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Long-Term Trends, Seasonality, and Spatial Patterns of Human Casualties from Sloth Bear Attacks in Chitwan National Park, Nepal

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Abstract

The sloth bear (*Melursus ursinus*) is both ecologically important and among the most feared wildlife species in southern Nepal. Despite this, long-term patterns of human–sloth bear conflict have not been well documented. This study assessed the annual, seasonal, and spatial patterns of human casualties resulting from sloth bear encounters in Chitwan National Park, Nepal. Verified incident records from 1999 to 2025, along with household surveys of 100 households, were used to describe trends and patterns in human-sloth bear interactions. Over 27 years, 196 human casualties were recorded, including one fatality. Annual casualties ranged from 1 to 29 and demonstrated a significant downward trend according to the Mann–Kendall test. Negative binomial regression, accounting for overdispersion, estimated an annual decline of 4.47% ($p = 0.0012$). Casualties were unevenly distributed seasonally, with winter (36%) and spring (32%) accounting for most casualties. Spatially, conflicts were recorded in 15 of 22 buffer zone user committees, with more than half occurring in the southwestern sector, particularly in the Madi Valley. Household surveys indicated that most encounters involved forest- and agriculture-dependent communities and frequently occurred while people were walking or undertaking forest activities. Most human sloth bear conflict incidents involved single bears, although mother–cub groups accounted for 31% of encounters. Despite the declining long-term trend, conflict remains spatially and seasonally concentrated. These findings provide a baseline for targeted conflict prevention, community safety measures, and long-term sloth bear conservation in Nepal.

Keywords: bear; human wildlife conflict; human bear co-existence; chitwan national park; conservation

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1. Introduction

Humans and wildlife proximity has increased over the years, particularly due to a growing human population and the associated loss and degradation of natural habitats. Effective conservation of threatened species and the well-being of people depend on the successful coexistence of people and wildlife [1,2]. However, human settlements are increasingly becoming conflict hotspots [3], creating costs for both people and wildlife. HWC arises when people and wildlife interact to fulfill their overlapping requirements for resources, leading to fear, injuries, loss, and damage to life and property. Human casualties

are higher and represent a severe form of conflict, particularly in rural wildlife-rich areas, where human and wildlife co-occur [3,4].

The sloth bear (*Melursus ursinus*) is one of three bear species found in Nepal (along with the Himalayan Black Bear and the Tibetan Brown Bear). It occurs in low-elevation national parks and some unprotected forest patches, particularly in Churia (Siwalik) landscape [4–7]. Evolutionarily adapted for myrmecophagy, the sloth bears are known to forage near human-dominated landscapes, particularly for cultivated crops and sometimes for waste and leftovers [8–10]. The risk of human-bear encounters is higher in landscapes where humans and bears compete for resources on the same land. Sloth bear attacks on humans have been recorded from forest [11] as well as agricultural fields in India [10]. Attacks by sloth bears vary by season and region and are often associated with human activity during those periods [12,13]. Despite being considered among the most unpredictable and feared wildlife species in Nepal [14], the dynamics of human-bear conflict remain unexplored.

High wildlife abundance and diversity, combined with high human density, make Chitwan National Park (CNP) and its surrounding buffer areas a prime location for human-wildlife encounters. The majority of people living near the park depend on agricultural, forest, and livestock-based livelihoods and often trespass on park boundaries to meet their resource needs. Wildlife such as sloth bears venture outside the park boundaries, often to forage or due to displacement in intra- and interspecific competition. This overlap in resource needs has led to human-wildlife conflicts since the park's establishment in 1973. To address this park-people conflict, the buffer zone program was introduced through the Buffer Zone Management Regulation, 1996. The core area of CNP is surrounded by a 729.37 sq.km formally designated buffer zone. Buffer zones provide an institutional framework for community participation in protected-area management and human–wildlife conflict mitigation. A buffer zone is an important area that acts as a transition between two different types of land uses, i.e., the land dedicated solely for wildlife and nature, and a multiple-use land area, both for people and wild animals. Buffer zones provide essential natural products and services to local people and serve as a foraging habitat for wildlife. Community institutions are organized into a three-tier structure under the Buffer Zone programs. User Groups are organized at the village level. Representatives from these village-level user groups come together to form a Buffer Zone User Committee (BZUCs). Chairpersons of each BZUC come together to form a Buffer Zone Management Committee (BZMC), which is the apex body representing communities around the park. In Chitwan, the buffer zone comprises 1891 User Groups and 22 BZUCs. The user committees are authorized to plan and implement conservation and community development programs. The majority of BZUC's land area (46%) is used for agriculture and settlement, while the remaining area consists of forests, tall grasslands, and water bodies, which are often used by wildlife. The BZUCs also play an important role in human–wildlife conflict management by facilitating communication between affected households, communities, and park authorities, and by verifying and recommending eligible wildlife-damage cases for compensation. To manage the park and its buffer zone more efficiently, the area is split into four administrative sectors: Madi in the South, Amaltari in the West, Kasar in the north, and Sauraha in the east (Figure 1). This institutional and spatial arrangement provides an important context for understanding the reporting, verification, and management of sloth bear conflict around CNP. However, the success of buffer zone programs has been questionable, as a sizeable portion of residents are unaware of its details and do not feel it is effective at addressing human-wildlife conflict [15]. Studies show that local people around the parks still face a high cost of conflict with wildlife in forms of human injuries, livestock loss, crop damage, and loss of life and property, particularly involving large mammals such as elephants, rhinos, tigers, and leopards [16–21].

