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Research Article

Spatiotemporal association of human-elephant conflict around Parsa National Park, Nepal

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Abstract

This study was carried to evaluate the Spatio-temporal association of human-elephant conflict (HEC) among five different rural municipalities (Nirmalbasti, Jirabhawani, Sakhuwaparsauni, Parsagadhi, and Paterwasugauli) of Parsa District around Parsa National Park in 2019. Primary data was collected by using questionnaire surveys with victims' family and local people using random sampling method, key informant interviews with Chief Conservation Officer of Parsa National Park, District Forest Officer, ZSL field official, Chairperson of Batika Buffer Zone User Committee, focus group discussion, and field visit to verify the information. Total six people were killed and one person was survived with severe injury by the elephant attacks between 2013 and 2019 in the study area. Crop raiding was perceived as the most serious conflict from the elephants by local people. People around the national park are mostly farmers with a low level of income. They are mostly dependent on agriculture for their livelihood. Elephants are damaging the crops of the farmers making their livelihood difficult. HEC intensity was highest during the rice harvest season (65%), and at night (83%). Local farmers also reported that the aroma of ripening paddy had an interesting relation with HEC, it was associated with elephants' crop-raiding behavior. Local farmers did not use any specific traditional mitigation measure but believed that planting unpalatable crops and constructing a solar fence around the national park minimizes HEC and will promote co-existence between people and elephants.

Keywords: Crop-raiding; Forest distance; Lowland Terai; Mitigation; Unpalatable crops

1 | Introduction

The Asian elephant *(Elephas maximus)*, the largest mammal in Asia, is the only living species of the genus *Elephas* (Elephantidae) that evolved in Africa (Sukumar 2006). The current population trend of the Asian elephant is decreasing and is classified as the "Endangered" category in IUCN red list (Choudhury et al. 2008; IUCN 2011) and appears on appendix I of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2019) reflecting high priority on the importance of conservation of the species. It is also a protected mammal species listed under the National Park and Wildlife Conservation Act of Nepal,1973 (IUCN 2011). The Asian elephants are considered a symbol of pride, status, and cultural heritage. The elephant holds a central place in Asian civilization as they are worshipped as a God, used as a warrior and ambassador. But now their survival has been under severe threat due to human-wildlife conflict (Fernando et al. 2008).

Conover (2001) suggested that "A human-wildlife conflict occurs when an action by humans or wildlife has an adverse impact upon the other or when humans do an adverse impact on wildlife". The territory of the elephant is witnessed from sea level to 3000 m and dwells in grassland, tropical evergreen forest, semi-evergreen forest, moist deciduous forests, dry deciduous forest, and dry thorn forest in a supplement to cultivated and secondary forests (Ram 2014). *Char Koshe Jhadi*, a chain of an uninterrupted forest, a major habitat of elephants adjoining the Nepal-India Border was cleared for making human settlement zones and farmland but mega-herbivore like elephants has a large distribution range and are easily affected by habitat fragmentation (Acharya et al. 2017).

In Nepal, there are approximately 200–250 wild elephnats:15–20 in Jhapa district, 17 in Koshi Tappu Wildlife Reserve, 8 in Sindhuli, and 45–50 in Parsa National Park and Chitwan National Park. Similarly, Bardiya National Park along with its neighboring municipalities is home to more than 100 wild elephants whereas 25-30 elephants reside in Suklaphanta National Park (Shrestha & Shrestha 2021). Two types of elephant herds are found in Nepal: large mobile herds that regularly migrate to and from India and small residential herds that inhabit permanently in the Nepalese forest (Neupane et al. 2013). Wild elephants come in direct contact with human beings in the course of their movement as they have migratory nature and become problematic for local communities because of their crop-raiding habit (NTNC 2019). Elephants shared 40% of human-wildlife conflict, 70% of the wildlife caused human casualties, and 25% loss in crop

production in Nepal and is considered as the most problematic large mammalian species (Neupane et al. 2017).

It is complex to anticipate where the human-elephant conflict will transpire as spatial patterns of human-elephant conflict (HEC) have shown few universal trends (Sitati et al. 2003). In these circumstances, a detailed study on the spatiotemporal association of human-elephant conflict has a gap in and around Parsa National Park (PNP). Therefore, this study aimed to explore the spatiotemporal association of human-elephant conflict around the PNP.

