



Human-wildlife conflicts in a Nepalese protected area: conservation challenges, mitigation strategies, and policy implications

Birendra KC · Rojan Baniya ·
Harsha Bahadur Singh · Binod Chapagain

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Abstract The global conservation movement is fueled by an increased number of protected areas (PAs), and it will continue to influence the conservation paradigm in the future. However, despite the unequivocal interest in PAs and their designation, their conservation success is compromised due to human-wildlife conflicts (HWCs). HWCs are age-old issues in PAs and conservation discourse, yet they continue to impede the conservation process and negatively impact the residents' wellbeing. Therefore, policy changes, including some changes in land-use patterns

(e.g., a buffer zone concept), were made to accommodate the residents' livelihood needs. Further, a damage relief mechanism was introduced to mitigate HWCs in PAs, but still, HWCs remain a challenge to conservation efforts. This study looks at the HWCs from residents' perspectives in the context of Bardia National Park in Nepal, where a detailed account of problematic wildlife is documented, along with the overview of strategies to mitigate HWCs, damage relief mechanism, and their idea to foster successful PA management. We collected 871 responses from a resident survey for this study. Our findings show that a few selected wildlife species are problematic to residents while they use a combination of strategies to control HWCs, with varying degrees of success. The damage relief mechanism was not perceived well, and residents demand participatory management. The findings are discussed in detail along with the practical implications for PA management.

B. KC (✉)

Department of Hospitality, Event, and Tourism
Management, University of North Texas, 1155 Union
Circle #311100, Denton, TX 76203-5017, USA
e-mail: birendra.kc@unt.edu

B. KC

Department of Geography, Environmental Management
and Energy Studies, University of Johannesburg,
Auckland Park, South Africa

R. Baniya

College of Business, Hawaii Pacific University, Honolulu,
USA
e-mail: rbaniya@hpu.edu

H. B. Singh

University of Göttingen, Göttingen, Germany
e-mail: harsha.b.singh99@gmail.com

B. Chapagain

Tennessee Wildlife Resources Agency, Nashville, USA
e-mail: binodpchapagain@gmail.com

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Introduction

Wildlife conservation through protected area (PA) management brings many positive benefits. Meanwhile, the cost of living around the PAs on residents is often an oversight. This is critical for the South Asian PAs because they possess high ecological worth with

high human concentrations, which sustains community living, bears stress from negative human-wildlife interactions, and adapts to rising commercial interests like tourism (Karanth & DeFries, 2010). Thus, harmonizing conservation aspirations and residents' livelihoods in adjacent communities is challenging. Two approaches to conservation, i.e., "exclusionary protectionism" and "people-inclusive", tend to conflict with each other. The school of thought favoring "exclusionary protectionism" claims that PAs are only for the sanctuaries of biological diversity and should be dedicated to minimizing the extinction of species (Joppa et al., 2008; Karanth & DeFries, 2010). However, there is criticism against such an approach disregarding Pas' social, political, and economic aspects (Morais et al., 2018; West et al., 2006).

On the contrary, the "people-inclusive" approach broadens the agenda of PA management by including biodiversity conservation, equity, and wellbeing (Raymond et al., 2022). With the growing concern regarding human-wildlife conflicts (HWCs) (Seoraj-Pillai & Pillay, 2016), it is necessary to understand the impacts of PAs on the residents and their livelihoods, specifically the impacts resulting from HWCs. A "people-inclusive" approach thrives by comprehending HWCs and finding resolutions to balance conservation and residents' livelihoods (Wei et al., 2018). However, it is equally challenging to create a win-win situation in the presence of HWCs around PAs. If not properly addressed, HWCs continue to pose obstacles to conservation management and deteriorate a sense of inclusivity among residents. Therefore, as a key stakeholder group, residents' perspectives on HWCs and their perceived inclusivity in the process of conservation management can play a significant role in improved policymaking.

According to the literature, HWCs are a result of disagreement arising due to insecurity for people living near or within the PAs, particularly when the conflict interferes with their ability to meet subsistence needs (Nyhus, 2016; Sunderlin et al., 2005). A solution must be sought to foster a win-win outcome, where the security of people and their properties are safeguarded along with ensuring wildlife protection (Faizi & Ravichandran, 2016). However, studies show that rural households in the vicinities of PAs tolerate the cost of conservation unswervingly while nature enjoys the gains (Treves, 2009; West et al., 2006). HWCs take place in many ways like livestock damage

(Tamang & Baral, 2008), crop damage (Pant et al., 2016), property harm, human casualties (Lamichhane et al., 2018), and the reciprocal killing of wildlife (Nyhus, 2016). These conflicts cause a loss-loss situation for humans and wildlife with significant environmental, social, and economic costs (Barua et al., 2013; Thirgood et al., 2005). To deal with these situations properly, an insight into where, how, and why these conflicts happen needs thorough evaluation (Silwal et al., 2017). Meanwhile, effective policy mechanisms are necessary to provide solutions to HWCs (Woolaston et al., 2021). However, a detailed account of the HWCs and an understanding of residents' perceptions of HWCs and existing resolution mechanisms are essential to devising an effective policy.

