



Contribution of Buffer Zone Programs to Reduce Human-Wildlife Impacts: the Case of the Chitwan National Park, Nepal

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Abstract

Buffer zones around parks/reserves are designed to maintain ecological integrity and to ensure community participation in biodiversity conservation. We studied the fund utilization pattern of buffer zone programs, mitigation measures practiced, and attitudes of residents in buffer zone programs of Chitwan National Park, Nepal. The buffer zone committees spent only a small portion (13.7%) of their budget in direct interventions to reduce wildlife impacts. Human-wildlife conflicts were inversely related to investment in direct interventions for conflict prevention and mitigation. Peoples' attitudes towards wildlife conservation were largely positive. Most of the people were aware of buffer zone programs but were not satisfied with current practices. We recommend that buffer zone funds be concentrated into direct interventions (prevention and mitigation) to reduce wildlife conflicts. Our findings will be helpful in prioritizing distribution of funds in buffer zones of parks and reserves.

Keywords Buffer zone · Human-wildlife conflict · Compensation · Fences · Chitwan National Park, Nepal

Introduction

Throughout the world, the expansion of human land use at the expense of natural ecosystems has caused wildlife habitats to become increasingly insular, fragmented, and degraded (Lambin and Meyfroidt 2011). Some remaining habitats are set aside for protection as parks/reserves where many wildlife

populations are recovering (Bruner *et al.* 2001; IUCN 2008; Naughton-treves *et al.* 2005). Often in close proximity to these areas, communities farm crops or raise livestock, presenting an attractive food source for wild animals, which consequently frequently raid crops, kill livestock or attack humans. In retaliation they may be killed. Such reciprocal impacts by humans and wildlife are among the major threats to wildlife conservation (Dickman 2010; Madden 2004). Management of such impacts is even more challenging where endangered wildlife causes serious damage to human lives or livelihoods (Woodroffe *et al.* 2005).

Historically, communities managed wildlife impacts locally by clearing habitat or removing wild animals perceived as threats (Treves *et al.* 2009). Such responses are illegal or socially unacceptable where they do not comply with national and international regulations for biodiversity conservation (Madden 2004). Wildlife managers strive to increase or maintain wildlife populations through protection and habitat management, while local communities are interested in access to the natural resources as well as their own safety and property (Andrade and Rhodes 2012). While human-wildlife impacts are the result of simple competition over shared resources, they may also reflect political conflict between local residents and institutions having contrasting viewpoints about wildlife (Treves *et al.* 2006). If such conflicts are not managed, affected communities can become antagonistic towards wildlife and

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conservation authorities, adversely affecting overall conservation goals (Madden 2004; Woodroffe *et al.* 2005). Managing conflict thus needs both a biophysical and a sociopolitical approach (Treves *et al.* 2006) to promote non-lethal management and strategies to increase community tolerance for wildlife (Treves *et al.* 2009).

When wildlife and humans are sharing the same landscape in close proximity, it is almost impossible to entirely avoid wildlife damage. However, community tolerance of actual and perceived threats can be built through co-management of conflict (Treves *et al.* 2006), including timely compensation for losses, participation in planning and execution of conservation programs, as well as equitable sharing of conservation benefits (Nyhus *et al.* 2005; Wegge *et al.* 2018). Buffer zones are often created surrounding core protected areas to facilitate such processes with dual purpose of maintaining ecological integrity and ensuring participatory conservation or co-management (Budhathoki 2004; Heinen and Mehta 2000; Persoon and Van Est 2003; Sayer 1991; Spiteri and Nepal 2008). Often in the buffer zone areas, communities are subsidized as compensation for wildlife impacts, while wildlife is protected with refuge habitats and migration corridors (Kolipaka 2018; Sayer 1991; Wegge *et al.* 2018). Reducing negative impacts of wildlife on communities and protecting wildlife and their habitat should be priority actions in the buffer zones (Budhathoki 2004; Heinen and Mehta 2000; Silwal *et al.* 2013).

Reducing human-wildlife impacts requires combination of strategies based on the location and species involved that can be broadly categorized into 1) preventive measures (or direct interventions), 2) mitigation measures, and 3) indirect interventions (Goodrich 2010; Treves *et al.* 2009). Direct interventions aim to reduce the severity of the impacts by lowering the frequency and extent of damage from wildlife, whereas mitigation measures and indirect interventions aim to raise residents' tolerance to impacts (Treves *et al.* 2009). Spatial separation of human and wildlife through physical barriers (fences), guards, and repellents are common preventive measures (Goodrich 2010; Karanth and Madhusudan 2002; Treves *et al.* 2009). In addition, altering human behavior through awareness about wildlife, establishing early warning systems, predator proof corrals, changing to crops less palatable to wildlife, improving livestock oversight, and manipulating problem wildlife (both lethally and non-lethally) also mitigate human-wildlife impacts.

We selected Chitwan National Park (CNP) in Nepal for this study because it typifies a national park in the tropics where wildlife density inside the park is increasing and communities around the park are experiencing frequent economic loss and safety threats from wildlife (Lamichhane *et al.* 2018). Participatory conservation and habitat restoration in the periphery of the park were initiated in the 1990s and a buffer zone was legally declared in 1998 (Budhathoki 2004). Despite

their existence of over 20 years, there are only a few studies focusing on buffer zone programs in Nepal, and whether they have helped reduce human-wildlife conflict is not well understood. In this study we examined whether buffer zone interventions are adequate in reducing the negative impacts of wildlife by analyzing buffer zone fund utilization over a decade around CNP. We assessed the fences and mitigation measures practiced by the communities, and examined attitudes of local communities towards wildlife conservation and the management of conflicts to gain more insight in the complex processes of human-wildlife interactions. Our research questions are 1) Are buffer zone funds adequate to reduce the damage caused by wildlife to human life and livelihood? 2) What preventive and mitigation measures are practiced and proposed? and, 3) What are people's attitudes towards wildlife conservation, conflict prevention and mitigation?

Methodology

Study Area

The study was conducted in the buffer zone of Chitwan National Park, Nepal. CNP (953 km²) is situated in South Central, Nepal between 27°16.56' - 27°42.14'N latitudes and 83°50.23' - 84°46.25'E Longitudes (Fig. 1). CNP is the first national park in Nepal, established in 1973 and a UNESCO world heritage site. It is well known for high biodiversity, with nearly 70 species of mammals, >600 birds, 54 herpetofauna, and 126 fish species (CNP 2013). CNP is one of the 42 tiger source sites globally and holds the second largest population of the greater one horned rhinoceros (*Rhinoceros unicornis*) (Subedi *et al.* 2017; Walston *et al.* 2010). A variety of ungulates including four deer (sambar *Rusa unicolor*, chital *Axis axis*, hog deer *A. Procinus*, and muntjac *Muntiacus vaginalis*), gaur (*Bos gaurus*), wild boar (*Sus scrofa*), nilgai (*Boselaphus tragocamelus*) are the major herbivores of the park. In addition to tigers and leopards, there is a range of carnivores such as sloth bear (*Melursus ursinus*), wild dog (*Cuon alpinus*), striped hyena (*Hyaena hyaena*), clouded leopard (*Neofelis nebulosa*), jackal (*Canis aureus*), fishing cat (*Prionailurus viverrinus*), and leopard cat (*Prionailurus bengalensis*).