2 | Materials and methods

2.1 | Study area

The study was carried at Nirmalbasti Rural Municipality ward no. 4, Jirabhawani ward no. 5, Sakhuwaparsauni ward no. 1, Parsagadhi ward no. 1, and Paterwasugauli ward no. 3 which lie around Parsa National Park (PNP) in Parsa District of central lowland Nepal (Figure 1). PNP was established for maintaining a healthy ecosystem and the wellbeing of local people surrounding the park (PNP 2018). PNP was initially established as Parsa Wildlife Reserve (PWR) in 1984 with an area of 499 km^2 to preserve the habitat for wild Asian elephants and a variety of other fauna. Through the Gazette of August 24, 2015, an area of 128.39 km^2 of Bara district was added to it including Halkhoria lake as one of the major wildlife habitats making a total area of 627.39 Km^2 covering parts of Parsa, Bara, and Makwanpur districts, located within 27º15' – 27º33'N and 84º41' – 84º58'E. With this extension, the status of Wildlife Reserve was changed to National Park on July 03, 2017. The overall biodiversity of the park includes 37 species of mammals, 490 species of birds, 13 species of reptiles, 31 species of butterflies, 8 species of Pisces, and 336 species of plants (PNP 2018; DNPWC 2019), and the park has a large resident population of the wild Asian elephant (PNP 2018)

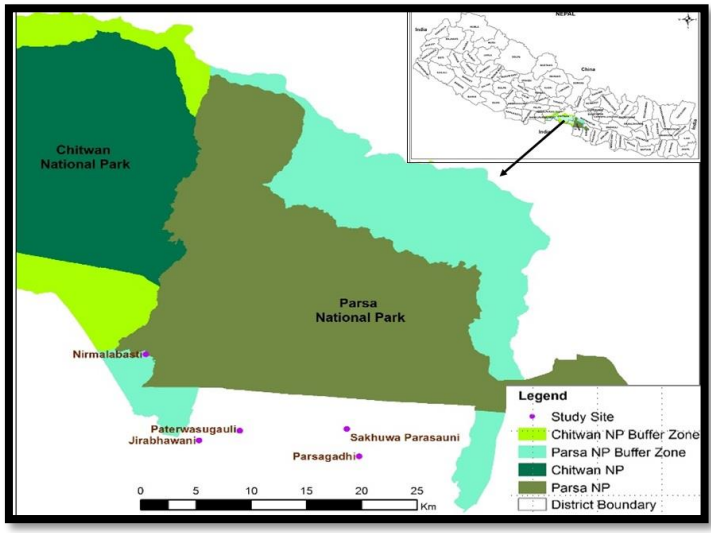

Figure 1. Map showing the study area around PNP

2.2 | Data collection

Primary data was collected through a questionnaire survey with the victim family and local villagers (n = 360), focal group discussion (n = 3), and key informant interview (n = 5). A semi-structured questionnaire was prepared for the household survey. For spatiotemporal analysis, GPS points of all incident sites, time of the incident were recorded by field visit which also verifies the information collected from questionnaires and secondary data. Research journal from various publications, reports from relevant offices, reviews of an operational plan, websites, published and unpublished articles, etc. were reviewed for secondary data and information.

2.3 | Data analysis

Data analysis includes classifying, grouping, tabulating, and frequency analysis in ArcGIS 10.1 and Microsoft Excel Program. The data acquired was both quantitative and qualitative. Data was coded and digitalized to establish easy analysis. The data were analyzed using simple descriptive statistics in Microsoft Excel and presented in the form of graphs, charts, tables, and pie charts. The effectiveness of the mitigation measures was measured by using a Likert Scale based on people's perceptions. Ranking of the most damaged crops was done based on the response from each questionnaire survey where the crops were divided into seven ranks/categories. The first rank/category crop was given seven points whereas the seventh-ranked (last ranked category crop) was given one point. The final score was calculated by multiplying each rank with the associated points and added for the total. Similarly, GPS points were plotted on the map using ArcGIS 10.1 to find out the spatiotemporal pattern of the conflict. The Chi-Square test was performed for social data at the 95% level of significance.

3 | Results

3.1 | Major crops

A total of 73% of respondents cultivated rice *(Oryza sativa)* and wheat *(Triticum aestivum)* which was followed by mustard *(Brassica nigra)* 62%. tobacco *(Nicotiana tabacum)*, maize *(Zea mays)*, lentil *(Lens culinaris)*, and vegetable was cultivated by 56%, 25%, 54% and 23% of the respondents.

3.2 | Ranking of crop mostly damaged by elephants

Rice was the most damaged crop during crop-raiding by wild elephants with a ranking score of 692 followed by wheat (557). Similarly, lentils ranked third (453) then mustard (452), maize (433), and vegetables (375) were listed as the most damaged crops (Fig. 2).

