
Response variables	
Views	Specifies respondent's response on whether increases in tiger populations led to high human-tiger conflict in the region. Their response was measured as binary, yes or no
Attitude	Indicates respondent's response on whether they enjoy having tiger in their nearby forest. The response was measured as binary, yes or no
Tolerance	Directs to respondent's response on future tiger preferences compared to current population occurring in their region. The response was ordinal measured at less, same and more populations. Less suggests having lower level of tolerance, same as moderate and more as high level of tolerance.
Predictor variables	
Settlement	Respondents were recorded as living in one of four settlements, including Thakurdwara, Neulapur, Dalla, and Pattharbhuji.
Forest visit	Reflects household survey responses on frequency of forest visitation as Daily (frequent), Weekly, Monthly and Yearly (rare) visitation.
Age	Reflects age class of primary information giver during household surveys as Young (19-39), Adult (40-50), and Old (>50)
Gender	Gender of the respondent was either Male or Female
Livestock herd size	A measure of the total number of livestock possessed by respondent's household. Livestock includes cows, buffalo and goats. Head count includes juveniles < 3 months old with mother as 1 head. Head count is Low (0-4 animals) or High (>4)
Monthly income	Reflects total earnings made by respondent family per month, as Low (<15,000 Nepalese Rupees) or High (>15,000 Nepalese Rupees). Exchange rate, 1 USD = ~120 Nepalese Rupees during field visit.
Occupation	Reflects primary occupation of the respondents. Farmers as whose primary income dependent on agriculture, Employees as any kind of jobholders and Businessperson as who owns any kind of bossiness.
Education	Measures the education level of the respondents. Educated as who has been to the school or have received any kind of

	formal education and Uneducated as who has never been to the school or have not received any kind of formal education
Tourism benefit	Reflects any sort of income benefit received by respondents family due to tourism. Beneficiary as family receiving benefit such as establishing hotels, homestays and shops, tourist guide, travel agencies, or selling milk, fruits, vegetables and meat products to hotels and homestays, and Non-beneficiary as devoid of any kind of tourism support.
Victim status	Reflects hostile interaction of respondent's with tiger. Victim, who, whose family members or livestock were previously attacked or killed by Bengal tigers and Non-victim, having no such interactions.

Results

Most respondents believed that tiger densities increased (67%) compared to the population a decade ago (Fig. 2). Only 4% considered populations remained the same and no respondents considered they have decreased or highly decreased for past 10 years (Fig. 2). There were significant differences among responses between same, increased, and highly increased response categories ($\chi^2 = 105.66$, $df = 2$, $p = 0.000$). No respondents thought tiger attacks on human and livestock have either decreased or highly decreased (Fig. 2). However, the remaining three response categories differed significantly ($\chi^2 = 13.66$, $df = 2$, $p = 0.001$) as majority of respondents believed attack trends have increased (45%) as opposed to highly increased (23%) and 32% considered that it remains the same (Fig. 2). A total of 89.8% of respondents favored the statement that increases in tiger populations have led to greater human-tiger conflict in the area (Fig. 3A). These views were statistically associated with human settlement ($\chi^2 = 8.29$, $df = 3$, $p = 0.040$) but not with other socio-economic characteristics (Fig. 4A).