Contiguous habitat exists toward the south-west (Valmiki Tiger Reserve, India) and the east (Parsa National Park). The park is bordered by the Narayani River in the west, the Rapti River in the north, and the Reu River and the international border with India in the south. On the other side of these rivers there are highly populated human settlements and agricultural areas. A corridor forest, Barandabhar, connects the park with the northern hill forest (Fig. 1). The park is dominated by forest (>80%), including a majority of Sal (*Shorea robusta*) forest followed by riverine forest, and mixed hardwood forest. Highly productive alluvial floodplain grasslands close to the

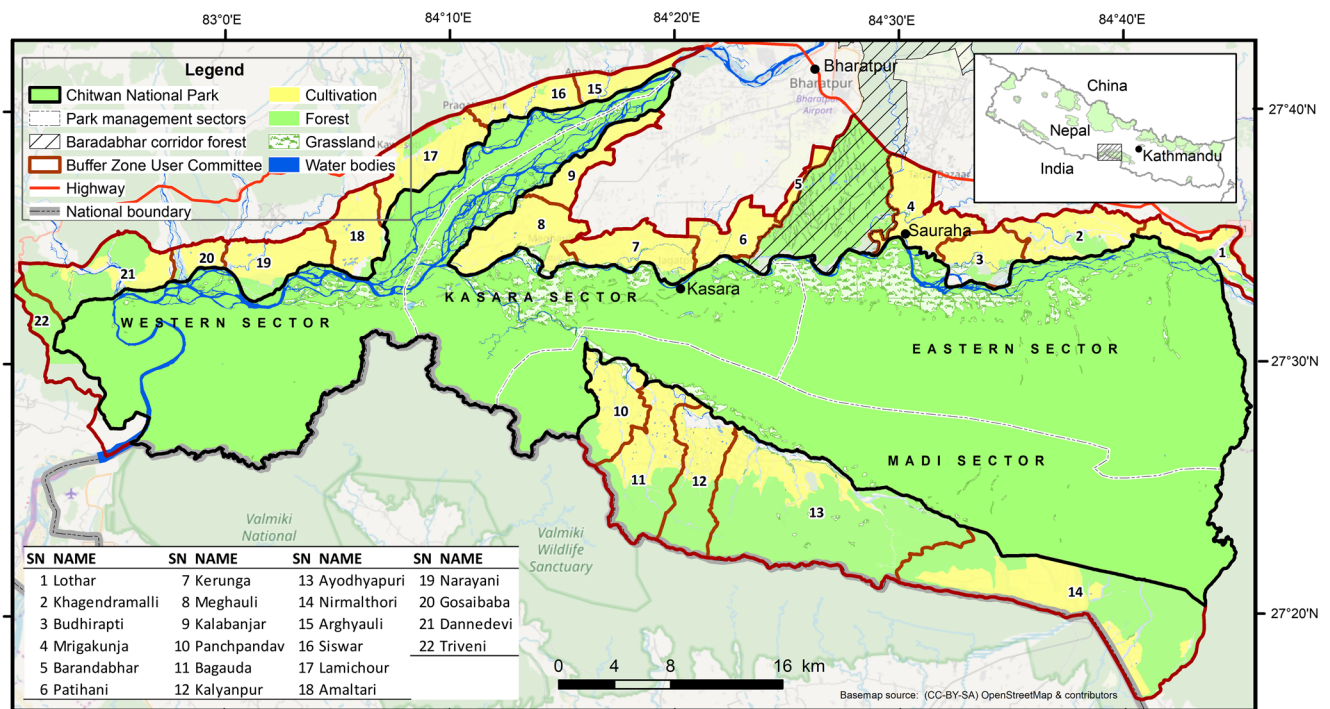


Fig. 1 Chitwan National Park and buffer zone area

bordering rivers cover 9.6% of the park, 5% exposed surface, and 3% water bodies (Thapa 2011; CNP 2015).

An additional 750 km² of the buffer zone surrounding CNP was created in 1996 (21 km² of the buffer zone was later included in the park in 2016). More than half (55%) of the buffer zone is effective wildlife habitat including forests, grasslands, and water bodies; the rest is used for agricultural land and settlements (Karki *et al.* 2015). There are more than 70 buffer zone community forests covering approximately 11,000 ha (CNP 2017). Buffer zone regulations and guidelines provide the legal framework of buffer zone programs in Nepal. Accordingly, the buffer zones are managed in three tiers: 1) user groups are formed at the hamlet level, 2) user committees are formed from the representatives of the user groups, and 3) chairpersons of the user committees form a buffer zone management committee for each protected area. In Chitwan there are 1770 User Groups and 22 Buffer Zone User Committees (BZUC). BZUCs are responsible for designing and implementing buffer zone programs. They also deal with the wildlife victims for the recommendation of compensation payments to the national park, and liaison between the community and the park authority. The park management and buffer zone are divided into four administrative sectors: Eastern (Sauraha), Northern (Kasara), Southern (Madi), and Western (Amaltari) (Fig. 1).

Historically, only a few settlements of the indigenous Tharu, Bote, and Darai communities (of Tibeto-Burmese origin) surrounded the present-day park. However, many people from the hilly area migrated into the Chitwan after the 1950s (Mishra

1982) and there is now a mix of indigenous people and immigrants from the hills including high caste Hindus (*Brahmin, Chhetries*), Tibeto-Burmese hill ethnic groups (*Tamang, Gurung, Magar*) and underprivileged lower caste Hindus (*Kami, Damai, Sarki* etc.). Human density is relatively high (261.5 persons per km² in 2011) and increasing rapidly by 2.1% annually (Central Bureau of Statistics 2012). The buffer zone includes more than 45,000 households in 12 municipalities in five districts (Chitwan, Makawanpur, Nawalpur, Parasi, and Parsa). A majority of people rely on subsistence agriculture but dependence on agriculture is decreasing as the younger generation prefers off-farm activities like tourism (nature-guides and work in hotels), service and foreign employment (Lamichhane *et al.* 2018). Livestock keeping is an integral part of subsistence agriculture, and grazing was common in the buffer zone until the last decade. In recent years there has been a gradual shift towards stall feeding combined with restricted grazing, and adoption of improved livestock (Gurung *et al.* 2009). The demand and preference of youth for off-farm labor has greatly increased during the last decade, resulting in a shortage of labor for farming (Lamichhane *et al.* 2018).

Data Collection

Fund Utilization Records

Our study focused on direct financial investments made through the BZUCs in the buffer zone of CNP. We focused on direct investment because it is often difficult to measure the

impacts of indirect interventions such as awareness raising, alternative livelihoods, and community development to reduce conflict (Treves *et al.* 2009). BZUCs are part of the legal bodies for buffer zone management and are mandated to operate their own accounts (Budhathoki 2004). We collected the income and expenditure records of the BZUCs from their audit reports from 2005/06 to 2014/15 (10 years). As per the buffer zone regulations, it is mandatory for each BZUC to conduct an annual financial audit. The reports are managed according to the Nepalese fiscal year, which runs from mid-July to mid-July based on the Nepalese Calendar (Bikram Sambat) (Lamichhane *et al.* 2018). For consistency of data for time series analysis, we used these fiscal years. The audit reports include the sources and amount of the income received by each BZUC in each fiscal year. The indirect benefits in the communities such as income generation in the buffer zone area from tourism do not fall within the scope of our research. Our study does not include the income and expenditure of the more than 70 community forest user groups in the buffer zone that also spend a large amount of their budget on prevention and mitigation of human-wildlife impacts.

Assessment of Fences and Conflict Mitigation Measures

We mapped the fences constructed along the boundary separating forest and human settlements/agricultural lands. Members of the survey team walked along the fences in all BZUCs with a GPS device (Garmin etrex 10) using the track log. Waypoints were recorded every 200 m and the type of fence, condition and functionality of fence, and year established were recorded in a standardized data form. The GPS tracks were downloaded by DNRGPS software and the fence line feature was extracted from the GPS track. Characteristics of the fences recorded in the data form were associated to a line feature. Spatial analysis such as type and length of fence in different user committees and management sectors of the parks was done in QGIS 2.7 (QGIS Development Team 2016).

The status of the fences and their role in conflict mitigation were assessed through a focused group discussion in each of the four sectors of CNP with 12–20 participants. One day-long focused group discussion was conducted in each sector (Fig. 1) during August and September 2016. Two authors (BRL and SP) facilitated the group discussions. The chairman, the secretary, and an office assistant of the BZUCs, who are key persons responsible for designing/implementing buffer zone programs and conflict management, were invited to participate in the discussion. The sub-group of three persons from each BZUC spent 2–4 h to assess the status of human-wildlife conflict, current practices, and future priorities of conflict mitigation within the respective BZUC area. For each of the mitigation measures, the group was asked to rank as high, medium or low construction costs, maintenance costs and

effectiveness in reducing conflict along with the risks/challenges. Each group member presented their findings written in a chart for all the participants. The participants provided feedback on the presentations and the chart papers were finalized for each committee. All BZUC representatives participated in the workshops actively. The information on the final chart paper was entered into the excel spreadsheet to represent the summary for each buffer zone user committee. This information is summarized from all BZUCs and presented in a table.

