Understanding the Dynamics of Human–Wildlife Conflicts in North-Western Pakistan: Implications for Sustainable Conservation

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Abstract: The high economic costs of human–wildlife conflicts (HWC) hinder long-term conservation successes, especially in developing countries. We investigated HWC by interviewing 498 respondents from 42 villages in Nowshera district, Pakistan. According to respondents, six species—the common leopard (Panthera pardus), grey wolf (Canis lupus), golden jackal (Canis aureus), red fox (Vulpes vulpes), Indian porcupine (Hystrix indica), and wild boar (Sus scrofa)—were involved in livestock predation and crop-raiding. Livestock predation (N = 670) translated into a total annual economic loss of USD 48,490 across the 42 villages, with the highest economic loss of USD 57.1/household/year attributed to the golden jackal. Crop damage by wild boar and porcupine incurred a total annual economic loss of USD 18,000. Results further showed that livestock predation was highly affected by location, prey type, prey age, and herding practices, while cereals and vegetables were preferred crops for wild boar and Indian porcupine. The grey wolf was declared as the most dangerous carnivore, followed by the golden jackal and common leopard. Negative attitude about golden jackal and wild boar prevails among 90% of the respondents of the study area. We strongly assume that the abundance of apex predators can control the economic impacts of meso-carnivores and wild boar on the community’s livelihood. Keeping relatively smaller herds may reduce carnivore attacks and educating the populous and compensation can minimise negative perceptions of HWC. To reduce HWC in the study area, there should be an incessant and timely coordination between wildlife officials and the local community.

Keywords: human-wildlife conflicts; Canis aureus; Sus scrofa; economic losses; livestock predation; crop damage; Nowshera; Pakistan

1. Introduction

Humans have dominated landscapes in the past two centuries, and almost every ecosystem on Earth is influenced by human activities [1,2]. Over the past two centuries, anthropogenic activities have undeniably transformed the planet Earth and started an Anthropocene era [3]. These transformations include various activities that vary substantially in intensity and consequences [2]. Of 40–50% of Earth’s surface transformation by humans, 10–15% is allocated for different land-use types such as urbanisation, agriculture, and irrigation, while an additional 6–8% has been converted into pastures [2]. All the activities...
mentioned above ultimately and actively result in human encroachments into wild habitats. Nearly 13% of the Earth’s surface constitutes the global network of protected areas that provides the “last stand” for several threatened and endangered wild species [4]. However, in most developing countries, many wild animals inhabit the landscapes beyond the protected areas, where they are frequently confronted with local communities [5,6]. Such encounters between humans and wildlife give rise to human–wildlife conflicts (HWCs).

HWC usually happens when the needs and behaviours of wildlife negatively impact human aims, or when human aims negatively impact wildlife needs [7,8]. HWC is assumed to be directly proportional to the human population [9]. Its intensity and complexity upsurge with an increase in urbanisation and reduction in green areas that are potential wildlife habitats [10,11]. A wide range of wild species come into conflict with humans [6,12], the impacts of which are grievous and best documented in the case of large mammals [5,13,14]. The visible and common impacts of HWC around the protected areas include crop damage, livestock predation, and attacks of wild animals on humans [4,15–17]. In addition, other impacts such as animal–vehicle collisions (AVC), property intrusions, damage caused by wild animals to cars, buildings, and other properties also exist but more frequently in urban areas [17,18].

The problem of HWC exists globally, yet comparatively, it is more severe in developing parts of the world, such as Asian and African countries [19–23], where a large human population depends on agriculture and livestock. The communities that rely on agriculture may lose up to 10–15% or even more of their total agriculture output to wildlife [20,22]. At the national level, such losses may seem insignificant. Yet, they cause exponentially high costs for the affected families and individuals, many of whom are amongst the least prosperous people in the world [4]. In addition, high rates of human mortalities occur in these developing countries due to wild animals attacks on humans [20,21,24–29].

Livestock predation by wild carnivores results in significant economic losses for the poor pastoral communities across the world, including Pakistan [30–34]. Any kind of livestock including cattle, goats, sheep, equines, and poultry can fall prey to wild carnivores [35]. Pakistan is an agricultural country [36] where livestock is a key sub-sector of agriculture and accounts for 37.5% of agriculture values addition and about 9.4–23.3% of Pakistan’s gross domestic product (GDP) [37–39]. Pakistan has a vast variety of livestock breeds including cattle, goats, sheep, equines, camels, and poultry, which are well adapted to the local climatic conditions [37]. The majority of national livestock herd structures are distributed in small units throughout Pakistan; however, the trend of keeping medium (7–20 animals) and large-size herds (>20 animals) has been increasing in recent years [37]. In the case of small ruminants in Pakistan, there is a general trend of keeping larger herds (>100–200 animals/herd) [37]. In Pakistan, most of the livestock herds freely graze in pastures and forests, thus frequently encountering wild carnivores and becoming easy prey for them [40]. In most cases, the affected communities are even unable to identify the real culprit, aggravating their hate toward the wildlife in general [4,41,42]. Locals’ hostile attitudes result in the retaliatory killing of wildlife using different methods, including poisoning, shooting, or hunting [40]. All these aforementioned human actions depend on people’s tolerance of damaging species [43]. Thus, conservation in the 21st century faces a major challenge reconciling human activities with the needs of wildlife inhabiting landscapes with high anthropogenic pressures [4].