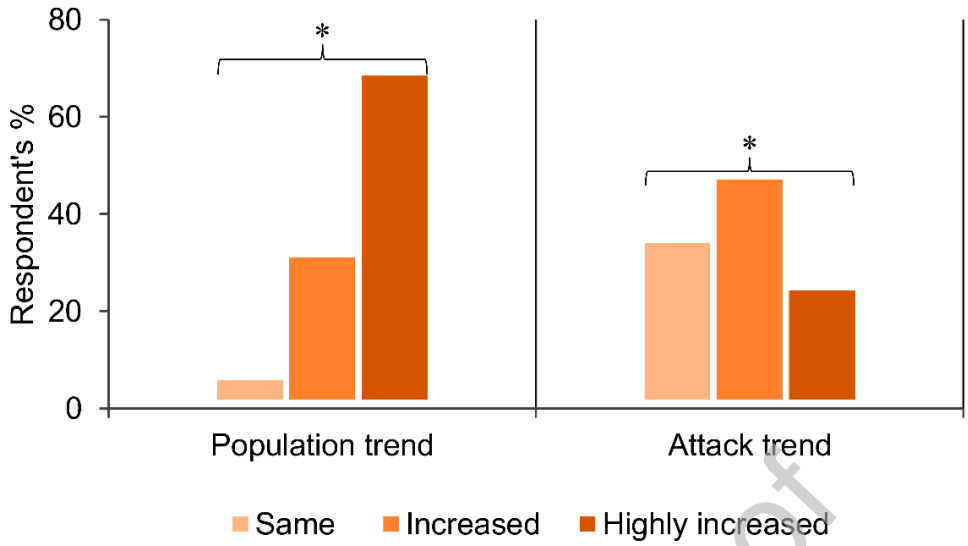

Figure 2. Survey responses (N = 177) reflecting change in tiger population and tiger attacks compared with recent past 10 years in Khata Corridor during December, 2021. Variation on responses between same, increased and highly increased was assessed through chi-squared goodness of fit. The p values are presented at the top of bar graphs and significant values (at 95% confidence) of ≤0.050 are marked by * which indicate statistically differed responses.

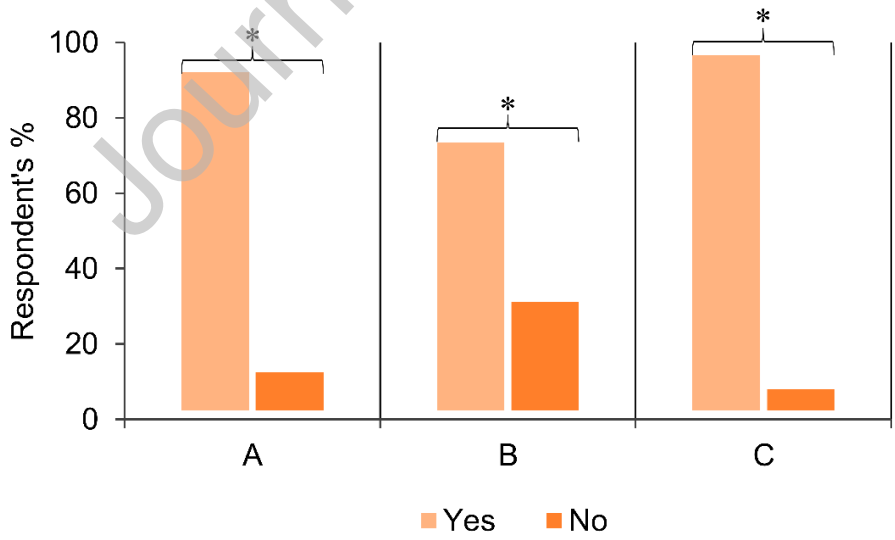

Figure 3. Survey responses (N = 177) reflecting A) whether people think rise in tiger population led to high human-tiger conflict in their area, B) whether people enjoy having tiger in their area, and C) whether tiger should be conserved in Khata Corridor during December, 2021. Variation on responses between yes and no was assessed through chi-squared goodness of fit. The p values are presented at the top of bar graphs and significant values (at 95% confidence) of ≤0.050 are marked by * which indicate statistically differed responses.

Most respondents (71.2%) enjoyed having Bengal tigers in their area and 94.4% were in favor of tiger conservation efforts, even given risks of attack, fear of attack, and potential loss of livestock (Fig. 3B & C). People's fondness with them was strongly associated with human settlement ($\chi^2 = 16.00$, $df = 3$, $p = 0.001$) and forest visitation pattern ($\chi^2 = 12.21$, $df = 3$, $p = 0.006$) but not with other socio-economic parameters (Fig. 4B).