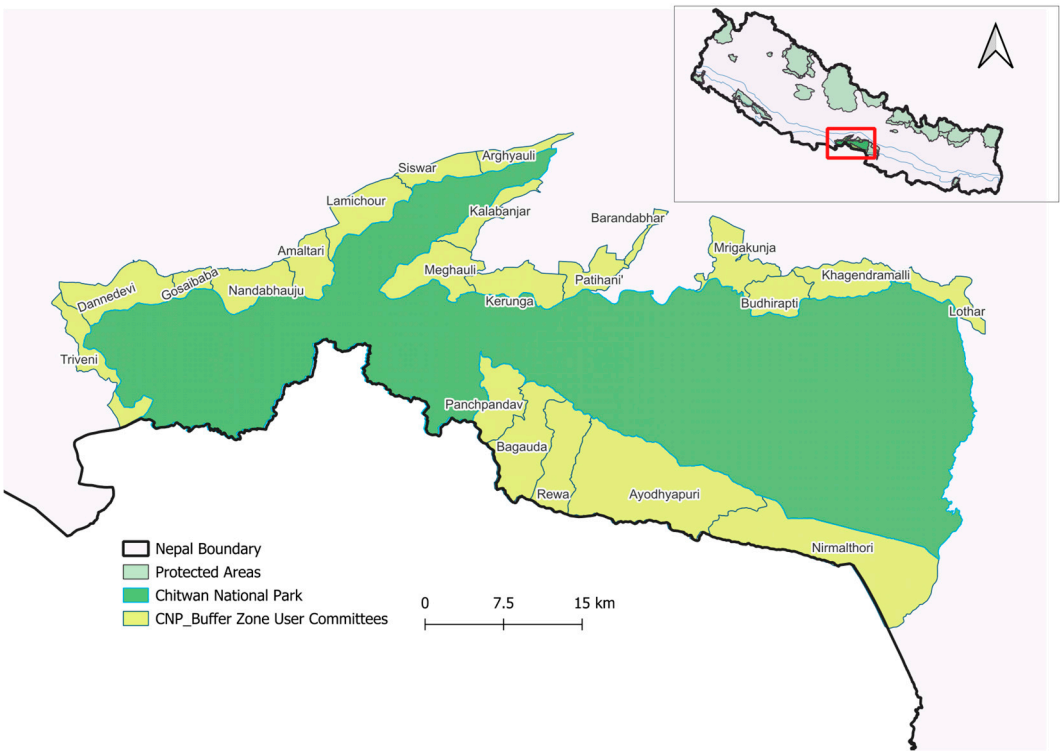


Figure 1. Chitwan National Park and its buffer zone user committees.

An effective coexistence strategy relies on a solid understanding of when, where, and why conflicts occur. Such evidence needs to be species-specific, as considering multiple conflict-causing species collectively can obscure trends and strategies for coexistence. Although sloth bear attacks are less frequently fatal than those of some large carnivores and megaherbivores, they can cause severe injuries, which may contribute to lifelong psychological distress and negative perceptions among locals toward bear conservation. An increase in human bear conflicts, inflicting costs to humans, can increase negative perceptions among victims and their community, trigger retaliatory killing, and augment locals' support for wildlife crime. In addition, high-conflict incidents may require park authorities to remove or translocate the conflict animals to new areas. Disregard for human bear conflict thus poses a challenge to park management and community-based conservation initiatives for which Nepal has been recognized. In this context, we analyze the annual count of human-sloth bear conflicts using available data from the past 27 years in CNP and household surveys to reveal patterns from the household surveys. Specifically, our objectives were to (i) quantify trends in human-sloth bear interactions over a 27-year period, (ii) analyze the seasonality and geographic distribution of human casualties from sloth bear conflict incidents, and (iii) characterize the socio-ecological contexts of encounters using household surveys. We tested the hypothesis that human-sloth bear conflict would remain similar over the years and uniform across seasons.