Pakistan is a developing country [44] and is home to 10 of 18 identified mammalian orders, reflecting remarkable diversity matching overall trends [45]. Like other parts of the world, issues concerning HWC also exist in Pakistan, yet are among the least documented [40]. Most of the studies published on HWC issues from Pakistan are mainly focused on the northern flanks of the country [32,40,46–53], which are assumed to be the biodiversity hotspots and relatively less human-dominated landscapes [54]. We presume this focus on the northern flanks has kept the rest of Pakistan deprived of investigations on these particular and similar issues, harbouring potential habitats with rich biodiversity [55].
HWC is often localised in specific spatial-temporal situations [56]. Yet, very little is known about how these interactions occur in human-dominated landscapes [18]. It is assumed that human-dominated landscapes often serve as hotspots or blackspots, with a higher occurrence of HWC events [57,58]. We selected the Nowshera district of Kyber Pakhtunkhwa (KP) Province, Pakistan, for this study because (1) this district harbours rich biodiversity [59] and (2) no such study has ever been conducted in study area. In the Nowshera district, about 7% of households depend on livestock (https://www.pbs.gov.pk/content/pakistan-livestock-census-2006, accessed on 3 September 2021). Keeping in view the human-dominated landscape of Nowshera district and its rich biodiversity, we presume that this area harbours hidden HWC at relatively large scales. These reasons provided great motivation for this study; hence, the first study objective was to assess and understand the dynamics and magnitude of HWC, and secondly, to suggest recommendations for mitigations of HWC in the area. We assume that this study will provide baseline information about HWC in North-Western Pakistan and serve as a gateway for further research in the study area and the country.

2. Materials and Methods

2.1. Study Area

The current study was conducted within the Nowshera district (34°0’55″ N, 71°58’29″ E) of KP Province, formerly known as the North-West Frontier Province of Pakistan. Nowshera district encompasses an area of 1748 km² and is divided into 47 union councils (UC). In terms of area, Nizampur is the largest UC, while Pabbi is the smallest. In the east, Nowshera district is bordered by the Attock district of Punjab Province. This district shares its borders with Sawabi district in the northeast, Mardan district in the north, Charsadda district in the northwest, Peshawar district in the west, and Kohat district in the south (Figure 1). Nowshera district harbours an undulating landscape with elevation ranging 234–1534 m above sea level (a.s.l) [59].

2.1.1. Climate

Nowshera district has a local steppe or semi-arid climate, with an average annual temperature of 24.4 °C and average annual rainfall of 532 mm. The coldest month is January, with an average monthly temperature lower than 10 °C, while June is the warmest month, with an average monthly temperature rising to 33.6 °C. In areas such as Cherat with higher elevation (1534 m a.s.l) and occasionally receiving mild snowfall, the winter temperature drops below 0 °C [59].

2.1.2. Flora and Fauna

Nowshera district harbours rich biodiversity. Protected areas within the Nowshera district include Manglot Wildlife Park (MWP), Nizampur Wildlife Park (NWP), and Cherat Wildlife Park (CWP). In addition, seven game reserves (GRs) are present in this district, including Nizampur GR, Maroba GR, Shamshatoo GR, Mohib banda GR, Bakhtai GR, Kotli GR, and Miangan GR; the last four are community game reserves. The habitat in these areas is broad-leaved evergreen scrub forests. The dominant plant species are *Olea ferruginea* (Olive, Zaithoon), *Acacia modesta* (Phulai), *Vachellia nilotica* (Kikar), *Zizyphus mauratiana* (Ber), *Monotheca buxifolia* (Gurgurah), *Dodonaea viscosa* (Sanatha, Gharahsky), *Adhatoda viscosa* (Baza), *Rhazya stricta* (Gandeer), *Saccharum munja* (Kana), *Cynodon dactylon* (Kabbal), *Cenchrus ciliaris* (Dhaman), *Cymbopogon jawarancus* (Spin wakha), and *Themeda anathera* (Mita gass). So far, 18 wild mammal species have been reported in Nowshera district, including notable species such as *Panthera pardus* (Common leopard), *Canis lupus* (Grey wolf), *Canis aureus* (Golden jackal), *Vulpes vulpes* (Red fox), *Sus scrofa* (Wild boar), and *Hystrix indica* (Indian porcupine) [59,60].
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2.2. Questionnaire Survey
The current study was conducted within the Nowshera district from 1 March 2021 to 20 June 2021, using semi-structured questionnaires (Supplementary Materials). Overall, 498 randomly selected households within whole population were interviewed from 42 villages. In HWC studies, the questionnaire surveys are considered as a key tool to collect information about the presence, perception, and tolerance of local communities toward the wild species of that particular area [61–63]. The current study assumed to interview only male participants because only males are involved in outdoor activities concerning livestock grazing and agriculture in our study area. On the other hand, females mostly stay at home performing household jobs. Moreover, the methodology assumed to randomly select respondents whose age was 18 years or above. Based on the criteria mentioned above, these households represent 0.066% (n = 498) of the total households in the Nowshera district. Respondents in the current study included the herders, farmers, government employees, locals engaged in different businesses, teachers and other professionals, and local hunters of the study area.

