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Livestock Depredation and Its Impact on Farmers in Trongsa District, Bhutan

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ABSTRACT

This survey was conducted in the Trongsa District of Bhutan to assess and document the depredation of livestock by wild predators, time, and seasonality of predation, estimate the economic value of livestock losses in three years (2019-2021), and assess farmers' perception of livestock depredation. A survey using a semi-structured questionnaire was done with 218 farming households from five subdistricts of Trongsa, Bhutan. From a total of 683 livestock kills recorded, the tiger (69.69%) killed more than the dhole (14.4%), leopard (13.7%), and bear (1.4%) in the last three years. Adult cattle (milch, Dry & Bull) were more vulnerable (n=496) compared to young (calf & heifer) cattle (n=169). The majority of predation was in summer (51.18%) and winter (23.62%) whereas the rests (25.19%) were believed to have occurred irrespective of seasons. The total loss of 683 livestock head was valued at 380,739.13$ of which the majority were cattle (n= 665, 345,219.69$) followed by yak (n=48, 35,032.87$). Each household on average lost approximately 23.8% of the annual household cash income in the last three years and only 13% (n=30) received some form of compensation. The majority of respondents (96.8%) attribute a current increase in depredation cases to wildlife conservation efforts such as strict conservation laws, protected areas, and biological corridors. We recommend livestock intensification programs such as pasture improvements in fallow lands and financial compensations for the loss of improved breeds as short-term measures. We recommend for enhanced discussion on livestock insurance schemes and involve farmers in managing human-wildlife conflicts.

INTRODUCTION

Human-wildlife conflict (HWC) poses a significant problem in many parts of the world, and Bhutan is no exception. Factors such as growing human population and subsequent loss of natural habitats, as well as growing wildlife populations due to successful conservation efforts are the influential factors driving these conflicts in certain areas (Saberwal *et al.,* 1994). The severity of the conflict is particularly high in those regions where there is a close association between rural communities and protected areas. In Bhutan, activities such as agriculture, livestock grazing, and collection of timber and non-timber forest products occur within or near protected areas, constitutes a vital component of the local pastoral and agricultural economy (Wang & Macdonald, 2006). Consequently, conflicts between humans and wildlife in these areas are inevitable and evidently there has been an increase in the number of livestock depredation in recent years, which is believed to be partly because of successful conservation efforts (Rajaratnam *et al.* 2016; Jamtsho & Katel, 2019)

Human-wildlife conflicts attract significant attention when the wildlife involved are either endangered or when the conflicts pose a serious threat to human welfare. In Bhutan, the most frequent predators causing menace to farmers include tiger (*Panthera tigris*), snow leopard (*Panthera uncia*), common leopard (*Panthera pardus*), and dhole (*Cuon alpinus*) (Katel et al. 2014; Rajaratnam et al. 2016; Tiwari et al., 2020; Dorji & Powrel, 2022; Joshi, et al., 2022).

Incidences of retaliatory killing of wildlife have been reported as a result of causing economic losses in the form of livestock depredation to farmers without satisfactory compensation, thereby giving rise to conflicts between farmers, wildlife managers, and the law. Although endangered predators like the tiger and leopard are culturally revered by the Buddhist population, resentment has grown over time as evident from the growing reports of retaliatory killings (Rajaratnam *et al.* 2016; Dhendup & Letro, 2016; Wangchuk, 2022).

All these aspects are relevant to human-wildlife conflicts in Trongsa, Bhutan. Although the issue of human-wildlife conflicts has been deliberated extensively but there is a lack of comprehensive study on quantifying the extent of livestock predation in the district. It is crucial to quantify and address farmer's economic losses, assess types of predators and patterns of predation, farmer's perception of these conflicts and to assess the adaptive measures for better coexistence. Therefore, the objectives of this study were to (a) to study the primary causes of livestock predation, predator types, its common livestock prey, time and season of predation, species predated, and age group of animals predated b) its socioeconomic impact on farmers and (c) to assess the farmers' perception on current compensation schemes and adaptive measures.