2. Materials and Methods

This study was conducted in Chitwan National Park (Figure 1). It is situated within the floodplains of the Rapti, Reu, and Narayani rivers in south-central Nepal. The local macroclimate is predominantly driven by the summer monsoon, with ambient temperatures ranging from a summer maximum of 38 °C to a winter minimum of 6 °C and a mean annual precipitation of 2400 mm [4]. This intricate matrix of heterogeneous habitats and varied climatic variables establishes the park as a critical regional biodiversity hotspot.

Consequently, CNP serves as a vital refuge for diverse wildlife assemblages, supporting a spectrum of fauna that extends from megaherbivores, such as the Asian elephant (*Elephas maximus*), to cryptic, threatened small mammals, including pangolins (*Manis* spp.). The park's 952.63 sq.km core area consists mostly of Sal (*Shorea robusta*) forest (73%). Other important habitats in the park consist of tall grasslands (12%), riverine forest (7%), and wetlands (8%). Parsa National Park and Valmiki Tiger Reserve, India, border the park in the east and south, respectively.

Incidents of conflicts and associated losses and damages are verified and recorded by protected area authorities, and relief amount is provided according to approved guidelines [16]. The cost of treatment for injured victims is determined by the supporting medical documentation. We collected the verified incidents involving the death or injury of people caused by sloth bears for the period 1999 to 2025 ($n = 27$ years). We successfully extracted the date, age, and gender; however, full details, including incident month, age, and gender of victims, are available only for recent years. The month of conflict was recorded in 62.75% of records ($n = 123$), and the victim's age was recorded in only 17.34% of official records ($n = 34$). We also conducted a questionnaire survey with the victims or their families ($n = 100$) to obtain details on the characteristics of human-sloth bear encounters. Household selection for the survey was conducted using a snowball approach, in which a list of victims was obtained from the park, and the surveyors consulted BZUC committee members to locate the victims and additional households involved in conflict with sloth bears. Between March and April 2020, we interviewed victims or their adult family members using a structured questionnaire. Verbal consent was obtained for their participation or non-participation in the survey. These interviews provided information on the characteristics of victims, the nature of the conflict, and the behavior of humans and bears during the incidents. This approach relied on asking individuals to recall the incidents to characterize conflicts and understand their perceptions.

We conducted a nonparametric Mann-Kendall trend test to understand the annual trend of conflict. We used the Theil-Sen slope estimator to estimate the magnitude of conflict. The Mann-Kendall trend test checks a monotonic upward or downward trend over time without any assumption for the distribution of data. So, we added a parametric test using generalized linear models (GLMs) with a log link, appropriate for count outcomes, to check for the trend. Poisson regression model was first fit with year as the sole predictor. The ratio of residual deviance (62.9) to residual degrees of freedom (25) exceeded 1, indicating overdispersion in the data so, a negative binomial regression model was subsequently fit to obtain correct standard errors and inferential statistics. The model fit between the Poisson and negative binomial models was compared using the Akaike Information Criterion (AIC). All analyses were conducted in RStudio (2026.04.0 Build 526) using the trend and MASS packages.

Seasons were categorized as spring, summer, autumn, and winter. The winter season was defined meteorologically (December–February, with December attributed to the following year) to align with the biologically relevant cold season rather than the calendar year. The first (2003) and final partial winter were excluded from seasonal comparisons due to incomplete data. We included March, April, and May as the spring season; June, July, and August as the summer season, and September, October, and November as the autumn season. To test whether attack injuries were uniformly distributed among the four seasons (winter, spring, summer, and autumn), we used a chi-square goodness-of-fit test. To visualize the spatial pattern of human-sloth bear conflict, we used the QGIS3.16.8.

3. Results

Between 1999 and 2025, 196 people suffered injuries or fatalities resulting from adverse encounters with sloth bears in the Chitwan National Park (Figure 2). One incident of human death from a sloth bear attack was documented during this study period.