Information was gathered regarding household demographics, education, employment, livestock possessions, sightings of wildlife species, conflicts, and perceptions about wildlife. Conflicts with wildlife were categorised into three main categories: livestock predation, crop damage, and attacks on humans. For livestock predation, associated details such as prey type, prey age, season, and location of predation was also recorded using same questionnaires. Attitude toward the wildlife was classified into four categories: increase, maintain, reduce, and eliminate. Similarly, the intensity of wildlife danger for livestock was categorised into five main types: least dangerous, slightly dangerous, moderately...
dangerous, very dangerous, and extremely dangerous. Respondents were asked to assign a number from one to five (low to high) for six mammal species based on threat intensity to their livestock and crops. The status of wildlife species was categorised into common, rare, and absent, and respondents were asked to assign a category to each species. The number of incidences of wild animals’ attacks on humans and the number of wild animals killed were also recorded. Colour-printed photographs of wild mammal species reported from Nowshera district [59] were displayed to the respondents to collect reliable information during the interview sessions [35].

2.3. Analytical Approach

Geographical information system (GIS) ArcMap10.2 was used to develop the study area map. We used descriptive statistics to calculate livelihood status, species status, number of killed wild animals, and economic losses caused by wildlife. All these calculations were executed in Microsoft Excel 2013.

The attitude of locals toward different wildlife species was analysed based on respondents’ education (illiterate, primary, middle, and graduate), occupation, experience with wildlife attacks on humans, crop damage, sighted wildlife species, age, earning members, and livestock owned (Table 1) by using a logistic regression model (LRM). A separate LRM was run for each species. The LRM with the variables used is given below:

\[
\log\left( \frac{Pr(Positive\ Attitude)}{Pr(Negative\ Attitude)} \right) = B_0 + B_1(Education) + B_2(Occupation) + \ldots + B_k(Live\ stock) + residuals
\]  

(1)

where \( B^s \) are the logistic regression coefficients and the exponents of \( B^s \) indicate the odds ratio.

The livestock predation by carnivores in the study area was analysed by fitting the LRM using explanatory variables such as season, location, prey type, prey sex, prey age, guarded (yes or no), and circumstances (grazing or non-grazing) (Table 1). Based on the season of livestock predation by various carnivores in the study area, the season was categorised into spring, summer, winter, and autumn. The location of livestock predation was categorised into forest and non-forest sites. The prey type had sub-categories of cow, goat, sheep, and others. Since the number of sheep killed by carnivores was minimum, for the sake of model fitting, sheep were merged with goats. Prey age was classified into two levels, young and adults (Table 1). Young included all individuals ranging between 1–2 years, while individuals aged two years or above were classified as adults.

To check the effect of different variables on livestock predation, we fitted the following LRM:

\[
\log\left( \frac{Pr(Meso)}{Pr(Apex)} \right) = B_0 + B_1(Season) + B_2(Location) + \ldots + B_k(Guarded) + residuals
\]

(2)

where \( B^s \) are the logistic regression coefficients and the exponents of \( B^s \) indicate the odds ratio.

The crop damage by two wild species, Indian porcupine and wild boar, was analysed using the two explanatory variables, i.e., season and crop type. Season was categorised into spring, summer, winter, and autumn, while the crop types were categorised into cereals (wheat + maize), fruits, and vegetables (Table 1). The LRM with the variables used is given below:

\[
\log\left( \frac{Pr(Porcupine)}{Pr(Wild\ Boar)} \right) = B_0 + B_1(Crop\ Type) + B_2(Summer) + \ldots + B_k(Winter) + residuals
\]

(3)

where \( B^s \) are the logistic regression coefficients and the exponents of \( B^s \) indicate the odds ratio.
Table 1. List of response and explanatory variables used in the logistic regression models.

