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Research Article

Status of Human-Wildlife Conflict and mitigation measures adopted by locals in Shivapuri Nagarjun National Park, Kathmandu Nepal

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Abstract

Human Wildlife Conflict (HWC) is one of the major challenges for wildlife conservation globally. This study assessed the status of HWC and the associated mitigation measures in two villages - Okhreni and Chilaune - of Sundarijal Shivapuri Buffer Zone User Committee at Shivapuri Nagarjun National Park (SNNP). Primary data were collected through household questionnaire surveys; key informant interviews and secondary data were collected from official records of SNNP, relevant journals, books, and reports. The survey was conducted in 115 HHs of both villages. 90 HHs were surveyed out of 300 HHs in Okhreni whereas 25 HHs were surveyed out of 50 HHs in Chilaune. Likert scale was used to identify the most problematic animal species involved in HWC. Wild boar (*Sus scrofa)*, Himalayan Black Bear (*Ursus thibetanus*), crested porcupine (*Hystrix brachyuran*), rhesus monkey (*Macaca mulatta*) and barking deer (*Muntiacus muntijak*) are the major animal species involved in HWC. 95% respondents from Okhreni and 97% respondents from Chilaune experienced crop damage by wild animals, with those near the forest being more affected. Maize was the most targeted crop followed by millet and wheat. Only a single case of human injury has been registered in the last five years. Crop depredation by wild boar was most prevalent in the study area. People from both villages are not satisfied with the existing compensation measures. However, the lack of incidences of livestock depredation and human injuries and fatalities combined with peoples' awareness about the significance of wildlife could be the probable reasons for positive attitudes towards wildlife and wildlife conservation in SNNP. People should be encouraged to cultivate less preferable and unpalatable crops and plants that are economically profitable as well. This could provide an alternative source of income and help reduce the incidences of HWC in the study area.

Keywords: Crop depredation, human wildlife conflict, problematic animal, Shivapuri Nagarjun National Park, wild boar

Introduction

Human wildlife conflicts (HWCs) traditionally defined as any negative interactions between people and wild animals that negatively impact both parties (Madden, 2004; WWF, 2005; Baral et al., 2022) is one of the major challenges for wildlife conservation globally. HWCs arise mainly because of the loss, degradation and fragmentation of habitats through human activities such as logging, animal husbandry, agricultural expansion and development to meet human needs (Fernando et al., 2005); animal behaviour and subsequent human retaliation (Gemeda & Meles, 2018). Rapid growths in human population and associated technological development have made the situation even worse (Air, 2015). A range of animals are responsible for HWC from big (eg. Elephants) to small (e.g., Small mammals, birds etc.); herbivores (deers, elephants, wild boars (*Sus scrofa*), birds, porcupines etc.) to carnivores (snow leopards, tigers, crocodiles etc.) (Woodroffe et al., 2005). Carnivores are responsible for causing livestock depredation and attacks on humans whereas herbivores mainly cause crop depredation and human injury (Hill, 2000; Jenks et al., 2013) though cases of property depredation and human attacks by herbivores also occur (Dangol et al., 2020). Attacks on humans are often fatal. HWC can occur in both urban and rural areas but are generally more common inside and around protected areas (PAs) or adjacent cultivated fields or grazing areas, where wildlife population density is higher, and animals often visit (Congress, 2003; Baral et al., 2022). HWC is a common phenomenon and has become a significant problem throughout the world (Wang a Macdonald, 2005). However, the frequency and intensity of HWCs vary based on geography, land use patterns, human behavior, and the habitat and behavior of wildlife species or individual animals (WWF, 2007).

Nepal with its 20 PAs covering around 23.39 % of the total land has its fair share of HWCs (DNPWC, 2021). The limitation on the use of forest resources, which are exclusively available within protected zones, increasing population and associated demands are exerting pressure on natural resources (IUCN, 1988; Bhatta and Joshi, 2020) which inevitably results into HWCs. Communities living in close proximity to PAs seem to be more affected (Subedi et al., 2020) though the magnitude and frequency of impacts differ across the country (Shrestha et al., 2007). However, the incidences and magnitude of HWCs in different PAs particularly in the buffer zones (BZs) are increasing as the latter tend to have human settlements (DNPWC, 2021). The dependency of such communities on forest for life supporting ecological goods and services such as firewood and fodder frequently results in HWCs (Budhathoki, 2004; Rayamajhi, 2009). The most common wildlife species involved in HWCs in these areas are mostly mammals such as Asian elephants (*Elephas maximus*), different species of monkeys such as the rhesus monkey (*Macaca mulatta*), crested porcupine

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(*Hystrix indica*) barking deer (*Muntiacus muntijak*), Himalayan black bear (*Ursus thibetanus*), wild boar (*Sus scrofa*), common leopard (*Panthera pardus*) and jackal (*Canis aureus*) (Silwal et al., 2017).