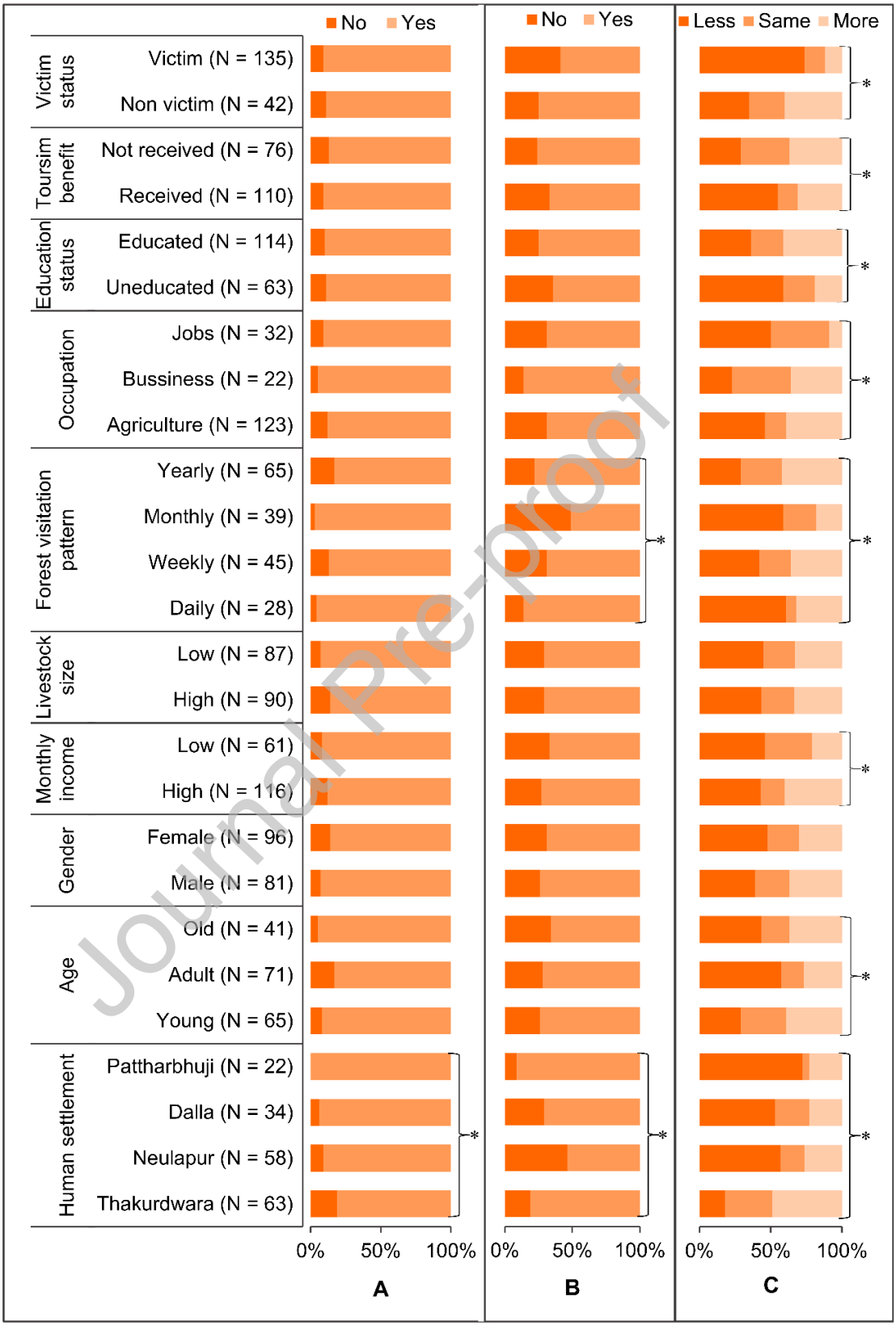

Figure 4. Survey responses reflecting how individuals responses (N = 177) on A) whether they think rise in tiger population led to high human-tiger conflict in their area, B) whether they enjoy having tiger in their area, and C) how many Bengal tigers would they want living in the forest in the next 10 years compared to current population, associated across varieties of independent variables. * indicates chi-square significant association ($p < 0.050$) between independent variables and responses on A, B and C.