| Response Variable | Explanatory Variables | Variable Type | Levels |
|-------------------|-----------------------|---------------|--------|
| Attitude          | Education             | Nominal       | Illiterate, Primary, Middle, Graduate |
|                   | Occupation            | Nominal       | Farmer, Employee, Labour |
|                   | Attacks on humans     | Continuous    | n/a    |
|                   | Crop damage           | Continuous    | n/a    |
|                   | Sighted wildlife species | Continuous | n/a    |
|                   | Age                   | Continuous    | n/a    |
|                   | Earning members       | Continuous    | n/a    |
| Livestock owned   |                       | Nominal       | Cattle, Goat, Sheep, Others |
| Season            |                       | Nominal       | Winter, Spring, Summer, Autumn |
| Location          |                       | Nominal       | Forest, Non-forest |
| Prey type         |                       | Nominal       | Cattle, Goat, Sheep, Other |
| Prey sex          |                       | Nominal       | Male, Female |
| Prey age          |                       | Nominal       | Young, Adult |
| Management practices |                   | Nominal       | Guarded, Un-guarded |
| Circumstances     |                       | Nominal       | Grazing, Non-grazing |
| Season            |                       | Nominal       | Winter, Spring, Summer, Autumn |
| Crop type         |                       | Nominal       | Cereals, Fruits, Vegetables |

2.4. Model Selection

Since the above models consider several factors, some may be statistically relevant, and some are noisy. To develop a parsimonious model, we removed noisy factors by using stepwise model selection based on the Akaike information criterion (AIC) (Table 2). The significance level was set at $p < 0.05$. All the models mentioned above were run by using program R version 3.6.3.
Table 2. Final best fitted models selected based on the Akaike information criterion (AIC).

| Model                     | AIC Full Model | AIC Selected Model |
|---------------------------|----------------|--------------------|
| Attitude toward common leopard | 4256.3         | 2217.2             |
| Attitude toward grey wolf  | 3807.8         | 1715.3             |
| Attitude toward golden jackal | 1925.7         | 1073.5             |
| Attitude toward red fox    | 2863.1         | 1625.4             |
| Attitude toward Indian porcupine | 3824.4         | 1007.9             |
| Attitude toward wild boar  | 1634.7         | 873.1              |
| Livestock predation        | 3125.2         | 1047.24            |
| Crop damage                | 942.7          | 324.1              |

3. Results

3.1. Livelihood System in the Study Area

The livelihood of locals in the study area was mostly agro-pastoral, and livestock was one of the main sources of income. Among the respondents, 39.15% were dependent on livestock and agriculture. During the current study, the 498 respondents reported 10,324 livestock (21 livestock per household) owned. Goat constituted about 51% of the total livestock, followed by others (donkey + poultry) with 23%; cattle and sheep constituted about 20% and 6%, respectively.

3.2. Sighting Report and Status

In the current study, respondents reported the sighting of six mammal species in the past two years (2019–2020)—the common leopard, grey wolf, golden jackal, red fox, Indian porcupine, and wild boar—in the study area. The respondents reported the highest average annual sightings for wild boar \((n = 44)\) (individual sightings per respondent), followed by golden jackals \((n = 16)\), foxes \((n = 6.49)\), and Indian porcupines \((n = 4)\). The respondents reported the least sightings for the common leopard \((n = 0.16)\) and grey wolf \((n = 0.37)\) in the study area.

Regarding the status of the common leopard, the majority (54.2%) of locals considered it a rare species while about 45% declared its status absent. Similarly, a large percentage (67.7%) of the respondents declared the grey wolf as a rare species in the area (Figure 2). In the case of the red fox, golden jackal, and wild boar, more than 80% of respondents viewed these three species as common in the area, while in the case of the Indian porcupine, 50.8% of respondents declared it a rare species (Figure 2).

Figure 2. Status of wildlife species in the study area based on respondents’ views.
3.3. Human–Wildlife Conflicts

3.3.1. Livestock Predation and Economic Loss

The 498 respondents of the study area held the carnivore species found in the area accountable for 670 livestock heads during the past two years (\(n = 335\) per year). Among the carnivore species, the golden jackal was held responsible for killing a total of 444 livestock (\(n = 222\) per year). The grey wolf, red fox, and common leopard were blamed for a total of 107 (\(n = 53.5\) annual predations), 90 (\(n = 45\)), and 31 (\(n = 15.5\)) livestock killings, respectively (Table 3).

In the case of the common leopard, the most preyed-upon livestock were cows (\(n = 16\)) and goats (\(n = 11\)), while in the case of the grey wolf, the most favourable prey species were cow (\(n = 43\)), goat (\(n = 32\)), and donkey (\(n = 29\)). The jackal mostly killed goats (392) and sheep (47), while the red fox entirely killed domestic hens (Table 3).

The reported figure of 670 (\(n = 335\) per year) livestock losses constituted an annual economic loss of USD 48,490 (USD 97.4 per household). Of the total economic loss, the golden jackal was responsible for a huge economic loss yearly, equal to USD 28,419 (USD 57.1 per household). At the same time, the grey wolf, common leopard, and red fox were held responsible for yearly economic losses of USD 15,410 (USD 30.9 per household), USD 4481 (USD 9.0 per household), and USD 180 (USD 0.4 per household), respectively (Table 3).