Shivapuri Nagarjun National Park is home to rich diversity of flora and fauna representative of subtropical and temperate climates (DNPWC, 2022). The interaction between humans and wildlife has been reported to increase since the establishment of the National Park (SNNP, 2017). Livestock loss due to leopards have been reported to be high particularly in the last 10 years (Bhandari et al., 2019). People are facing HWCs and many cases of it have been registered in buffer zone user committee (BZUC) offices. 72 cases of crop depredation were registered in the fiscal year 2019/2020 from Sundarijal Shivapuri BZCU alone (SNNP, 2019/20). HWC studies so far have focused on a few villages like Jhor Mahankal, Goldhunga (Air, 2015). Hence, this study attempts to assess the status of HWC in two villages of SNNP's BZs namely Okhreni and Chilaune. The objective of this study was to assess the status of HWC, and subsequent mitigation measures adopted by local people in the BZs of SNNP.

Materials and Methods

Study Area

The study was conducted in two villages in BZs of SNNP (Fig. 1) namely Okhreni and Chilaune. The Park has an area of about 159 km^2 and the elevation ranges from 960 (Narsingh Ghat) to 2732 (Shivapuri peak) m.a.s.l. (meters above sea level). The geographical coordinates of the Shivapuri and the Nagarjun forests are 27°45' to 27°52' N latitude and 85°16' to 85°45' E; and 27°43' to 27°46' N latitude and 85°13' to 85°18' E respectively. The Park and its buffer zone cover parts of Kathmandu, Nuwakot, Sindhupalchowk and Dhading districts of Central Nepal.

This Park comprises four types of forests which support rich floral and faunal diversity. The park is rich in various mammalian species, reptiles, birds, vegetation, etc. It is home to 30 species of Mammals including nine threatened Mammalian taxa including pangolin (*Manis spp.*), leopard cat (*Prionailurus bengalensis*), clouded leopard (*Pardofelis nebulosa*), himalayan black bear, goral (*Naemorhedus goral*); 177 species of birds, 102 species of butterflies and 129 species of mushrooms (DNPWC, 2024).

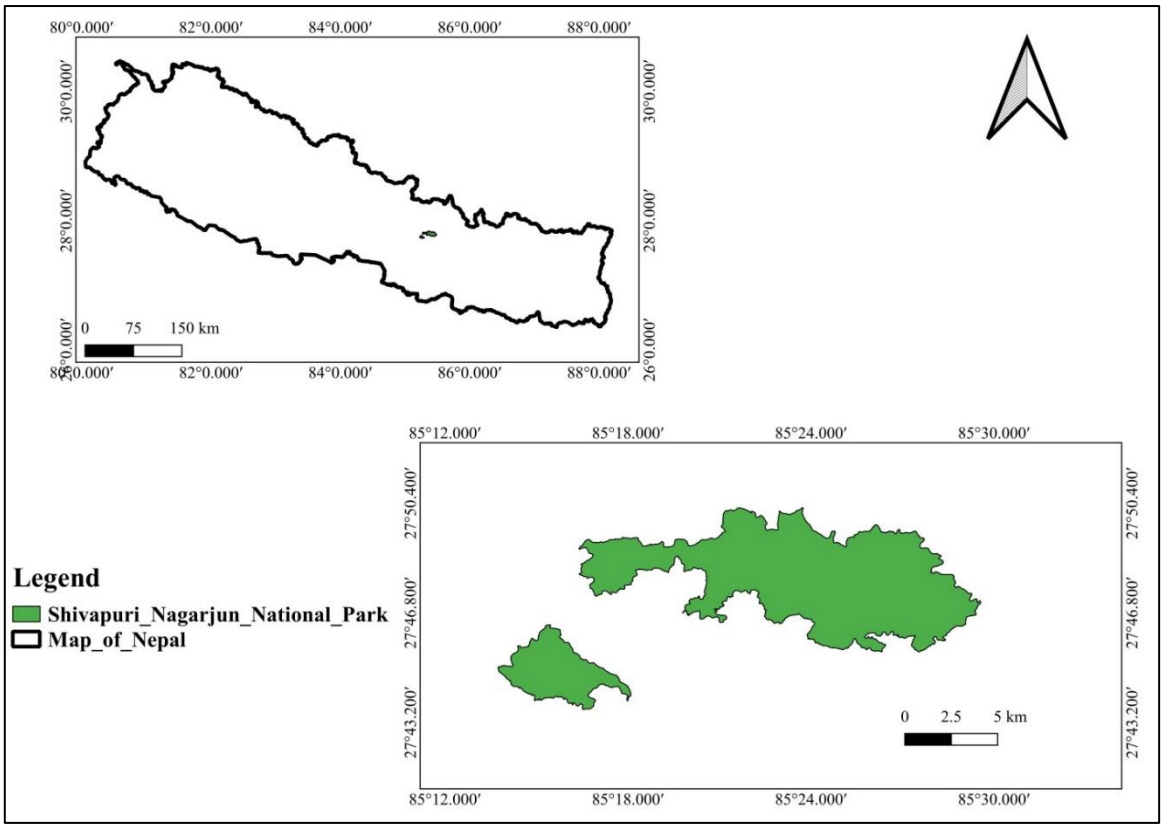

Figure 1. Map of the study area showing the SNNP

Data collection

Both Primary and secondary data were collected. Primary data were collected through Household (HH) questionnaire survey and Key Informant Interviews (KII) whereas secondary data were collected from different relevant research journals, books, Park Annual Report and websites (SNNP, 2017; SNNP, 2019/2020) From these literatures, information related to

conservation issues, Park management at SNNP and its buffer zones were collected. A preliminary site visit was carried out to identify key informants, to assess the feasibility of the survey and to identify main conflict areas. A mandatory permit was taken from the DNPWC prior to the survey. The survey was conducted from October 7 to 15 of 2021.