MATERIALS AND METHODS

Study Area

Trongsa District is located at a latitude of 27°30'9.36" N and longitude of 90°30'25" E has an area of 1807m^2 of which 1273m^2 falls under Protected Areas (PA) and Biological Corridors (BC). The elevation ranges from 800 meters to 4,800 meters above sea level and has a total population of 22,276 as of July 2021. The District consists of five sub-districts with Drakteng covering 85 km², Nabji Korphu with 290 km^2, Nubi with 559 km², Langthel with 508 km² and Tangsibji with 372 km² (National Statistical Bureau [NSB], 2021). The District receives an annual total rainfall of 1225.60 mm and an annual average temperature ranging from 9.44 to 19.68°C (National Centre for Hydrology and Meteorology [NCHM], 2022)

Data Collection

Trongsa District has five subdistricts with each subdistrict consisting of five chiwogs (community) making up a total of twenty-five chiwogs. Initially, the aim was to interview a total of 250 households (10 from each chiwog and 50 in total from each subdistrict) either rearing livestock or is a victim of livestock depredation. However, due to the unavailability of respondents in the households during the visit, the study interviewed only 218 respondents. Purposive sampling using the Snowball sampling method was used, whereby the interviewee and the *Tshokpa* (community representative) were asked to suggest another until the required sample size of 10 households was achieved for each chiwog. Face-to-face interview was done using a semi-structured questionnaire. The questionnaire consisted of six main sections; (1) Demographic Information, (2) Information about the farm, (3) Impact of Livestock Depredation, (4) Seasons, species, and age group of livestock depredated, (5) Compensation schemes and (6) Adaptation to livestock depredations.

Data Analysis

Data was entered in Microsoft Excel 2019 and was imported and analyzed using IBM-SPSS (Statistical Products and Service Solutions) version 26. Age, income from different sources, number of depredations (predator as well as predated wise), and economic valuations were presented using descriptive statistics such as mean, range, standard deviations, and sums wherever appropriate. Percentages and frequencies were calculated for subdistrict on livestock and land holdings, livestock management, distribution of predators, composition of livestock predation by different predators, composition of depredated livestock categories, and perception of compensation schemes as well as adaptive measures were presented descriptively. Kruskal Wallis' non-parametric test was used to find the differences in income, age, predation numbers, and economic valuation between the five subdistricts. The chi-square test of independence was used to find differences between the subdistricts for categorical variables such as herd management, predator type, time, and seasonality. Simple linear regression was done to examine the relationship between the total household income and other sources of income, including livestock, crop, and off-farm income. A map presenting Protected areas and biological corridors in Trongsa was generated using ArcGIS (10.8).

RESULTS AND DISCUSSION

Demographic Characteristics of Respondents

From the total respondents (n=218) interviewed, 52.8% (n = 115) were female, and 47.2% (n = 103) were male, with a mean age of 41.96 years and ranging from 22 to 72 years. Around 56.9% (n = 124) of the respondents were below the mean age, while 43.1% (n=94) were above the mean age. On average, each household consisted of 4.99 members. All respondents (100%, n = 218) were farmers.

Landholding and Livestock Population

The mean land holdings per household was 4.56 acre (ac) of which 1.25 acre is wetland and 3.31-acre dryland. Among the 218 respondents, 93.11% (n = 203) reared cattle, including local Siri cattle, Mithun-cross, and Jersey-cross breeds, while 6.89% (n = 15) did not rear any cattle at the time of data collection. Jersey Cross (n = 619) and local cattle (Siri and Mithun cross) (n=784) populations were the highest among the total livestock population in the study area. Nubi had the largest cattle population (n = 550), whereas Korphu had the lowest (n = 215). Yaks and sheep were seen only in Simphu under the Nubi subdistrict.