The formulation and implementation of an effective policy play a significant role in mitigating the HWCs. Lin et al. (2021) suggest that solid policies such as hunting ban and economic compensation for damages can only have a short-term impact and do not address the issue in the long term. To have a policy that can successfully reduce HWCs, Woolaston et al. (2021) stated that policymakers and wildlife managers should resolve all societal influences. Policy instruments should be devised to incentivize conservation practices, intended to inculcate a greater sense of awareness and pride among community members (Brito et al., 2018). The policy must implement the agenda for inclusive conservation practices where the locals play active roles in managing the PAs and resources associated with it (Raymond et al., 2022). The link between policy and HWCs is critical (Woolaston et al., 2021), yet it is often overlooked in the literature. Increasing concerns over the issues indicate that the existing policies are ineffective; suggesting a systematic appraisal of interventions to inform policy decisions is a much-needed step (van Eeden et al., 2017). However, HWCs and contextual differences play an important role in developing a suitable policy (Lin et al., 2021; Woolaston et al., 2021).

Located in the western lowland of Nepal, Bardia National Park (BNP) is a region of frequent conflict between the park authority and locals over damage resulting from wildlife (Tamang & Baral, 2008). These conflicts are further escalated by the population increase of wildlife species, like tigers, in the park. Previous studies of HWCs have mainly focused on documenting livestock destruction and crop damage

from wildlife (Bhattarai & Fischer, 2014; Tamang & Baral, 2008; Thapa, 2010). This study aims to provide a complete account of the damage resulting from HWCs and residents’ experiences and sentiments regarding such conflicts, which is rare in previous literature. It further explores the potential role of conservation policy and its adaptability to address HWCs adequately to fill the gap in the literature. Specifically, this study explores answers to two distinct questions:

- (1) How does wildlife impact the residents’ livelihoods living around PA?
- (2) What are the residents’ perceptions regarding damage relief mechanisms, wildlife management, and decision-making?

Firstly, it provides a true account of the current scenario as diagnostics that entails an account of problematic wildlife and its impacts in terms of injuries, financial loss, and the strategies employed by

locals. Second, it provides residents’ perceptions of wildlife management, the damage relief mechanism, and their happiness with the damage relief mechanism. Residents’ opinion and insight into the details of the damage caused by wildlife is vital in formulating effective measures to minimize conflict and enhance amicable coexistence between people and wildlife. Accordingly, HWCs and residents’ perceptions of conflict and resolution mechanisms are discussed with policy relevance.

Study methods and materials

Study context

The study was conducted in the buffer zone of BNP, Nepal (Fig. 1). The park is situated in the mid-western flatland of Nepal and is renowned for its extensive area of 968 km² (Karki et al., 2016). Initially,