People's preferences on future tiger population densities differed significantly between less, same and more responses categories ($\chi^2 = 11.63$, $df = 2$, $p = 0.003$; Fig. 5). Greatest proportion of respondents (0.44) preferred populations to be reduced in the next 10 years compared to current population numbers (Fig. 5). This was not significantly different than a response preferring no change to tiger density ($\chi^2 = 2.94$, $df = 1$ $p = 0.086$) but was significantly greater than the response preferring increased tiger densities ($\chi^2 = 11.50$, $df = 1$, $p = 0.000$) (Fig. 5). Individuals' preferences for future population trajectories was significantly associated with several socio-economic parameters including human settlements ($\chi^2 = 31.59$, $df = 6$, $p = 0.000$), age ($\chi^2 = 12.30$, $df = 4$, $p = 0.015$), occupation ($\chi^2 = 20.76$, $df = 4$, $p = 0.000$), education status ($\chi^2 = 10.77$, $df = 2$, $p = 0.004$), monthly family income ($\chi^2 = 8.38$, $df = 2$, $p = 0.015$), forest visitation pattern ($\chi^2 = 15.40$, $df = 6$, $p = 0.017$), benefit from tourism ($\chi^2 = 15.35$, $df = 2$, $p = 0.000$), and victim status ($\chi^2 = 20.32$, $df = 2$, $p = 0.000$) but unrelated with gender of the respondent ($\chi^2 = 1.37$, $df = 2$, $p = 0.050$) and number of livestock owned ($\chi^2 = 0.066$, $df = 2$, $p = 0.967$) (Fig. 4C).

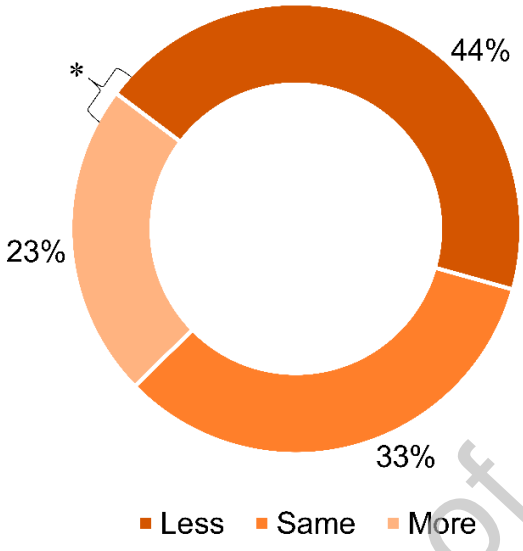

Figure 5. Survey responses (N = 177) reflecting on future *P. t. tigris* preferences, population respondents would like to live in the nearby forest compared to the current population number during December 2021 in Khata Corridor. Variation on responses between less, same and more and between two responses were assessed through chi-squared goodness of fit. Significant p values (at 95% confidence) of ≤0.050 are marked by * indicating statistically diverged responses.

Our model including human settlement and education status variables was the most supported based on lowest AICc value and highest AICc weight (Table 2). Compared with Thakurdwara, likelihood of people preferring less or same number of Bengal tigers was significantly higher in Pattharbhuji, Dalla and Neulapur (Table 3). The odds of Thakurdwara residents preferring less or same population was 0.28, 0.30, and 0.15 times lesser than from Neulapur, Dalla and Pattharbhuji residents respectively (Table 3). Similarly, among individuals who were educated, the odds of preferring more tiger (compared with less or same) was 0.45 times greater than among individuals with no education (Table 3).

Table 2. Candidate models developed for ordinal regressions to check how people's tolerance with tiger affected by communal characteristics following stepwise addition of variables (Table1 provides detail description of variables). Models were ranked based on Akaike information criterion with small sample bias adjustment (AICc). "K" indicates number of parameters in the model, "LL" as log-likelihood, "ΔAICc" as the difference in AICc score between the best model (model with the lowest AICc value) and the model being compared, "**ω**" as the proportion of the total amount of predictive power of the model. Based on AICc, model with settlement and education stand out as best model compared with other models. This model also had low AICc value than null model suggesting variables in the model better explained people's tolerance with Bengal tigers.