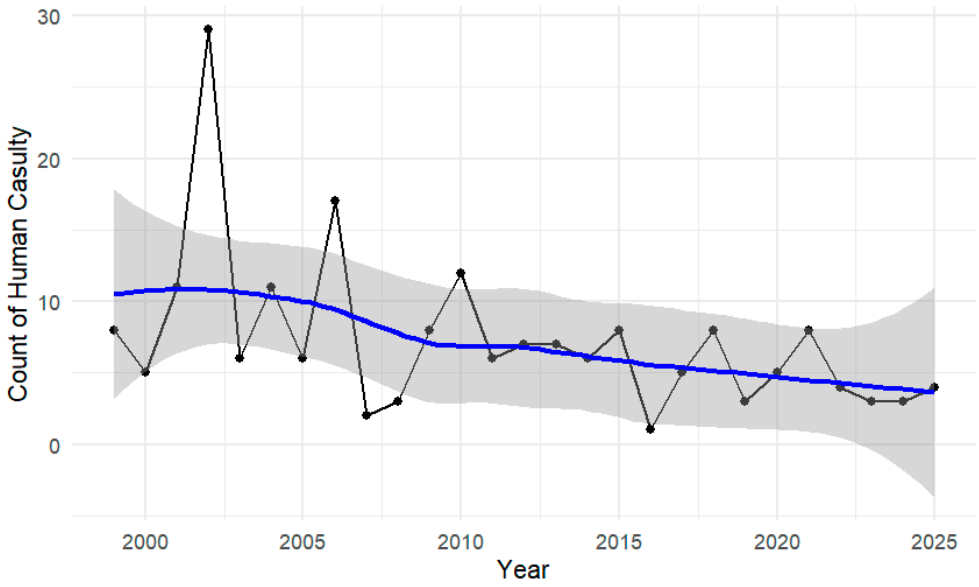


Figure 2. Annual trend of human casualties resulting from sloth bear attacks in Chitwan National Park (1999–2025). The blue line shows a LOESS smoother (span = 0.75, local quadratic fit); the shaded band is the 95% confidence interval of the fitted curve.

3.1. Temporal Patterns of Conflicts

Over the 27-year study period, annual counts ranged from 1 to 29 (median = 6), with two notable high-count years in 2002 ($n = 29$) and 2006 ($n = 17$). The Mann-Kendall test indicated that the trend of human-sloth bear conflict was decreasing over last two decades ($\tau = -0.336$, $S = -113$, $p = 0.018$). The Theil-Sen estimator placed the median rate of decline at −0.21 counts per year (95% CI: −0.38 to 0.00). Mann-Kendall test excluding the two high-count years (2002, 2006) showed a similar declining trend at −0.17 counts/year (95% CI: −0.33 to 0.00) but at a statistically non-significant rate ($\tau = -0.280$, $S = -80$, $p = 0.062$). This finding was also supported by a Poisson regression analysis ($\beta = -0.045$, SE = 0.010, $p < 0.001$, AIC = 165.1, 95% CI: 0.92 to 0.98), which estimated a 4.4% annual decrease in human casualties from sloth bear attacks. The ratio of residual deviance to residual degrees of freedom was 2.73, indicating that standard errors from the Poisson model likely underestimated true uncertainty. Therefore, we fitted a negative binomial model, which showed that the human sloth bear conflict decreased substantially at an estimated annual decline of 4.47% ($\beta = -0.046$, SE = 0.014, $p = 0.0012$; AIC = 150.1). Overall, test results show that human casualties from sloth bears are declining over the study period.

3.2. Seasonal Trend

A chi-square goodness-of-fit test showed that Sloth bear attacks were not uniformly distributed across seasons ($\chi^2 = 15.13$, df = 3, $p = 0.0017$). Most conflict events resulting in human casualties occurred in winter (36%), followed by spring (32%). Human injuries resulting from sloth bear attack were relatively less frequent in the autumn season (16%) and summer (17%) (Figure 3).

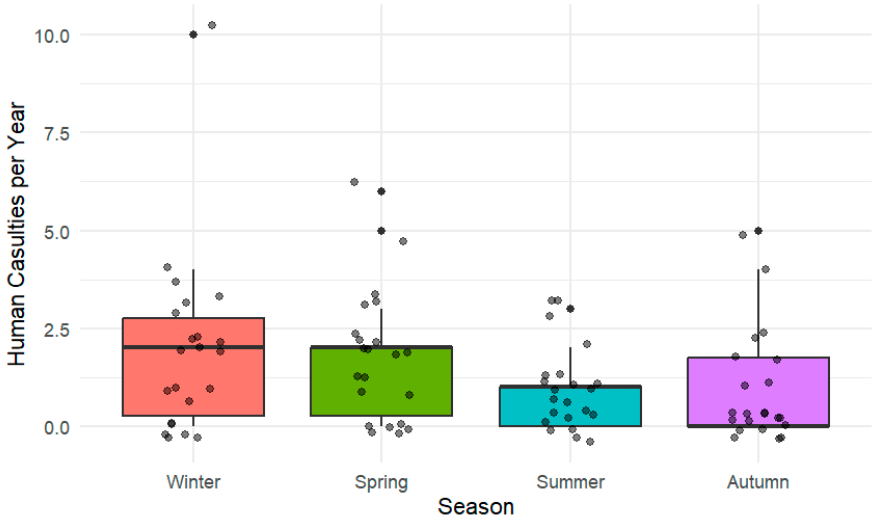


Figure 3. Yearly variability in human casualties from sloth bear attack according to the season.