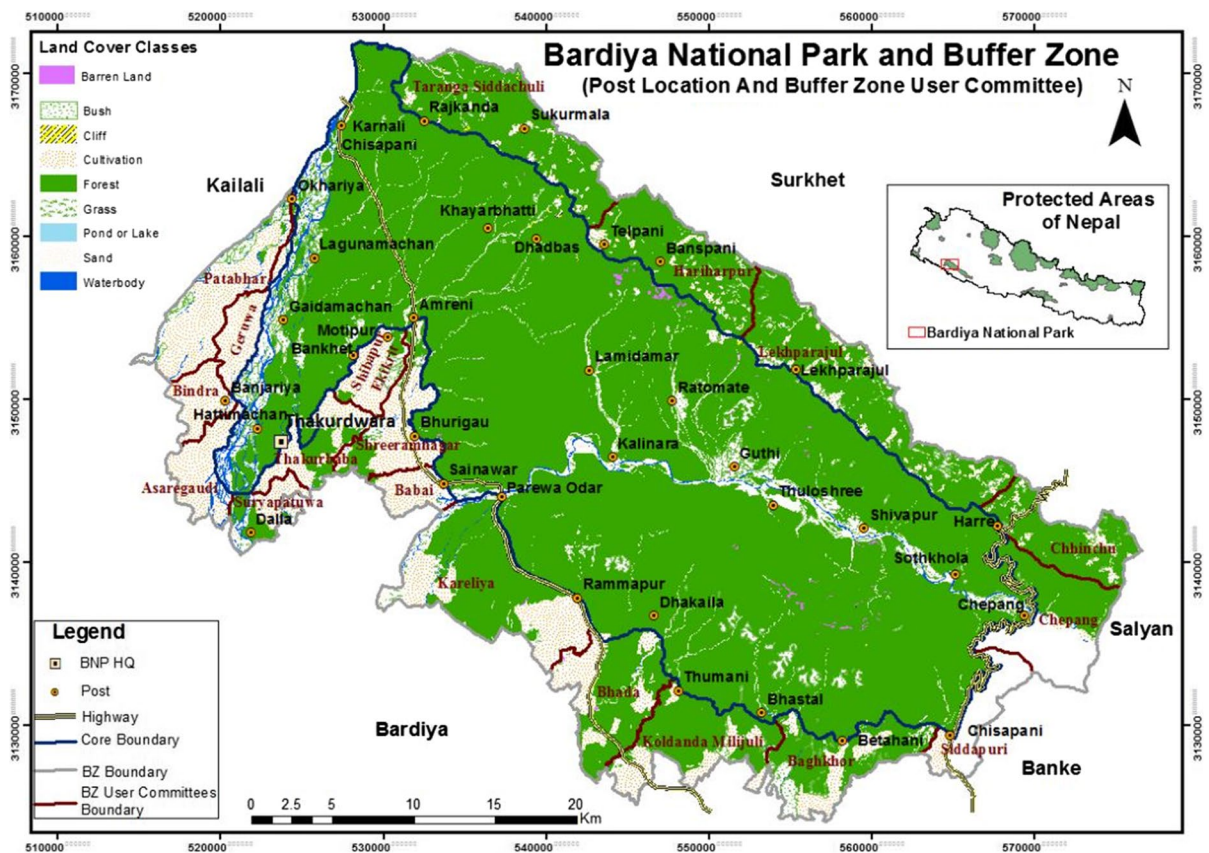


Fig. 1 Bardia National Park and buffer zone communities (source: BNP, 2020)

it was established as a hunting reserve in 1969 and upgraded to a wildlife reserve in 1976 following subsequent policy and institutional improvements (Karki, 2013). Eventually, it was declared a National Park in 1989 (Allendorf et al., 2007). Due to the general nature of national park establishment movements in the country, which was primarily characterized as a traditional top-down approach, it led to many HWCs that affected both the long-term goal of wildlife conservation and residents' livelihoods living in the surrounding areas (Budhathoki, 2003). Park-people conflicts were rampant in the presence of the "exclusionary protectionism" approach used in national park management (Thapa & Klaus, 2011). In 1996, the area surrounding the national park was announced as a buffer zone, which now covers an area of 507 km² (Thapa, 2010). The primary purpose of declaring a buffer zone is to invest the park's income in community development projects, strengthen the local economy, and gain people's support for conservation (BNP, 2016).

The buffer zone of BNP consists of human settlements, agricultural fields, and buffer zone community forests. It comprises newly reformed five municipalities and four rural municipalities from the previous 20 Village Development Committees (VDCs). A total population of more than 116 thousand resides in the buffer zone and it is administered through 19 user committees (BNP, 2020) (Fig. 1). The ethnic composition of this population is diverse, and most people belong to the indigenous Tharu community (Bhattarai et al., 2016). Almost 50% of the residents in the area share poor status in terms of educational and economic backgrounds (BNP, 2016). Their livelihoods are primarily driven by agricultural and farm practices (Bhattarai & Fischer, 2014), and their family income is shaped by their farm activities (Tamang & Baral, 2008).

Forests, grasslands, and swamps are prime habitats in the park for faunas such as the Bengal tiger, Asian wild elephant, greater one-horned rhinoceros, spotted deer, blue bull, common leopard, and wild boar (BNP, 2020). These wildlife species in search of food and space often encounter residents (Prins et al., 2022). However, the park authority has been applying different mitigation measures to reduce such confrontation events (Thapa, 2010). The park is known for conserving varieties of flora and fauna that are of national as well as international importance.

However, increasing wildlife damage incidents and strict conservation measures that limit the use rights of residents put the local livelihood and conservation efforts at peril (Budhathoki, 2003).

Locals face wildlife-related damages such as livestock depredation, crop raiding, human casualties, and property loss (KC et al., 2022). Increasing incidents of HWCs are becoming a critical challenge for park management (BNP, 2016). Since the park's establishment, numerous conflict management measures have been practiced to mitigate such issues, including financial compensation to the victims (e.g., educational scholarships for children), construction of wildlife deterrent infrastructures (e.g., electric fences, net wire fences, watch towers, trenches, and reinforced cement concrete [RCC] wall), and promotion of farming non-palatable cash crops (BNP, 2020). Similarly, livelihood-supporting activities such as alternative energy sources (solar and biogas), hospitality and cooking training, nature guide training, and handicraft-making training were provided to locals (LeClerq et al., 2019). Moreover, organizations like World Wildlife Fund (WWF) Nepal, in collaboration with the park authority, are supporting and promoting ecotourism programs such as homestays in the buffer zone communities to enhance the socio-economic wellbeing of the locals (KC, 2021). These homestay initiatives to capture ecotourism prospects around PAs are popular among residents (Upadhaya et al., 2022).

The Government of Nepal (GoN) has continuously developed and revised policies to minimize HWCs since the establishment of national parks in Nepal, including ways to promote an inclusive conservation approach. The effective regulations include National Park and Wildlife Conservation Regulation 1973 and its amendments, Buffer Zone Management Regulation 1996, and Buffer Zone Management Guideline 1999 (DNPWC, 2020). Likewise, Wildlife Damage Relief Guideline 2006 was developed to provide financial relief to victims of wildlife damage (Acharya et al., 2016). Despite all these efforts and policy interventions, HWCs remain a significant challenge in PAs of Nepal, including BNP. Meanwhile, locals in surrounding areas of PAs still follow traditional measures (e.g., guardian dogs, trenches, and scarecrows) to minimize HWCs (Hussain et al., 2022). Their level of effectiveness is unknown and must be examined to identify and prioritize better remedies.

