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Research Article

First Ministry-Academia Collaborative Report on Causes and Remedies of Human-Animal Conflict at Hastinapur Wildlife Sanctuary, Uttar Pradesh, India

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Sustainable coexistence of different components of an ecosystem is a fundamental requirement for the overall welfare of the human population worldwide. Despite this fact, continued growth in human population, increasing demand for various available natural resources, and invasion of all inhabitable habitats have led to the destruction of the coexistence of wildlife and human and also caused the fragmentation of natural habitat for the wildlife in India. This in turn may viciously affect the rural population residing in the nearby area of such regions, for example, the area covered for sanctuaries, which are established in consideration to provide protection to the indigenous wildlife. Hence, it becomes essential to mitigate such conflicts to create a healthy environment for cosurvival of all stakeholders. Here, in this study, we have tried to figure out the possible reasons and provide certain cures to avoid the recurring human-wildlife conflicts in one of the largest wildlife sanctuaries, Hastinapur wildlife sanctuary, situated in Uttar Pradesh, India.

1. Introduction

World wildlife fund for Nature Inc. report 2020 delineated 68% decline in global fauna from 1970 to 2016 [1]. Threats causing this large depreciation include habitat loss, lesser plant pollinators, increased chemical pollutants, climate change, illegal wildlife trade, propagation of invasive species and diseases. The biggest, among these, is increasing human habitat cover, diminishing the habitat of wildlife. Man and animals evolved to coexist but entered the crossroads of a mutual conflict, in the utilization of resources. Evolution of life forms, since Proterozoic stromatolites [2], to today's complex organisms like human, has progressed in a unidirectional mode to adapt coexistence with optimum resource sharing, the latter, became inadvertent for survival. The monstrous expansion of industries, roads, and infrastructure to meet the increasing demands of the increased human population has resulted in the encroachment of the natural habitat of wildlife. Apart from this, excessive human interventions like poaching, hunting, deforestation, and fossil fuel combustion-mediated pollution have also been instrumental in affecting the symbiotic relationship of human-wildlife. Increased human causalities, crop destruction, livestock damages are some of the examples of reciprocal responses from the wildlife across the globe especially in tropical region like India [3, 4]. Ecotourism is major part of global interest in wildlife [5]. Other interests include wildlife conservation, wildlife diseases, and environmental

sustainability. Consequentially, legal implementations vary with national interest. In India, the plethora of endogenous species such as Asiatic lion, `Royal Bengal tiger, antelopes, Indian elephants, and leopards as well as migratory birds [6], animals such as Snow Leopard and aquatic animals, are protected by Wildlife Protection Act [7]. The act restrained human interference in National Parks and Sanctuaries to reduce human-wildlife conflict. At present, almost 1.3% of the total geographical area has been reserved as 104 National Park and 566 wildlife sanctuaries covering around 4% of the geographical landscape [8].

The nature of challenges to human and animal inhabitants of Hastinapur wildlife sanctuary has not been addressed in detail [9]. Geographically, the Hastinapur area is a culturally productive field and is in suitable proximity to the industrial area of the national capital region. It has witnessed extreme industrial growth and conversion of forest land into nonforest areas (Figure 1). Inadvertently, there is a depletion of wildlife habitat and sharing of natural resources for human use. Besides one report from the Wildlife Institute of India (WII), the research investigation into the causes and the nature of wildlife-animal conflicts has been inadequate. Albeit, few studies on human-wildlife conflict across the country have shown an increase in human-animal conflict in protected areas [10–12] across the country have been reported. The present study was a state university-state government collaboration, engaging Master's students to collect first-hand information from the stakeholders. This field study took into consideration the perspective of local residents and challenges faced by them. Besides, outreach to the villagers to sensitize them towards animals, the present report was intended to contribute an overview of an unbiased opinion, a neutral perspective, and the biological understanding to help us to understand the causes of HWC, to ensure different practices among residents, to counteract conflicts, protecting key areas for wildlife, and also provide measures for conservation of wildlife that is on the verge of extinction.

2. Materials and Methods

2.1. Study Area. Hastinapur wildlife sanctuary was declared in 1986, named after the ancient city of Hastinapur. The area covered under sanctuary is 2073 km^2 encircled by the borders of Bijnor, Meerut, Muzaffarnagar, Ghaziabad, and Noida (28°46′ and 29°35′N Latitude and 77°43′ and 78°30′E Longitude) of western Uttar Pradesh. Annual weather cycles involve significant temperature variation with Summers in the range of 26°C–41°C and Winters 8°C–25°C, and an average rainfall is ~100 cm–120 cm. Demographically, this sanctuary harbors variable plantation in accordance with the annual weather cycle. The vegetation has been classified into tall wet grasslands, dry short grasslands, shrubs, and other plantations [13].