Overall, 79% of the humans injured in sloth bear attacks during the period were males ($n = 155$). The proportion of females involved in sloth bear attacks was lower than males across all seasons (Figure 4). A relatively higher proportion of female casualties was observed in winter (36%) compared to other seasons. The age-related information of the victims was available in a limited number of official reports of human-sloth bear conflict incidents ($n = 34$). The mean age of the victims involved in the sloth bear attack was 41.2 ± 16.2 years, with a median of 37 years and a range of 16–76 years.

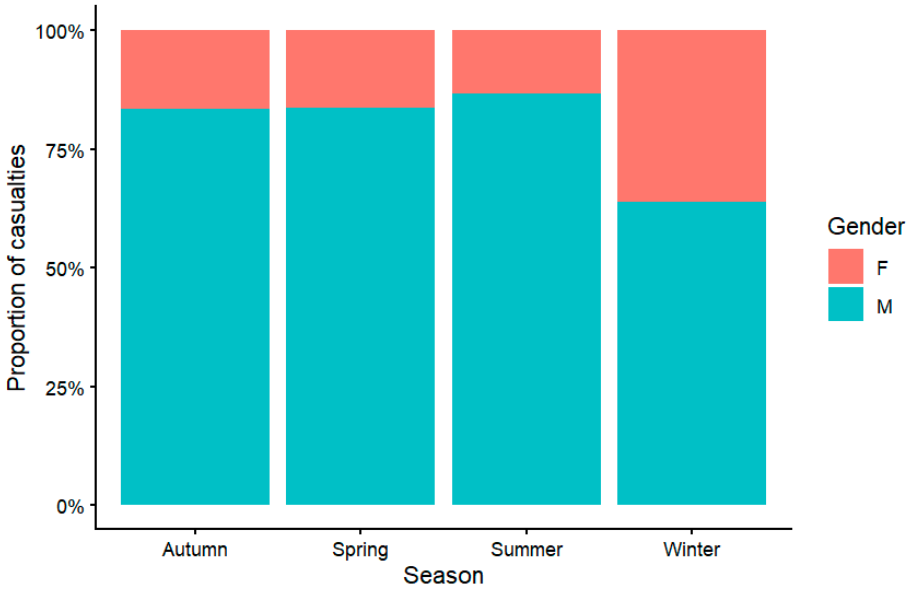


Figure 4. Proportion of males and females getting injured in sloth bear attacks in different seasons.

3.3. Spatial Patterns of Conflicts

CNP has a total of 22 BZUCs, of which human casualties from sloth bear attacks were recorded from the areas of 15 BZUCs. Madi municipality, located in the southwest boundary of the park, was identified as a primary location where the majority of the human casualties (69.9%) from sloth bear attacks occurred. Within the BZUCs, Aayodhyapuri, Panchpandav, Bagauda, and Rewa had the highest count of human-sloth bear conflict. These four BZUCs combined accounted for more than 60% of all human casualties from the sloth bear attack (Figure 5).