Household Income

All interviewed households depend on agriculture and livestock farming for both home consumption and cash income. For farmers in the Korphu, agriculture income (mean = US $2785.86) was found to be the most important source of cash income of which cardamom cultivation being a major source, followed by off-farm activities (mean= US $1155.67) and income from livestock (mean= US $208.55). Whereas for Nubi and Tangsibji, the major source of income is from off-farm activities (mean = US $827.80 & $909.29 respectively) followed by income from livestock (mean = US $625.26 & $751.66 respectively). However, farmers of Nubi and Tangsibji obtained cash income from selling vegetables whereas farmers of lower elevations like Langthel, Drakteng, and Korphu depend on mustard, oranges, cardamom, guava, and green tea.

The average annual income per household from agriculture, livestock, remittance, and non-farm activities was approximately US $2456.30. Among these, non-farm activities earned the highest income (US $1005.48 per year per household) followed by agricultural activities ($998.18) and livestock ($447.30). This suggests that households derive a significant part of their income from non-farm activities, indicating the presence of diversified sources of income.

There was a significant association between total cash income and off-farm income of farmers (r_s = 0.70, p < 0.05). Similarly, there was a significant difference in the income from non-farm activities between the five subdistricts (H (4) = 35.12, p <.05). There was also a strong relation (r_s= 0.861, p < 0.05) between income from agriculture and total cash income and it was significantly different among the five subdistricts (H (4) = 66.39, p < 0.05). However, the land holdings of farmers showed no relation with their cash income (r_s = 0.065, p < 0.05). A similar pattern of farming was also reported by Blench (2005) and Wang & Macdonald (2006). The total income from agriculture was highest in Korphu, whereas Tangsibji and Nubi had more income from the sale of livestock products compared to the other three subdistricts. There was a significant difference in average cash income from livestock between the five subdistricts (H (4) = 79.16, p < 0.05). However, income from livestock and the number of cattle owned showed a weak association (r_s = 0.123, p < 0.05).

Livestock Rearing Characteristics and Protection Measures

A comparison between subdistricts showed that Drakteng had the highest number of households (n=44) practicing a sedentary type of cattle management followed by Nubi (n=43), whereas Nubi had the highest number of households that follow night in day out rearing system in which they let their cattle for grazing into fallow fields(n=28) and Forest (n=11). Of 203 households that rear cattle, only 12.31% (n = 25) follow stall feeding system. Out of the total (n=218), 71.1% (n=155) had fencing around their farm and 28.9% (n=63) did not have fencing around their farms. Out of the total respondent (n=155) having fences, 54.19% (n=84) has electric fencing followed by 29.67% (n=46) with a barbed wire fence and 16.12% (n=25) with wooden fence.

Similar to Katel *et al*. (2014), high-performing dairy cows particularly calves and milking cows were seen to be more protected by stall feeding in an enclosure or shed while others were sent for grazing or tethered in the fields during the day.

Bulls and oxen were seen most often kept outside in fallow lands. This could be the reason for bulls and native cattle being more vulnerable compared to improved breeds like Jersey and milking animals (Table 2).

Livestock Depredation in General

A total of 683 livestock were reported to be killed by predators (Tiger, Leopard, Dhole & Bear) in three years and the perceived losses had increased over the years (Table 1). Nubi (37.04%) reported the greatest proportion of livestock loss followed by Tangsibji (21.4%). The study revealed a mean loss per household (that lost livestock) of 3.13 livestock head per annum. This mean loss was considerably higher for households in Nubi (5.06 per household) followed by Tangsibji (3.10 per household) than in the other three subdistricts.