It also suggests that the HWCs should be examined holistically, including assessing the existing policies to provide policy recommendations. This study also aims to inform on necessary policy interventions to minimize HWCs and promote sustainable residents' livelihoods along with a strong conservation focus.

Data collection and analysis

Eight out of 19 buffer zone user communities were selected (i.e., Patabhar, Geruwa, Bindra, Asaregaudi, Shivapur Ekikrit, Shreeramnagar, Thakurbaba, and Suryapatuwa) to administer the survey questionnaire for this study (Fig. 1). These buffer zone user communities were selected based on consultation with the BNP officials after a preliminary assessment of the prevalence of HWCs cases reported. A stratified random sampling technique was used to allow the equal representation of the selected communities (Paudyal et al., 2018). We distributed 110 survey questionnaires to each selected buffer zone community, ensuring that at least 5% of households were represented in the study, which resulted in a total of 871 usable survey questionnaires.

This study was reviewed and approved by the tier-one public research university in the U.S. Also, a permit was granted by the Department of National Park and Wildlife Conservation, Nepal. The data was collected in July 2019. The heads of the households were surveyed first, then recruited another household adult who was at least 18 years of age when the head of the household was unavailable. The research team filled out the questionnaire on behalf of the participants. The first author, a native of Nepal, and Nepalese field assistants collected the data. The field assistants were provided training before the data collection to familiarize them with the questionnaire and its content. The importance of the study and potential practical implications resulting from the study were briefly explained prior to administering the survey. Verbal consent was obtained and documented from each study participant before administering the survey. No compensation was provided to the study participants. The surveys were collected from early morning to evening to allow flexible hours to increase our chances of meeting participants during the monsoon season

and a period of high agricultural activity in Nepal (KC et al., 2022).

The study participants were asked to list the top three problematic wildlife, their group size, damages caused in terms of economic loss, perceived damage experienced (1 being none to 4 being high), and whether these damages were reported to the authority. We allowed them to self-interpret the definition of problematic wildlife. Also, a semi-structured list of problematic wildlife was provided for ranking (1 being the least problematic to 9 being the most problematic) to better understand the issue with problematic wildlife and a range of problematic wildlife. We used a list of strategies (more than 20, excluding an option to add more) that residents use to mitigate HWCs and their rating for effectiveness (1 being not at all effective to 5 being very effective). We also surveyed their views on wildlife management by the park management authorities, and it included a list of 10 statements rated from 1 (strongly disagree) to 5 (strongly agree). Residents were asked to indicate whether they received any relief package for the damage caused by problematic wildlife along with their level of happiness with the damage relief mechanism (1 being very unhappy to 5 being very happy).

A total of 871 surveys and their responses were entered into Excel sheets, and every question was coded for data analysis. A descriptive analysis was performed using Stata 16.1. The effort was put into translating the data into results regarding frequency distributions, means, and percentages. This study collected and summarized vast amounts of data and information in a manageable and organized manner so that a clear picture could be observed and evaluated. Specifically, we collected and analyzed data to evaluate species-specific results using a holistic approach, unlike other studies focused on one or only major wildlife species (Acharya et al., 2016; Branco et al., 2020; Virtanen et al., 2021), or general HWCs issues (Manfredo & Dayer, 2004; Treves et al., 2006). We also assessed residents' opinions on the overall approach to conservation management and decision-making. We believe that using a holistic approach to evaluating HWCs to the extent possible can help offer better implications, including policy recommendations (Karanth et al., 2013).

Results

Participants' information

A total of 871 valid survey questionnaires were collected. Among the participants, 54% were males, and 46% were females. More than 65% of the participants reported total household (HH) members in a range from 3 to 6. A majority (50.1%) of the participants were between 30 and 50 years of age. More than half (55.5%) of the participants reported primary education as their highest education level. Furthermore, more than 50% of the participants reported owning a land holding size of less than 10 Kattha [1 Kattha=338.63 m²]. More than 50% of the participants reported having an annual income of less than NRs. 100,000. Lastly, more than 70% of the participants reported total annual damage up to NRs. 59,999, and more than 25% of the participants reported total annual damage of NRs. 60,000 and above.

Details on problematic wildlife

According to the residents, the top three animals causing damage to the properties were elephants, wild boar, and spotted deer, with 97%, 61%, and 53% mentioned, respectively (Table 1). Similarly, other animals reported to damage the properties, crops, cattle depredation, and human casualties were tigers, rhinos, and common leopards.

The participants were provided a semi-structured list of problematic wildlife to rank (1 being the least problematic and 9 being the most problematic). The results are similar to the free listing of the top three problematic wildlife (Table 1). In ranking from most problematic to least, elephant ranked the highest with a mean score of 8.6 followed by wild boar (7.8), spotted deer (7.8), common leopard (7.6), tiger (4.7), others (monkey, parrot, fox, porcupine) (4.5), and rhino (4.2), respectively. Residents were asked to rate the damage experienced from the top three problematic wildlife from none, moderate, high, to very high. Based on the perceived level of damage, elephants, wild boars, and spotted deer were rated highly, with a rating of 3.1, 3.1, and 3.3, respectively.