Models	**K**	**LL**	**AICc**	**ΔAICc**	**ω**
Settlement + Education	6	-172.22	356.59	0.00	0.72
Settlement + Education + Occupation	8	-171.59	359.45	2.86	0.17
Settlement	5	-175.44	360.99	4.40	0.08
Victim	3	-177.70	361.44	4.85	0.02
Settlement + Occupation	7	-174.28	362.77	6.18	0.01
Education	3	-182.79	371.62	15.02	0.00
Education + Occupation	5	-181.43	372.97	16.37	0.00
ForestVisit	5	-182.78	375.66	19.07	0.00
TourismBenefit	3	-184.91	375.86	19.27	0.00
Age	4	-185.85	376.72	20.13	0.00
Occupation	4	-185.85	379.77	23.18	0.00
Null	2	-188.23	380.47	23.88	0.00
Monthly income	3	-187.24	380.52	23.93	0.00

Table 3. Summary of best ordinal regression model. An estimated coefficient, p-values (≤0.050 are marked by *) at 95% confidence, and odds ratios (exponential value of coefficients) are provided. The dependent variable is tolerance i.e. people's response (less, same and more) on future tiger preferences, where more is compared with less and same response and marked by [c]. Independent variables include human settlement (hs), and education staus (Table 1 for detail

description of variables). Thakurdwara and educated is compared with other settlements and uneducated respectively and are marked by [c], N is the number of respondents.

Variable in equation	**Future tiger preferences: less and same (more[c])**		
	Coefficient	Odd ratio	p value
Human settlement			
Pattharbhuji (N = 22)	-1.87	0.15	0.001*
Dalla (N = 34)	-1.20	0.30	0.003*
Neulapur (N = 58)	-1.26	0.28	0.000*
Thakurdwara[c] (N = 63)			
Education			
Uneducated (N = 63)	-0.79	0.45	0.012*
Educated[c] (N = 114)			

Discussion

Nepal has been a success story for tiger conservation. Among other places in Nepal, Bardiya National Park and associated Khata Corridor experienced an increase in Bengal tiger populations, through both community and government engagement, where positive linkages between tigers and people were balanced through opportunities from eco-tourism (Budhathoki, 2004; Lamichhane et al., 2019; Nepal and Weber, 1994). Although, in general, people throughout this region are positive (Bhattarai and Fischer, 2014), increased Bengal tiger population abundances still pose direct and indirect risks for local communities and attacks by them undermines a generally positive attitude and high-level of tolerance. Our results indicate people occurring in the Khata Corridor are still positive towards Bengal tigers and their conservation despite continuing population growth of both tigers and peoples accompanied by periodic negative interactions. Importantly, levels of tolerance were unevenly distributed based on differences among local communities.

Settlements through the Khata Corridor have reported a significant increase in tiger populations and attacks in recent decades, based on their observations of frequent tiger roars and pugmarks (tracks). This aligns with national tiger count surveys and documented conflicts, indicating that the reported increase in tiger densities is consistent with local experiences. According to the respondents, the increase in tiger populations is attributed to various factors, including government conservation efforts, awareness programs, an expansion of suitable habitat with greater prey availability, and a decrease in poaching and illegal hunting. These conservation initiatives have been undertaken jointly by the Nepalese government and international organizations, with the aim of promoting tiger population recovery throughout the region (Bhattarai et al., 2017; Ghimire, 2022). Similarly, respondents attribute the increase in tiger attacks to a combination of factors, such as the rising tiger population, illegal use of forest resources, poor conflict management, reduced prey availability, and livestock depredation opportunities in settlements. While most respondents agree that an increase in tiger populations leads to a rise in conflict, the responses vary depending on the settlement type rather than other factors. In Pattharbhuji, where the majority were adults with frequent forest visitation, without tourism support or victim relief (Fig. 6), and in Dalla and Neulapur, where over 90% of respondents thought conflict in the region was directly related to increased tiger population growth. However, in Thakurdwara, where the majority were young, occasionally visit the forest, benefited from tourism, and were not conflict victims (Fig. 6), nearly 20% did not associate the growth of tiger populations with increased conflict. These differences in perception suggest that age groups, frequency of forest visitation, income opportunities from tourism, and the number of hostile interactions contribute to the view of Bengal tigers as responsible for conflict. However, this conclusion is based only on a comparison between two dissimilar communities, as when

these variables were tested separately in this study considering people from other settlements, the responses were not statistically associated with these variables.