The household survey was conducted using semi-structured questionnaires. Random sampling method was done using Excel to select the Households (HHs) (Arkin & Colton, 1963). In Okhreni, 90 HHs were surveyed out of 300 HHs (30% of total HHs) whereas in Chilaune, 25 HHs were surveyed out of 50 HHs (50% of total HHs). Senior members of HHs or 18 years above members were chosen for the survey.

Data analysis

Data was analyzed in IBM SPSS (Version 25). The status of livestock ownership, magnitude of crop depredation and perception of the respondents were estimated in percentage. The Likert scale was used to rank the most problematic species. The Likert scale is the most widely used approach to scaling responses in survey research (Likert, 1932). The rank of perceived problem animals where animals visit was recorded with 1st was considered the most problematic species and 6th as the least problematic species.

Results and Discussion

Socio-Economic characteristics of the respondents

The majority of the respondents belong to the Tamang and the Chhetri communities. Only 15.6% in Okhreni and 20% in Chilaune could read and write in Nepali. In both villages, major occupations are livestock rearing and agricultural activities. Most of the HHs had multiple livestock that comprised of cows, buffalo, chicken, goat. The population of goats was highest followed by chicken, buffalo and others, the population of cow was lowest in both villages (Fig. 2).

The majority of the HHs have landholdings less than 0.4 ha in both villages. The average landownership in Okhreni is 0.33979 ha and in Chilaune is 0.30744 ha. All the respondents possessed their own property. People used to grow paddy in the past in Okhreni and Chilaune but due to the lack of water holding capacity of land, they have shifted to other crops. The majority of the people grow agricultural crops such as wheat, maize and millet in both villages although other crops such as mustard, buckwheat, yam and others are also grown by people. For the majority of Nepalese people, agriculture is one of the main sources of food, income, and employment (WWF, 2005). The major forest resources collected by people in both villages were firewood, grass, and fodder. In Okhreni, firewood users were high whereas in Chilaune grass collectors were high.

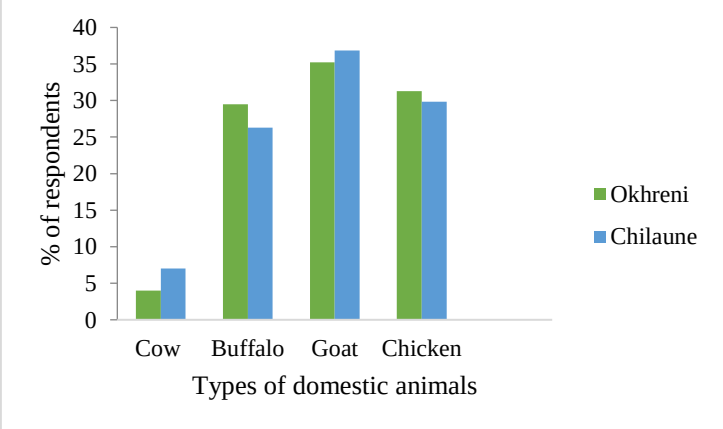

Figure 2. Types of domestic animals reared by respondents

Status of HWC in SNNP

Wildlife species involved in HWCs

Different animal species involved in different types of conflicts in SNNP are shown in Table 1 with crop depredation being the major impact. Wild boar, Himalayan Black Bear, crested porcupine, barking deer, monkeys (*Macaca assamensis* and Rhesus monkeys) and birds were identified as the most problematic animal species involved in crop depredation in both the villages. These species were reported by others as well in other villages such as Jhor Mahankal, Goldhunga, Sundarijal in their study on the BZ of SNNP (Bajracharya et al., 2005; Charoo et al., 2009; Pradhan et al., 2012; Prasad et al., 2012; Jayson et al., 2016). Based on the Likert scale, wild boars were identified as the most problematic species for crop depredation in both Okhreni (60%) and Chilaune (62%) and barking deer (*Muntiacus muntijak*), as the least problematic animal for crop raiding (Table 1). Similar response from the villages can be attributed to the location of these villages in the same periphery. Respondents said that wild boars not only depredate the crop but also damage the field by burrowing. The incidences of wild boar human conflict have increased in the last 30 years in Nepal (Thapa, 2010; Sapkota et al., 2014) including in other PAs in the country such as Rara NP, Langtang

NP, Dhorpatan Hunting Reserve, Shuklaphanta NP (Koirala et al., 2014; Bista & Aryal, 2013) and elsewhere (Barrios et al., 2012). Several aspects of wild boar ecology make them particularly damaging to crops. For instance, they raid the crops more frequently during flowering and fruiting seasons and continue to raid the same field until they destroy all crops (Thapa & Chapman, 2010). These habits coupled with their burrowing activities make wild boars one of the most problematic species. Surprisingly, leopards in HWC as reported by Bhandari et al (2019) was not involved in these two villages.