Human-wildlife conflicts and damage relief mechanism

Only the most problematic wildlife and their damages were often reported to the authorities. The damage caused by rhinos, elephants, and common leopards was reported more than damage from other animals (Table 2). However, problematic wildlife and their scale of damage did not necessarily correspond with the reporting rate to the authority.

Only 27% of the residents received damage relief and 73% did not receive damage relief. Of residents who reported damage from common leopards, only 57% received relief associated with the damage. Only 50% of the residents who reported damage from

Table 1 Top three animals causing damage, their group size, residents' perceived level of damage, and problematic ranking of each animal (n=871)

Animals	Top three animals causing damage* (%)				Animal group size	Perceived level of damage** (mean)	Problematic rank ⁺ (mean)
	First Mention	Second Mention	Third Mention	Overall			
Elephant	86	7	5	97	4.4	3.1	8.6
Wild boar	6	30	26	61	11.7	3.1	7.8
Spotted deer	5	21	29	53	27.0	3.3	7.8
Tiger	1	21	6	27	1.4	2.3	4.7
Rhino	1	16	7	24	1.8	2.5	4.2
Common leopard	1	2	17	20	1.2	2.7	7.6
Others	1	4	9	14	11.5	2.7	4.5

*Participants were asked to list the top three problematic animals based on damage experienced

**Level of damage experienced was measured on a 4-point Likert Scale ranging from 0 (none) to 4 (very high)

⁺Problematic animal ranking was measured on a Likert Scale ranging from 1(least problematic) to 9 (most problematic)

Table 2 Damage reporting rate, financial loss accrued from wildlife damage, relief received, and participants' happiness level with the damage relief mechanism

Animal	Reporting rate (%)	Financial loss per HH (Nepalese Rupees)	Damage relief received (%)	Level of happiness* (n = 871)
Elephant	68 (n = 847)	18,380.98	28 (n = 847)	2.38
Wild boar	42 (n = 529)	14,093.36	21 (n = 529)	2.21
Deer	39 (n = 465)	17,535.56	17 (n = 465)	1.95
Tiger	29 (n = 238)	25,064.10	50 (n = 238)	2.82
Rhino	79 (n = 206)	15,729.71	26 (n = 206)	2.82
Common leopard	47 (n = 173)	13,282.83	57 (n = 173)	3.16
Others	25 (n = 118)	9,972.17	14 (n = 118)	2.07

*Happiness associated with the damage relief mechanism was measured on a 5-point Likert Scale ranging from 1 (very unhappy) to 5 (very happy)

tigers received damage relief, followed by 26% of the residents who reported damage from rhinos received damage relief (Table 2). This finding suggests that residents are more likely to receive damage relief when they reported damage from animals such as leopards and tigers, which may result in human casualties and livestock depredation. While the happiness to the damage relief mechanism was relatively higher (i.e., 3.16) for residents who experience damage from common leopards, the level of happiness was less for the residents' receiving financial relief for the damage from other animals (with a mean score < 3). Residents were most dissatisfied with the damage relief associated with deer, with only 20% of residents reporting damage receiving the relief and their level of happiness was only 1.95 out of 5.

Strategies to mitigate negative wildlife interactions

The findings on strategies to mitigate negative interactions with problematic wildlife suggest that some techniques are more popular than others, depending on the type of problematic wildlife. At the same time, the effectiveness of each measure also varies based on problematic wildlife (Table 3). For example, for 847 observed elephant interactions, 91% of the participants reported using fire and firecrackers, with a mean effectiveness score of that strategy to be 3.7. Fire and firecrackers are not only used extensively for elephants but also used for other problematic wildlife such as wild boar, spotted deer, tiger, rhino, common leopard, and others. The average effectiveness score of fire and firecrackers as a strategy was above 3 (1 being not at all effective and 5 being very effective). Community and household control of wildlife measures were extensively used after fire and firecrackers,

while their average effectiveness scores were 3.5 or higher.

Electric fencing was used quite often (~40% of residents reported using it for all problematic wildlife). However, its effectiveness score was much less (< 3) than using fire and firecrackers, community control of wildlife, and household control of wildlife. Some notable mentions regarding frequently used strategies were watch tower, shooting, bio-fencing, tin hitting, hadbadai (another form of tin hitting), jhukka (a localized name for scarecrow), and RCC wall. The use of pet dogs was rare, but its effectiveness seemed to be the highest. Some measures still exist, but their effectiveness scores were low, such as trenches, early-warning siren systems, growing alternative crops, planting crops and fruits away from home, and barbed wire fences. Some measures were not frequently used, but their effectiveness scores are low, such as planting medicinal and aromatic plants to repel the use of chemicals and trapping. Some measures were rarely used, but their effectiveness scores were high or seem to work for certain problematic wildlife, such as using net wire, acoustic devices, and translocation.