Farmers attributed 476 kills (69.69%) to Tigers, 94 (13.7%) to leopards, 99 (14.4%) to dhole, and 10 (1.4%) to bears. Nubi (37.6%) reported the majority of tiger kills followed by Tangsibji (22.7%). Korphu and Langthel reported the highest depredation by leopards (24.5%), whereas depredation by tigers was lowest in these two subdistricts (17% in Tangsibji and 16% in Nubi). Losses reported to bears were highest in Korphu (60%) and Tangsibji (40%), while reported losses to dhole were most frequent in Nubi (57.6%) and lowest in Korphu (4.04%) and Drakteng (7.07%). The study revealed that dholes are the second dominant livestock predators in the area similar to Tshering & Thinley (2017) who also found it to be the dominant predator besides tigers and leopards. Therefore, the study suggests livestock officials and wildlife conservationists to equally consider losses to dholes as equally as being prioritized for tigers and leopards.

Such livestock losses combined with restriction on the use of natural resources and retaliation is likely to generate a hostile attitude towards conservation efforts as reported by Gurung (2008) and Wang & Macdonald (2006). In this study, for example, farmers of the Nubi subdistrict which has the highest area under protected areas (Table 4) expressed the opinion that it had become more difficult to rear livestock as the number and size of protected areas keeps on increasing and subsequently livestock predation rate has also increased and as a result farmers have lost hope in rearing livestock and developed hostile attitude resulting in retaliatory killings of predators which is also evident as per Wangchuk (2022) who reported that seven farmers from Trongsa were facing prosecution for allegedly killing two tigers. The cases were reported from Langthel and Drakteng subdistricts. As per the forest and nature conservation rules and regulations of Bhutan, (2017), tigers for example fall under totally protected species of wild animals. Killing a tiger is considered a violation, resulting in a substantial fine of Ngultrum 1 million. Further deliberation in 2021 increased the offense of killing wild fauna and species listed under Schedule I, to a felony of third degree (Wangchuk, 2022). This ongoing conflict has generated a negative perception of the park and other conservation endeavors.

Table 1. Number of depredations by different predators in five subdistricts of Trongsa district as recorded in the survey

Subdistrict	Tiger	Leopard	Dhole	Bear
Tangsibji	108	16	17	4
Nubi	179	15	57	0
Drakteng	83	17	7	0
Langthel	52	23	14	0
Korphu	54	23	4	6
Total	476	94	99	10

Table 2. Number of livestock depredated in three years (2019-2021) as recorded in the survey

Subdistricts	Milch	Dry	Heifer	Calf	Bull	Yak	Sheep	Horse	Poultry
Tangsibji	40	9	20	15	62	0	0	0	0
Nubi	47	14	22	30	80	48	10	2	0
Drakteng	21	3	5	17	61	0	0	0	0
Langthel	17	2	5	25	41	0	0	0	0
Korphu	6	2	7	23	43	0	0	0	6
Total	131	30	59	110	287	48	10	2	6

Among livestock types, the present study showed cattle to be the most vulnerable to predation, probably because the majority of the respondents reared only cattle (Table 2). The results show that adult cattle (Milch, Dry & Bull) were most predated (n=496) and young cattle (calf & Heifer) were less vulnerable (n=169). Farmers ensured the safety of calves and improved breeds of milking cows by housing them in sheds or enclosures during the night, thus protecting them from predators.

Whereas adult cattle (bull & non-milking) were let freely into the forest or away from the farm vicinity during day time for grazing and at night most of them are often kept outside which as a result increases the probability of predation. Due to poor management of adult cattle (Bulls & non-milking), the number of predations is higher in adults than in young cattle. Katel et al. (2014) also reported that adult cattle, specifically bulls and non-milking, experienced a higher incidence of predation. Treves & Karanth (2003) also found indigenous cattle breeds were more vulnerable to predation compared to improved breeds such as Jersey crosses. The same study also found that non-milking cows were more vulnerable compared to milking cows. This disparity could be attributed to the fact that milking cows were either stall-fed or enclosed within the farm vicinity and they were economically valued.