### Table 3. Livestock predation and economic loss due to carnivore species in the study area during the years 2019 and 2020.

| Livestock | Price | Common Leopard | Grey Wolf | Golden Jackal | Red Fox | Total |
|-----------|-------|----------------|-----------|---------------|---------|-------|
| Cow       | 442   | 7072 (16)      | 19,006 (43)| -             | -       | 26,078 (59)|
| Donkey    | 252   | 504 (2)        | 7308 (29) | -             | -       | 7812 (31) |
| Sheep     | 158   | -              | 474 (3)   | 7426 (47)     | -       | 7900 (50) |
| Goat      | 126   | 1386 (11)      | 4032 (32)| 49,392 (392)  | -       | 54,810 (435)|
| Hen       | 4     | -              | -         | 21 (5)        | -       | 380 (95) |
| Total loss| 8962 (31) | 30,820 (107)     | 56,838 (444)| 360 (90)     | 380 (95) | 96,980 (670)|
| Annual loss| 4481 (15.5) | 15,410 (53.5)  | 28,419 (222)| 180 (45)     | 97.4 |
| Per hh/year loss| 9.0 | 30.9 | 57.1 | 0.4 | 97.4 |

Numbers in parentheses represent the number of livestock killed by the carnivore species. hh = household; 1 USD = 158.8 PKR. Unit price for each kind of livestock was confirmed from Livestock and Dairy Development; Department KP (in personal communication).

The wild boar and Indian porcupine species were also blamed for substantial crop damage during the past two years, translating into an economic loss of USD 18,000 (USD 9000 per year, USD 18.07 per household). Wild boars were responsible for about 81% of crop damage, while Indian porcupines were responsible for 19% of crop loss. Most of the crops raided by these two species were cereals and vegetables.

3.3.2. Human Attitude toward Wildlife

The attitude of locals toward wildlife was categorised into four categories: maintain, increase, decrease, and elimination. These four categories were further classified into positive attitude (maintain and increase) and negative attitude (decrease and elimination). In the case of wild boar and golden jackals, more than 90% of respondents possess a negative attitude. They either wanted elimination or a reduction in their numbers. Regarding the common leopard, grey wolf, red fox, and Indian porcupine, more than 60% of the respondents wanted elimination or a reduction in the number of these species in the study area (Figure 3).

The attitude of locals toward wildlife species was analysed using LRM. The analysis shows that locals’ attitudes toward common leopards are significantly affected by their education, sighting of wildlife species (wolf, jackal, and porcupine), and goats owned (Table 4). The LRM analysis indicates that respondents’ attitudes toward the common leopard are more positive with increased education levels. Primary, middle, and graduate respondents have 2.263, 2.266, and 2.549 times more positive attitudes toward the common
leopard than illiterate respondents (Table 4), respectively. With the one unit increase in wolf, jackal, and porcupine sightings, the positive attitude toward leopards decreases by 0.571 ($B = -0.559$, $p = 0.066$), 0.924 ($B = -0.079$, $p < 0.001$), and 0.938 times ($B = -0.064$, $p = 0.04$), respectively. Similarly, the attitude of locals becomes 0.939 times more negative ($B = -0.062$, $p = 0.005$) toward common leopards when related to goat ownership (Table 4).

![Figure 3. The negative attitude of respondents toward mammalian species in Nowshera district.](image)

Table 4. The effect of various socio-economic factors on the attitude of locals toward various wildlife species.

| Factors          | Common Leopard | Grey Wolf | Golden Jackal | Red Fox | Indian Porcupine | Wild Boar |
|------------------|----------------|-----------|---------------|--------|------------------|-----------|
|                   | Odds Ratio     | Coefficient | SD  | $p$ Value | Odds Ratio     | Coefficient | SD  | $p$ Value | Odds Ratio     | Coefficient | SD  | $p$ Value |
| ED: graduate      | 2.549          | 0.936      | 0.49 | <0.001    | 2.420          | 0.884      | 0.49 | 0.006     | 3.105          | 1.133       | 0.52 | 0.03      |
| ED: middle        | 2.266          | 0.818      | 0.38 | <0.001    | 2.183          | 0.781      | 0.39 | 0.048     | 2.266          | 0.827       | 0.42 | 0.05      |
| ED: primary       | 2.263          | 0.817      | 0.38 | <0.001    | 2.038          | 0.712      | 0.38 | 0.063     | -              | -          | -   | -         |
| Sighted grey wolf| 0.571          | -0.559     | 0.66 | -0.079    | 0.581          | -0.543     | 0.3  | 0.074     | -              | -          | -   | -         |
| Sighted golden jackal | 0.924    | -0.079     | 0.09 | <0.001    | 0.927          | -0.075     | 0.02 | 0.001     | 0.922          | -0.081      | 0.03 | 0.001     |
| Goat              | 0.939          | -0.062     | 0.02 | -0.062    | 0.939          | -0.062     | 0.02 | 0.006     | 0.933          | -0.069      | 0.02 | 0.004     |

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**Table 4.** The effect of various socio-economic factors on the attitude of locals toward various wildlife species.
Regarding the grey wolf, the attitude of locals becomes more positive with an increase in education. The LRM shows that the attitude of graduate respondents is 2.420 times more positive (B = 0.884, p = 0.069) compared to illiterate respondents. The attitude of locals becomes negative with the one unit increase in wolf, jackal, and porcupine sightings (Table 4). Similarly, the attitude of locals becomes 0.939 times more negative (B = −0.062, p = 0.006) toward common leopards when related to goat ownership (Table 4). Similarly, the attitude of locals toward golden jackals increases positively with an increase in education. The attitude of respondents becomes negative toward golden jackals when related to golden jackal sightings (0.922 times negatively) and goat ownership (0.933) (Table 4).