The main objective for the establishment of this sanctuary was to preserve the diverse flora and fauna of the Ganga basin, and a few of them Swamp Deer (*Rucervus duvaucelii*) Leopard (*Panthera pardus*), Jungle Cat (*Felis chaus*), Monkey (*Macaca fascicularis*), Nilgai (*Boselaphus tragocamelus*) are known mammals whereas prominent reptilian fauna includes turtles, tortoise, monitor lizard, and python (*Python molurus*). This sanctuary is also enriched with creeping faunas such as crocodile and gharial. Apart from this, known avifauna includes Crane (*GRus antigone*), owl, maina, common crow, wild crow, and parrot. Also, every year thousands of migratory birds like Woolly necked stork and bar-headed goose visit the sanctuary for winter breeding [14].

3. Methods

Adequate permission was obtained, and 15 one-day visits were undertaken by joint teams of wildlife department officials and students of Chaudhary Charan Singh University Meerut, India, between December 2020 and March 2021. Hastinapur sanctuary encompasses 5 districts of Uttar Pradesh State of India. The present study was conducted in areas that encompass 3 districts. One region was treated as a single quadrant (Figure 1, green fluorescent boxes on map, link https://maps.app.goo.gl/LJdV2oiasXisTm2RA), and 4 quadrants, i.e., Parikshitgarh (Meerut), Bijnor, Muzaffarnagar, and Hastinapur, were surveyed. 5 plots were included in one quadrant. The criteria of plot size included a survey from at least 5 informants per plot.

During preparations for the visit, the semistructured questionnaire was developed after brainstorming with senior government officials from the wildlife department of Gujarat, India. The questionnaire was subjected to 10% customization depending on the faunal specificities of each district. Student teams filled out the questionnaires during their interactions with local residents (Figure 2 for details and sequence of activities). Detailed discussions with forest guards, locals, and owners of crop fields aided in to collect cumulative information on the despoliation of the crop and livestock as well as on protection measures adopted by farmers and implementing the government compensation scheme for livestock depreciation.

After physical visits, samples were checked for quality, and the data were assembled. Evidence through the photography of dung, hoof marks, and damage signs was also collected. Depending on information overlap, a site-wise summary was prepared by visiting team and cross-verified with forest officials. Region-wise sample size varied and depended on informants' availability. Data organization and statistical analyses were done using Graph Pad Prism software, V9.4.0, where required.

4. Results and Discussion

Table 1 shows the contribution of different stakeholders in the study design. Both human-inflicted and animal-inflicted conflicts were identified in all 4 quadrants, studied (Table 2). It was noted that the presence of young investigators was comfortable to the local residents of the Sanctuary area, in bringing out facts which otherwise remain conceded due to ignorance and fear among locals.

4.1. Human-Wildlife Conflict within Protected Area (Hastinapur Quadrant). The first site to study HWC (Figure 1,

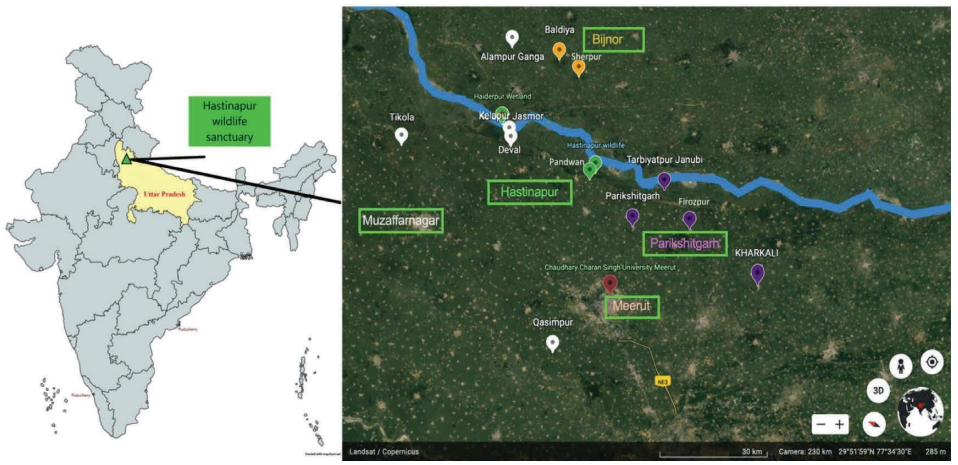

FIGURE 1: Map of India to show the location of Hastinapur wildlife sanctuary (left panel) and different quadrants (green boxes) and sites of study (right panel: yellow-Bijnor, green-Hastinapur, white-Muzaffarnagar, and purple-Parikshitgarh).