Time, Place, and Seasonality of Livestock Depredation by Wild Predators

In all, 51.18% of total kills were in summer and 23.62% during winter whereas 25.19% of predation took place irrespective of the season. The result showed that out of different wild predators, the Tiger has the highest number of predations during summer (58.9%). Out of total predation, 56.29% of the predation took place during the day and 43.70% during the night. The findings showed that 46.35% of predation incidents occurred in forest areas, followed by 29.18% in the farm vicinity such as fallow fields, and 24.4% within the farm premises. Rests were not aware of the exact time and place of livestock predation. Farmers reported that they provided adequate care for their cattle, particularly during the winter and early spring seasons when they were relatively free from agricultural activities. During these months, they feed their cattle with paddy straws, crop residues, dried grasses, and paddy stumps by tethering them in fields. In contrast, during summer months when fodder is abundant in the forest and farmers are busy with agricultural activities, cattle is often allowed to graze freely in the nearby forests. It is during such periods that cattle were highly vulnerable to wild predators as evidenced by the responses wherein 51.18% of total kills were in summer and 23.62% during winter months. A similar finding was reported by Tshering & Thinley (2017) in the Northwestern part of Bhutan whereby livestock released to nearby forests for grazing were more vulnerable to predation than those stall-fed and kept within some enclosures. Studsrød & Wegge (2016) also reported that livestock left freely and unguarded during grazing has higher chances of predation compared to livestock being herded by farmers.

Predation by Tiger

Out of total tiger predation, 60.3% of predation occurred during day and 39.7% of predation occurred during the night out of which Nubi (27%) and Tangsibji (28.1%) reported the highest number of tiger predation during the day. A total of 58.9 % of the Tiger predation occurred during summer and 11.3% during winter. The remaining 28.5% of the attacks occurred irrespective of the season out of which Nubi (38.5%) and Tangsibji (35.9%) reported the highest among five subdistricts. In the other three subdistricts, the majority of the tiger predation took place in summer (Drakteng (64.5%), Langthel (70.6%), and Korphu (52%). Results showed that

the majority of the tiger predation occurred in forest (57%) followed by farm vicinity (33.7%) and within farm (9.3%). Nubi reported 39.2% of tiger predation to be in farm vicinity which is the highest among five subdistricts.

Predation by Leopard

Leopard predation occurred mostly during the night (79.7%) out of which Drakteng (20.3%) and Langthel (18.6%) reported maximum cases of leopard predation during the night compared to the other three subdistricts. The result showed that leopard has predated 50.8% during the winter season, 35.6% during summer and rest of the predation occurred irrespective of the season. Leopard predation in winter was reported maximum in Drakteng (20.3%) compared to the other four subdistricts. Leopard predation within farms is reported to be the highest (64.4%) compared to predation nearby farm vicinity (23.7%) and forest (10.2%).

Predation by Dhole

Livestock predation by dhole is reported only during day time and the majority of the dhole predation occurred in Nubi (48.8%) followed by Tangsibji (25.6%) and Langthel (11.6%). Dhole predation was commonly reported during the summer season (39.5%) than in winter (27.9%) and other seasons (32.6%). Place of predation by dhole was mostly seen in farm vicinity (53.5%) and nearby forest (44.2%), from which Nubi (27.9%) reported maximum cases of dhole predation around farm vicinity followed by Tangsibji (16.3%).

Predation by Bear

Although bear predation was less common in the study area, livestock depredation by bear was reported only during the night (n =4) out of which three cases were reported from Tangsibji and one case from Korphu. Bear predation occurred mostly during summer (75%) and winter (25%) from which all reported cases occurred within the farm. Similar findings were also recorded by Jamtsho & Wangchuk (2016) in which Asiatic black bear predating on livestock within the farm area causing destruction to animal sheds and wounding livestock.

Economic Valuation of Reported Livestock Losses

Economic loss to predators per household was estimated using average local live animal prices during the time of data collection as shown in Table 3. The total loss of 683 livestock was valued at US $380,739.13 in last three years, of which the majority losses were from cattle (n=665, US $345,219.69) followed by yak losses (n=48, US $35,032.87), horse losses (n=2, US $486.57), sheep loses (n=10, US $182.46) and losses from poultry (n=6, US $36.49). The average annual household income was US $2439.98. Overall, each household lost an average of US $1748.63 in three years which is approximately 23.8% of the annual household cash income of three years.