Fourteen percent of the respondents on Okhreni and 12% respondents in Chilaune said that Himalayan Black Bear are responsible for crop damage particularly maize and wheat. However, the respondents also mentioned only a single case of bear attack and subsequent human injury in the last five years. Bears are omnivores and are identified as causing three forms of conflicts namely crop raiding, livestock depredation and human attacks sometimes with fatal results and they may turn to eating livestock such as sheep, goats and cattle (Sathyakumar et al., 2011). Increased human activities in natural habitats, competition for resources, fear of animals and illegal trade of different body parts of bears have been cited as increased frequencies of human bear interactions (Joseline, 2010; Khatun et al., 2013; Nath et al., 2020).

Ten percent of respondents in Okhreni and 10% respondents on Chilaune claimed that crested porcupines frequently damage potatoes and yam and also damage their field very badly. The crested porcupine is a herbivorous burrowing animal which can damage fields as well as crops (Akhtar et al., 2022). This species is known to consume different plant parts such as roots, bulbs, succulent tubers, ripe fallen fruits and bark of some tree species (Jayson et al., 2016) and thus can damage crops and other vegetation. Crop damage by porcupines have been reported not only from PAs such as Chitwan NP, Annapurna CA, Kanchenjunga CA (Aryal et al., 2012; Adhikari et al., 2018) but also from outside the PAs in a large number of districts such as Bajhang, Banke, Doti, Kailali, Kanchanpur, Nawalparasi, Parbat, Rupandehi, Kavrepalanchowk districts, in Nepal (Pudasaini, 2020). Several countries such as Ethiopia, China, Georgia, India, Afghanistan, Pakistan, Sri Lanka, Turkey (Ekanayaka et al., 2011; Hafeez et al., 2011**;** Mamo et al., 2021) have also reported porcupine as crop raiders.

Nine percent of respondents on Okhreni and 8% respondents on Chilaune claimed birds as one of the problematic species and they claimed that maximum damage by birds is caused during harvesting season which coincides with the ripening of cereal crops particularly millet (Table 1; Fig. 3). Most of the respondents (50%) said that the birds were released by visitors although a key informant claimed that naturally occurring birds are also responsible for seed consumption. Many species of birds, particularly seed eaters, can cause damage to small grain crops such as millet, sorghum, maize etc. (Carlson et al., 2013).

Four percent of respondents on Okhreni and 6% respondents on Chilaune claimed that monkeys also damage their crops. They said that the monkeys mostly damage maize. Different species of monkeys found in SNNP are Assamese monkey and Rhesus monkey (SNNP, 2019/20). Crop raiding and damage by different Primate species is one of the most widespread and common human-primate conflicts in many places and regions (Hill, 2000). Human –monkey conflicts have been observed across Nepal including the PAs, agricultural fields and even in urban and sub-urban areas (Air, 2015; Awasthi & Singh, 2015; Thapa, 2019). Anthropogenic habitat alteration and subsequent habitat loss, scarcity of food, increase in monkey population, behavioral changes in monkeys due to artificial provisioning by Hindu pilgrims, etc. have been implicated as major causes of monkey species turning into crop-raiders (Priston et al., 2012). In the absence of food, these animals are known to come and settle near human settlements in search of food and increase their rate of breeding (Leslie et al., 2019).

Three percentage of the respondents on Okhreni and 2% respondents on Chilaune said that deer are responsible for crop depredation, especially leaves of vegetables and they frequently visit the field during daytime. Barking deer (*Muntiacus muntjak*) are found in SNNP (DNPWC, 2014) and they prefer to live near cultivated areas like gardens and plantations, where they can find food. Different species of deer have been identified as crop raiders in different PAs of Nepal such as Gaurishankar CA, Shuklaphanta NP, Sagarmatha NP, Annapurna CA (Awasthi & Singh, 2015; Thakuri, 2016; Bhatta & Joshi, 2020). Musk deer in Sagarmatha NP, Sambar deer in Annapurna CA (Thakuri, 2016) are some of the examples. Deer feed on foliage and shoots of shrubs and trees in their natural habitat (NTNC, 2015).

The incursion of wild animals in the crop land was found high during night hours, though wild animals such as birds, monkeys and deer damaged crops in the daytime also. 98 % of respondents said the wildlife visited cropland during nighttime (Fig. 4). Availability of food inside the park determines the movement of wildlife and its frequency moving outside the park. Respondents also indicated that wildlife visit frequently, and attempts were found to be high during the growing and harvesting seasons of crops. The regular visit of wild creatures to cropland at nighttime expands the harm of the harvests principally due to the poor visibility, dispersed population and limited HH members in the family (WWF, 2007).