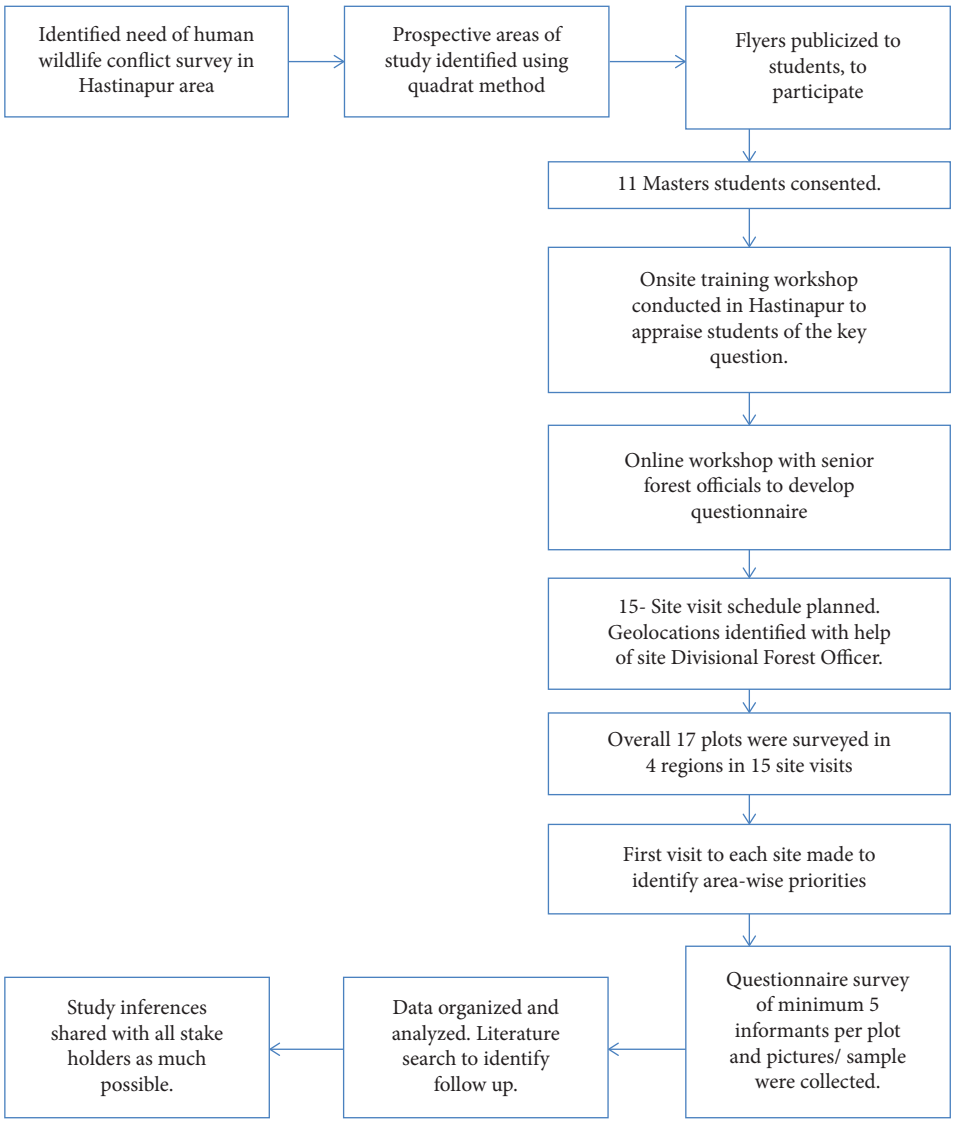

FIGURE 2: Flowchart to depict important activities and aspects of human-wildlife conflict (HWC) in Hastinapur wildlife sanctuary.

Table 1: Brief details and contribution of different stakeholders in the study design.

Person	Role	Number
Forest department administrators	Brainstorming, questionnaire development	3
Divisional forest officers	Streamlining activity, resource	4
Wildlife ecologist	Discussion	1
Forest guards	Activity support, information	6
Village informants	Information	43
Forest staff informants	Information	29

Table 2: Table summarizing the site-wise human-wildlife conflict in Hastinapur wildlife sanctuary and measures.

S. No.	Reason for human-wildlife conflict	Caused by	Encountered in	Measures
1	Rise in infiltrating the territory of wild animals	Human	Parikshitgarh	Use of bright colored cloth to prevent entry of animals in fields. Use of bio - repellants use of solar fencing
2	Reducing forest cover for industrial needs	Human	Pandwan, Bijnor	Plantation drives for encouraging tree; sensitizing villagers
3	Unauthorized felling of trees, fishing, and grazing	Human	Pandwan, Parikshitgarh	Villagers encouraged for stall-feeding instead of illegal livestock grazing; arrange some human-made arrangements like tube well and fodder collection for domestic animals
4	Forest fires arising from unaccountable fires	Human	Pandwan, Parikshitgarh	Avoid stubble burning in forest area
5	Growing dependency on forest	Human	Parikshitgarh	Awareness campaigns and alternate job opportunities
6	Wild animal nuisance to agriculture	Human	Parikshitgarh	Usage of domesticated dogs to repel the intruder animals and high noise-making through drums and other objects like utensils etc.
7	Drying of natural water sources due to human interventions	Human	Pandwan, Parikshitgarh	Water holding plants to increase groundwater level and additional supply of water to villagers by the forest department
8	Increased visit frequency of animals in residential areas	Leopard, tiger, elephant, bear, monkeys, wild pigs	Pandwan, Parikshitgarh, Bijnor, Jansath range	Use of masks, if encounter any wild animal. Plantation of marigold to avoid monkeys in their fields.
9	Crop and house damage by wild animals	Monkeys, nilgai, elephant, wild pigs, Barasingha	Pandwan, Parikshitgarh, Bijnor, Jansath range	Electric fencing, usage of domesticated dogs to repel the intruder animals, and high noise-making through drums and other objects like utensils etc.
10	Livestock killing by wild animals	Leopard, Tiger, elephant, bear	Parikshitgarh, Bijnor	Electric/bio-fencing, usage of domesticated dogs to repel the intruder animals, and high noise-making through drums and other objects like utensils, etc.
11	Human casualties by wild animals	Leopard, tiger, elephant, bear, monkeys	Bijnor, Jansath range	Inhabitant participation in wildlife conservation programmes advised and training/equipping for self defence