Residents' perceptions of wildlife management strategies

Regarding the perception of current wildlife management strategies, residents were asked to rate the statements from 1 (strongly disagree) to 5 (strongly agree). Their perceptions are reflected regarding wildlife management strategies instead of individual problematic wildlife. The residents strongly agreed that their participation in wildlife management and decision-making is vital (Table 4).

Table 3 Used percentage and effectiveness of strategies used to mitigate negative interactions with wildlife

Strategies to mitigate negative interactions	Elephant (n = 847) [Used* %, (Mean ⁺)]	Wild boar (n = 529) [Used* %, (Mean ⁺)]	Spotted deer (n = 465) [Used* %, (Mean ⁺)]	Tiger (n = 238) [Used* %, (Mean ⁺)]	Rhino (n = 206) [Used* %, (Mean ⁺)]	Common leopard (n = 173) [Used* %, (Mean ⁺)]	Others (n = 118) [Used* %, (Mean ⁺)]
Fire and fire-crackers	91 (3.7)	90 (3.9)	92 (3.9)	92 (3.3)	82 (3.7)	91 (3.1)	86 (3.8)
Electric fencing	49 (2.2)	46 (2.2)	52 (2.2)	50 (2.4)	39 (2.5)	49 (2.0)	66 (2.8)
Trenches	18 (1.7)	10 (1.1)	16 (1.2)	35 (2.2)	12 (1.4)	42 (2.2)	1 (2.0)
Watchtower	62 (3.3)	62 (3.5)	62 (3.3)	57 (3.2)	65 (3.3)	54 (3.0)	66 (3.8)
Early-warning siren system	31 (2.6)	24 (2.7)	18 (2.8)	51 (2.4)	40 (2.5)	50 (2.4)	36 (3.1)
Community control of wildlife decision-making	83 (3.9)	82 (3.9)	88 (4.1)	84 (3.7)	63 (3.7)	83 (3.4)	87 (4.1)
Household control over wildlife decision-making	78 (3.6)	77 (3.6)	83 (3.7)	76 (3.4)	61 (3.5)	84 (3.5)	81 (4.0)
Plant medicinal and aromatic plants to repel problem animals	2 (2.4)	2 (2.8)	2 (2.3)	2 (2.2)	1 (2.0)	1 (1.0)	3 (3.0)
Growing alternative crops	14 (2.6)	17 (2.5)	20 (2.6)	6 (2.7)	8 (2.5)	3 (1.6)	7 (3.1)
Planting crops and fruits away from the home	11 (2.9)	14 (2.9)	16 (2.9)	5 (2.9)	6 (2.9)	2 (2.3)	9 (2.8)
Barbed wire fence	14 (2.7)	18 (2.6)	19 (2.7)	11 (2.7)	1 (3.0)	6 (2.1)	11 (3.7)
Net wire	4 (3.0)	5 (3.1)	6 (3.1)	3 (2.2)	0 (3.0)	1 (1.0)	2 (4.0)
Chemicals (e.g., poison)	1 (2.2)	1 (2.7)	1 (1.6)	2 (1.2)	1 (3.5)	2 (3.3)	1 (1.0)
Acoustic device (e.g., megaphone)	26 (3.2)	27 (3.5)	21 (3.5)	24 (2.2)	33 (3.6)	31 (2.0)	31 (3.4)
Translocation	1 (3.7)	1 (3.9)	2 (3.6)	2 (4.0)	0 (4.0)	0 (N/A)	4 (4.2)
Trapping (e.g., snare)	1 (2.0)	0 (3.0)	1 (1.3)	2 (2.3)	0 (N/A)	0 (N/A)	1 (1.0)
Shooting	38 (3.2)	35 (3.1)	36 (3.1)	64 (3.2)	5 (3.0)	67 (3.2)	21 (3.4)
Bio-fencing	32 (3.8)	37 (3.7)	25 (3.8)	17 (3.7)	57 (3.9)	15 (3.6)	48 (3.8)
Tin hitting	55 (3.4)	55 (3.5)	49 (3.7)	64 (3.2)	44 (2.9)	75 (3.0)	45 (3.8)
Use hadbadai	38 (3.1)	45 (3.0)	50 (3.1)	20 (3.1)	26 (2.8)	12 (3.1)	50 (3.6)
Use jhukka	70 (3.1)	67 (3.1)	66 (3.2)	76 (3.2)	59 (2.4)	85 (3.1)	84 (3.5)
Use pet dog	0 (5.0)	0 (N/A)	0 (5.0)	0 (N/A)	0 (N/A)	0 (N/A)	1 (5.0)
Use RCC wall	11 (3.7)	12 (3.5)	12 (3.5)	11 (3.9)	11 (3.7)	8 (4.0)	10 (2.5)

*Percentage of the residents using the measure to mitigate negative wildlife interaction

⁺Effectiveness of each mitigation was measured on a 5-point Likert Scale ranging from 1 (very ineffective) to 5 (very effective)

Table 4 Residents' perceptions of wildlife management strategies

Wildlife management strategies	Overall (n = 871)
My community should be involved in wildlife management	4.7
More food for big animals to eat in the park would keep them away from my land	4.3
The public should be involved in wildlife decision-making	4.2
Roads are more important than wildlife conservation	2.9
Locals should bear some of the cost of wildlife conservation	2.8
I am trying to get at the continued development of the landscape at the expense of wildlife habitat	2.5
The park is only for wild animals	2.4
My community is involved in wildlife management	2.3
Protection of wildlife is more important than human rights	2.1
We should be able to retaliate against wildlife that does damage	1.9

*Residents' perceptions of wildlife management strategies were measured on a 5-point Likert Scale ranging from 1 (strongly disagree) to 5 (strongly agree)

Residents believe wildlife conservation is essential and does not necessarily support development and retaliation against wildlife. They also agreed that the residents should not bear the cost of wildlife conservation and that parks should be managed considering their rights to support their livelihoods. Therefore, they do not support park management solely for wildlife.