The attitude of respondents regarding foxes is significantly affected by two factors: education and sightings of red foxes. The attitude of graduate locals is 3.792 times more positive compared to illiterate respondents, while the attitude becomes 0.677 times more negative when the respondents sighted fox (Table 4). In the case of Indian porcupine, the attitude of respondents becomes positive with an increase in education. The attitude of middle and graduate respondents was 2.415 and 3.031 times more positive than illiterate respondents, respectively. The attitude of locals becomes negative when the attitude of respondents was related to porcupine sightings (0.843) and goat ownership (0.954) (Table 4). In the case of wild boar, locals’ attitudes were affected by sightings of golden jackals, red foxes, damaged crops, and other factors.

3.3.3. Perceived Danger

Respondents had mixed views about the perceived danger of wildlife for livestock and crop damage. The grey wolf was rated to be the most dangerous (average score 4.3), followed by golden jackal (4.0), common leopard (3.6), red fox (2.2), wild boar (1.0), and Indian porcupine (0.9) (Figure 4).

![Figure 4](image-url) The danger of mammals perceived by respondents in Nowshera district. Perception is ranked from 1–5 (least dangerous to most dangerous). Note: Standard deviation is shown on the bars.

The LRM analysis shows that the predation of livestock by carnivores was highly affected by the location where livestock predation occurred, prey type, prey age, and whether livestock was guarded or not (Table 5). Similarly, livestock predation occurred 2.373 times more in non-forested areas than in forested areas. The analysis also indicates that goats are most vulnerable to carnivore predation. The predation of goats occurred 8.23 times more than other animals (Table 5). The LRM also shows that young livestock
is 2.623 times more vulnerable to predation than adult livestock, and that livestock is 12.395 times more vulnerable to carnivore predation when guarded.

Table 5. Livestock predation by meso and apex predators as a function of circumstances in the study area. Coefficient represents estimates of parameters, retained by top LRM model.

| Factors    | Levels    | Odds Ratio | Coefficient | SD   | p Value |
|------------|-----------|------------|-------------|------|---------|
| Location   | Non Forest| 2.373      | 0.864       | 0.377| 0.022   |
| Prey type  | Goat      | 8.23       | 3.037       | 0.347| 0.000   |
| Prey age   | Young     | 2.623      | 0.964       | 0.368| 0.009   |
| Guarded    | Yes       | 12.395     | 2.517       | 0.608| 0.000   |

The LRM estimates show that irrespective of the season, cereals and vegetables were more prone to wildlife attacks, as shown in (Table 6).

Table 6. LRM estimates retained top models for crop damage inflicted by wildlife in the study area.

| Factors    | Levels   | Odds Ratio | Coefficient | SD   | p Value |
|------------|----------|------------|-------------|------|---------|
| Crop type  | Cereal   | 0.031      | −3.468      | 1.012| 0.001   |
|            | Vegetable| 0.100      | −2.306      | 1.135| 0.042   |

3.3.4. Consequences of Human–Wildlife Conflict

HWC has consequences both for human and wildlife species in the study area. In the past two years, the respondents reported a total of nine wildlife attacks on humans. Respondents reported wild boar in eight attacks, while a golden jackal was found in a single attack. Serious injuries were reported as a result of these attacks, but none of the attacks were fatal. HWC also has consequences for wildlife species. The locals reported a total of 468 (\( n = 234 \) per year) wildlife kills in retaliation to livestock predation, crop damage, and attacks on humans. Wild boars were killed in greater numbers (65.7%), followed by golden jackals (23.7%), red foxes (4.6%), Indian porcupines (4.3%), grey wolves (1.3%), and common leopards (0.4%).

4. Discussion

The current research is the first-ever large-scale study of HWC in North-Western Pakistan. The first and very important step in designing robust and effective mitigation strategies for HWC is to identify the key drivers of HWC locally [53]. Livestock predation causes economic loss for rural communities, largely dependent on livestock as a part of their livelihood. In the study area with an average herd size of 21, predation caused an economic loss of USD 97 per household/year. According to the Household Integrated Economic Survey of Pakistan (HIES 2018–19), the average annual income of rural households in KP province is USD 2580, with an average household size of 7.6 in Nowshera district (https://www.pbs.gov.pk/, accessed on 6 September 2021), where livestock predation losses constitute about 3.8% of their annual income. Given the low income and poverty prevailing in agro-pastoral communities, this is a substantial loss to farming households. Species inventory shows that different species of carnivores are present in the study area [59], contributing economic losses by predating on livestock, and were also sighted by local farmers. The detection and reporting of carnivore species engaged in livestock predation are affected by factors such as forest cover, terrain, and topography of the area [64]. Our study area is mostly covered with broad-leaved scrub vegetation, which may cause a low sighting rate for different species. Keeping in view the habitat potential and undulating topography of the study area [59], we assume that in such habitats, it becomes difficult for the herders to properly manage larger herds to minimise predation by carnivores [64].

Our results show that the number of livestock killed by golden jackals is far greater than that of the common leopard and grey wolf, although the latter are both large carnivores.
The golden jackal is a medium-sized canid that lives in packs of 3–6 and is flexible and adaptable [65–67]. They can only hunt small-bodied prey; in our case, mostly sheep and goats fell victim to jackals. The golden jackal was ranked as common species in the area and was the most sighted carnivores by the respondents, reflecting its abundance, and, hence, was reported to have the highest predation rate of the species. In a particular ecosystem, apex predators’ absence or low density is considered the relaxation in the suppressive top-down bottom effects, thus facilitating the abrupt and exponential growth of meso-carnivores [68]. In other areas of Pakistan, golden jackals are associated with the highest predation rates after the common leopard [47]. Only common leopards and grey wolves were reported to prey on large-bodied animals. At the same time, most of the livestock killed consist of goats and sheep, indicating that livestock of medium and small size are easy prey for carnivores [23,40,47]. Wolves are held responsible for more livestock losses than other large carnivores where they co-occur [69,70]. Moreover, wolves also live in social groups, increasing the need to kill more livestock to meet dietary needs than the solitary common leopard. Our results indicate that the livestock predation rate was lower in the study area with less than one livestock killed per year per household compared to other reported studies such as [40] and [46], which reported a loss of 1.85 and 1.74 livestock per household per year, respectively.

Carnivores are an integral part of the ecosystem. Their involvement in livestock predation is one factor accelerating HWC, while the expanding human population and growing needs contribute in most cases [71,72]. In the current study, the predation rate was 2.273 times higher in non-forested areas than in forests. The non-forested area was classified as villages and surrounding open fields and meadows used as grazing ground for livestock. Interestingly, this was a novel trend observed in contrast to other existing conflict studies carried out in Pakistan [23,35,40,46]. The reason for this pattern is the open and weakly-built pen structures constructed in villages at a reasonable distance from human settlements for hygiene purposes, ideal for predators to enter, resulting in surplus killings [35].

The most predated type of livestock was goat, and its killing rate was 8.23 times higher than other livestock in the study area. There is a general trend of small ruminants being more prone to carnivores than large ungulates, owing to their small body size, making it easy to kill and drag them to a safe distance for consumption [23,40]. Usually, herders keep many goats in their herds due to their high value in the meat market compared to other livestock. Moreover, goats are more agile than sheep and cows and grazed in far-off grazing grounds. Predominantly, the herds in this study were mixed, including young and adult animals. Young animals are more vulnerable to predation, and a similar trend was observed in this current study. Usually, the young ones from the herd are separated and kept in pens while adults are let loose for grazing [35,40], which can possibly minimise predation by wild carnivores. Active guarding of livestock is essential to keep carnivores at bay and to ensure minimum losses by large carnivores [73]. The losses in guarded situations were 12.395 times higher than non-guarded circumstances and this was a novel trend observed in this study, contrary to others studies conducted in northern Pakistan [35,40]. The reason may involve some underlying factors and needs further investigation for better understanding. However, this notion predicated on the indigenous knowledge of shepherds suggests that livestock tends to cover larger areas under human watch during grazing activity and are thus more prone to fall prey to carnivores as compared to unguarded practices, where they prefer to be around pastures close to human settlements.

Of all the species reported in the current study, wild boar and porcupines were also key drivers of HWC because of crop-raiding. Our results declared wild boar as the primary crop raider in the study area, causing four times (81%) more damage than porcupines (19%). In many parts of the world, wild boar has been identified as the key driver of HWC in crop-raiding [74–76], damaging a wide variety of crops, including cereals, vegetables, and fruits [77]. Our results further indicated that although wild boar raided almost all crops, i.e., cereals, vegetables, and fruits (melons) available in the study area, the major damage
was recorded for cereals (maize and wheat) and vegetables. Similar results have also been reported from other parts of the world [77–83]. We assume that such high damage of cereals (maize and wheat) and vegetables by wild boar is because these are the major crops grown in the study area (http://kpboit.gov.pk/nowshera-district/, accessed on 7 August 2021). Such high rates of crop damage can be attributed to the exponential increase in the wild boar population in the study area. We assume that the wild boar population in the study area is increasing numerically and expanding geometrically because (1) wild boar are not hunted for meat or trophy because of strict religious prohibitions—this immunity has favoured the exponential increase in the wild boar population across the current study area and in whole Pakistan [59]—and (2) decreased or limited numbers of apex predators in the study area. Our results also indicate that wild boar is one of the species that can arise hostile attitudes of the community toward wildlife in general (Figure 3).