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Table 1. Prioritization of wild animals as crop raiders by respondents

Animals	Magnitude of rating									
	Most Problematic		Problematic		Moderate Problematic		Less Problematic		Very Less Problematic	
	Okhreni	Chilaune	Okhreni	Chilaune	Okhreni	Chilaune	Okhreni	Chilaune	Okhreni	Chilaune
Wild boar	✓	✓								
Bear			✓	✓						
Porcupine					✓	✓				
Bird					✓	✓				
Monkey							✓	✓		
Deer									✓	✓

Figure 3. Millet depredated by birds (2021)

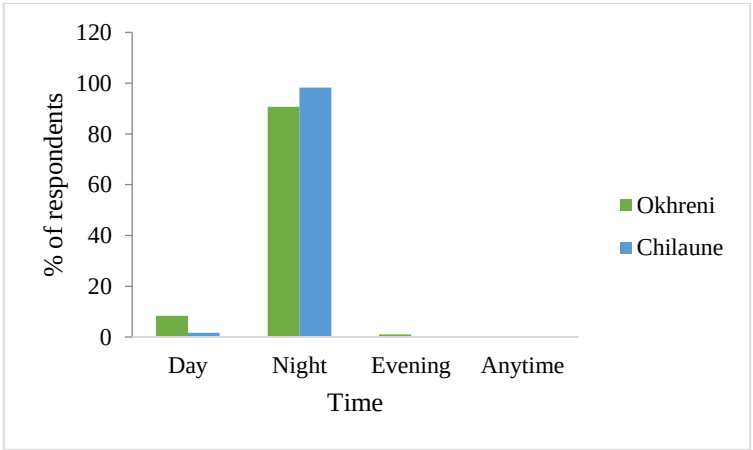

Figure 4. Prime hour for wild animals to raid crops

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Incidences of HWC and factors causing HWC in SNNP

The majority of the respondents (85% in Okhreni and 90% in Chilaune) experienced HWC in SNNP. The major conflicts in both villages were crop depredation, livestock depredation and human injury. However, the intensity of crop damage was usually greater than other damages. About 95% of the respondents had suffered from damages of crops followed by livestock depredation (3%) and human injury (2%) in Okhreni. About 97% of the respondents suffered from damage of crops followed by livestock depredation (2%) and human injury (1%) in Chilaune (Fig. 5). This indicates that crop loss is the most dominant impact of HWC in SNNP. Crop harm by animals has been identified as the most prevalent type of damage of HWC than livestock depredation, human injury and casualties (Barnes et al., 2003; Karanth & Nepal, 2012). The major agricultural crops that were damaged by wild animals in the study area were maize, millet and wheat although other crops such as potato and vegetables were also reported to be damaged (Fig. 6). Maize was the most affected crop followed by millet and wheat. In earlier studies in different buffer zones of SNNP such as Goldhunga, Jhor Mahankal, Okharpauwa and Bishnu also, maize was the most damaged crop followed by millet, wheat and paddy by wild boars and Rhesus macaque (Suwal, 2009; Air, 2015). Likewise, maize has been reported as the most raided crops in Banke NP as well (Ayadi, 2011). It may be due to its large-scale production as most of the farmers cultivate maize in the study area. The trend of increasing crop depredation has been observed in other PAs of Nepal as well (Ghimirey et al., 2012; Dhakal, 2020) and elsewhere (Priston et al., 2012). Most of the respondents (97.8% in Okhreni and 96% in Chilaune) claimed that the HWC has been increasing in both villages (Fig. 7). The frequency of crops being raided by animals is likely to be related to abundance of that particular crop (Khan, 2013). However, the type of crop being raided are found to vary regionally as well (Leslie et al., 2019) attributed to topographical and climatic variations. For instance, paddy is highly affected and damaged crops by wild animals in Koshi Tappu WR, Chitwan NP and Bardia NP (WWF, 2007; Ghimire, 2019) as opposed to potato damaged by musk deer and Himalayan tahr in Sagarmatha NP (Thakuri, 2016). In contrast, banana is damaged by Asian elephant and African elephant (*Loxodonta Africana*) in India and Africa respectively (Ekanayaka et al., 2011; Raphela & Pillay, 2021). Crop depredation can occur in different ways such as consumption by wild animals, damage of crop fields by burrowing, trampling (Gubbi et al., 2014).