Table 3. Live Animal Price in the study area (Existing price during Data collection, 2022)

Livestock Type	Price per Animal (US $)
Cattle	559.55
Yak	729.85
Horse	243.28
Sheep	18.25
Poultry	6.08

*Existing price during the time of data collection.

Farmers' Perception of Wildlife Conservation and Livestock Predation

Out of the total respondents, 95.9% of the respondents (n=209) have knowledge and concept of wildlife conservation and its importance. The study also showed that 93.6% of the respondents have understood the concept of Protected areas and biological corridors and its prevalence in their region. But on the other hand, 96.8% of the farmers claim that there is a direct relation between wildlife conservation efforts and livestock predation. Increasing protected areas and biological corridors directly impact farmers residing nearby PA and BCs (Norbu & Norbu, 1999; Bruggeman et al. 2018; Yeshey et al. 2023)

Protected Area, Biological Corridors, and Livestock Predation

Nubi has the largest Protected Areas and Biological Corridor as shown in Figure 1 and Table 4 and has the highest number of livestock depredations records. Though whole of Korphu subdistrict falls under Jigme Singye Wangchuck National Park (JSWNP) area (Table 4), the subdistrict reported only 87 cases of livestock depredation in the last three years which is the least among subdistricts. The livestock population in Korphu is less compared to other subdistricts, which may be the reason for least predation record compared to the other four subdistricts. Farmers

claim that due to increasing numbers of protected areas, number of livestock predation has also increased. Now, wild animals are seen nearby farms and residential areas even posing risks to humans. Such findings were also recorded in Dorji & Kriechbaum (2009) who found out that the frequency of spotting wild predators nearby farms was increasing yearly near Jigme Dorji National Park as a direct impact of successful conservation efforts.

The study also recorded 12 human casualties inflicted by wild predators in last three years out of which Langthel recorded the highest as shown in Figure 2. Two cases of human casualties were inflicted by leopard in Jangbi village under Langthel subdistrict. Out of total human casualties one case was recorded for Tiger in Nubi and rest were inflicted by bear on cattle herders. Tangsibji subdistrict has no cases as of now however farmers fear that such cases might arise any time as wild predators such as tiger and leopard are seen nearby farms even during the day time.

Farmers mentioned that predators were mostly encountered during day time (82.7%) when farmers are off to work in forests nearby village. Out of the total respondents, 37.2% mentioned having encountered livestock predators out of which 55.6% mentioned having encountered in forest near their village and 21% mentioned to have encountered within farm vicinity during late night and rest (23.5%) reported to have encountered enroute while traveling.

Farmers' Perception of Livestock Compensation

Out of the total respondents (n=218), 68.8% of the respondents (n=150) had heard and known about the compensation scheme that was provided by the Wildlife Endowment Fund under the Department of Forest and Park Services (DoFPS) whereas 31.2% of the respondent (n=68) were not aware of the compensation scheme that was provided till 2015. Although 68.8% of the respondents where aware on compensation schemes yet only 13.76% of the respondents (n=30) have received the compensation as of now and rest (86.2%) of the respondents (n=187) did not receive any compensation at the time of data collection.

Table 4. Protected areas and biological corridors in Trongsa District (Protected Area and Biological Corridors Data, 2018)

Subdistrict	Total Area (sq.km)	Biological Corridors (sq.km)	Protected Areas (sq.km)	Total PA & BC
Tangsibji	372	33	270	303
Nubi	559	88	264	352
Drakteng	85	0	0	0
Langthel	508	159	169	328
Korphu	290	0	290	290
Total (Trongsa)	1814	280	993	1273