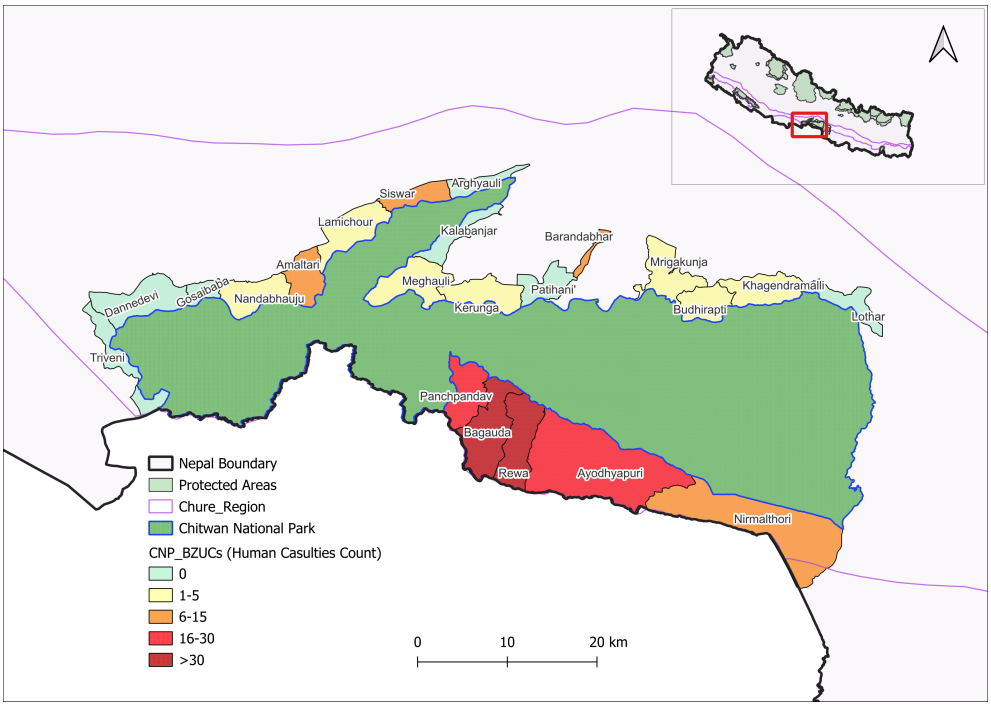


Figure 5. Study area map showing the distribution of the total count of human casualties occurring from sloth bear attacks according to buffer zone user committees during the 1999–2025 period.

3.4. Characteristics of Conflicts

Questionnaire surveys with households in the study area revealed the demographic and livelihood-related aspects of victims. The majority of families experiencing adverse encounters with sloth bears were found to have a livelihood based on farming with heavy reliance on the forest for fodder, fuelwood, and livestock grazing (79%) (Table S1). Recall of conflict incidents showed that a majority of people (40%) were walking alone in the vicinity of villages when the attacks occurred. 39% of the attacks involved various human activities associated with forest visits, including livestock grazing, wild fruit and vegetable collection, and fuelwood collection. 14% of victims were attacked during their regular activities near their home, and 7% of victims were attacked when they were busy in agriculture farm-based activities (Table S2, Figure 6).

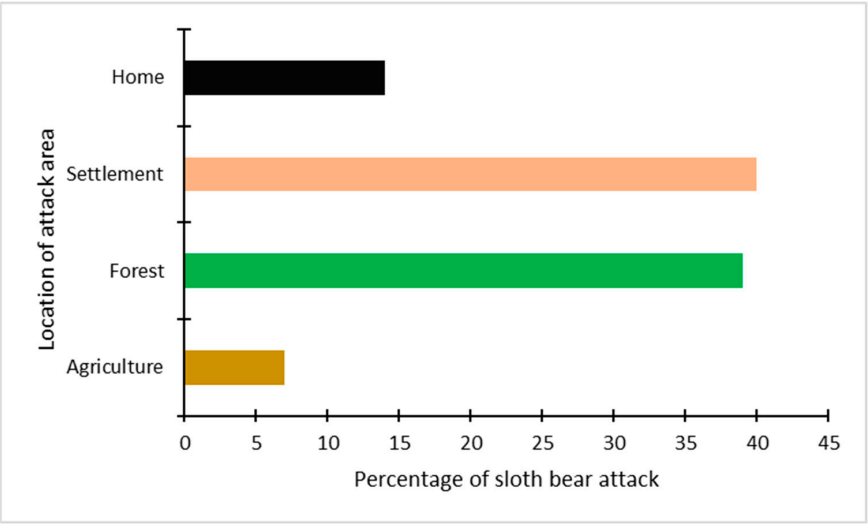


Figure 6. Area of human activity during the sloth bear attack.

Interviews with the victims and their families suggested that in the majority of incidents (59%), a single sloth bear individual was involved in the attack. Respondents indicated that during 31% of conflict incidents, sloth bear cubs were nearby when the person was attacked. A majority of respondents (48%) could not identify the sex of the sloth bear involved in the conflict, while 40% identified the conflict-causing bear as female and the remaining as male (12%). The majority of respondents (59%) said that sloth bear attacks occurred in the evening (5–7 p.m.). 36% of respondents recalled the conflicts occurring during the daytime (11 a.m.–4 p.m.). Only a limited number of respondents (5%) reported that the attacks occurred at night (8 p.m.–5 a.m.).