right panel; green color pin) was the area covered within the protected zone and was studied for two different locations, i.e., Government guest house, Arjun Block, a one hundred forty-two hectares landscape of Pandwan, the Ganga Vyakhyana center alliance of the Water program, and Ganga River site. These areas are covered by a variety of floral species such as *Pinus*, *Santalum album*, *Tectona, Yucca aloifolia, Bougainvillea glabra*, *Cyathula*, *Jasminum subtriplinerve*, *Casurina*, *Grevillea roubsta*, Ashoka, *Eucalyptus*, and many more. Arjun Block of Pandwan had only one artificial water pond constructed by the forest department. The formation of these ponds depended on the distance of forest cover from the Madhya Ganga River. The need for additional artificial water ponds was highlighted (Table 2, Figure 3). The major flora of this block includes various types of trees such as Kadi Patta (*Murraya koenigii*), Papdi tree (*Terminalia catappa*), Khair tree (*Senegalia catechu*) also known as Katha, Amaltas (*Caria fistula*), Sagon tree (*Tectona grandis*), Jungli Jalebi (*Pithecellobium dulce*) also known as Madras thorn. This region also harbors Flying Fox (*Pteropus*) a crepuscular and frugivorous megabat, exhibiting aggressive behaviour by making echolocation and Black Drongo (*Dicrurus macrocercus*) with aggressive territorial behaviour [15]. Another major concern was the illegal cutting of trees of commercial potential like Katha by native people and recurring forest fire capable of destroying the large area leading to deforestation. Due to the shrinkage of covered