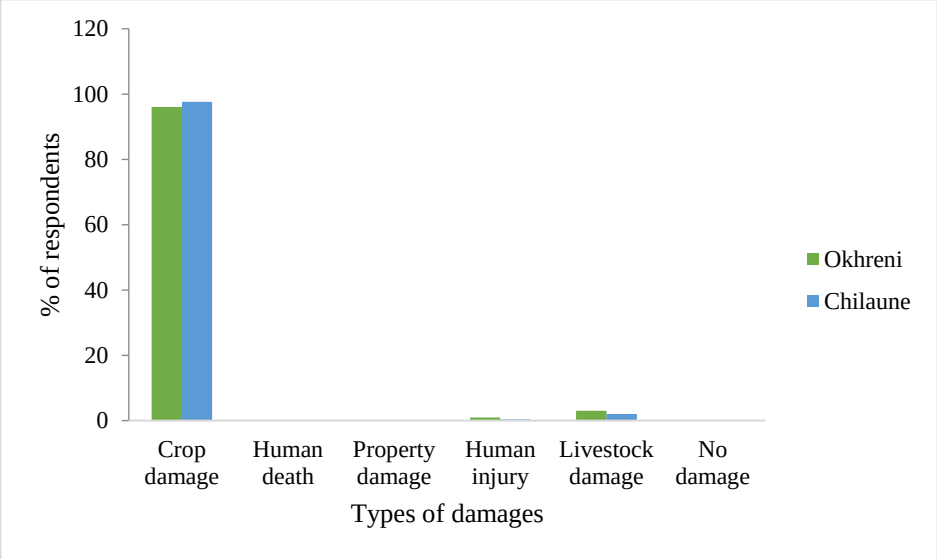

Figure 5. Major types of damage done by wild animals

Different factors responsible for HWC in SNNP are listed in Fig. 8. Among them, the main factor responsible for HWC is animals visiting the fields in search of food. Many studies in different PAs of Nepal shows that HWC is occurring due to animal visiting agricultural land in search of food (Awasthi & Singh, 2015). This may be due to the high number of wild animals in the forest which creates intra and inter species competition for space, food and mating (Upreti, 1985). Such situations force wild animals into cropland. Additionally, people's reliance on forests for firewood, grass, fodder, and other activities (like housing and fencing) increases the frequency and nature of conflicts. Furthermore, the proximity of the villages to the forest contributes to the damage caused by wild animals. As the distance from forests to settlements decreases, the magnitude of damage increases, which shows that there is a direct relation between crop damage and the distance. Respondents living closer to forest territories tend to suffer from more incidences and costs of crop losses as compared to people living far from forest boundaries (Mackenzie & Ahabyona, 2012). Various studies have found that crop damage by wildlife often occurs at the peak availability of crops especially during the crop harvesting time (Warren et al., 2007).

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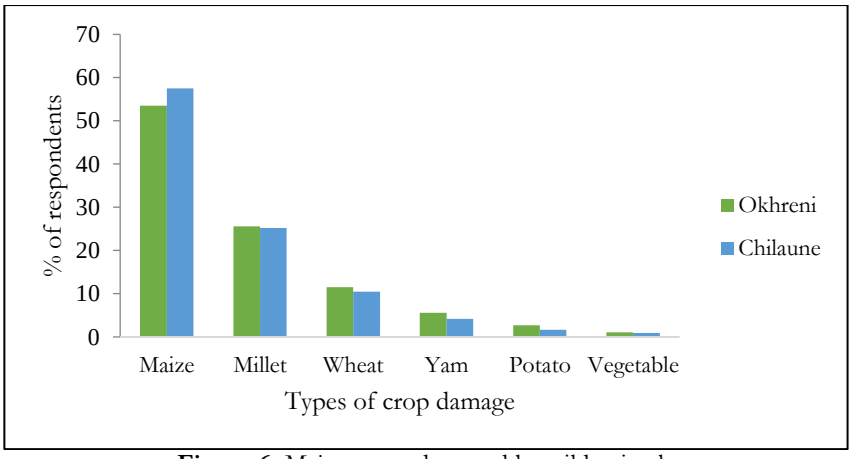

Figure 6. Major crops damaged by wild animals

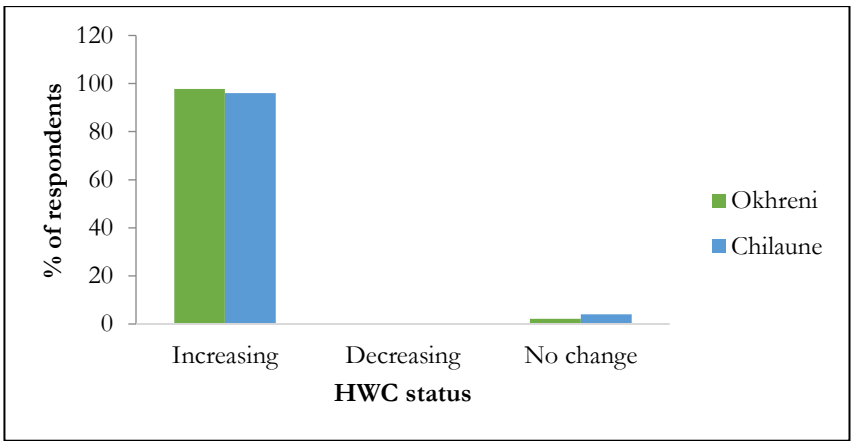

Figure 7. Status of HWC

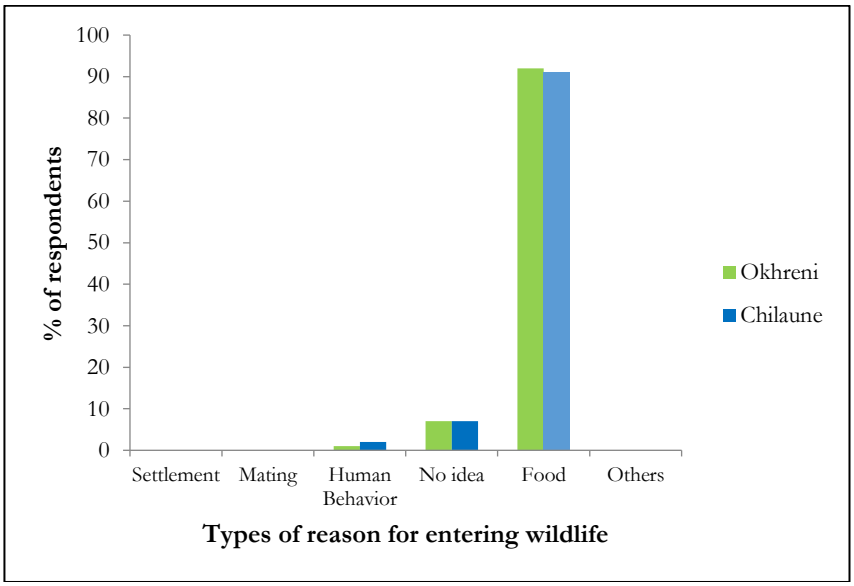

Figure 8. Major reasons for entering wild animals in human settlements

People's Perception on HWC and conservation

Despite the fact that HWCs exist in SNNP, majority of the respondents in Okhreni (94%) and Chilaune (95%) expressed positive attitude towards wildlife conservation and only a few respondents showed negative attitude towards wildlife conservation (Fig. 9). Respondents had different views towards positive conservation. 72.7% of total respondents in Okhreni perceive that wildlife should be conserved because it is perceived as a national asset, 14.6% believe that wildlife should be conserved for future generations while 12.7 % are aware of legal implications and punishment

against wildlife killing (Fig. 10). 41.2 % of respondents in Chilaune perceive wildlife as national asset, 41.2 % believe that wildlife should be conserved for future generations and the rest are aware of laws and regulations of wildlife destruction and killing (Fig. 10). In contrast only 6% and 5% in Okhreni and Chilaune respectively showed negative attitude towards wildlife and wildlife conservation. However, it is evident that the majority of people of Okhreni and Chilaune are positive towards wildlife conservation. According to Hill and Plumptre (2002), people develop negative perceptions and attitude towards wildlife when damage caused by wildlife exceeds the limit of tolerance. For example, livestock losses, together with crop damage, human casualties are considered major causes of negative attitudes toward conservation policy around PAs (Wang & Macdonald, 2005). People show resentment against conservationists and the government as they are more concerned about wildlife than about human well-being which also creates negative attitude towards wildlife and wildlife conservation (Mwamidi et al., 2012; Bhatta & Joshi, 2020). The fact that there are almost no incidences of livestock depredation and human injuries and fatalities combined with peoples' awareness about the significance of wildlife could be the probable reasons for positive attitude towards wildlife and wildlife conservation in SNNP.