4. Discussion

The results highlight a persistent and recurring pattern of conflict between buffer zone communities and sloth bears over the past 27 years. The number of people injured and seeking relief from the park authorities declined during the study period. Most sloth bear attacks occurred in winter. Male victims were proportionately higher compared to females, with a higher proportion of females getting injured in the winter season.

The annual decrease in conflict contrasts with the increasing trends reported in North Gujarat [22] and Odisha [23] in India. Sloth bears are widespread across various habitats in India, and many conflict incidents have occurred due to habitat degradation, limited food availability, and competition for food resources on human-modified lands [24]. Sloth bears have damaged crops and attacked people, mostly in areas where local people frequently visit agricultural fields and forests to collect fruits and vegetables, graze domestic animals, and defecate in open spaces [22–25]. The diet of sloth bears in CNP shows a higher insect composition, particularly ants and termites, rather than a plant-based one, with no recent evidence of crop-raiding [26]. Their smaller home range in CNP indicates a resource-rich habitat [27]. These findings suggest that resource-rich habitats may mitigate the escalation of human–sloth bear conflicts, whereas degraded habitats with limited food resources likely exacerbate negative interactions.

Robust estimates of the sloth bear population are unavailable for our study area, but a 1990s study estimated that around 250 individuals were present [28]. A more recent study using non-invasive genetic methods confirmed the presence of at least 32 sloth bears in the CNP [7]. The number of sloth bear individuals recently counted was lower in the southwestern Madi sector [6], where most human casualties from sloth bear attacks were located. While studies on human-tiger conflict in the study area associate increases in tiger populations with increased conflict incidents [29], other studies report no clear association between increases in tiger or human populations and conflict trends [17]. In addition, changes in land use, variation in food availability, and changes in agricultural practices could influence sloth bear movement patterns and the likelihood of encounters, thus contributing to conflict patterns independent of population changes. Research on wild tigers from the same study area indicates that older individuals who could not compete with dominant individuals in the population were too weak to hunt wild prey, left the core area, and were involved in attacking people or their animals [30]. Indeed, the spike in of human casualties in the year 2002 was associated with a problematic sloth bear that raided livestock sheds, attacked goats, and consumed visceral organs. More than 60 livestock losses were recorded in that year, along with a relatively much higher number of human injuries. The problem bear was captured and later killed. The reduced number of conflicts in the immediate subsequent years may be attributed to this incident. Responses from the victims also suggest that most conflicts involving sloth bears in the study area are driven by sudden surprise encounters rather than by direct increases or decreases in human or bear populations.

Most of the individuals in our study area got attacked by sloth bears during the winter season (36%). The findings are similar to those reported from Gujarat [22] and Karnataka [25], where 57% and 48% of conflicts occurred in winter, respectively. However, the seasonal pattern observed in our study area contrasts with that reported for the Dnyanganga wildlife sanctuary [13] and the north Bilaspur Forest division [24], where more than 51% and 54% of conflicts were reported during the monsoon season. In the Kanha-Pench corridor in central India, 40% of attacks occurred during the summer [12]. Increased human activity on farms and in forests, such as protecting crops, harvesting crops, grazing in forests, and collecting non-timber forest products like mahua flower (*Madhuca* spp.) was often correlated with human-sloth bear conflicts [13]. Unlike some other bears, sloth bears do not hibernate, and female sloth bears with cubs emerge from their dens to forage during winter [27,28,31]. Human activity peaks in winter, as local farmers harvest the main crop and are busy in the fields, watering vegetables, grazing livestock, and collecting fuelwood. Further, visibility is significantly reduced by fog and shorter daylight hours in winter. Reduced visibility and increased human and bear activity may lead to more surprise encounters, increasing the risk of human injuries from bear attacks.

While wildlife population numbers, behavior, and ecological characteristics are important, socio-economic aspects of a community can be equally influential in driving such conflicts with wildlife [32]. Most of the human injuries from sloth bear attacks were recorded in the Madi sector along the southwestern boundary of the park. The Someshwar Hills (part of the Chure/Siwalik range) merge directly into the Madi Valley landscape, forming a continuous forested habitat that links human-dominated lowland settlements to core areas of Chitwan National Park and Valmiki Tiger Reserve in India, increasing the risk of bear encounters. In addition, survey data on respondents' demographics and the context of the encounters reveal that heavy reliance on forest- and farm-based livelihoods can be a primary factor increasing the risk of human-bear conflicts. This pattern aligns with reported cases from India, where a large number of sloth bear attacks occurred in human-dominated landscapes consisting of indigenous people with high reliance on outdoor activities associated with forest and farming [13].