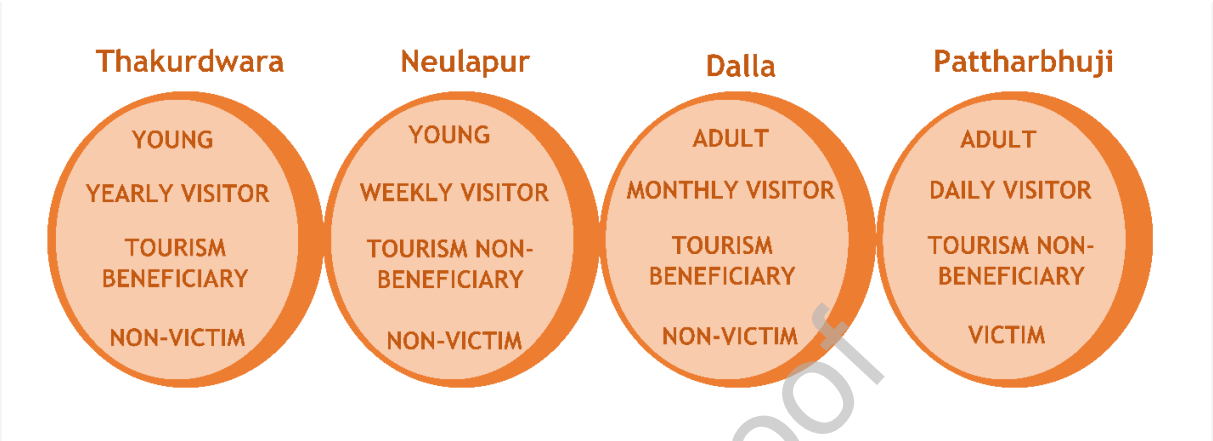

Figure 6. Settlements in Khata Corridor with dissimilar characteristics based on age of the respondents, their frequency of forest visitation, status on tourism benefit and hostile interaction with Bengal tigers.

Respondent's generally had a positive attitude toward Bengal tigers, enjoyed having them nearby, and were supportive towards their conservation, as has been found elsewhere in Nepal (Bhattarai and Fischer 2014). In addition, nearly 30% of respondents agreed Bengal tigers should be conserved considering their key role for maintaining prey-predator relationships, despite not liking them. This likely reflects awareness among settlements in the Khata Corridor that local farmers experience significant crop damage by *Axis axis* and *Sus scrofa*, and these crop pests can be mitigated through tiger predation. As such, local knowledge of key ecological roles, coupled with additional economic benefits from eco-tourism likely leads to optimistic viewpoints on Bengal tigers. Dislike of Bengal tigers was, however, highest among people from Pattharbhuji (54.5%) followed by Neulapur (39.7%), compared with >80% of people from Dalla and Thakurdwara strongly liking them. Similarly, people who visit forest more often (on a daily,

weekly or monthly basis) disliked Bengal tigers but people who visit forests only rarely (on a yearly basis) liked them. However, individuals' frequency of forest visitation was strongly associated with human settlement. Increased frequency in forest visitation can likely increase the plausibility of Bengal tiger encounter rates which can change individuals' attitudes towards their conservation efforts (Carter et al., 2014; Inskip et al., 2016, 2014).

Most people surveyed would like the number of Bengal tigers to either stay the same or decrease in the next 10 years. This preference for lower Bengal tiger populations is likely due to increased negative interactions with humans in recent years (Mandal and Panthi, 2022; Rauniyar, 2021), which is in stark contrast to the general positive perception towards them. Although multiple factors were associated with tolerance in Khata Corridor, individuals with higher levels of education were found to be more tolerant of Bengal tigers. This suggests that education plays a strong role in determining people's willingness to coexist with tigers. On contrary, this also indicates lack of sufficient community specific awareness programs in Khata Corridor. The Pattharbhuji settlement is located in an area that is separate from other nearby settlements and is not within the boundaries of the Bardiya National Park or its buffer zone. Because of this, they do not have as many opportunities for tourism and may not have been exposed to programs that promote coexistence with wildlife. In general, economic benefit from tourism, community development and awareness programs are generally inversely proportional to settlement distance from the boundary of protected areas (Brandt et al., 2017; Neupane et al., 2017). Although Pattharbhuji fall under the managerial obligation of Terai Arc Landscape, funds for promoting tourism and generating awareness programs are limited (Wikramanayake et al., 2010; Yadav et al., 2022). Our data also indicate that Pattharbhuji individuals were the most frequent visitors of forested areas and experienced more antagonistic interactions with Bengal tigers. These factors

likely played a substantial role on individuals' opinions of future tiger population sizes (Carter et al., 2014; Dhungana et al., 2022; Inskip et al., 2016; St. John et al., 2018; Struebig et al., 2018).