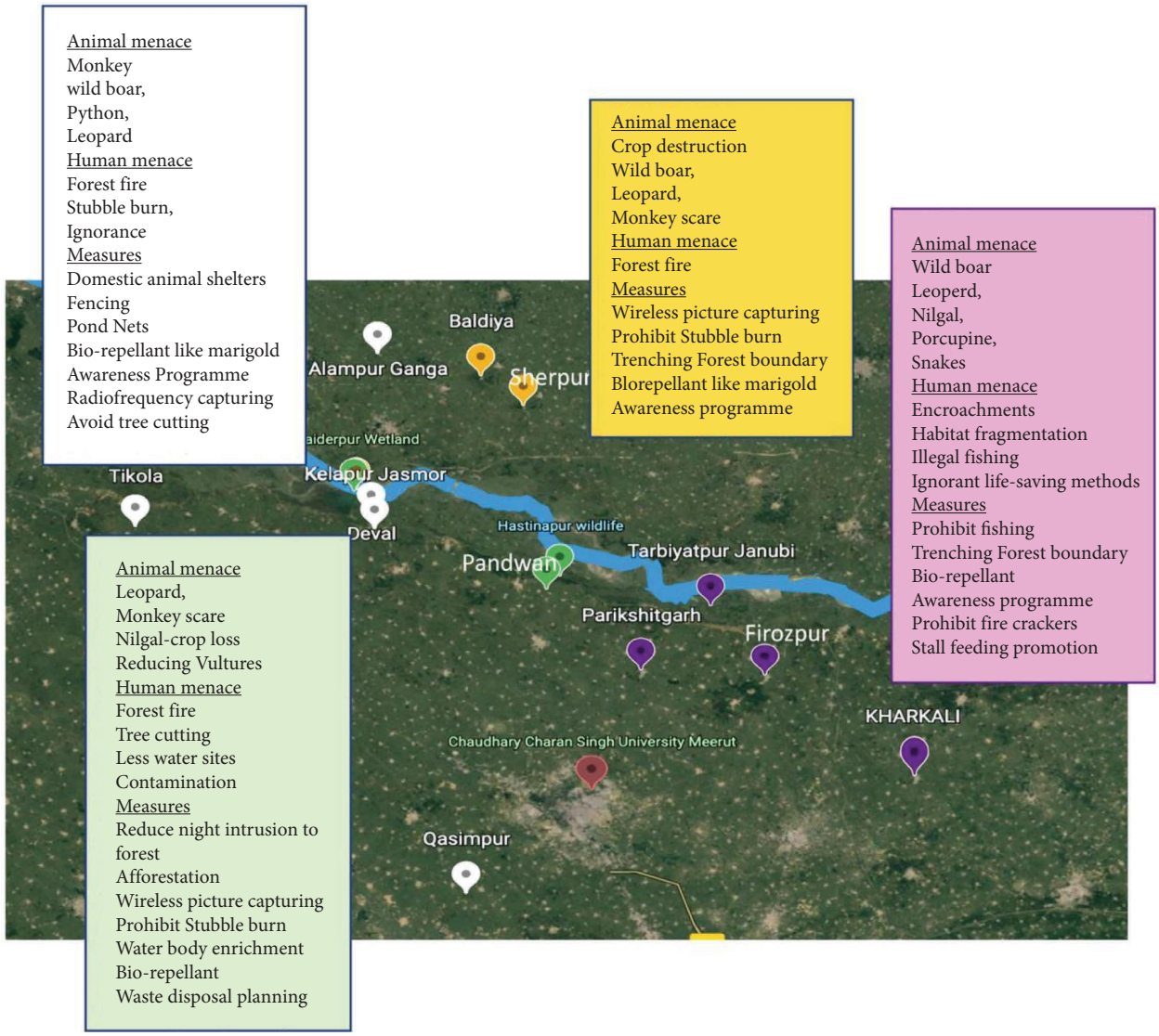

Figure 3: Map depicting human-wildlife conflict in Hastinapur sanctuary—animals and human menace and measures suggested to reduce conflict (color codes-same as Figure 1).

grassland, owing to increased human activities, level-1 animals like leopard can enter into the residential areas. Apart from this, water in the artificially constructed pond is contaminated frequently with algal bloom due to eutrophication making it unusable for drinking due to its awful taste. At present, as per information from forest guards, the leopard count is around 10-12 in the protected region. Wolves, foxes, and jackals are seen rarely as these animals reside in dense forest areas. In recent years, an observation regarding the phenomenal decrease in the vultures population, probably due to the consumption of carcasses of milch animals causing their kidney failure, was also reported. Also, there is an exponential increase in the monkey population leading to their frequent entrance into residential areas.

Suggested measures to reduce HWC (Figure 3) in the landscape of Pandwan and protected areas are as follows: (1) the creation of sufficient additional artificial water ponds, (2) prohibiting the illegal cutting of Katha and other trees of commercial potential, (3) reduce night intrusion of locals in forest areas to save lives from wild cats, (4) electric and bio-fencing to protect human life from monkeys, wolves, foxes, and jackals, and (5) decrease in the use of diclofenac to protect from the reduction in vultures population.

5. Human-Wildlife Conflict in Parikshitgarh

Parikshitgarh (28°59′N 77° 56′E) is a town situated in western Uttar Pradesh, 28 kilometers away from the Pandwan of Hastinapur wildlife sanctuary connected via State Highway 47. The annual temperature variation is in the range of 5°C-45°C with annual rainfall ~120 cm. We identified few sites, namely, the area around Samajik Vaniki Prabhag, Kharkhali, Firozpur, and Tarbiatpur villages. Major flora in this region includes *Acacia arabica* (Babool),

Dalbergia Sissoo (Sheesham), *Terminalia arjuna* (Arjun tree), and *Syzygium cumini* (Black plum, Figure 4).

Interestingly, the slightly basic (~8-10) nature of soil and river water in Parikshitgarh is considered to be suitable for this perennial timber and medicinal plants. Major fauna includes *Boselaphus tragocamelus* (Nilgai), *Hystrix* (Porcupine), *Panthera pardus* (Leopard), *Cuon alpinus* (Wild Dog) and *Sus scrofa* (Wild Pig), *Macaca mulatta* (Monkey). *Coracias* (Indian roller), and *Corvus culminatus* (Wild Crow). Remarkable signs of human interference in this region were apparent (Figure 5) through traces of fire, illegal deforestation, illegal fishing, and scarcity of water despite some human-made arrangements like tube well and fodder collection for domestic animals, etc. These all activities have led to the human encroachment into the natural habitat of wildlife causing them to penetrate the village boundaries, and major conflicts observed were due to leopard, monkey, nilgai, porcupine, snakes, python, jackal, wild boar, etc.

Animals, such as porcupines, nilgai, and monkeys, are mostly responsible for crop destruction whereas snakes, pythons, and leopards were majorly involved in livestock depredation (Figures 6 and 7). The main reason for human-wildlife conflicts in this region is habitat fragmentation, change in agricultural pattern, increased waste accumulation, and dependency of humans on the forest for livelihood due to increased population.

Suggested measures to reduce HWC in Parikshitgarh are as follows: (1) preventive measures must begin with increased tolerance to wildlife, (2) measures like the use of fencing, nylon nets over the ponds, rehabilitation centers for animals, (3) general awareness among the native human populations in these villages about the habitats and habits of wildlife, (4) use of bio-repellent and electric fencing to protect lives, and (5) better agricultural planning to avoid habitat fragmentation and reduction in dependency on the forest for livelihood.