We found that the mean age of victims involved in sloth bear attacks was 41.2 ± 16.2 years, with a median of 37 years, and that a higher proportion of males were involved in conflicts with sloth bears than females. This contrasts with the age distribution and sex ratio reported for the conflict area, i.e., Madi municipality, which had a mean and median age of 32 and 24, respectively, and a higher proportion of females (53%) in the population [33]. This finding corroborates the study reporting a large proportion of male casualties in human-tiger conflict in the same area [29]. Differences in the proportions of males and females can indicate associations with gender differences in activity, with males being more mobile on farms, in forests, and in settlements.

This study provided temporal and seasonal patterns of conflict and the characteristics of conflict events using the conflict records and household surveys. The observed temporal trend primarily reflects changes in recorded casualties. It is possible that the actual number of human-sloth bear conflict incidents and associated casualties may be higher, as not all the conflict events are reported. Conflict events involving small expenses for minor injuries may not be claimed by victims due to difficult, often time-consuming procedures for wildlife relief and compensation. The month of conflict was recorded in 62.75% of records ($n = 123$), and the victim's age was recorded in only 17.34% of official records ($n = 34$). The seasonal pattern revealed in this study should be interpreted as recent, dating to after 2003. Since the ages of victims involved in conflict were available in only a small number of cases from 2017 onward, the results should be interpreted as a recent pattern rather than a long-term trend. This data gap was partly attributable to inconsistencies in the formats used by park

authorities to record and report conflict incidents, underscoring the need for standardized documentation and reporting protocols. Further, the characteristics of conflict were based on the questionnaire survey, which may have several limitations. Respondents could generally be expected to recall major conflict incidents, their location, season, and activity during the attack. Other details, such as the number and sex of bears involved, the presence of cubs, and the precise timing of attacks, may have been affected by recall bias and observational uncertainty during stressful encounters. Accordingly, these findings should be interpreted as respondents' accounts of the circumstances of conflict rather than as independently verified observations of sloth bear behavior. Deeper investigations examining sloth bear behavior in fringe habitats of parks near human settlements are required to address these conflicts. Securing the future for both local communities and sloth bears in Nepal requires responses rooted in an understanding of social and ecological drivers and underlying causes of conflict.

5. Conclusions

We provide important insights into human-sloth bear conflict using multi-decadal information from Nepal. The decline in annual counts of human-sloth bear conflict in Chitwan National Park for the past 27 years is an encouraging trend. However, socio-ecological stakes of conflict are still high, as the conflict remains prevalent across the majority of the buffer zones, causing severe injuries to humans. A majority of conflicts appear to have occurred as sudden defensive attacks, mostly in the winter season when local people are busy with farm- and forest-based activities. Human-bear conflict mitigation cannot rely solely on managing bear populations, as no causal link between bear populations and conflict has been established. Victims' responses suggest a complex nature of human-sloth bear conflict, in which factors related to sloth bear behavior, human activities, and the habitat features may be driving these conflict trends. Thus, we suggest human-sloth bear conflict management strategies in CNP to focus on managing the risk of human-bear exposure. This may include establishing early-warning protocols to increase local awareness of bear activity and behavior-change campaigns to shift human activity outside the bear's active period, particularly during the low-visibility winter season. As multiple species are involved in conflict with humans in the study area, we suggest integrating sloth bear-specific strategies as an integral component of the park's broad human-wildlife coexistence program. This study provides a crucial baseline on human-bear conflict, underscoring that long-term bear conservation in Nepal should be grounded not just in sound ecological information but also in policy frameworks that equally consider communities as their core.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/d18110668/s1, Table S1: Characteristics of the respondents involved in the survey; Table S2: Characteristics of human–sloth bear conflict events; Table S3: Mann–Kendall trend test with Sens Slope estimate; Table S4: Details of Poisson and Negative Binomial model parameters; Table S5: Annual count of human casualties from sloth bear attacks in Chitwan National Park.

Author Contributions: Conceptualization, R.P.P.; methodology, R.P.P. and R.K.; formal analysis, R.P.P. and A.T.; investigation, R.P.P.; data curation, R.P.P., A.T. and R.B.K.; writing—R.P.P., A.T. and A.K.; writing—review and editing, R.P.P., A.K., A.T., R.K., R.B.K., C.P.P. and T.T.; supervision, T.T., C.P.P. and R.K.; project administration, R.P.P.; funding acquisition, R.P.P. and T.T. All authors have read and agreed to the published version of the manuscript.

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Data Availability Statement: All the data supporting the reported results are included within the manuscript and provided in the Supplementary Materials.

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Conflicts of Interest: The authors declare no conflicts of interest.

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