Discussion and conclusion

Mekonen (2020) pointed out that HWCs occur when the necessities and conduct of wildlife adversely affect humans or when humans negatively influence the needs of wildlife. Our study investigated the issue of HWCs in BNP and confirmed that it negatively affects residents' livelihoods and threatens conservation goals. Several wildlife animals were problematic, especially elephants, wild boars, spotted deer, tigers, rhinos, and common leopards. Likewise, for the damage experienced, elephants, wild boars, and spotted deer were perceived to cause the most significant damage. Interestingly, only a few selected problematic wildlife such as rhinos, elephants, and common leopards, and their damages were only reported to authorities. However, this study found that residents' perceived damage experience and economic loss associated with the damage are also much higher for other problematic wildlife like spotted deer. Residents also ranked spotted deer higher than common leopards in terms of damage experience and economic loss, while

fewer residents received damage relief from deer than common leopards. However, the DNPWC's wildlife damage relief guideline 2013 (with amendments), which is only a policy document provisioning financial relief for wildlife damage, there are no policies developed so far to fully compensate for the damage (DNPWC, 2018). Similarly, the current relief guideline does not list spotted deer as problematic wildlife and thus PAs including BNP implementing this guideline do not provide relief for the damage caused by spotted deer. Residents reported receiving relief associated with the damage caused by spotted deer, perhaps this is due to the relief offered by the local government.

In a study of four PAs in Rajasthan, India, there was a large discrepancy between the perceptions of conflict experienced and reported by locals and officials (Johnson et al., 2018). The local government's definition of HWCs did not include crop damage by herbivores. Therefore, park officials did not compensate for the damage, increasing locals' antipathy toward wildlife. Johnson et al. (2018) argued that this displayed a divergence in conservation priorities and reality. Conservation is important to protect nationally and internationally valued species such as rare, threatened, or endangered species. However, in this case, "non-priority" species caused a conflict. Our findings reveal a similar reality. Perhaps the government authorities believe that only certain problematic wildlife species cause damage. The rest are harmless. This clearly shows the disconnect with reality. Improved policy intervention is required for HWCs resolution. Hence, the first step to wildlife conflict

management in Bardia, and similar PA settings, is the accurate assessment and identification of HWCs.

Residents reported ways to mitigate HWCs such as fire and firecrackers, community control of wildlife decision-making, household control over wildlife decision-making, watch tower, bio-fencing, tin hitting, and use of RCC wall, among others. Surprisingly, fire and firecrackers as a strategy is declared by the park authorities as illegal, but it is the most used as well as an effective measure by the residents. Likewise, shooting seems to be useful and relatively effective, which could be often the case when residents had to get support from the Nepalese Army to avoid human casualties. However, there is also a lack of a comprehensive list of HWCs mitigation strategies (legal vs. illegal) from the park authorities. This lack of clear communication between the residents and park authorities could deteriorate their relationships while dealing with HWCs (KC et al., 2023).

Given the effectiveness of some strategies over others, the ‘one size fits all’ approach does not apply to mitigate the impacts of all problematic wildlife. Therefore, there is a need for a holistic approach to solving HWCs rather than one specific technique. Prioritizing mitigation options depends on the nature of problematic wildlife and the level of effectiveness of a technique, considering the legality of mitigation measures. The concept of zoning could be a possible avenue to mitigate HWCs (Nyhus, 2016). Perhaps the use of zoning based on problematic wildlife and their primary area of HWCs could allow rather concentrated use of effective mitigation strategies. This study has a limitation where only a few selected buffer zone communities were included. Future studies could be expanded to include all the buffer zone communities surrounding BNP and other PAs, while comparison across other PAs could further assist to elucidate the issue of HWCs and mitigation measures. Even though HWCs and their negative impacts on residents are apparent to BNP residents, their conservation ethics and perceived importance of wildlife conservation were clearly demonstrated.