Implications for conservation

Our findings on people's perspective regarding future Bengal tiger preferences in Khata Corridor presents a conundrum for future conservation decision-making. Specifically, although people overwhelmingly share positive perceptions towards Bengal tigers, there is very little support for further increasing their densities. Continued success of Bengal tiger conservation will critically rely on maintaining positive viewpoints, and this will be a challenge if Bengal tiger (and human) populations both continue to increase without mitigation efforts towards ongoing conflict, especially in poorer communities. It is worth noting that conflicts in the Khata Corridor are primarily related to people from underprivileged communities who rely on the forest for resources, rather than Bengal tigers regularly entering human settlements. However, it is important to recognize that these conflicts still result in the loss of resources and, in some cases, even human lives for the local people. Moreover, those living near forest edges are more exposed to tiger conflicts, and their ability to cope with potential risks associated with tiger conflict is often limited (Braczkowski et al., 2023; Dickman, 2010; Inskip et al., 2013). If Bengal tiger population sizes continue to increase, negative impacts on community members' livelihoods are likely to intensify. Therefore, it is crucial to strike a balance between Bengal tiger conservation and the needs of local communities. We must acknowledge that people's livelihoods are dependent on the forest, and a loss of resources can be devastating for them.

The expansion of Bengal tiger populations in this landscape as well as other similar areas within their distribution range may be feasible, but the potential for human-tiger conflicts in the future must be taken into consideration. To effectively manage their populations and mitigate

human-tiger conflicts, two key considerations must be addressed. First, alongside population monitoring, further ecological research should be prioritized (Chanchani et al., 2016), with use of modern technologies and experimental design to infer the absolute carrying capacity of Bardiya National Park and associated Khata Corridor for Bengal tigers. The areas constituting poorer habitat quality, for example in the northern part of Bardiya National Park, should be managed through regular monitoring of resource availability for Bengal tigers so that these places could absorb stresses of the places with high density i.e. in Khata Corridor from increasing population. If frequencies of Bengal tiger attacks keep on increasing, allowable removal number should be translocated to other National Parks of Nepal or India that currently support lower densities, and based on regional scientific evidence for appropriate carrying capacity to maintain local ecosystems, coupled with local human interests and protections against risks. Second, community engagement and their perspectives, which has already proven to be an integral ingredient for Bengal tiger conservation not only in Nepal but also across its distributional range (Bookbinder et al., 1998; Dinerstein et al., 2013), is a critical consideration, especially in regions of growing human populations and associated conflict. Positive attitudes among local communities could be weakened if tiger attacks continue to increase. Our study highlighted that tolerance level of people can be raised via reducing their dependency on forests through promoting income generating activities or regulated tourism. Thakurdwara and Dalla settlements had a plethora of income generating activities through effective management of tourism, which somewhat reduced their dependency on forest, whereas Pattharbhuji and Neulapur settlements had no support from tourism which pushed them to exploit forest resources more frequently. Communities similar to Pattharbhuji, with high conflict due to increased population, could be an opportunity among wildlife managers, conservationists and donors to create a coexisting

environment between humans and Bengal tigers. A primary challenge will be to overcome issues associated with marginalized and financially poor households, uneducated people, and victims of conflict without relief.

Acknowledgement

We express our deepest appreciation to Nepal Open University for providing (BS) an opportunity to complete Master's Degree in Natural Resources and Development. Thanks also to the Resources Himalaya Foundation, Lalitpur, Nepal for providing a dissertation grant to conduct this piece of research work. We are grateful to the Department of National Park and Wildlife Conservation, Nepal for providing a research permit to carry out this study, and Bardiya National Park, Community Based Anti-Poaching Unit, and Dalla Homestay Committee for support during field visit. We are also want to thank Mr. Gokarna Dhakal for assisting in the field.

Data availability

Data will be provided upon request to the corresponding author.

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Declaration of interests

☒The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: