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COMMUNICATION

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COMMUNICATION

Patterns, perceptions, and spatial distribution of human-elephant (*Elephas maximus*) incidents in Nepal

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Abstract: Nepal has an estimated population of 109 to 142 wild Asian Elephants *Elephas maximus* L.. We carried out a survey of human-elephant incidents (HEI) of conflict in the buffer zones of Chitwan National Park and Parsa National Park Nepal, using a structured questionnaire, focal interviews, and secondary data collection. Furthermore, data of HEI were also extracted from published literature in order to analyse spatial-temporal patterns of competition throughout Nepal. Elephant related incidents were higher in the pre-winter season and concentrated along the southern forest boundary; incidents decreased with increasing distance from the park/reserve. Crop damage by elephants occurred in pre-monsoon and winter seasons with the most impact on rice (the major crop). Bulls (single or in pairs) were involved in crop raids (44%), property damage (48%), and human casualties (8%); family herds were only recorded to have raided crops (39%) and damaged properties (36%). The average herd size recorded was 10 individuals, with a maximum group size of ≤22 elephants. Generally, incidents per elephant was high in western Nepal, whereas human and elephant casualties were higher in central and eastern regions. To reduce human–elephant incidents 53% of local residents suggested restoring core and boundary areas with native elephant food plants, 40% suggested planting alternative crops along park boundaries, 6% favoured elephant translocation, and only 1% percent was in favour of culling elephants. Mitigation measures already in place include wooden watch towers used by villagers to detect elephant incursions. Low impact traditional averting techniques, such as drumming and the use of flame torches, were used to deter intruding elephants at the areas surveyed. In conclusion we suggest potential mitigation measures such as identifying elephant refugia and mitigate the impact and assessing the year-round availability of preferred foods; in addition, we advocate for introducing an equitable compensation to gain support from local communities adjacent to protected areas.

Keywords: Asian Elephant, human-wildlife incidents, endangered species, conservation, questionnaire, stakeholder solutions.

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Author contributions: RKK and WJ designed the study; RKK collected the data; RKK, DR, YT and WJ analyzed the data. RKK wrote the manuscript, and all authors contributed to the editing of final version of the paper. All authors read and approved the final manuscript.

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INTRODUCTION

The Asian Elephant *Elephas maximus* is among the largest living land mammals and is 'Endangered' according to IUCN Red List (Williams et al. 2020). Global estimated population of Asian Elephants is 41,410–52,345 in the wild and 16,000 in captivity, distributed across 13 Asian countries (Sukumar 2003; Choudhury et al. 2008). Elephant populations in most of their natural ranges have been declining with the increase in human populations and land development causing erosion and degradation of forest habitats (Choudhury et al. 2008). Such habitat degradation in the form of deforestation, increases the frequency of incidents with Asian Elephants (Riddle et al. 2010; Puyravaud et al. 2019), which is hindering conservation efforts in some regions (Hoare 1999; Perera 2009). Thus, averting habitat destruction and fragmentation is probably most important in reducing problems with elephants (Hoare 2000; Sukumar 1989, 2006; Puyravaud et al. 2019).

Nepal provides habitat for an estimated 120–215 Asian Elephants (Pradhan et al. 2011; Koirala et al. 2016). The recent loss of over 80% of elephant habitat to human settlement (Joshi & Singh 2007), however, has eroded the carrying capacity. In the past, elephants were distributed throughout the Terai forests (Pradhan & Wegge 2007). These forests, which spanned Nepal from east to west, have now been reduced to 24% of their original size of 593,000ha (Satyal 2004). The country's elephant population is now limited to only four areas due to vast anthropogenic pressure and dwindling resources (Pradhan et al. 2011). Human activities, which encroach on elephant habitat, also force elephants into direct contact with humans, which results in adverse incidents (Hoare 1999; Sukumar 2006).

The spatial and temporal nature of incidents varies within Nepal (Koirala et al. 2016). In central Nepal, the elephant population is mostly resident. Incidents arising from crop raids were first recorded in the Parsa Chitwan area in 1994, when a single bull elephant moved into cultivated agricultural lands (Velde 1997). Incidents have increased substantially since then, which poses a serious threat to local people as well as to resident elephant populations (Pant & Hockings 2013). In Nepal alone, 66 people and 18 elephants have died as a result, over a period of 16 years, from 1986 to 2002 (Yadav 2007). In central Nepal, nine people were killed over a period of five years, from 2008–2012 (Chitwan National Park 2012).

Incidents caused by elephants is the main conservation issue throughout the elephant's home range (Hoare 1999). The nature and extent of damage caused by these animals to humans and vice versa is not clear. In the present study, we examine multiple aspects of human-elephant incidents in Nepal mostly focussing on central Nepal. To the best of our knowledge, one study has identified the spatiotemporal distribution of human–elephant incidents (HEI) at a national level in Nepal through an indirect measure: by way of newspaper articles (Neupane et al. 2013). The present study, however, has quantified the spatio-temporal pattern and perception of elephant problems by residents using a questionnaire surveys and secondary data. We consider data reliability for the former study to be greater for the reporting of human casualties, and elephant deaths, while our study aimed to generate reliable data on all types of human-elephant incidents including peoples' perception on human-elephant coexistence. Thus, the aim of this study was, therefore, to assess the magnitude and nature of the human-elephant incidents and to obtain the opinions and perceptions of local people on mitigating elephant impacts and on enhancing elephant conservation. To explore these topics, research questions were asked in relation to type, frequency, and trends in elephant visitations and damages, with an overall goal of finding local solutions to minimise competition with humans.

In addition, for the purposes of comparison, we explored spatial and temporal distribution patterns and the driving forces of human-elephant incidents in other regions in Nepal.

MATERIALS AND METHODS

Data were collected between July 2012 and December 2014 in villages distributed throughout the northern and southern buffer zones of the Chitwan and Parsa National Park (Fig. 1).

Information on human-elephant incidents was collected through a structured questionnaire designed to document the personal details of the respondent, their occupation, agricultural practices if any, problems encountered with elephants, major forms of damage sustained from elephant visitations (Appendix 1). The details of the spatio-temporal nature and extent of crop and property damage and human and elephant casualties, alsthe timing and frequency of damage, major crops and also plant parts eaten, and locals' mitigation methods were requested.

In total, we surveyed 302 households, focussing more on villages near park boundaries. Every fifth household

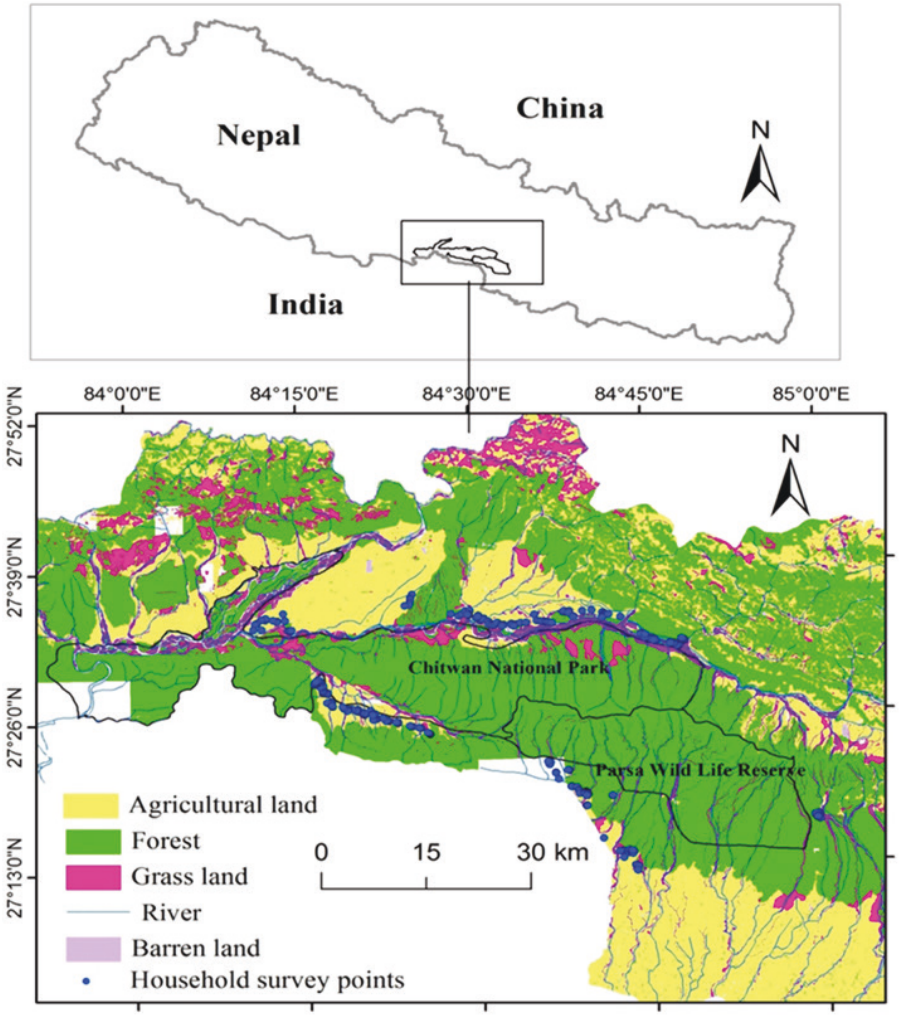

Figure 1. Study area: blue circles are the spatial position of the households surveyed in the buffer zones of Chitwan and Parsa national parks. Parsa National Park was established as a wildlife reserve in 1984. Since 2017, it has had the status of a National Park.

within each village was selected, and interviews were conducted with the head of the household. If the head of the household was not present, the most senior member of the family was chosen for interview. If no one was at home, the next house was selected for interview. Verbal consent of the respondent was obtained before conducting the interview (Pant & Hockings 2013), and none of the respondents declined to participate in the survey. All information received was treated as approximate, since it was based on respondents' estimates and recollections (Kulkarni et al. 2010). Altogether, 75 villages under the auspices of 17 village development committees (VDC) were surveyed within four districts (Chitwan, Parsa, Makwanpur, and Bara). VDCs were local government bodies in rural Nepal, equivalent to municipalities in urban areas till 2016. The Gaunpalika system was established in 2017, replacing the VDC system that was in use since 1990. The geographical coordinates of the households where interviews were conducted were obtained by marking their location using a Garmin eTrex Venture global positioning system (GPS) unit.

Kangwana (1995) has cautioned that conclusions cannot be drawn based entirely on farmers' and householders' replies to a questionnaire. To validate the household survey records, secondary interviews information was collected from existing record of incidents in the park and buffer zone office and focal interview were conducted with key informants from community and park and buffer zone committee officials. Their experience and knowledge of existing elephant populations, HEI causes, measures taken and potential solution to the problem were recorded.

Furthermore, data of HEI were also extracted from published literature in order to analyse spatio-temporal patterns of competition throughout Nepal. Among four elephant distribution areas, the eastern region was covered by forest remnants and only 175km^2 was under protection. Edge habitat covered 12,892ha (Nepal WWF 2007) while in central Nepal intact forest

under protection totalled 3,549km^2 with 28,500ha edge habitat in the Chitwan National Park buffer zone (Baidya et al. 2009). While in western region covering Bankey and Bardia National Parks, patchy forest remnants were distributed in the south and south-western part of the parks. A total area of 1,437km^2 was under protection at the time of our study. Forest edge habitat totalled 12,979ha. The far western area in Shuklaphanta Wildlife Reserve supported a 305km^2 area of intact, fully protected forest. Forest edge habitat covered 33,554ha, the largest forested edge habitat in Nepal (Nepal WWF 2007).

Data analysis

We examined data over a 10-year period (2003–2012). Relative incident intensity among villages was calculated by the relative frequency of different categories of incidents (crop depredation, property damage, human casualty, and elephant casualty). The intensity of 3 was the lowest and 1 was the highest intensity with a combination of different types of incidents.

The per capita elephant damage rate calculated using the equation below and used as an index of incident intensity (II).

$$\text{Incident intensity (II)} = \frac{\text{Frequency of incidents/year}}{\text{Total number of elephants}}$$

GPS location data of HEI were used to prepare a detailed map in ArcGIS version 10.1. Chi-square test was used to assess trends in elephant damages, the respondents' attitudes towards elephant caused damage and the local perceptions on elephant conservation. Pearson correlation tests were conducted to determine the relationship between the number of crop raiding/property damage incidents and human casualties and the spatio-temporal relationships between elephant damage and the spatial location of villages. The IBM statistical package for social sciences (SPSS) version 22 was used to analyse data.

RESULTS

Respondents and their major incident experiences

Of 302 respondents, 258 (85%) were males and 44 (14.6%) were females. A total of 170 (56%) interviewees resided in the buffer zone of Chitwan National Park, and 132 (44%) were within the buffer zone of the Parsa Wildlife Reserve. The mean age of respondents was 45 years (n= 302 ± SD= 10) and ranged from 21–73 years. Interviewees were distributed unevenly between the 17 village development zones: representation by zone ranged from a low of 1.7% in the Bhandara area in Chitwan to a high of 12.6% in the Nirmal Basti village development committee in the Parsa buffer zone.

Respondents reported crop raids to be the most common form of elephant damage, comprising 77% of total HEI, followed by property damage (22%) and human casualties (1%) (Fig. 2). Nearly half (45%) of the respondents indicated that property damage had increased in the last 10 years, 46% of interviewees had not noticed any changes in HEI trends, 8% had observed a decrease in incidents and 3% of respondents did not answer the question. Similarly, 72% of respondents noted increased crop raids, 21% did not notice any change and 6% indicated a decreasing trend.

A minority of respondents (22%) indicated an increase in human casualties, 60% did not notice any change, and 10% indicated a decreasing trend. More than 80% of respondent could not provide information about elephant mortality in relation to HEI, and only 10% indicated a decreasing trend in elephant casualties (Fig. 3). Most of the respondents (72%) reported an increasing trend in crop raids over the past years. In summary, local perceptions indicated a more significant increase in crop raids than in other types of damage (χ^2= 95.0, df= 3, P= <0.001).

Crop type, damage incidence, and seasonal changes

Rice was the most common crop grown by 99% of the interviewed households, followed by maize (79%) and wheat (43%). More than half (55%) of the households, located predominantly to the south of the reserves, produced one crop of rice per year, while 45% of the households, situated mainly to the north of the reserves, produced two crops a year. Only one crop of wheat and maize were grown per annum throughout the buffer zones of both reserves.

Just over half of the respondents (51%) indicated that elephants raided rice, over more than a quarter of the respondents (34%) had witnessed elephants raiding maize regularly, and 15% of respondents reported that wheat was a regular food choice for raiding elephants. Most of the respondents reported that the crop damage by elephants occurred in the pre-monsoon and pre-winter seasons.

Forty-four percent of reports of HEI involving single bulls or two bull elephants were of crop raids, 48% were of property damage and 8% were human casualties. Family herds were found to raid crops (38%) and damage property (36%), but there were no records of a human casualty caused by a family herd (25%).

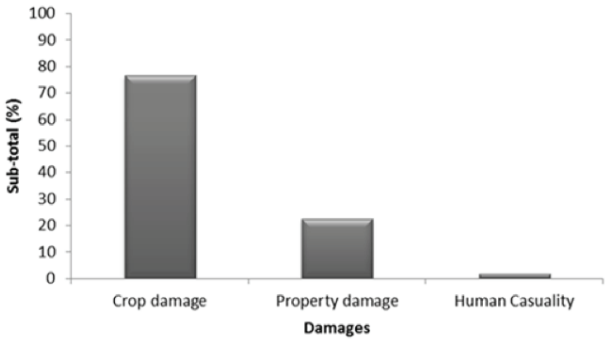

Figure 2. Respondents' view on the trend of damage by types of HEI in the buffer zones of Chitwan National Park and Parsa Wildlife Reserve.

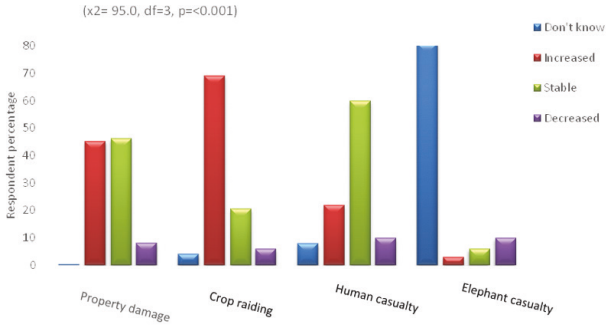

Figure 3. Distribution of respondents' views on the trend of human-elephant incidents from 2004 to 2014.

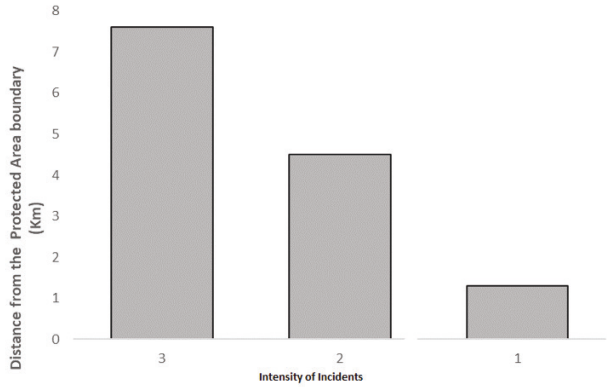

Figure 4. Incident intensity with increasing distance from the periphery of the parks.

There was significant correlation between the number of crop raiding/property damage incidents and human casualties (r^2= 0.8, P= <0.01). There was a significant difference in the number of incidences of HEI relative to the time of day, with almost 95% of all incidences occurring during the night (18.00–02.00 h) (χ^2= 108.30, df= 3, P= <0.001).

Plant parts preferred by elephants

Altogether 23% of interviewees described rice grain with husks as the food most targeted by Asian elephants, followed by whole rice plants without roots with 13% (χ^2= 181.79, df= 2, p= <0.001). Twenty-eight percent of the interviewees reported maize grain with husks as likely to be selected by crop-raiding elephants (χ^2= 274.89, df= 2, p= <0.001). Eight percent of the respondents reported that whole wheat plants without roots were also favoured, and 7% described wheat grain with husks was also part of the raiding elephants' diet while 21% of the respondents could not answer on preference for any of the foods.

Incidents distribution by village

Overall, 55% of incidents were centred in southern and southwestern parts of the park buffer zones. Over half of the incidents (56%) occurred in the Chitwan National Park buffer zone, and 44% occurred in the Parsa Wildlife Reserve buffer zone. Ayodhyapuri Village in Chitwan reflected the highest frequency of incidents (12%), followed by Gardi Village (11%). In the Parsa Wildlife Reserve buffer zone, Manahari Village suffered the highest frequency of incidents (9.78%), followed by Nirmal Basti (8.0%). There was significant negative correlation between the distance of a village from park boundaries and the Incidences (r= –0.42, P= 0.02) (Fig. 4).

Regional trends

In the easternmost region, incidents per elephant was 1.74 (Fig. 5), and the number of human and elephant casualties was with 5.75 per annum (4.45 human casualties and 1.3 and elephant casualties). Human and elephant casualties were high across all four known elephant distribution areas, however, the intensity of casualty per elephant was only 0.06 as the number of elephants in this region was the highest (around 100 individuals) within the four elephant distribution regions in Nepal (Pradhan et al. 2011) (Fig. 5) at the time of this study.

In central Nepal (the Chitwan and Parsa areas, Fig. 5), intensity of incidents was 1.53. The casualty per elephant (0.17) was highest in this region (Fig. 5). The elephant population was estimated at 25–30 individuals (DNPWC 2009; Pradhan et al. 2011) and they are mostly residents.

Incident intensity excluding casualties was highest in Bardia and Banke National Parks in western Nepal (3.08), however, the rate of human and elephant casualties per elephant was the lowest among all regions of the

country (0.04) (Fig. 5). The population was estimated to be around 80 individuals in Bardia National Park only (Pradhan et al. 2011).

In the far western region (Shuklaphanta National Park and surrounding areas), the Asian Elephant population was low at the time we conducted the research, with approximately 10 mixed migratory and resident individuals (Velde 1997; Pradhan et al. 2011). Incident intensity per capita (i.e., per elephant) was the lowest (0.19) among all the regions. Human casualties were low at the time of the present study.

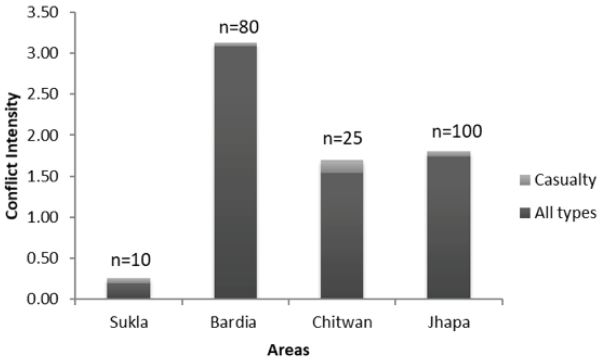

Figure 5. Spatial distribution of elephant population represented by numbers with the intensity of all types of damage represented by black bars and the intensity of human and elephant casualty represented by grey bars.

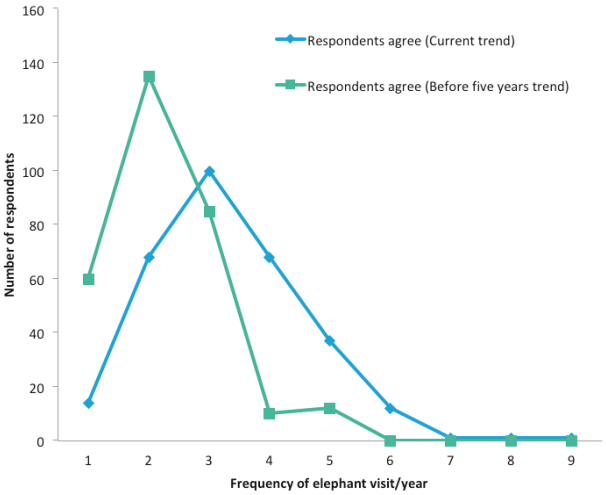

Figure 6. Frequency of elephant visitation over time.

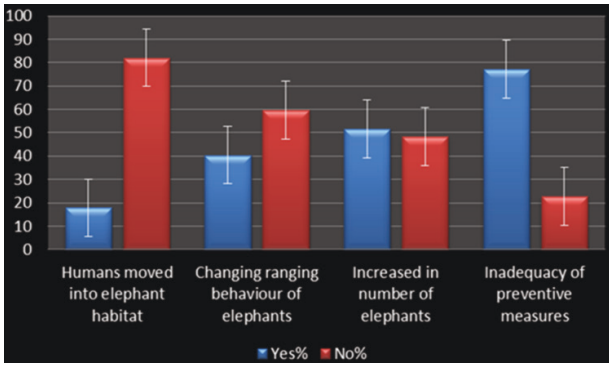

Figure 7. Responses to the questions on the prime cause for the increased human-elephant incidents.

Minimising incidents

Of the questionnaire respondents, 46% of questionnaire respondents reported a decrease in elephant abundance over the past 10 years, while just under half (53%) of the participants reported an increase. Half of respondents were of the view that the frequency of elephant visitations had been steady before five years, ranging from one to three visits per year. However, 47% of respondents thought that the frequency had increased from only one to three to six visits per annum over the most recent 5-year period, while 3% of respondents did not answer this question (Fig. 6).

When asked which of the given determinants they think is the prime cause for the increased human-elephant incidents in this region, many village residents (78%) identified the ineffective and inadequate elephant deterrents such as trenches and electric fences as one of the causes of increased HEI in the Chitwan-Parsa region. Half (50%) of the residents interviewed believed that a higher number of elephants was the major cause of increased problems (Fig. 7). The responses were analyzed by categorized favour and disfavour proportions using z test of proportion. Parametric large sample z tests showed that there were statistically significant differences between favour and disfavour proportions on 'human moved into elephant habitat' ($z = -14.5$, $p < 0.01$), 'changing ranging behavior of elephants' ($z = -3.6$, $p < 0.01$) and 'inadequacy of preventive measures' ($z = 11.17$, $p < 0.01$) but responents perceived the statistically equal proportion of favor and disfavour proportions on increase in the number of elephants ($z = 0.35$, $p > 0.1$). Overall, more respondents disfavoured responses on the 'human moved into elephant habitat' and 'changing ranging behavior of elephants', but they perceived the more favour on inadequacy of preventive measures.

The proximity of agricultural lands to forest fringes allowing easier access to elephants was regarded by 50% of respondents as being the primary reason for elephants moving into human-occupied areas. A total of 45% of respondents believed that depletion of natural wild foods in the forests resulted in elephants moving

into human habitats. An additional 5% of respondents believed that human disturbance of elephant habitats was the cause of elephants visiting villages in search of foods (χ^2= 244, df= 13, p= <0.001)

Many of the respondents thought that food supply should be a key focus in conflict mitigation: over half (53%) felt that the regeneration of natural food plants in the forests would help reduce the frequency of elephant visitations to cropped fields, and 40% were in favour of growing alternative crops and pursuing other livelihoods. Six percent of respondents favoured translocation of problematic elephants to remote areas and 1% of participants suggested culling repeat offenders.

In response to questions about how elephants could be protected, 59% of the respondents were in favour of habitat management inside parks, 33% supported raising people's awareness about elephant conservation and 32% suggested strong legal protection. A clear majority of local respondents (87%) were positive about coexisting with elephants. Responses about how human-elephant coexistence could be sustained in the region included a 74% majority who favored a compensation program to replace income lost to elephant damage. Over half of the participants (56%) suggested electric fences as a way to reduce HEI and to enhance peaceful coexistence.

DISCUSSION

Our data showed that the scale of human-elephant interactions differ according to the type of incident. Crop damage was the most common type of incident. Of the most heavily cultivated crops, rice was the most frequently raided. Crop raiding by elephants is a major issue in many parts of Asia and is caused by many factors, including elephant migration patterns, shifting water resources, habitat depletion and seasonally dependent nutritional requirements (Sukumar 1990). In our study area, rice was cultivated twice per annum, and was the crop of choice for local farmers. The primary reason for elephants' preference for rice could be related to the proximity of rice fields to their seasonal migration routes (Neupane et al. 2017). In addition, our study has shown that the spatial distribution of crop-raiding activity was not uniform in either buffer zones of Chitwan or Parsa. Documented crop raids were mostly concentrated in the southern buffer zone regions of the park areas, especially in areas where cultivated crops were closer to park boundaries (Fig. 1). Therefore, proximity plays a vital role in crop-raiding activity.

Elephant raids of rice during the grain producing season (pre-winter) occurred more frequently than raiding of other crop types. This may be due to nutritional drivers. Our unpublished data shows higher protein content in the grains of cereal crops compared to wild grass species.

Elephants' preferences for certain grain crops can be explored further by identifying repeat raiders. Most crop raids were by a single adolescent or a few bull elephants identified by local villagers as repeat visitors that returned multiple times over a period of several years. This repeat crop-raiding behaviour could be correlated with adult bulls having higher nutritional requirements than other elephants because of their size and the high-energy behaviours associated with the male drive for reproductive success (Sukumar & Gadgil 1988).

Our study also found that family herds ventured into agricultural fields and caused damage. This group behaviour could be predicted based on changed migration patterns and home ranges (Pamo & Tchamba 2001), as some of them have been found to visit new areas (Piple and Manahari VDC) in the northern parts of the Parsa Wildlife Reserve and Chitwan National Park where there had been no record of visitation by family herds in the past. The changing behaviour of elephants could be triggered by resource constraint in the area. The exploration of new areas is likely to be due to habitat shrinkage, water depletion and the increasing proximity of rice fields are consistent with elephant habitats. Such behaviour change cannot be denied as there has been a recent report by Srinivasaiah et al. (2019) that young male elephants in India, which are typically solitary, are now forming large male herds to protect themselves from human retaliation. Our results showed that elephant visitations have substantially increased in some areas during the last five years, especially in the non-traditional migration regions.

The spatial distribution of village households and their agricultural lands also played a crucial role in influencing HEI. Households in the forest fringe within <5km of the periphery of national parks/reserves were more frequently affected than more distant villages. This was irrespective of their crop's stage of growth, what type of crop was cultivated or what type of property villagers held. A similar trend has been reported by Sukumar (1990) in southern India and by Pant & Hockings (2013) in Nepal.

Interviewees' perceptions of elephant conservation were found to be unanimously positive in this study. People viewed natural food sources and habitat restoration as the main areas to be addressed to achieve conservation goals and to mitigate incidents.

Existing mitigation measures such as electric fences and traditional herding techniques were seen to be least effective. The cultivation of elephant deterrent plants in villages in the forest fringe was deemed not to be practical by surveyed residents, as alternative income streams would be needed to replace the loss of income from crops displaced by non-edible deterrent flora. Villagers suggested that night patrols during peak crop-raiding times might not be feasible because of a lack of resources.

The spatial and temporal nature of incidents and incidence intensity varied with region countrywide (Koirala et al. 2016). Our results indicated that eastern and western regions were incident hotspots, while medium and lower incidence intensities were typical in central and far western regions, respectively. The eastern region, which extends from Jhapa District in the far east through to Udaipur District in the far western portion of the eastern-most quarter of the Asian Elephant's home range, was a critical conflict area. The elephant population was as large as 100–115 individuals, mostly migratory (DNPWC 2009; Pradhan et al. 2011). In addition, incidence was high in this region in terms of elephant and human casualties, but the intensity of damage per elephant was less than in other regions because this region contained a higher number of migratory elephants. The higher number of casualties was attributed to the smaller area of forest-edge habitat (Nepal WWF 2007). There was also a higher probability of raids occurring whereever there was a longer perimeter of cultivated habitat (Sukumar 1990). People in this area grew a variety of crops. Some of these were high-profit cash crops, and frequent elephant raids of such valuable crops may have been intolerable to residents. As a result, retaliatory killings of elephants and human casualties had occurred. In contrast, in the western region (Bardia and Banke areas), the Asian Elephant population was estimated at ≤80 individuals at the time of study, most of them migratory, with few permanent residents. Where elephants were fewer in number, human casualties were less.

It was expected that this study would yield a detailed account of crop and property damage caused by elephants in Nepal. Because the study period was short (just over two years), comparing long-term trends was not possible. We expected that we would find that different deterrents were used by locals in different regions, and that evaluations of their effectiveness would lead to recommendations for novel damage mitigation measures. We further expected to obtain information about other mitigation measures from the literature and from other parts of Nepal with similar HEI problems.

In addition, another of our goals was to understand local people's perception and attitudes towards the conservation of elephants, in order to shed light on the scale of the problem and what measures would be appropriate to introduce to reduce incidence in the future. Furthermore, information on the historic distribution and threat status of Asian Elephants in Nepal would allow us to draw conclusions on how the situation has changed over the past 10 years, and which factors have contributed significantly to the current situation. Overall, results from this study were expected to provide some basis for planners and conservationists to design innovative approaches to reducing HEI in Nepal, because the dearth of information available, makes conservation of the species extremely difficult.

In summary, our study suggests that in central Nepal, the Asian Elephant population is increasing, and animals are mostly resident, and the intensity of casualties was highest compared to other elephant populations of the country. Crop raids by elephants were the primary cause of HEI. A combination of factors, including the depletion of natural food in the forests, the higher nutritional content of crops and the proximity of rice fields to elephant movement routes appeared to trigger crop raids, and HEI.

Based on our results, we have identified factors that need to be assessed further to realise Asian Elephant conservation outcomes and peaceful coexistence with humans. We recommend the following measures in the form of an integrated approach to minimise incidence and to conserve these endangered animals and their habitat for promotion of peaceful coexistence.

1. Identify elephant refugia and migration routes and assess the year-round availability and nutritional content of preferred food plants in and around those areas.

2. Extension of effective electric fences in all major agricultural areas of the buffer zones and consideration of digging elephant deterrent trenches along remote park boundaries.

3. Introduce fair and workable compensation schemes to address losses suffered from crop and property damage and to gain support from local communities.

4. Restore degraded lands with a full suite of food species preferred by elephants (Dharmaratne & Magedaragamage 2014) including bamboo, banana, and other palatable plants.

Note: The most widely used term 'conflict' was minimized and replaced with term 'incident', 'competition', and 'coexistence' (Davidar 2018).

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Appendix 1. Survey questionnaire to assess human-elephant interaction, focusing on crop raiding pattern in Persa-Chitwan region, Nepal.

- Date:
- Questionnaire Number:
- Interviewer Name:

Part One: Basic Information about the interviewee:

1. Name----------; Age-----; Sex; Male ☐ Female ☐
2. VDC/Municipality----------Ward No-------- Village Name----------
3. GPS Location: (Way point)-----

Part Two: Human Elephant conflict:

4. Since how long ago have you been living in this village? …….. years

5. Have you or your family member experienced conflict with elephant over the last ten years:
   a) Yes b) No
6. If yes you have experienced conflict, what type of conflict was it?
   1) Property damage; 2) Crop raiding; 3) Human casualty 4) Human injury 5) successfully chased without any damage.
7. Did you or your fellow villagers injure or kill any wild elephants that attacked the villagers and raided crops?
   a) Injured b) Killed c) No

8. Of the problems 1-5 above caused by wild elephants, what are the most serious problems experienced by your village (in order of frequency and severity)?

9. Do you have crop fields? a) Yes, b) No
   If Yes-- What are the different crops/ vegetables and fruits you grow?
   Paddy, Wheat, Maize, Mustard, millet, Sugarcane, Banana --- others (tick or write)

10. What is the extent of different crops cultivated?

11. Which months you cultivate these crops?

12. Which crops were perceived by the respondents to be the most raided (in order)?
    Paddy, Wheat, Maize, Mustard, millet, Sugarcane, Banana --- others (tick or write)

13. Parts Eaten/ Trampling:
    a) Whole plant b) Whole plant without root, c) Only grain with husk d) Leaves e) stem
    Parts eaten: Paddy, …….. Wheat,….. Maize, …… Mustard,….. Millet,……Sugarcane ……. Banana…….. others….
    Parts Trampled: Paddy, …….. Wheat,….. Maize, …… Mustard,….. Millet,……Sugarcane ……. Banana…….. others….

14. Which growth stage?
    a) Vegetative b) reproductive c) Heading d) Maturity

Growth Stage: Paddy, …… Wheat,……. Maize, …… Mustard,….. millet,……Sugarcane,….. Banana,……Others…..

15. Which months of the year elephant damages occur?

a. Property damage b. Crop Raiding c. Human/ Elephant casualty.

16. What is the frequency of elephant visit and crop raiding?

17. What is the time of the day the damage by elephants most likely occurred (early morning 2 am to 6 am; morning 6 am to 10 am; day 10 am to 2 pm; afternoon 2 pm to 6 pm; evening 6 pm to 10 pm; night 10 pm to 2 am)?

18. What is the trend of elephant damage over the last ten years?

I. Property damage (Mark)
   a. Increased (…..)
   b. Steady (…..)
   c. Decreased (…..)

II. Crop raiding (Mark one)
   a. Increased (…..)
   b. Steady (…..)
   c. Decreased (…..)

III. Human casualty (Mark one)
   a. Increased (…..)
   b. Steady (…..)
   c. Decreased (…..)

IV. Elephant casualty (Mark one)

   a. Increased (…..)
   b. Steady (…..)
   c. Decreased (----)

Part three: Causes of conflict

19. What are the major causes of human-elephant conflict? (In order of priority)

a. b. C.

20 Why do you think elephant move to human habitation (Circle one or more)?

a. In search of better nutritive forage
b. Easy access to agriculture field near elephant habitat
c. Depletion of natural food plants in the forests
d. Problem elephant
e. Traditional elephant range
f. Others (describe)----------

21. Which of the following do you think is the prime cause for the increased human-elephant conflict in this region (Circle one or more)?

a. Increase in number of elephants
b. Changing ranging behaviour
c. Human moved into elephant habitat
d. Inadequate preventive measures
e. Others (describe)----------

22. What is the composition of the raiding group (Single male or Family herd) caused the most damage? (Rank 1-high damage, 2-medium damage, 3- lesser damage)

Single Male	Family herd
a. Property damage: ……a	Property damage: ……
b. Crop raiding: ……	b. Crop raiding: ……
c. Human casualty: ……	.c. Human casualty:----------
d. Human Injury ----------	d. Human injury----------

23. How do you know?

a. I've seen them;

b. Household member has seen them;

c. Have seen tracks;

d. Have seen feeding sign,

e. Have seen elephant dung;

f. Have heard elephant sound.

g. Have seen elephant damaged property;

h. Have seen other signs.

24. Do elephants move to your area from a specific route or from different routes?

25. Can you show the elephant use area to the interviewer on a map or through participatory mapping? (Record the locations through GPS and mark in the map)

Part four: Peoples Attitude towards elephant conservation:

26. What do you think is the relative abundance of Elephants in your area?

a) Today: rare----- ( ) fairly common----- ( ) abundant ( ) (Tick one)

b) 10 years ago: rare---- ( ) fairly common------ ( ) abundant ( ) (Tick one)

27. Do you think elephants should be protected?

Yes ------- No

If Yes, How?

28. What should be done to minimize conflict between people and elephant in this area?

a. Translocation of problem elephant

b. Culling

c. Shift to alternative crop and livelihood option.

d. Help regenerate natural food plants in the forests

29. Do you want human-elephant coexistence in this area? a). Yes b). No

30. If yes how?

a. b. c.

b.

31. If no what should be done?

a. Culling of elephants

b. Relocate elephants

c. Relocate affected villages.

d. Others

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