Questionnaire Survey

We conducted a questionnaire survey in the buffer zone of CNP during April–June 2016 to assess attitudes towards buffer zone management practices and human-wildlife conflict management. To ensure spatial coverage, we stratified our survey in four management sectors of the CNP and three buffer zone user committees (BZUC) were randomly selected within a sector. Within the map of the 12 selected BZUCs (three in each sector), we generated 35 random GPS points using QGIS. The nearest household to the GPS point was navigated using a map and GPS device. If there was no household within 500 m of the random point, it was excluded from the survey. We requested the household head to participate in the survey whenever possible. If the household head was not available or willing to participate, we interviewed another member of the household aged 16 or above. We moved to the next household for the survey if there were no members of the first household available or they were not willing to participate in the survey. Consent to participate in the survey was read out to the respondent as some of them were unable to read themselves. All the households approached agreed to participate in the survey. Four trained field assistants with long experience in the buffer zone conducted face-to-face interviews using a structured questionnaire that took one hour on average to fill out. The questionnaire was originally prepared in English and translated into a local Nepali language. A pilot survey ($n = 12$) was conducted to test the questionnaire and train the field assistants. The questionnaire was reviewed and approved by the ethics committee of Institute of Cultural Anthropology and Development Sociology, Leiden University (Supplementary file S1). Similarly, the Department of National Parks and Wildlife Conservation in Nepal issued a research permit for this study after approval from a ‘technical committee’ at the department that reviews research applications in Nepal’s in protected areas.

The questionnaire was divided into four sections: 1) personal and household information such as age, gender, ethnicity, occupation, migration, household income sources, land and livestock owned, forest resources need; 2) past experience with wildlife and their impacts on the households; 3) conflict management and compensation practices; and 4) attitude

towards the wildlife and buffer zone program. Attitude of the respondents towards different statements related to wildlife conservation, national park, buffer zone, and conflict management was measured on a five point Likert scale where 1 denoted ‘Strongly agree’ and 5 denoted ‘Strongly disagree’ (Likert 1932; Stapp *et al.* 2016). The statements were read to the respondents and they were asked to score the statements on the scale.

Data Analysis and Statistics

We categorized income sources of the BZUCs derived from audit reports into four categories: 1) committee internal sources, such as fees or royalties for resource extraction (mostly sand gravel, sometimes wood) within committee’s area, memberships, fines, and income from investments; 2) park revenue shared according to existing buffer zone guidelines (30–50% of the total park income); 3) grants and subsidies from other government line agencies (municipalities, district coordination committees); and 4) support provided by conservation NGOs, projects, and environmental non-governmental agencies for conservation actions within the BZUC. Redundant budget headings such as programs advance and bank balance from previous year that could be repeated with the previous year’s budget were excluded from the analysis.

The buffer zone management guidelines provide five broad categories (and proportion of budget) for expenditure namely a) community development (30%), b) wildlife conservation (30%), c) income generation (20%), d) conservation education (10%), and e) administrative costs (10%). BZUCs prepare a five-year action plan and implement priority actions based on the available budget. Sometimes, the conservation NGOs and government line agencies also approach to the BZUCs to implement activities related to their interests within the framework of BZUC action plan. Thus, there are a wide range of activities conducted by the BZUCs, some cross cutting the five categories. Although all these activities are supposed to reduce the wildlife impacts on humans and increase community tolerance, there is no specific category for targeted activities on wildlife conflict prevention and mitigation. As our research interest lies in the direct investment on reducing human-wildlife impacts, we re-categorized expenditure based on the activities mentioned in the audit reports into eight categories and two additional items, i.e., others and unspecified for those not covered within eight categories and unspecified in the audit reports (Table 1). The amount of funds received and expenditure in each category was summarized as percentages and presented in bar graphs in the final analysis.

We used linear regression and Pearson’s correlation to assess the relationship between the investment made to reduce human-wildlife impacts in the buffer zone and frequency of wildlife

Table 1 Expenditure categories of the buffer zone user committee fund utilization

SN	Expenditure category	Description of the category
1	Prevention and mitigation of wildlife impacts	<ul style="list-style-type: none"> • Construction and maintenance of the fences • Subsidy for predator proof corrals • Relief for the wildlife victims
2	Wildlife conservation and habitat management	<ul style="list-style-type: none"> • Plantation, grassland and wetland management, anti-poaching patrolling, forest management, wildlife monitoring
3	Community development	<ul style="list-style-type: none"> • Construction of buildings • Road, culvert, bridges, canal etc. • Community infrastructures (cremation site, resting places) • Drinking water and irrigation facilities
4	Community engagement and IGA	<ul style="list-style-type: none"> • User groups mobilization, saving and credit groups, cooperatives, trainings on income generation activities such as vegetable farming, mushroom farming, livestock husbandry
5	Conservation education	<ul style="list-style-type: none"> • Awareness materials development and broadcast such as radio programs, hoarding boards, posters, pamphlets • Conduct awareness camps targeted to specific groups • School education support • Exposure visits
6	Alternative energy	<ul style="list-style-type: none"> • Biogas subsidy, solar energy, improved cooking stoves
7	Climate change adaptation and disaster risk reduction	<ul style="list-style-type: none"> • Preparation and implementation of community adaptation plans • River embankments, dykes, etc., to prevent floods • Disaster relief funds • Support to the disaster victim families
8	Administrative costs	<ul style="list-style-type: none"> • Salary of the office secretary • Salary of the forest guards and other support staff • Allowances for the committee members • Trainings for the committee members and office staff • Office maintenance costs (electricity, fuel, telephone, water, sanitation etc).
9	Others	<ul style="list-style-type: none"> • Other than the above mentioned eight categories such as investment on share market, household surveys, food & snacks etc.
10	Unspecified	<ul style="list-style-type: none"> • Unspecified in the audit reports

attacks on humans and livestock. The data on frequency of wild-life attacks over the years were obtained from Lamichhane *et al.* (2018). Analysis was done in R (R Core Team 2017).

The Likert scale attitude data were converted into the attitude index by summing response values for each question divided by number of respondents (De Vaus 2013; Spiteri and Nepal 2008). We also assessed the socioeconomic variable explaining the positive attitude using a binary logistic regression in SPSS 20 (IBM 2012). The attitude index towards buffer zone management was converted into a dichotomous value to use as response variable in logistic regression. Values below the mean value on the 1-to-5 were scored as ‘1’ representing the positive attitude and vice versa. Eight independent variables included in the regression analysis which could affect the attitude of people