Most importantly, residents’ interests in being included in the conservation management decision-making seem very strong. Heinen and Shrestha (2006) stated that Nepal instituted progressive management in the 1970s that allowed improved legislation but there was support from foreign-based projects. The authors also argued that Nepal is reactive

to adopting conservation programs, mostly influenced by international conservation trends and funding from foreign agencies. There is still much scope for more inclusive legislation including better approaches to assess biotic changes as well as societal needs and challenges, reflecting adaptive management regimes (Heinen & Shrestha, 2006). Even though local participation in conservation management is well understood in Nepal, the locals probably are not well integrated into the process. Practically, local communities are bearing the high cost of conservation in terms of damage from wildlife compared to the benefits they get from wildlife conservation. In this regard, there is a need for a robust approach to maximize benefits to local communities. The inclusive approach to conservation recognizes that the resources are governed by, with, and for local communities (Buijs et al., 2019). Locals’ participation in conservation management is not evident from the findings. They sought greater involvement in the conservation management and decision-making processes. Nepal should proactively embrace PA management to promote biodiversity conservation, equity, and wellbeing goals simultaneously, recognizing the plurality of multiple stakeholders (Raymond et al., 2022).

Literature suggests using social and cultural factors to innovate HWCs mitigation strategies (Manfredo & Dayer, 2004). A participatory approach is needed to effectively incorporate such details (Treves et al., 2006). The past literature has pointed out a wide range of tactics encouraging people to work together to resolve conflicts proactively—education and information sharing, co-management, collaborative and participatory planning, risk assessment, strategies to change perceptions, poverty alleviation programs, community-based natural resource management, and other forms of stakeholder engagement and processes (Loss et al., 2013; Madden, 2004; Manfredo & Dayer, 2004; Morais et al., 2018; Redpath et al., 2013; Woodroffe et al., 2005). The need for stakeholder engagement and collaborative and participatory planning resonates strongly with our findings.

Often economic incentives are extensively applied to boost forbearance for wildlife (Bruskotter et al., 2014). However, the current damage relief practice in Bardia is inadequate. In our study context, even though there is a relief guideline to cover different problematic wildlife, the relief rate for each species differs, which may not completely satisfy the

residents for their economic loss from the damage. Perhaps the dissatisfaction with the relief arises from this process. The current practice shows that residents get a certain amount of money as relief from the park administration, depending on the damage. Primarily, the relief is significantly low compared to damage to bring meaningful changes to these rural livelihoods. On the other hand, the relief amount is used by the victims for their basic requirements like food, health, etc., rather than for conservation or conflict mitigation measures, which the government expects from such a damage relief mechanism. On top of that, the process includes many tedious assessment works (quantification of damage experienced and monetary valuation of such damages), including the paperwork. Therefore, the current strategy is neither helping victims nor creating any positive impacts on conservation and mitigation efforts. In this scenario, it is plausible to have unhappy residents as it relates to the damage relief mechanism.

In moving forward, damage relief guidelines should expand their coverage and not disregard the extent of damage including proper quantification of economic loss. In addition, compensation should be provided based on the level of damage instead of the relief amount associated with specific wildlife. This scenario suggests a policy change to allow meaningful compensation mechanisms for problematic wildlife regardless of their status or importance for conservation. Unfortunately, a large portion of the cases are not reported, indicating that people are not comfortable going through the tedious process or do not believe in getting fair compensation. According to the annual report of BNP (2020), most incentives for communities in the study area are in agriculture and livestock farming that are obviously forest-dependent and ultimately end in conflict with wildlife. Thus, the managerial authority needs to reorient their ways to deal with HWCs mitigation strategies. They should simultaneously focus on effective habitat management in the park, implementing effective strategies to mitigate negative impacts, investing in effective mitigation, and uplifting the livelihoods of locals.

In conclusion, there are several policies and programmatic implications of this study. Foremost, the present study showed BNP's apparent HWCs situations, a representative case study for PAs prone to HWCs in Nepal. The current understanding of HWCs is inadequate, so the governing bodies must understand

the realistic picture of such conflicts holistically. Multiple HWCs mitigation measures exist but the combination of problematic wildlife and the effectiveness of each measure should be further analyzed to deal with HWCs, including the zoning process to identify the prevalence of problematic wildlife and the areas of their frequent dwellings. In addition, this study revealed a lack of local participation in the wildlife management process in Bardia. Hence, there is a lack of an effective system to accommodate and empower residents. This situation demands inclusive conservation with transparent and open communication dialogues among stakeholders, specifically between the residents and the park management authority (KC et al., 2023). The damage relief distribution process must be accessible as well as easy to follow the guideline. Instead of damage relief, a provision of fair compensation is deemed necessary. Meanwhile, it is important to ensure its equitable distribution among residents.

There is an increased HWCs in the face of increasing conservation efforts. Nevertheless, the management approach should not deviate from the need to enable thriving rural livelihoods in communities under the influence of PAs. The conservation movement is on the rise in Nepal (Heinen & Shrestha, 2006; Heinen et al., 2020), and so is the global conservation movement (Jones-Walters & Čivić, 2013; KC, 2022; McCool & Spenceley, 2014). This movement will continue to evolve, and our conservation efforts must be improved in tandem with the modern conservation philosophy to recognize the importance of locals and their livelihood needs, as well as their effective participation in the conservation of wildlife and nature.

Declarations

Conflict of interest Authors declare no conflict of interest.

Ethical approval This research meets all the ethical standards (i.e., this study was approved by the Institutional Review Board at the University of North Texas, USA; and the permit was granted by the Department of National Park and Wildlife Conservation, Nepal).

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