6. Human-Wildlife Conflict in Bijnor

Bijnor (29o37′N, 78o13′E) is one of the major districts of Uttar Pradesh and one of the major constituents of Hastinapur wildlife sanctuary. Of the total 4,04,900 hectares in the Bijnor district, 54,898 hectares of area are under green cover. Bijnor district has two main forest ranges which fall under Hastinapur wildlife sanctuary are Bijnor and Chandpur. Major flora includes *Dalbergia sissoo* (Sheesham), *Eucalyptus Globulus* (*Eucalyptus*), *Prosopis juliflora*, *Santalum album* (Chandan) whereas fauna is almost as same as previously described in Parikshitgarh range. As far as the agro-economic aspect of Bijnor is considered, it has climbed to the second largest sugarcane cultivator position in the state after Lakhimpur Kheri, and with the depletion of forest cover, incidents of man-animal conflict have been on the rise. The major region that has been covered during this study included two plots each in Baldia and Sherpur villages. These villages have faced counter from leopard, tiger, elephants, bear, and snake mainly as it has become a major cause of concern due to their repeated infiltration into the boundaries of the village and causing domestic animal death and human injuries or causalities as observed (Figures 8 and 9). The heightened sugarcane crop can be used for the hiding places for the small animals such as cats, dogs, rabbits, goats, and other cattle. So, these animals become an easy prey for these wild cats, and sometimes, these wild cats themselves can hide behind these sugarcane crops, which sometimes can create panic among the local human population. These leopards have been given the name of "Sugarcane leopard" although, in the recent past, it has been observed that rescue of these wild animals has been done more as compared to the harm caused by them (Figure 9). Other than this, crop destruction by a herd of the elephant is also a cause of concern for the farmers. So, livestock depredation resulting in real or perceived economic losses to individual farmers is the most common cause of human-wildlife conflict. The prevention and mitigation of conflicts are challenging issues not only because of its urgency as many large fields are threatened, but solutions have to take into account complex and locally dependent social and cultural aspects.

Suggested measures to reduce HWC in Bijnor are as follows: (1) better crop planning in sugarcane fields which should be visited with utmost precaution, once the crop heightens, (2) prohibit stubble burning, (3) elephant traps on sensitive spots, and (4) use of bio-repellent and trenches, (5) monitoring can use camera traps to protect lives.

6.1. Human-Wildlife Conflict in Muzaffarnagar-Jansath Range. The next site for studying the ongoing human-wildlife conflict studies was the Jansath forest range of Muzaffarnagar district (29°28′56″N 77°42′00″E) of Uttar Pradesh that covers a large area of Hastinapur sanctuary. We have covered a few villages specifically in the Jansath range, namely, Tikola Ahmoodpur Dera, Alampur, Kelapur Dera, Deval, and Qasimpur. Flora and Fauna of this area are also similar to the rest of the regions covered and mentioned earlier. Interestingly, this region is also having rich biodiversity in terms of wild animals such as leopard, elephant, barasingha, wild pig, python, nilgai, and monkey. The seasonal appearance of leopard, during winters near the Madhya Ganga River and other elevated areas, has been observed as it is not much observable during rainy seasons in villages of the deep forest. Most of the region is covered as agricultural land, and it is mostly affected by the huge population of monkey and nilgai. In deep forest villages, where leopards can be seen, the population of nilgai is less than expected but in the regions present outside, nilgai is a major cause of problems of natives either directly or indirectly by destroying their fields of seasonal crop. Also, monkeys are major problems in these areas, and they destroy fields of sugarcane, wheat, etc., and even harm locals. Sometimes, these are released from urban areas to village areas. Locals use normal wooden sticks and stones to protect them. Monkeys cause problems in both deep forest villages and infringe area villages.

There are occasional encounters with pythons and wild boars too, though conflict is negligible. Apart from this, Crocodiles (*Crocodylinae*), Gharial (*Gavialis gangeticus*), Tortoise, and Surkhab (*Chrysolophus pictus*) are present in

(a) (b) (c)

Figure 4: Plantation at different sites of Parikshitgarh. (a) Ganga river site. (b) First block. (c) Second block.

(a) (b) (c)

Figure 5: Human interference in Parikshitgarh. (a) Ashes observed due to fire in bushes, (b) illegal deforestation and wood log loading in trolley, (c) electrocution of the peacock.