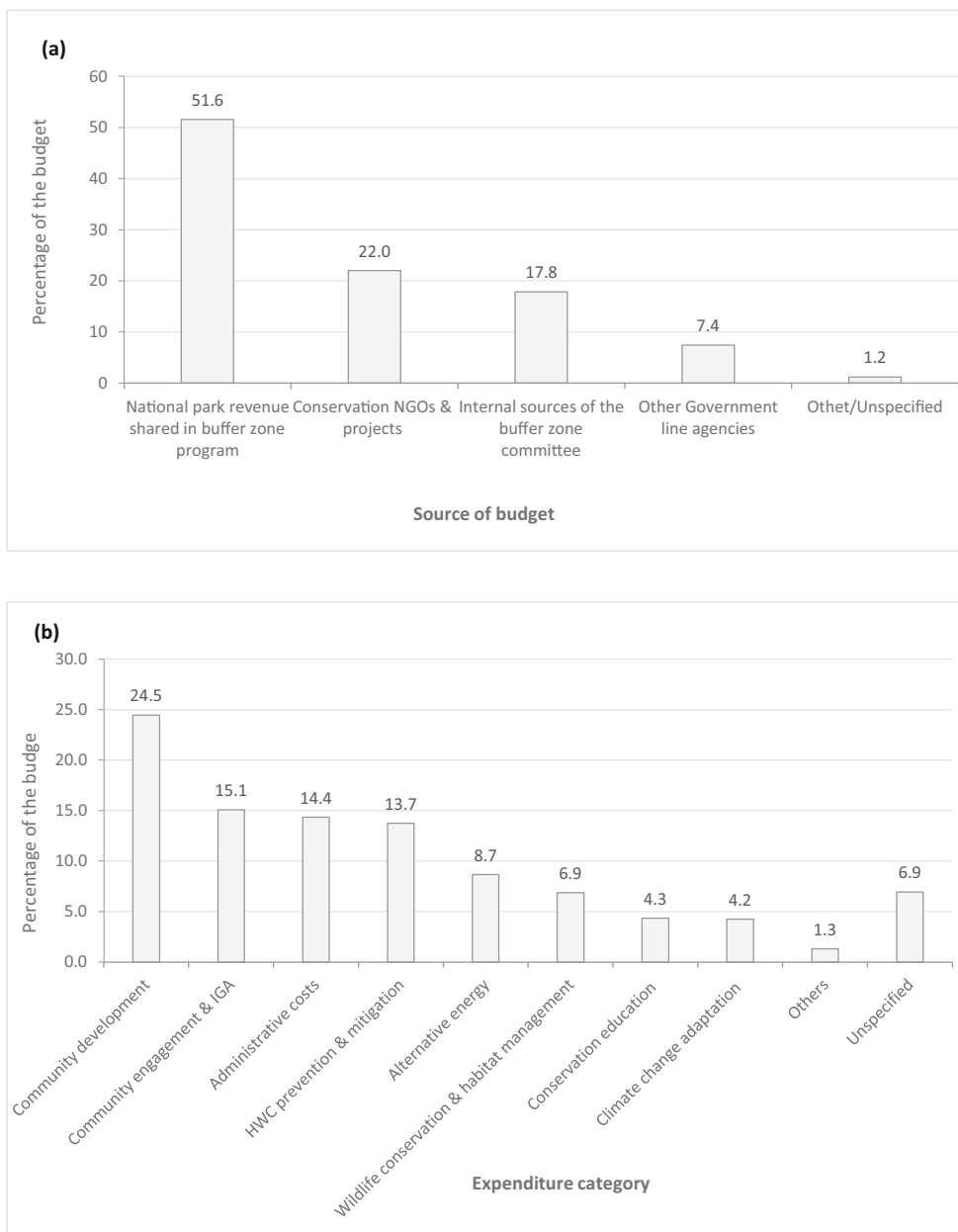
(Carter *et al.* 2014) were 1) distance to the park, 2) distance to the forest edge, 3) ethnicity, 4) management sector, 5) sex, 6) education, 7) land ownership, and 8) occupation.

Results

Buffer Zone Investments and Fund Utilization

Through the BZUCs more than US\$5.6 million of direct investment was made during 2005/06–2014/15 in the buffer zone of CNP, an average of US\$558,000 (range 130,000 – 1,173,000) per annum. Revenue shared by the national park contributed more than half of the BZUC budget (Fig. 2a).

Fig. 2 a Income sources and b expenditure by the buffer zone user committees of Chitwan National Park, Nepal during 2005–2015 based on annual audit reports



Contrary to our expectation, the buffer zone user committees spent only a small portion (13.7%) of their fund directly on prevention and mitigation of human-wildlife conflict through activities such as construction/maintenance of fences and providing relief for victims (Fig. 2b). However, the amount spent for wildlife conflict prevention and mitigation has been increasing gradually as the total park revenue has been increasing (Fig. 3a). The investment for conflict mitigation interventions was negatively correlated to wildlife attacks on humans (-0.49) and livestock depredation (-0.56) but the relationship was not significant ($p = 0.14$ and 0.09 respectively) (Fig. 3b).

Assessment of the Mitigation Measures

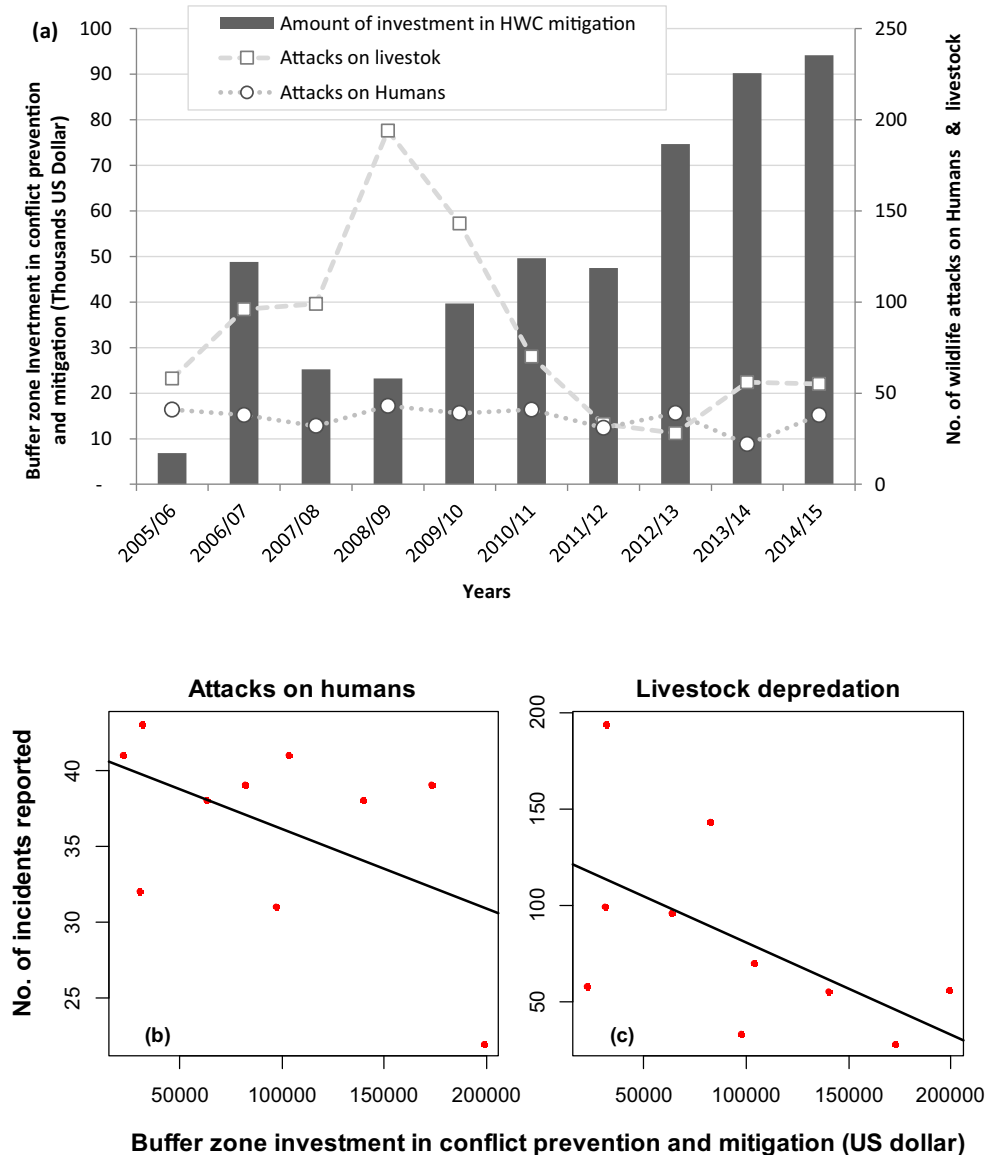
Out of the total budget spent on conflict prevention and mitigation, BZUCs invested most of the funds in the construction and maintenance of the physical barriers (85%). The buffer zone

communities have constructed approximately 275 km of fence along the forest–settlement border (Fig. 4), about half including electric fences (140 km). The other half includes fences (single or combination with electric fence) made from barbed wire, mesh wire, PCC with mesh wire, or a dyke (along the rivers) (Table 2). Community leaders evaluated multiple mitigation measures undertaken within the BZUCs during the focused group discussions (Table 3). Most of the BZUCs (13 of 22) proposed mesh wire fences (5–7 ft) with PCC on the bottom (2–3 ft) as the priority for conflict mitigation in future (Table 3).

Attitude towards the Buffer Zone Programs and Conflict Mitigation

A total of 399 respondents were interviewed, a majority male (58%) and involved in farming (85%). Ages ranged between 16 and 78 years with an average of 45 years. About three

Fig. 3 Buffer zone investments to minimize human-wildlife impacts and number of incidents (wildlife attacks on humans and livestock) over the years based on audit reports (a); linear regression of investment versus wildlife attacks on humans (b); livestock depredation (c)



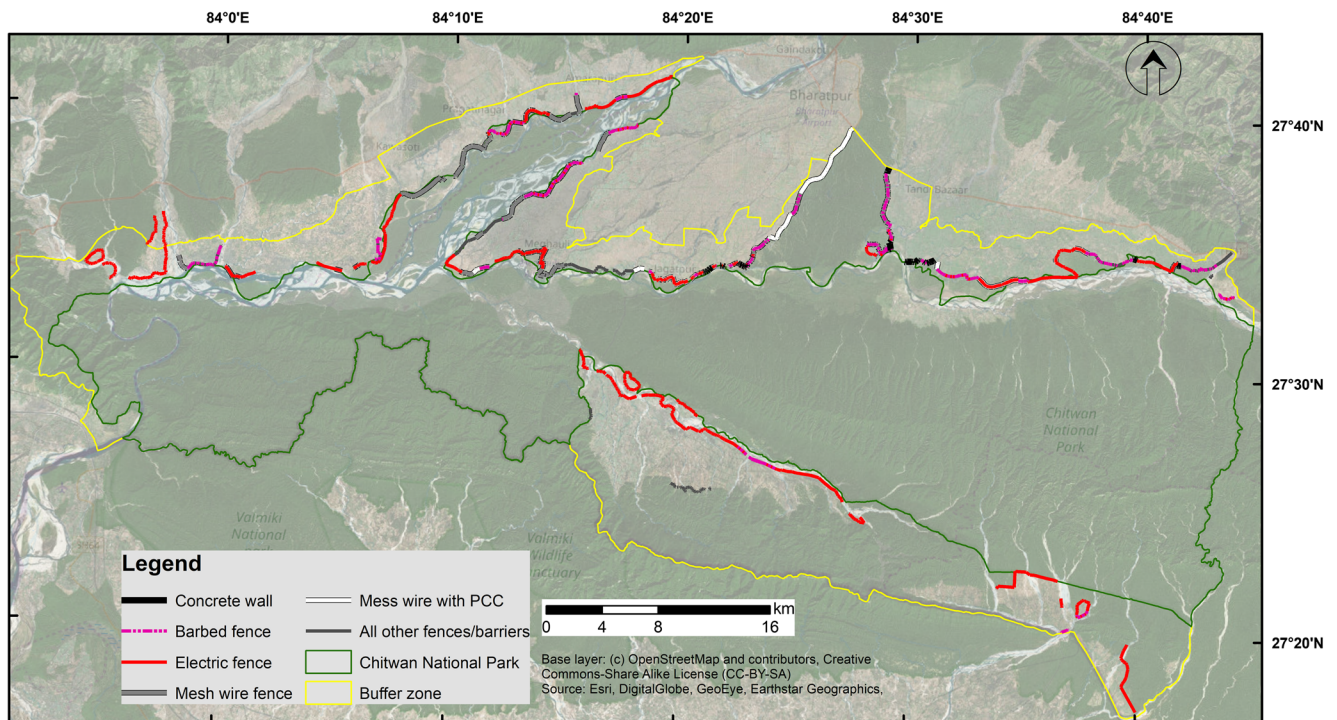


Fig. 4 Fences installed along the forest-settlement borders in the buffer zone of Chitwan National Park, Nepal

quarters (73%) of respondents had primary education while fewer than 10% had secondary or higher education, and 17% were illiterate. Ethnicity was divided into four categories 1) High cast Hindu (44%), 2) Hill Tibeto-Burmese (24%), 3) Terai Tibeto-Burmese (21%), and 4) Lower caste Hindu (11%). Average land holding per household was 0.5 ha. Most of households (87.5%) have livestock or poultry.

The overall attitude of respondents towards wildlife conservation was positive ($2.37 \pm \text{SE } 0.25$) on a 1-to-5 scale (Table 4). People's attitudes towards the participation of households in wildlife conservation, particularly willingness to manage human-wildlife conflicts, were more positive (1.91) compared with attitudes towards current practices of conflict mitigation (2.51), the role of the national park (2.42), and the role of the buffer zone program (2.84). Regression analysis shows the positive attitude is associated with the management sectors (East and Kasara) and ethnicity (Table 5).

Conflict Management and Compensation Payments in Buffer Zone

About half of the respondents (44.6%) reported the increase in damage from wildlife during the previous five years primarily due to widespread crop raiding by herbivores, while 43.9% think damage either decreased or has not changed (11.5%). The highest number of the respondents (67%) reported wild boar as the main problem causing species around CNP followed by rhino and chital. Conflicts with carnivores were reported to be less severe. Five carnivores – tiger, jackal, sloth bear, leopard, and jungle cat – were reported to be affecting local residents by threatening safety or predated on livestock/poultry. Additionally, smaller animals such as monkeys, birds, snakes, and porcupines were also reported having negative impacts on lives and livelihoods on smaller scales (Fig. 5).

Table 2 Types and lengths of the fences in different management sectors of buffer zone in Chitwan NP based on field survey in October–December 2017

Management sector	Types and lengths of fences (km)						Total
	Electric	Barbed	Mesh wire	Mesh wire with PCC	Concrete wall	Others	
East	25.5	21.9	8.9	5.8	4.1	1.8	68.02
Kasara	26.4	13.6	24.0	15.0	1.9	–	80.95
South	47.4	4.8	–	–	–	1.5	53.78
West	40.9	10.5	21.0	–	–	–	72.36
Total	140.2	50.9	53.9	20.8	6.0	3.4	275.10

Table 3 Major types of fences and other preventive measures currently practiced for reducing HWC in buffer zone of Chitwina NP

Type of intervention	Years of implementation	No. of BZUCs practicing	Total length of the fences (km)	Future priority action for no. of BZUCs	Target species	Construction costs #	Maintenance costs	Effectiveness in reducing conflict	Additional evaluation/remarks
Physical barriers									
Barbed fence	1989–2017	16	50.9	–	All	Medium	Medium	Low	Effective for deer, not effective for wild boar, rhino and elephants
Electric fence	2001–2017	19	140.2	9	Rhino, elephant	Medium	High	Medium	Effective when maintained properly, regular maintenance is a challenge
Mesh wire fences	2008–2012	12	53.9	–	All	Medium	Medium	Low	Stops deer but not effective for wild boars, rhinos
Mesh wire fences with PCC	2013–2017	7	20.8	13	All	High	Low	High	Effective for most of species except elephants, cost of construction is high
Concrete wall	2015–2017	3	5.9	1	All	Very High	Low	High	High construction costs, stops natural water flow in flood prone areas
Predator-proof corrals	2015–2017	7	NA	6	Tiger, leopard	Low	Medium	High	Chances of predation when animals are out of the corrals
Community Guarding machan	All time	4	NA	–	All species	Low	Medium	Medium	Labor intensive, needs active guarding
Awareness programs	1995–2017	All	NA	15	All species	Low	Medium	Low	Effective in reducing wildlife attacks on humans, more awareness programs needed
Other*	Different periods	7	3.4	8	Selected species	NA	NA	NA	

* Other includes flashlights, dykes, fish ponds, etc

costs (USD) per km of fence construction (Very high – more than 10,000; High – between 5000 and 10,000; Medium between 1000 and 5000; low – less than 1000)

Table 4 Attitude of people towards carnivore conservation, participation, and conflict mitigation in Chitwan National Park, Nepal, based on questionnaire survey in April – June 2016