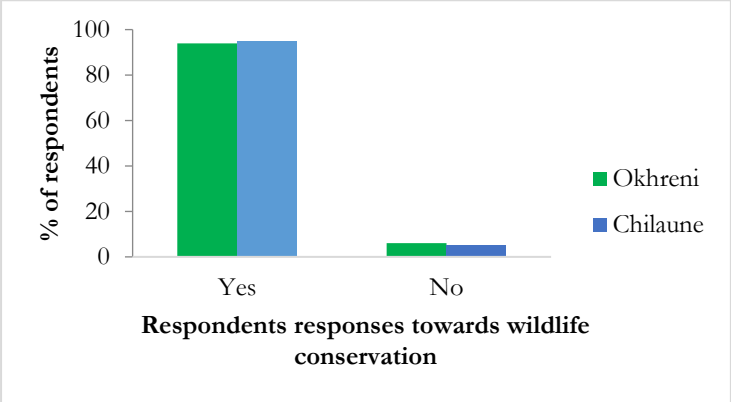

Figure 9. Respondents' responses towards wildlife conservation

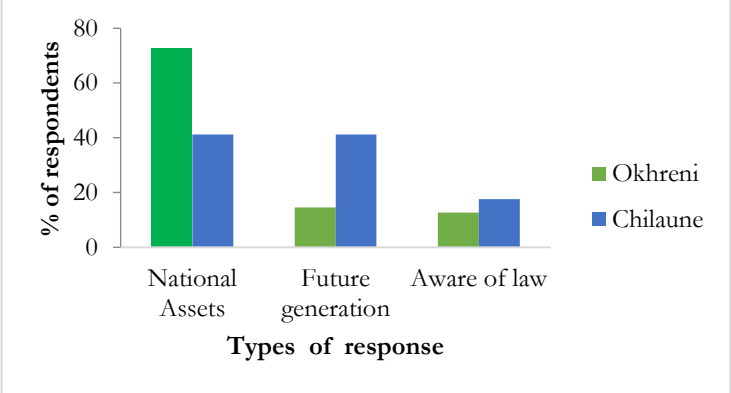

Figure 10. Perception of respondents towards wildlife conservation

Existing mitigation measures and their effectiveness

Different mitigating measures adopted by the people of Okhreni and Chilaune are group shouting, bio-fencing and use of scarecrows (Fig. 11). Group shouting is the most common measure adopted by people. These methods along with other traditional methods are widely used to minimize crop loss and livestock depredation against a variety of animals (Waladji & Tchamba, 2003; Thapa, 2010; Neupane et al., 2013; Pandey et al., 2016). However, only 18.6% of respondents from Okhreni and 10% from Chilaune were applying these mitigation measures (Fig. 12). Of these, the majority of the respondents (85.7% in Okhreni and 85% in Chilaune) claimed that the mitigating measures they adopt against different wildlife species are not effective. These respondents said that the reasons for not adopting mitigating measures and failure of effectiveness of mitigating measures are because most of the wildlife species damage and destroy the crops during nighttime with less visibility during this time. In the past, people used different techniques to prevent the entry of wild animals in their fields such as throwing flaming sticks, playing radio and drums during night. However, now the Park is trying to construct mesh wire fencing in different BZs of SNNP to prevent the entry of wild animals to reduce the incidences of HWCs and the construction is already completed in some places such as in Nayapati, Sindhupalchowk.

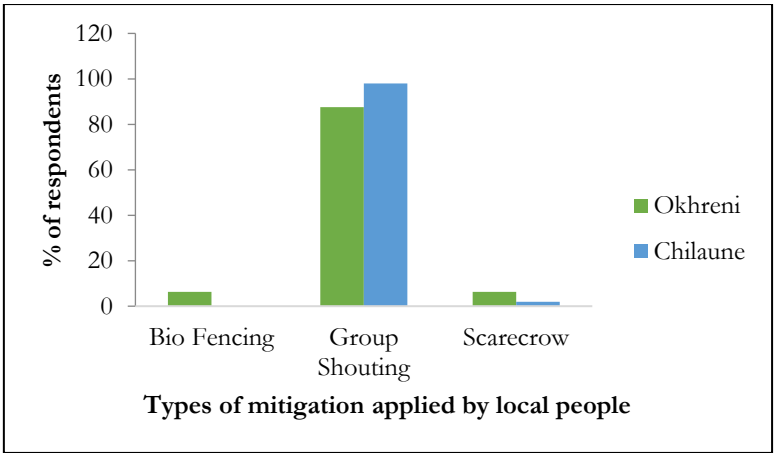

Figure 11. Types of mitigation measures adopted by respondents

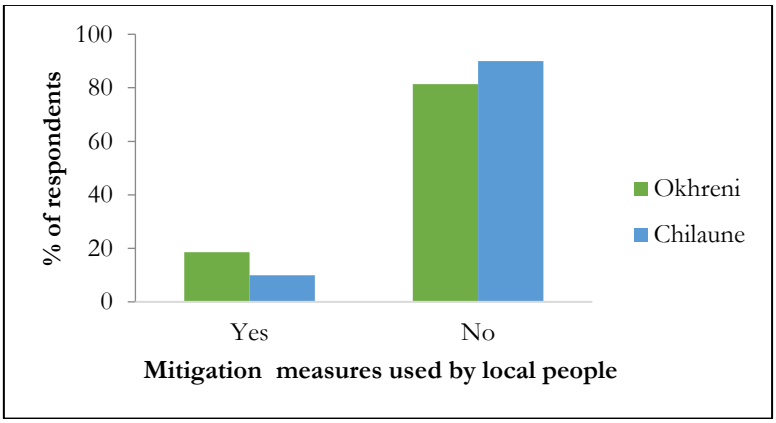

Figure 12. Respondents adopting mitigation measures

Conclusions

The cases of HWCs have been increasing in recent years in SNNP. Wild boar was the most problematic animal species involved in HWC with crop depredation as the most prevalent impact. Maize was the most affected crop in the area. Animal's search for food; higher density of animal species attributed to Protected Areas and distance between the forests and human settlements were the likely factors causing HWC in SNNP. Lack of incidences of livestock depredation, human injuries or fatalities may be attributed to the type of animal species present in the Park. These factors coupled with peoples' awareness about the significance of wildlife could be the probable reasons for positive attitude towards wildlife and wildlife conservation in the SNNP buffer zone.

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Author Contributions: PP: Questionnaire survey, MS preparation; MR: Questionnaire survey, MS preparation; SG: Conceptualization, data analysis, MS preparation, revision; NR: Questionnaire preparation, data analysis, MS preparation.

Conflict of Interest: The authors declare no conflict of interest.

Data Availability Statement: The data of this study are available from the corresponding author, upon reasonable request.

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