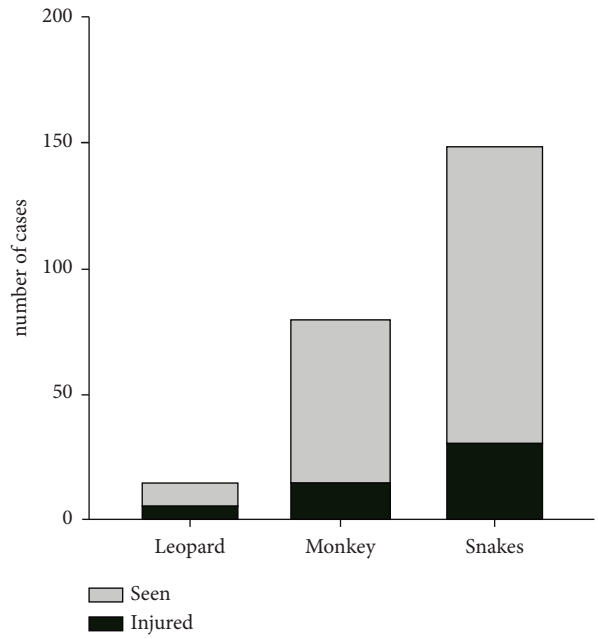

Figure 6: Animals inflicting injuries to sanctuary inhabitant in Hastinapur wildlife area—the number of animals witnessed as compared to injury caused by them.

(a) (b) (c)

Figure 7: Wildlife penetration inside village boundaries of Parikshitgarh as visible through pugmarks of (a) jackal, (b) fishing cats, and (c) leopard.

(a) (b) (c)

Figure 8: (a) Hoof marks, (b) animal blood, and (c) animal remnants in the Bijnor region of Hastinapur wildlife sanctuary, as witnessed by the survey team.

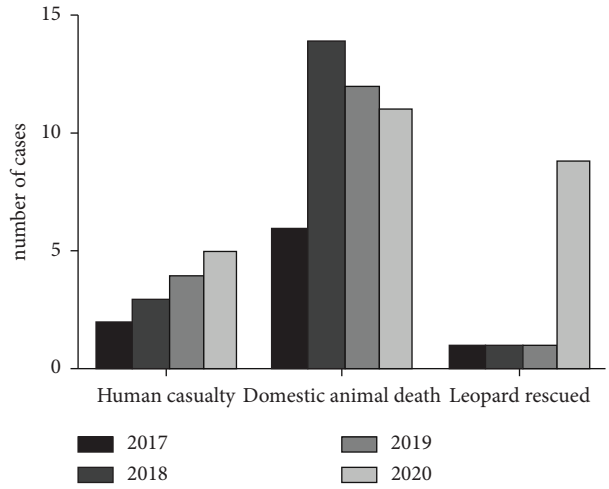

Figure 9: Observations in the Bijnor area of Hastinapur wildlife sanctuary regarding human casualties, killing of human domesticated animals, and leopards rescued.

the Madhya Ganga River but no case of harm by these is recorded yet.

Suggested measures to reduce HWC in Bijnor are as follows: (1) monitoring through the use of radio-frequency and camera traps to spot nilgai and wild cats must be ensured, (2) domestic animal shelters be promoted, (3) fencing and pond nets, and (4) use of bio-repellent, (5) prohibit tree cutting, and (6) extensive awareness programmes and education on sensitive areas through proper signages.