As a large rodent pest, porcupines destroy a wide range of wild and cultivated plants and agriculture crops, devouring both surface and subsurface vegetation at any growth stage [84]. As per the respondents’ views, porcupines in the study area mainly raided maize and vegetables and ate tree barks, thus causing a substantial economic loss of USD 3420 to the communities. The same results have been reported from the neighbouring Attock district and other parts of Pakistan [85,86].

Understanding local community attitudes toward wildlife is critical for making context-sensitive conservation planning and management decisions that may facilitate better human–wildlife co-existence [87]. In our study area, the attitude of locals toward wildlife species (mostly involved in the conflict) is affected by many factors, e.g., level of education, sighting of wildlife species, crop damage, and livestock owned. The LRM was run to link the locals’ education level and attitude. The analysis shows that locals’ attitudes become positive with an increase in education, and vice versa. Education plays an important role in changing locals’ attitudes toward wildlife [40]. According to a study conducted by [88], respondents with primary or secondary school education are more tolerant toward damaging species than the illiterate respondents. The attitude of locals in the study area also became negative with the sighting of damaging species. The sighting of wildlife species may cause unacceptability for wildlife among locals due to livestock predation by carnivores and crop damage by wild boar and Indian porcupine. As a result, their acceptance levels may change negatively with sightings. It is widely acknowledged that livestock predation and crop raiding by wildlife are major reasons of economic losses [41], thus causing the attitude of locals toward wildlife in general to be negative. In some cases, the presence of large predators may produce thoughts of fear in most of the peoples, while others may feel encouraged to confront the danger [89], which results in negative attitudes and killing of wildlife. The locals’ attitude is also highly negative toward damaging species if the species have no economic benefits for local communities, e.g., trophy hunting. Sport hunting has been acknowledged for promoting the protection of wildlife resources as well as both ecological and economic sustainability [90]. Thus, we assume that sport hunting of wild boar with some incentives for the local community may be helpful. The economic benefits thus generated could be used to compensate some of the losses, and the practice will also control the expanding population of the pest species.

Economic losses caused by livestock predation and crop damages lead to retaliatory wildlife killings, particularly in underprivileged communities [33,71,91]. In many cases, livestock predation is a major driver of carnivore persecution [92,93]. The issue is exacerbated when livestock predation is coupled with fear for personal safety, resulting in a strong negative attitude. The current study unveiled the killing of 468 wild animals. Wild boar, golden jackals, and Indian porcupines are declared as pest animals which can be hunted according to schedule first, Part V of the Khyber Pakhtunkhwa Wildlife and Biodiversity (Protection, Preservation, Conservation and Management) Act, 2015. According to schedule first, Part IV, grey wolves can be hunted by acquiring a big game hunting permit. The common leopard is declared as protected animal under schedule third, Section 2(zz) of the same act. The protection level for the red fox is not stated (http://kpwildlife.com.pk/, accessed
on 6 September 2021). We assume that such relaxations in the protection laws may have contributed to the killing of a very high number of wild animals. Further understanding of socio-ecological factors may help in devising strategies to cope with the issue. Different approaches are suggested, including establishing protected areas, providing economic incentives and compensation schemes, and focused conservation education according to the situations and needs [12,31,94,95] to change the local attitudes toward wildlife.

5. Conclusions

Our results showed that Nowshera district harbours extreme levels of human–wildlife conflicts, and this needs serious consideration. HWC arising from livestock predation and crop damage is a major issue impacting the livelihood of the local communities and threatening the survival of wildlife in the study area. Management strategies based on empirical studies are needed to resolve the issue. Based on the results obtained in the current study, we strongly assume that low density and absence of top predators may have led to an abundance of meso-carnivores and other nuisance species [68,96–98], which are causing damages to the livestock and crops. These species cause a substantial loss to the average annual household income. Current livestock management practices need further studies, and better livestock management in terms of keeping manageable herds may decrease livestock predation rates. Enhancing the protected areas network and focused conservation education are among the tools proven effective in other areas. Compensation schemes for livestock predation and crop damages may improve the area’s human–wildlife relations, turning the locals’ attitude toward wildlife more positive. The wildlife department should establish an online or manual repository where locals can report livestock predation and crop damages to be inspected and verified by wildlife officials. We strongly recommend launching awareness campaigns and educating local people about the worth of sustainable conservation of wildlife. Concerned departments and organisations should vaccinate their livestock regularly, and compensating affected families can greatly reduce negative perceptions. Moreover, we also recommend studies concerning population dynamics of both the predator and prey species in Nowshera district.

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