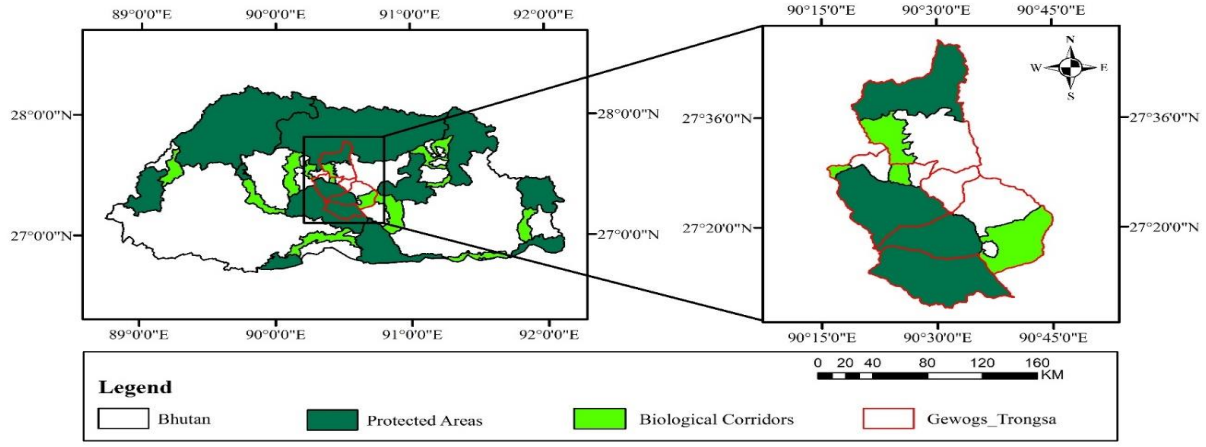

Figure 1. Map showing PA and BC in Trongsa District (PA and BC data, 2018)

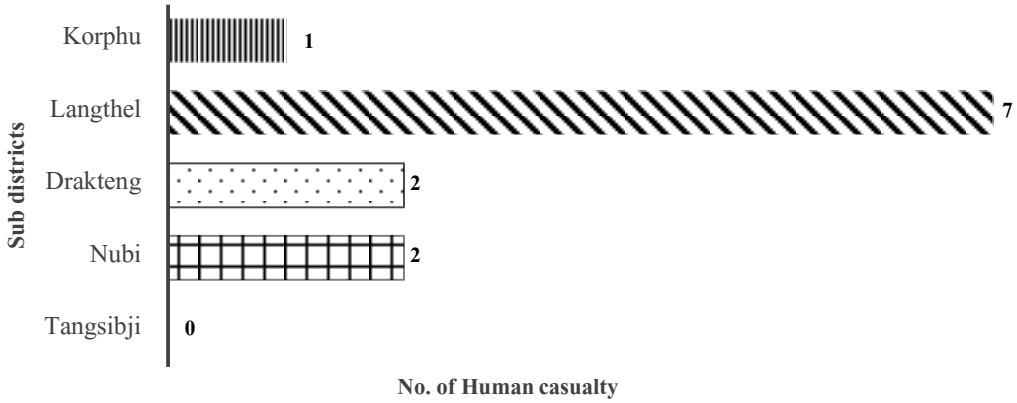

Figure 2. Human casualty from wildlife attack in last three years as recorded in the survey

From the total respondents, 51.6% of the respondents (n=112) have reported the case and applied for depredation compensation but have not received it. Only 13.76% of the respondents (n=30) have received the compensation from DoFPS. Whereas 34.4% of the respondents (n=75) refused to report the cases. From the respondents who received the compensation, 56.6% said that the compensation received was satisfactory (n=17) while rest believed it was not worth the livestock losses and was unsatisfied (n=13). The farmers shared that compensation has not been provided for more than five years and farmers have lost hope and interest in reporting the depredation cases. They also mentioned that compensation received during different DoFPS events (for example, International Tiger Day) were unsatisfactory and not worth the animal loss and hence majority of the farmers reported to have lost interest and no longer reported the cases to the concerned officials. Dorji & Kriechbaum (2009) also reported similar responses from settlements within and near Jigme Dorji National Park whereby the majority of farmers claimed to have never received any form of compensation and the majority even refused to claim because of lengthy procedures and lack of certainty in receiving compensation (Wangmo, 2020; Wangchuk, 2022).