Questions 1-to-5 scale (1 = Strongly Agree, 5 0.0 Strongly disagree)	Average score		
	\bar{x}	S.E.	$G \bar{x}$
General attitude towards wildlife			2.04
1 Wild animals have a right to live in the forest	1.45	0.06	
2 Wildlife attracts tourists and brings revenue to the Park, which benefits us	1.90	0.05	
3 If tiger and leopard disappear from Chitwan, it is a not a good news for me.	1.55	0.04	
4 Tiger and leopard population should be increased in coming years	2.29	0.08	
5 Wildlife conservation benefits me directly.	3.01	0.07	
Conflict management			2.51
6 Wildlife should be conserved only if conflict with humans can be reduced.	1.43	0.05	
7 Existing conflict-mitigation measures for wildlife conflict is not adequate	1.89	0.05	
8 In case of severe conflict, problem animals should be terminated	4.20	0.05	
Role of national park			2.42
9 National Park authorities are responsible for HWC, they should manage it	1.89	0.06	
10 National Park authorities are playing a positive role for human wildlife conflict mitigation	2.75	0.05	
11 Government relief for loss done by wildlife is helping to victim families.	2.63	0.05	
Role of buffer zone			2.84
12 Buffer zone institutions playing a positive role for human wildlife conflict mitigation	2.57	0.05	
13 Buffer zone institutions have given adequate priority to HWC mitigation	3.34	0.05	
14 Community forests are playing a positive role for HWC management	2.62	0.05	
Household responsibility & participation for conflict mitigation			1.91
15 I live close to the forest with risk of wild animals and it's also my responsibility to avoid it	2.30	0.05	
16 I would like to participate in community wildlife conflict mitigation programs.	1.84	0.04	
17 I would like to learn more about wild animals, their behavior and ecology.	1.66	0.04	
18 I should participate to maintain electric fences and physical barriers constructed to avoid conflict	1.85	0.04	

\bar{x} and *S.E.*, mean and standard error of the attitude scores for each questions; $G \bar{x}$, mean attitude score for each group of questions

The majority of the respondents (60%) was not satisfied with the buffer zone programs and suggested more focus on direct interventions to reduce wildlife impacts (Fig. 6a). Similarly, more than two-thirds of respondents (71.7%) were aware of government compensation for wildlife damage. However, most (more than 90%) were not satisfied with the existing payment mechanism. It took an average of 6.6 months to receive payments and most respondents viewed it as a lengthy and highly bureaucratic procedure. The highest number of people (36.1%, $n = 399$) prefer that compensation payments be made by buffer zone committees or community forest user groups, while others think municipalities, other conservation organizations, or the national park authority itself should make the payments (Fig. 6b).

Discussion

We found buffer zone program around CNP has been firmly institutionalized. They receive regular support from the government (30–50% of the park revenue is shared with buffer zone) as well as grants and subsidies provided by other conservation organizations and government line agencies. We documented that a relatively low proportion of the budget was spent on direct interventions to reduce wildlife impacts on communities (13.7%). However, amount of investment in

buffer zone programs as well as funds spent on reducing human-wildlife impacts are gradually increasing over the years with increasing revenue of the park. We suggest that various preventive and mitigation measures practiced by the BZUCs have contributed to reduce wildlife attacks on humans and livestock, although crop raiding was found to be widespread. Most people were positive towards wildlife conservation but they were not satisfied with current practices of the buffer zone program as well as conflict prevention and mitigation measures.

Buffer Zone Fund Utilization

The annual budget of all buffer zone user committees amounts more than US\$1.2 million in recent years, which is a large amount in a poor country such as Nepal. The annual budget of the park and buffer zone substantially increased after the government raised the daily entry fee for foreign visitors in 2013 from Nepalese Rupees 500 (~ US\$5) to Rupees 1500 (~US\$15). The number of visitors is also increasing gradually (CNP 2017). In addition to park revenue, more than 70 community forests in the buffer zone also earn approximately US\$0.5 million annually from ecotourism activities (CNP 2017), spending some of it to manage human-wildlife impacts. Not all parks/reserves in Nepal have such a large revenue (DNPWC 2017). Despite such large and sustained

Table 5 Binary logistic regression examining relation between socio-demographic variables and positive attitudes towards buffer zone management in Chitwan National Park

Variables	B	S.E.	Wald	P
Distance to park	0.00	0.00	0.85	0.36
Distance to forest edge	0.00	0.00	1.56	0.21
Ethnicity				
High caste Hindu	–	–	5.51	0.14
Hill Tibeto-Burmese	1.39	0.61	5.25	0.02*
Terai Tibeto-Burmese	1.18	0.65	3.29	0.07
Lower caste Hindu	1.39	0.63	4.85	0.03*
Management sector				
East	–	–	9.75	0.02*
Kasara	–0.97	0.45	4.59	0.03*
South	0.04	0.39	0.01	0.91
West	0.48	0.42	1.34	0.25
Gender				
Male	–	–	–	–
Female	0.21	0.29	0.53	0.47
Have livestock				
Yes	–	–	–	–
No	–0.27	0.50	0.30	0.58
Education				
Illiterate	–	–	5.30	0.15
Primary education	–0.83	0.75	1.23	0.27
Secondary education	0.13	0.60	–	0.83
Higher education	0.72	0.79	0.82	0.37
Land ownership				
less than 0.1 ha	–	–	2.91	0.41
0.1–0.5 ha	–0.09	0.57	0.02	0.88
0.5–1 ha	0.50	0.46	1.22	0.27
greater than 1 ha	0.48	0.48	1.01	0.32
Occupation				
Agriculture	–	–	2.67	0.45
Off-farm business	–0.47	0.69	0.46	0.50
Student	0.14	0.90	0.02	0.88
Other	0.43	0.91	0.22	0.64

investments over two decades in Chitwan's buffer zone, wildlife damage to lives and livelihoods of the local communities is still substantial (Dhungana *et al.* 2018; Lamichhane *et al.* 2018; Pant *et al.* 2016; Silwal *et al.* 2017). Studies show a marginal decrease of wildlife attacks on humans and livestock by carnivores in recent years (Dhungana *et al.* 2018; Lamichhane *et al.* 2018) while people reported a rise in crop raiding by wild herbivores.

The buffer zones are designed primarily to create human-wildlife coexistence by providing an ecological buffer to wildlife and a socioeconomic buffer to the communities (Budhathoki 2004; Heinen and Mehta 2000; Nepal and Weber 1994). Although, Nepal endorses these aims, the buffer zone program in Chitwan has given higher priority to community development (24.5%) compared with prevention and mitigation of human-wildlife impacts (13.7%). Similar findings of a much higher proportion of budget spent on infrastructure development (42%) have been reported by Silwal *et al.* (2013). Additionally, community engagement and IGA programs (15.1%) and alternative energy such as biogas subsidies, solar energy, and improved stoves (8.7%) were also implemented to develop alternative livelihoods and reduce forest dependency. In contrast only 7% was spent on wildlife and habitat management. Such preference towards community development programs is influenced by the political interest of the buffer zone leaders. Although the buffer committees are elected through a democratic process, local political parties have a great influence. The elected members are also interested in gaining popularity in the community through such development activities to support their political careers. The infrastructure development and construction work also generate local economic opportunities for a broader range of

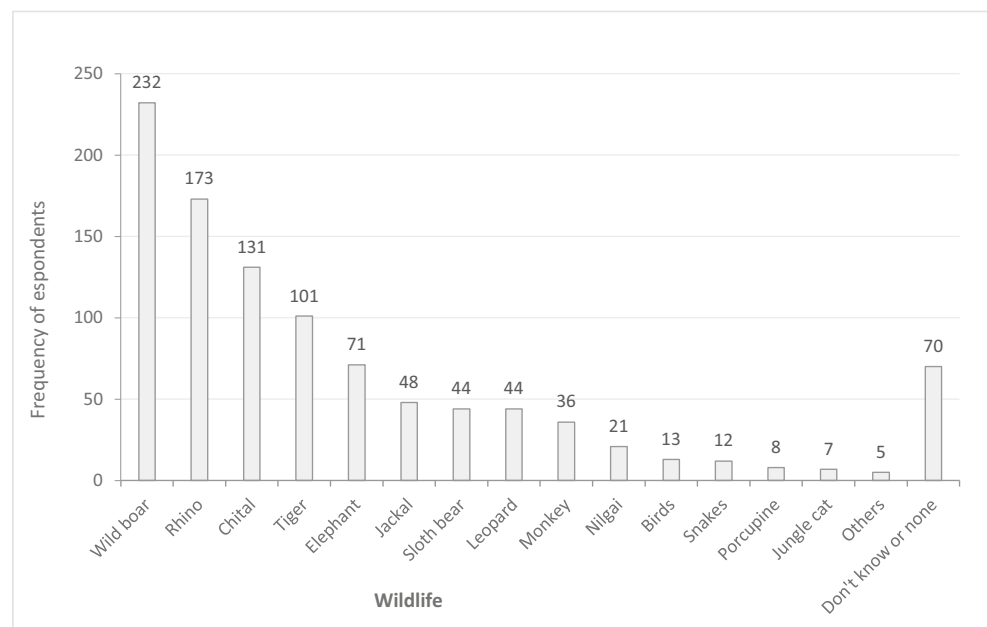
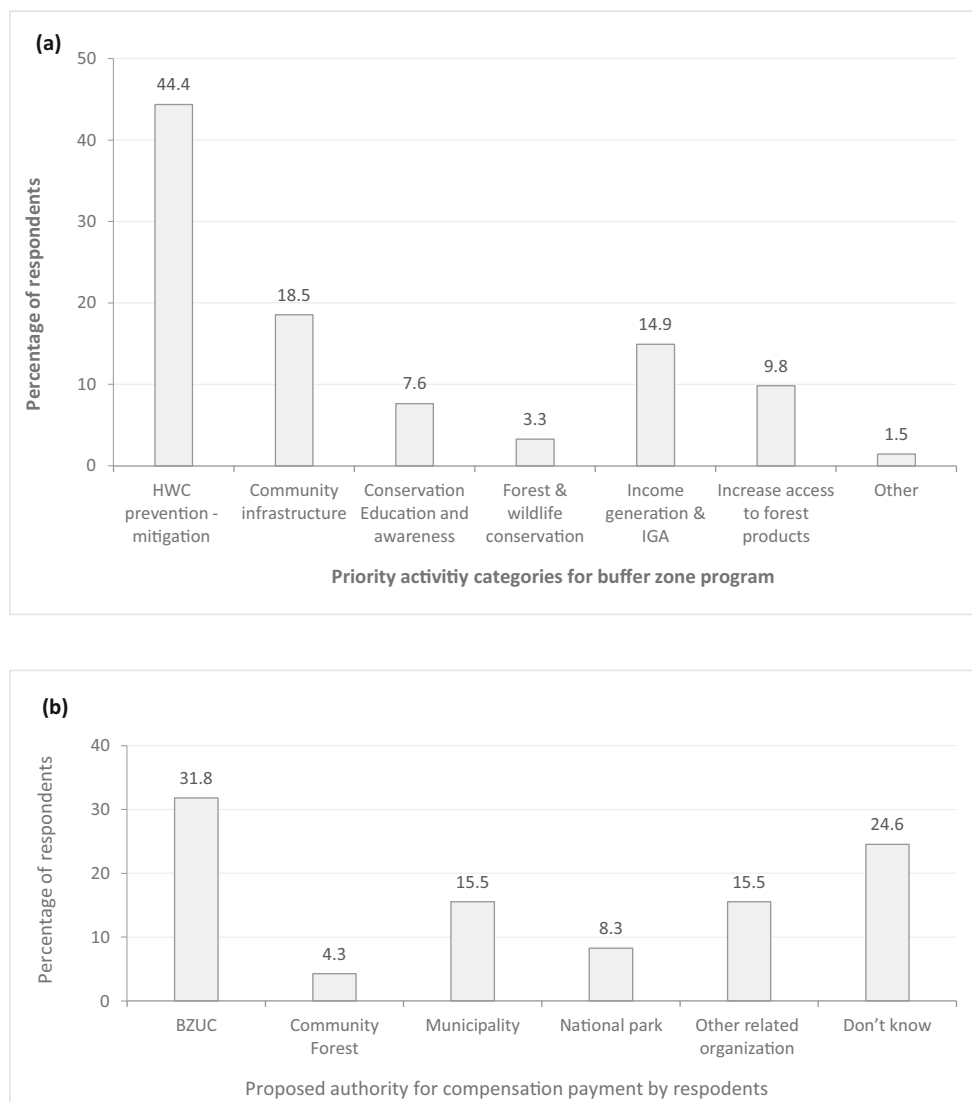
Fig. 5 Frequency of respondents reports of problems caused by different wildlife species during a questionnaire survey conducted in April – June 2016 in the buffer zone of Chitwan National Park, Nepal

Fig. 6 **a** Priority actions of the buffer zone program and **b** authority for compensation payments as per the respondents in Chitwan National Park, Nepal



community members such as employment for laborers and markets for different products and services. However, investments in community development raise people's expectations from the buffer zone program, which is unable to fulfill the extensive development needs with a limited budget. Such concerns have been raised since the establishment of the buffer zone programs in Nepal (Heinen and Mehta 2000). Hence, prioritization of the activities is required to obtain the intended benefits of the buffer zone programs.

The inverse correlation between budget spent in direct interventions for conflict prevention/mitigation and wildlife attacks on humans and livestock respectively indicates the importance of such interventions. Populations of large carnivores and herbivores are increasing over time (Karki *et al.* 2015; Subedi *et al.* 2017) whereas conflict incidents have not increased proportionally (Lamichhane *et al.* 2018). Fences have been installed along the forest-settlement borders by the buffer zone committees and community forest user groups using

their internal funds as well as support from the park, conservation NGOs, and other government agencies (Banikoi *et al.* 2017). In addition, interactions between wildlife and humans have also decreased through facilitation of buffer zone programs and livelihood diversification from off-farm income (less dependence on forest products, and hence, less frequent visits to wildlife inhabited forests) (Paudel Khatiwada *et al.* 2017). Buffer zone programs also initiated a compensation payment mechanism for wildlife damage to humans, livestock, and property in 1999 which continued in a different form after the government endorsed relief guidelines for wildlife damage in 2009 nationally (Lamichhane *et al.* 2018). Most of the buffer zone committees have also established a fund for immediate relief of victims. Such measures probably have also contributed to reduce communities' resentment towards wildlife.

Although our findings indicate the need of prioritization of buffer zone programs towards direct interventions on conflict

prevention and mitigation, the existing buffer zone policy of Nepal favors community development with 30% of the annual budget (Budhathoki 2004). However, the policy suggests such activities should be small-scale and production-oriented with clear linkage to reducing pressure on forests and enhancing human-wildlife coexistence (MOFSC 1998). In contrast, the community development activities in Chitwan's buffer zone include community buildings and infrastructure (30%), river embankments (26.1%), road construction (24.1%), and drinking water and irrigation facilities (13.7%). A study focusing on conservation incentive distribution in Chitwan's buffer zone shows residents experiencing the greatest costs in terms of crop damage or livestock have benefited least from these developments (Spiteri and Nepal 2008). Thus, despite large investments in buffer zone programs, the affected communities remain disadvantaged.

Direct Interventions to Reduce Human-Wildlife Impacts

We documented a range of preventive and mitigation measures practiced over time in the buffer zone of CNP for reduction of detrimental wildlife impacts on local communities. During the initial years of the buffer zone programs (early 1990s), barbed fences (sometimes accompanied by trenches) were installed along forest borders with the dual purpose of preventing domestic livestock grazing and limiting wildlife access to settlements (Sharma 1990). These fences effectively stopped some wild herbivores such as chital and muntjac, although rhinos and wild boars usually break through such fences (Sharma 1990).

In early 2000, electric fences were adopted (constructed using local materials) in the buffer zone to stop large animals like elephants and rhinos (Sapkota *et al.* 2014). Generally, the electric fences are 5–6 ft tall with 2–3 parallel galvanized-wires attached to wooden poles using plastic insulators and connected to the energizer, which gives intermittent electric pulses. Electric fences became very popular; 19 of the 22 BZUCs installed them in their areas during 2006–2012 with a total length of 140 km. In some communities, electric fences reduced up to 60% livestock depredation and 70% of crop loss especially from the rhinos (Sapkota *et al.* 2014). Regular maintenance of the electric fences is necessary to function well, which was the major challenge in CNP's buffer zone. Banikoi *et al.* (2017) reported only 26% of the electric fences are operational around CNP, the rest are non-functional due to lack of maintenance. Although BZUC receive funds from the park annually, they do not automatically allocate funds for maintenance of the fences. During our survey we also observed that local people sometimes break the fences to enter forests for collection of forest resources.