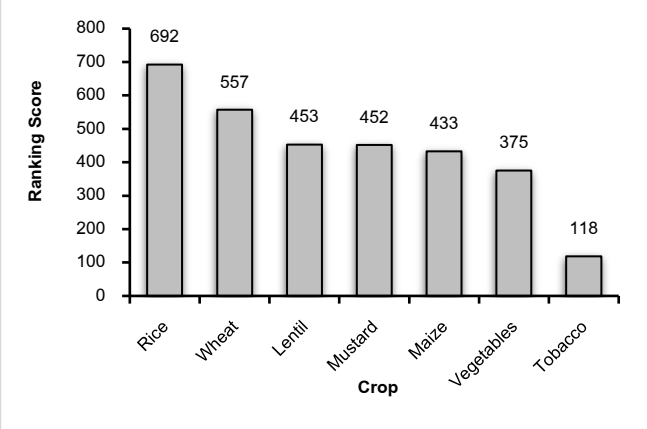

Figure 2. Ranking of crop damage by elephants

3.3 | Temporal pattern of human-elephant conflict

Human elephant conflict had a seasonal impact, and this was reported by 80% of the total respondents. Among them, 65% of the total respondents notified that the peak season for crop-raiding was in the winter season (September-December) when rice gets ripen and becomes ready for harvesting. Similarly, 18% of the total respondents said that another peak season for crop-raiding is spring (January-March) when wheat gets matured for harvesting (Fig. 3).

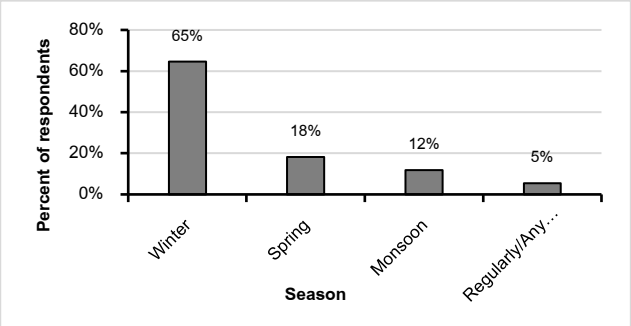

Figure 3. Frequency of conflict with different seasons

Similarly, 83% of the total respondents reported that crop-raiding by wild elephants mostly occurs at night, whereas 10% saw the HEC in the evening and 7% noticed them at any time.

3.4 | Spatial pattern of human-elephant conflict

All the surveyed locations suffered crop-raiding by wild elephants. Farmland closest to park boundary was frequently raided by wild elephants and other wild animals such as wild boar *(Sus scrofa)*, gaur *(Bos gaurus),* pangolin *(Manis* sp.*)*, blue bull *(Boselaphus tragocamelus),* four-horned antelope *(Tetraceros quadricornis)*, spotted deer *(Axis axis)*.

During the survey we recorded that six people were killed by elephants in Parsa district in between 2013–2019. The human casualty occurred when people visit Bhata temple for the annual fair. The crop-raiding was the highest in Nirmalbasti and Jirabhawani Rural Municipality, the Rural Municipalities adjoining to India border.

The farmland of 59% of the respondents was within 500 m to the forest boundary. 29% was between 500–1000 m, 8%'s farm lies between1000–1500 m, and 4% of respondents had their farmland more than 1500 m away from the forest boundary. The frequency of crop-raiding by elephants was higher within 1 Km. from the forest boundary and decreased with the increase in the distance from the forest boundary. About 63% of respondents whose farmland was within 500 m of forest boundary, and 31.32% of HH within 500–1000 m of the forest boundary had experienced the HEC. The percent of conflict decreased with the increase in the distance from the park boundary (Fig. 4). Since the value of R^2 = 0.9143, it means there is a significant correlation between distance and conflict supporting the number of conflicts decreases with an increase in distance.

Moreover, the χ2-test between conflict with, fuel use in the kitchen, household's distance from park or forest and sources of income and HH distance from the park boundary, and source of income had a significant relationship with HEC (P >0.05).

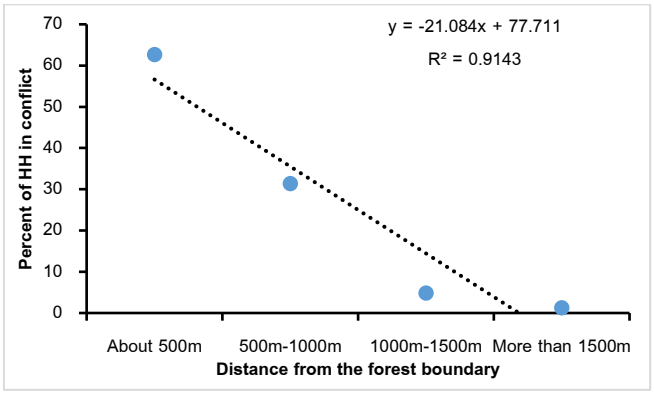

Figure 4. Relation between household in conflict and distance from the forest boundary

4 | Discussion

After the closure of Birgunj Sugar factory in 2002, and frequent raiding of sugarcane cultivation by wild elephants in the past, the farmers of Parsa, Bara, Dhanusa, and Sarlahi districts have gradually discontinued cultivating sugarcane (Ghimire 2020; Sharesansar 2012). Instead of sugarcane, they have started cultivating tobacco, which is unpalatable to elephants. This result is similar to the study conducted by (Santiapillai et al. 2010) in Sri Lanka where crop damage to paddy accounted for 65% of the complaint. Pradhan et al. (2011) reported that paddy is the most raided crop in Nepal by elephants. Dangol et al. (2020) also emphasized that the most raided crops by elephant were paddy, maize, wheat and mustard and the crop raiding was significantly higher when the paddy was ready for harvesting. Nath et al. (2009) study in Assam, India showed paddy suffered maximum crop-raiding event (69%) by elephant where Tobacco was only damaged by tramping, as it is an unpalatable crop to elephants. The peak season for crop-raiding by wild elephants is September-November for paddy, January-March for wheat, and May-July for maize (Yadav et al. 2013; Neupane et al. 2013; Pradhan et al. 2011; Pant et al. 2016; Neupane et al. 2017).

Elephants usually enter the cultivated field after sunset and leave before dawn (Sukumar 1990). Neupane et al. (2013) found that the HEC was higher during the winter season, at night, and during paddy harvest season. The easy availability of accessible food, the crop raiding increases near the crop harvest season (Chen et al. 2016). Nyhus (2016) in his study indicated that the pattern of conflict is influenced by the distribution of wildlife and people as depredation by elephants tends to decline with increasing proximity to human habitation. Conflict tends to highest close to protected areas and the frequency of incidents decreases with increasing distance of human settlement zone from the forest boundary (Neupane et al. 2013). Similarly, Dangol et al. (2020) explained that the number of HEC incidents decreased with the increase in the distance from the forest edge of the National Park. Pant et al. (2015) observed HEC is caused by three types of elephants in central Nepal: (i) elephant herds raiding crops while passing through crop field during their seasonal migration, (ii) single males or small group of males raiding crops as an supplement to their optimal foraging behaviour, and (iii) problem elephants, which are adapted to taking risk causing human casualties while in the process of crop raiding. Mulonga et al. (2003) in their study concluded that HWC can intensify poverty for a poor household in rural areas as people grow their own supply to eat and to sell the surplus. Source of income has a significant relation with conflict because people are dependent on agriculture as their main source of income and their farmland is located next to the boundary of the national park. Also, they use fuelwood in their kitchen and must visit the forest area frequently to collect fuelwood thus increasing the number of conflict incidents in comparison to local people who use liquid petroleum gas in their kitchen. Any damage to crops threatens people's livelihood with food security and investment, especially who do not have any other source of income except agriculture.

5 | Conclusions

The local people living near the PNP lost their lives and crop due to HEC. The conflict was seasonal, basically, winter season (September-December) and raid mainly rice and wheat at night. The pattern of conflict was more severe in Thori-Nirmalbasti and Jirabhawani Rural Municipality, which lies near the India-Nepal border. The study shows, HEC has a correlation with farm and household distance from forest and income source that depend on natural resources collected from the forest. Therefore, the houses near the forest need special attention for mitigation and saving human life. The farmland near the forest or conflict-prone area needs the cultivation of unpalatable crops for elephants.

6 | Research implications

This research work has confirmed the severe human-elephant conflict around the Parsa National Park. The HEC is seasonal and has taken human life and crop damage especially rice and wheat. People respect the elephant due to cultural and religious beliefs but mitigation practice against HEC is very poor. Hence, this study can help in the formulation of the management plan to develop a mitigation plan and action.

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Authors' contributions

Kurmi, S. K. performed the field study and analyzed the data. Both the authors wrote the manuscript.

Conflicts of interest

Authors declare no conflict of interest.

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