Out of the total respondents (n=218), 92.9% of the respondents (n=197) prefer monetary compensation and rest 7.1% prefer live animals as compensation (n=15). 71.3% (n=154) out of total respondents are aware of Livestock insurance provided by Royal Insurance Cooperation of Bhutan Limited (RICBL). However, 44.2% of the respondents (n=95) mentioned that they cannot afford to insure their livestock and only 49.1% of the respondents (n=106) are willing to join and register for livestock Insurance.

Adaptation to Livestock Depredation and Potential Alternatives

The majority of the respondents in the study area rear cattle (n=201) and they are mostly interested in dairy farming than any other alternative livestock farming. The majority of the respondents believe herding (n=101) as best option to reduce livestock predation followed by stall feeding (n=63). Farmers expressed that they would herd their cattle regardless of the breeds or time of the year if they had adequate manpower, as herding was considered the most effective and safest approach to cope with the increasing incidence of predation. However, most of the households cited acute shortage of labor in their households as the major problem. Another important reason was the lack of abundant pasture and fodder resources in the farm.

Although, 61.9% of the respondents (n=135) claim to know about alternative livestock farming like poultry (layer & broiler), piggery, apiculture, and fishery (cold and warm water fishery), the majority (65.5%) have no interest in adopting other livestock apart from dairy. On the other hand, 38.1% (n=83) claim to not know at all apart from dairying. Therefore, promoting livestock farming other than dairy cattle would not be a good alternative. This is attributed solely to religious sentiments surrounding the rearing of animals other than cattle.

Since shortage of pasture and fodder resources is cited as one of the main reasons for letting their livestock to graze in forests, farmers suggest concerned officials and departments to help develop pasture on fallow agriculture lands and improve pasture and fodder on a cost-sharing basis. They also suggest providing electric fences to adapt and mitigate increasing livestock depredation rates. Further, greater vigilance during grazing, tethering of livestock, and switching to secured dairy sheds should be done. Compensation in the form of improved breeds of animals on cost cost-sharing basis is also an alternative since they can be reared at home in enclosures. Authorities must also impose restrictions on grazing in predator hotspots to reduce encounters with predators and future compensation schemes should impose strict conditions wherein claims must be supported by evidence of effective husbandry practices. As stated by Rajaratnam *et al.* (2016), unless the socio-economic impacts of livestock predation are addressed and alleviated, the cultural and religious fabric binding people and nature conservation in Bhutan could also be in serious jeopardy.

CONCLUSION

The study revealed a total of 683 livestock loss to predators out of which the highest predation was caused by tigers followed by dhole, leopards, and bears. Nubi recorded the highest livestock depredation followed by Tangsibji. The lowest was recorded in Korphu. Among livestock animals, cattle were the most vulnerable. In terms of time, place, and seasonality of depredation, the highest kills were in summer months compared to other seasons, whereas predation incidences were recorded higher during day time when animals were sent for grazing in the forest as a result of scarce fodder resources. However, a considerable number of incidences were also recorded in the farm vicinity depicting an increasing encroachment by predators including cases of human casualties over the years. Considerable economic loss was inflicted over the years due to the predation where farmers linked direct relation between wildlife conservation efforts and livestock predation. The majority of the farmers have not received any form of compensation so far and although the majority have heard about the livestock insurance scheme of Royal Insurance of Cooperation Bhutan Limited (RICB), most are unclear of scheme and are ignorant. Moreover, the majority showed no interest in other livestock farming besides dairy cattle. The study recommends for an enhanced awareness on livestock insurance schemes, the development of pasture on fallow lands, electric fencing around the farm vicinity, promotion of improved breeds of cattle with secure dairy sheds as some of the adaptive measures.

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