With the recent failure of the electric fences, the BZUCs are replacing or complementing them with the construction of mesh wire fences or concrete walls. During the focused group discussions with community leaders, a majority expressed a preference for construction of fences that are effective for wide range of species, of reasonable cost, durable, and requiring a low level of maintenance. Among the different types of the fences, most of them preferred the 5–7 ft tall mesh wire fence with a 2–3 ft concrete base along the forest-settlement borders (Fig. 7). In areas with frequent elephant visits, they suggested two electric fence wires attached towards the forest side of the mesh wire fence. Along the rivers, dykes with

Fig. 7 An example of the mesh wire fence communities prefer to construct along the forest-settlement border. The fence has a concrete base of about 2 ft and 5 ft tall mesh wire anchored to the iron poles set in a concrete base



electric fences on the top were proposed. The construction of fences should be synchronized among the committees to avoid the increase of wildlife impact in other areas without fences. In addition to monetary investments of the buffer zone programs, some regulations such as grazing restrictions (Gurung *et al.* 2009) and limits on forest resources collection have also contributed to a reduction of damage caused by wildlife, especially to livestock depredation around CNP (Lamichhane *et al.* 2018). Because most livestock depredation happened in animal stalls, some committees (six of 22 BZUCs) recommended a subsidy for predator proof corrals, especially for goats.

Attitudes towards Conservation and Buffer Zone Program

Peoples' attitude towards wildlife conservation was largely positive, similar to reports of previous studies (Carter *et al.* 2014; Stapp *et al.* 2016). We found that people's willingness to participate in conflict prevention and mitigation is relatively high compared with the attitude towards current practices of the buffer zone and management of human-wildlife impacts. Although the attitude index is still towards positive side (below 3 on 1-to-5 scale), the role of buffer zone programs received the least positive response among the categories.

Only ethnicity and the management sector had a significant effect on attitudes towards buffer zone programs. The eastern sector of Chitwan showed a generally positive attitude, reflecting the greater attention it has received since the establishment of the park and the buffer zone activities initiated here in 1990s. Likewise, the generally negative attitude in Kasara sector reflects the high number of human (western and central parts) and livestock losses (eastern part) caused by wildlife it has experienced. Although the southern Madi sector is believed to be the most affected by the wildlife impacts, their attitude was not significantly different. Hill Tibeto-Burmese ethnic groups are involved in more off-farm activities and foreign employment, which could have resulted in positive impacts as they have less day to day interaction with wildlife. The positive attitude of lower caste Hindus was not expected but recent focus of buffer zone programs on underprivileged groups might have been a contributing factor.

The majority of respondent think wildlife damage is decreasing or has not changed over the previous five years, as documented in an earlier study based on reported cases of wildlife attacks on humans and livestock (Lamichhane *et al.* 2018). Compared to the initial decades of park establishment (Mishra 1982; Nepal and Weber 1995; Sharma 1991) wildlife damage has declined over the most recent decade (Dhungana *et al.* 2018; Lamichhane *et al.* 2018; Sapkota *et al.* 2014). However, about half (44.6%) of the respondents still think there is an increase in wildlife impacts. The reason could be the widespread crop raiding by herbivores. For instance, locals reported herbivores

like wild boar, rhino, and spotted deer are causing more damage than carnivores (Lamichhane *et al.* 2018). Although different preventive measures are practiced, they seem to be less effective in deterring crop-raiding herbivores, especially wild boar, from entering agricultural areas. The majority (55%) of respondents were aware of buffer zone activities in their locality but only 40% were satisfied with current interventions. Although a wide range of activities has been covered by the buffer zone programs over the years local people suggested a greater focus on direct interventions to reduce wildlife impacts.

Although ~75% of respondents were aware of compensation for wildlife damages, a large majority (more than 90%) were not satisfied with current practice. They think the process is lengthy and highly bureaucratic, and payment is not sufficient. The Nepalese government has endorsed compensation guidelines for damages caused by major 14 wildlife species throughout the country (MOFE 2017). To receive the payment, victims are required to make an application to the respective park together with 6–9 supporting documents for the type of damage (attack on human, livestock, property damage, or crop raiding) including photographic proof of damage, amount of financial loss assessed by authorized persons, and a recommendation from the respective municipality as well as the BZUC. In the past, the park would forward the application to regional forest directorates, which review the application and release the funds. Recently, the government amended the guidelines and gave authority of fund disbursement to respective park authorities. On average, locals received the payments more than half a year after the incident. The compensation payments cannot deliver the intended outcome of increasing tolerance of wildlife damage when victims are dissatisfied with the payment in terms of time, amount, and procedure (Nyhus *et al.* 2005). Respondents thus suggested simplifying the payment process and authorizing local institutions such as BZUCs, respective parks, or local government (municipalities) to make the compensation payments. Moreover, the existing compensation scheme only covers a group of species (tiger, common leopard, snow leopard, clouded leopard, rhino, elephant, gaur, wild water buffalo, bears, wild boar, wild dog, grey wolf, mugger crocodile, Burmese python). Crop raiding by wild boar and chital is reported frequently and was not covered by the compensation guidelines during our survey. Losses caused by chital and wild boars are widespread in the buffer zone, and thus considered too costly for the government to cover, and quantification of the loss is difficult. However, a recent amendment of the compensation guidelines in 2018 included coverage for crop loss from wild boar.

Implications for Buffer Zone Policy in Nepal

Our study documents the importance of the buffer zone program in reducing human-wildlife impacts and encouraging community participation in conservation. It has been more than two decades since the buffer zone program was formally recognized in Nepal

(Budhathoki 2004; Heinen and Mehta 2000). At present, Nepal is in political transition after promulgation of a new constitution in 2015 establishing a federal democratic republic. Subsequently, a range of policies and institutional reforms has been ongoing within the framework of the new constitution. The position of national parks and wildlife reserves are well defined under the responsibility of the federal government, whereas the status of buffer zone management is not clear. As the buffer zone is part of an integrated system of a protected area, its close association with the respective park is important. However, the buffer zone may fall under the jurisdiction of the state government and the local government (municipalities) based on constitutional provisions. This could impact effective implementation of the buffer zone programs.

Along with institutional arrangement, buffer zone management guidelines also need a prioritization of activities. Our study shows the need for increasing investment in direct intervention to reduce human-wildlife impacts. Local residents of the buffer zone in our study suggested prioritizing buffer zone activities to minimize wildlife impacts on people and increase access to forest products rather than emphasizing community development. There are various government line agencies to carry out development works. Thus, we recommend amendment of the buffer zone management guidelines with the provision of 25–50% of the buffer zone budget for direct interventions for conflict prevention and mitigation. Recently, Shivapuri-Nagarjun National Park outside Kathmandu (the capital city of Nepal) has developed separate guidelines for its buffer zone management allocating 25% for the prevention and mitigation measures of human-wildlife impacts. This could be adopted by other buffer zones of the national parks and reserves in Nepal.

Conclusion

Our study has several implications for conservation policy particularly on designating buffer zones and prioritizing actions. First, prioritizing the buffer zones programs in direct interventions to reduce wildlife impacts by provisioning certain portion (25–50%) of buffer zone funds will benefit local communities as well as reduce conflict. The communities preferred construction of 5–7 ft tall mesh wire fences with 2–3 ft concrete base along forest-settlement border through buffer zone funds. Second, improving benefit sharing by targeting the most affected communities will result in more positive attitudes towards wildlife management and conservation efforts (Spiteri and Nepal 2008). Similarly, compensation payment guidelines should be revised to cover all conflict-causing wildlife and payment procedures should be simplified by giving more responsibility to buffer zone user committees, local government bodies like municipalities, or the respective protected areas. We also recommend a systematic review of current implementation of buffer zone programs to understand existing problems and design improved strategies

for local engagement in wildlife management and conservation in the changing national and global context.

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Compliance with Ethical Standards

Conflict of Interest Authors declare that they have no conflict of interest.

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