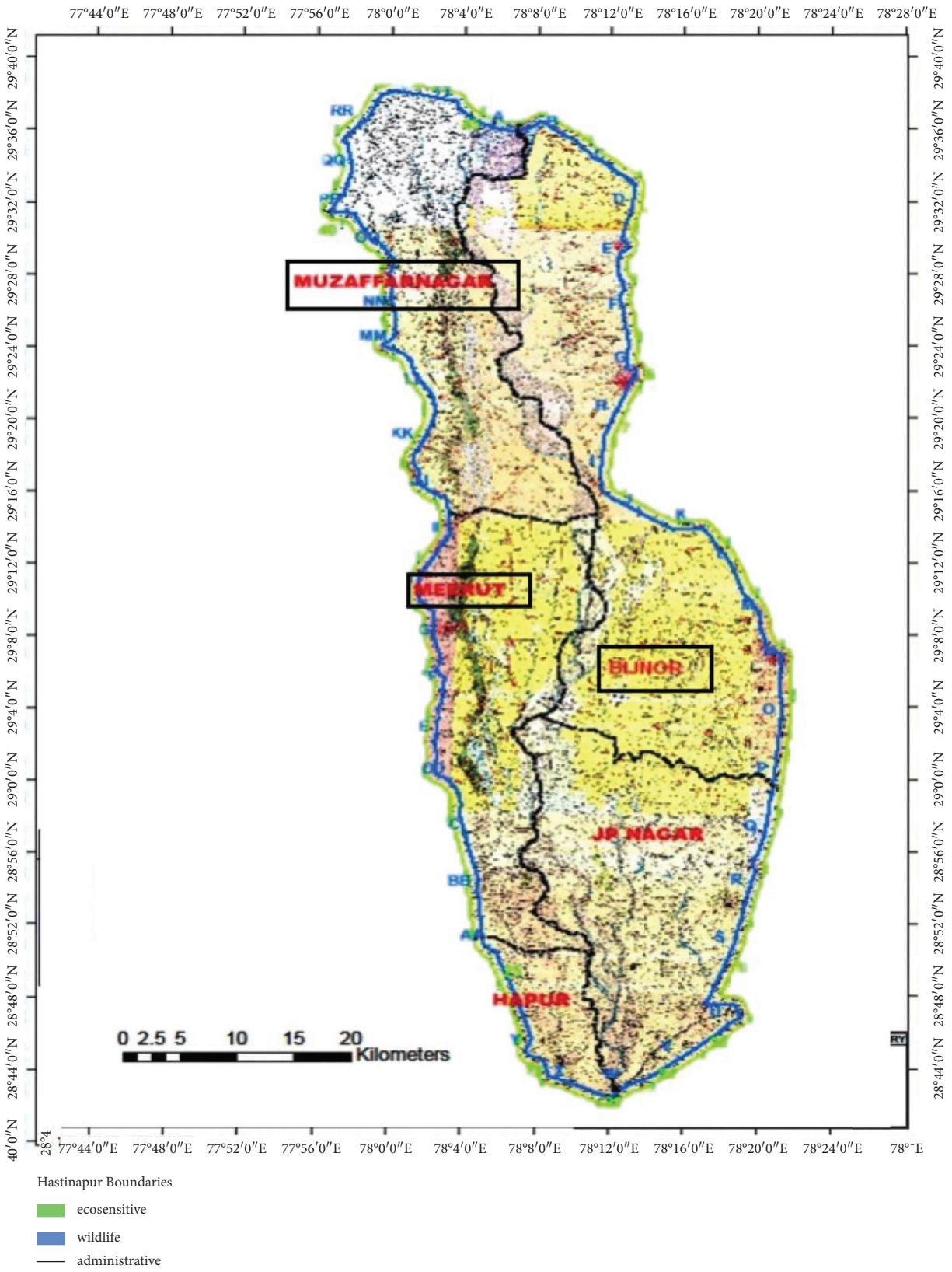

Figure 10: Map of the eco-sensitive zone of Hastinapur on the survey of India (Adopted from The gazette of India: extraordinary [Part II, Page 30; Section 3(ii)] Annexure- II).

Despite being rich in biodiversity, interestingly, as compared to other sites discussed earlier, local people have managed well with any of the conflicts associated with the above wild animals by using alternative methods such as electric fencing, usage of domesticated dogs to repel the intruder animals and high noise-making through drums and other objects like utensils, etc. While, in earlier study, a report available about Hastinapur wildlife sanctuary had detailed the community's attitudes towards wildlife conservation [9], the present study is a qualitative report of outreach activity of Government Academia partnership. The study has revealed a few social facts not revealed earlier: (1) the village locals who had been inhabiting the area through several generations viewed animals as their coinhabitants, (2) difficulties faced by forest guards could be highlighted for the first time, (3) extent of ignorance among village locals could be revealed, and (4) extreme anthropogenic pressure were highlighted. Notably, livestock depredation and crop-raiding caused by recurring incidents of human-wildlife conflicts render an overall negative impact on the residents due to economic damages. Furthermore, the relationship of local residents with the forest department personnel appeared affected and eventually creates an impact on wildlife conservation initiatives and hampers the protected area management activities. Therefore, local people's participation in wildlife conservation programmes and protected area management is advisable. The government needs to increase the compensation grant so that it should meet the loss of villagers who economically suffer due to conflict with wildlife. For suggestive measures, trenching at the boundary of the protected area is necessary and would help in reducing the frequency of conflict issues by reducing the tress passing of human and wildlife across the protected area boundary. Villagers could be encouraged in stall-feeding instead of illegal livestock grazing. This would help in reducing anthropogenic pressure inside the sanctuary and incidents of livestock depredation. Ignorant use of firecrackers by villagers could be avoided through interpersonal interaction and training. Frequent involvement of nongovernment organizations and students (just as in the current study) could reduce the conflict between locals and animals. The use of barbed-wired fences could be replaced by bio-fences such as chili fences, bee hives, etc., and harmless radio-frequency devices, to deter wild animals from raiding the agricultural field. Education and awareness among the villagers are foreseen to be the most important remedy. Realization of the importance of forest and wildlife conservation by locals would reduce the illegal human activities like poaching etc. inside the sanctuary. The initiation of wireless picture capturing of the forest cover would be helpful in generating adequate quantitative data in the future.

This study enabled a first-hand understanding of the most suited reasons behind the recurrence of human-wildlife conflict (HWC) at Hastinapur wildlife sanctuary. The suggestive measures such as the participation of the local public through awareness, enforcement of law and government policies, and conservation programs have been suggested earlier, but the mutual inhibition among the locals and the forest guards beside the extent of friendliness and amity among the stakeholders has been highlighted for the first time. It is suggested that more such studies should be conducted as ministry academia collaborations because they add not only to the direct training of students but also bring a comfort to the less educated locals inhabiting forest areas. Overall, there is an increasing need to address the conflict issues of HWC in the Hastinapur sanctuary area, due to increased inhabitation (Figure 10) in the eco-sensitive zone of the sanctuary.

Data Availability

The graphical and statistical data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest

Authors' Contributions

All authors contributed equally.

Acknowledgments

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