Human Dhole Interaction and its Implication to Farmer's Livelihood in Jigme Khesar Strict Nature Reserve

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Abstract

Human-wildlife conflict is a serious problem to conservation effort worldwide. This is also true for Bhutan, where carnivores constitute a threat to livestock of farmers, affecting farmer's livelihood, however there is sparse documentation on the extent of human dhole interaction in Bhutan's some of the important areas of conservation interest. Therefore the aim of this research was to evaluate the extent of human dhole conflict, income lost due to depredation and the perception of the farmers towards dhole conservation. Data were collected from 160 households within two strata of rural and semi-urban area in western Bhutan. Semi-structured questionnaire were used to collect data related to farming activities, household income, extent of livestock lost and income lost to depredation by dhole and wild predators. Livestock depredation involved seven predators, which caused loss of 5% of the total average annual income of the farmers; which were significantly different between the predators involved. Dhole killed significantly more livestock than other predators followed by common leopard and maximum kills were made in rural area than semi urban area. 60% of the incomes lost due to wild predators were caused by dhole with major impact in rural area. Majority of the respondents from rural area exhibited negative attitude towards dhole conservation, where they suggested livestock depredation compensation schemes and other livelihood alternatives to minimize the impact of conflict and create harmonic co-existence, whereas majority of the respondents from semi-urban suggested electric fencing around their village as a measures to reduce human wildlife conflict. Livestock compensation and insurance schemes, integrated conservation development programs, educational outreach programs with other livelihood alternatives such as ecotourism are recommended as intervention strategies to minimize human dhole conflict and create harmonic co-existence.

Key words: Depredation, income, perception, rural, semi-urban

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Abbreviations

ANOVA	Analysis of Variance
FNCA	Forest and Nature Conservation Act of Bhutan, 1995
FNCR	Forest and Nature Conservation Rules if Bhutan, 2006
HH	Household
ICDP	Integrated Conservation Development Program
IDW	Inverse Distance Weighting
JDNP	Jigme Dorji National Park
JKSNR	Jigme Khesar Strict Nature Reserve
JSWNP	Jigme Singye Wanggchuck National Park
Km	Kilometers
MAI	Mean Annual Income
masl	Meters Above Sea level
Nu.	Ngultrum
SD	Standard Deviation
SPSS	Statistical Package for Social Science
SPSS	Statistical Package for Social Science
Sqkm	Square Kilometers
USA	Unites State of America
USD	United States Dollars
WCD	Wildlife Conservation Division

Acronyms

Dzongkhag	District
Geog	Sub District
Gup	Head of local government
Tshogpa	Head of village

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Chapter One

Introduction

1.1 Background

Human dhole interaction involves where the human encroach the dhole habitat and dhole comes into the human dominated periphery and cause threat or competition to the livelihood of the farmers. Increase in dhole population causes the livestock depredation, which results in negative attitude of the farmers towards dhole, there by killing the dhole in retaliation and impacting the dhole conservation (Tshering and Thinley, 2017). Study conducted by Gusset et al. (2008) in Hluhluwe-imfolozi Park in Africa reported 66.7% of the respondent said that human African wild dog was mainly due to less prey availability for African wild dog, where less prey were due to hunting by the local communities. It is reported that the expansion of urban areas into natural landscapes has affected the biotic composition, species composition and change in dhole behavior resulting in an increasing human dhole conflict (Ngongolo et al., 2015). 72% of the respondents in protected area of Thailand believe that increase in human dhole conflict was due to its habitat destruction by the alignment of roads (Jenks et al., 2014). Wang and Macdonald also stated that, the influential factor contributing towards human dhole conflict includes increasing human population, loss of natural habitat, less pray and in some regions and increased dhole population resulted from conservation program actions (2006).

Bhutan is an agrarian country where majority of the population are dependent on agriculture and livestock for their livelihood and most of the settlements are located to the proximity of the forest (Sangay and Vernes, 2008). The major wild predators depredating livestock includes tigers, common leopard, black bear and dhole (Wang and Macdonald, 2006). Livestock depredations are common in areas where livestock holding forms the integral part of farmers livelihood (Katel et al., 2014). Number of livestock owned by the farmers were found positively correlated with the predation hotspots in Bhutan (Wang and Macdonald, 2006).

Among the wild predators, dhole caused major negative impact to the livestock holding communities livelihood (Sangay and Vernes, 2008). Human dhole interaction in form of livestock depredation has led to threat to dhole population by the farmers involved with the livestock rearing in its distribution ranges (Thinley et al., 2011). In Bhutan dholes were nearly extirpated in 1970s due to perceiving as pest to livestock and mass poisoning campaign for the dhole. Due to increase in population of wild pig, Bhutan government initiated reintroduction of dhole in early nineties and now the species has re-established and its population is in rise (Thinley et al., 2011).

Presence of dholes in buffer area of Jigme Khesar Strict Nature Reserve (JKSNR) has been confirmed through systematic camera trap and moreover, many incidences of livestock depredation have been reported. However, the status and the extent of human dhole interaction are not known in present study site. It is paramount to know the impact of human dhole interaction, so as to appraise whether the impact is significant to cause threat to the species conservation and towards farmer's livelihood and to create a harmonic co-existence.

1.2 Problem statement

Dholes are endangered predator species with an estimated population of 2,500 individuals in the wild (Aryal et al., 2015). Dholes are considered as nuisance predators, livestock killers and are considered as pest to livestock (Lyngdoh et al., 2014). Although livestock predations by the wild predators are common, their impacts on livelihood of the farmers are poorly understood (Rajaratnam, et al., 2016). In Bhutan, dholes have received less attention compared to other endangered wild predators like tiger and snow leopard (Rajaratnam et al., 2016). It is not included under protection in Forest and Nature Conservation Act of Bhutan, (FNCA), 1995 and Forest and Nature Conservation Rule (FNCR, 2006) despite being in endangered.

In Bhutan, studys on dhole were conducted by Thinley et al. (2011), Katel et al. (2014) and Johnsing et al. (2007) in north western part of Bhutan, and study on livestock depredation by wild predators by Wangchuk and Jackson, (2004), Wang and Macdonald, (2006); Sangay and Vernes, (2008); Sangay and Vernes, (2014) and Rajaratnam et al. (2016), were all conducted in central Bhutan but present study site was located in extreme western part of Bhutan which is first of is its kind in the present study site. Presence of dhole was confirmed while conducting tiger presence camera trap survey and livestock depredation cases were also reported. However, there is sparse information on human dhole interaction, extent of impact on farmer's livelihood and perception of the farmers towards dhole conservation.

1.3 Research questions

Is there difference in extent of livestock depredation by dhole and other predators, its impact on farmer's livelihood and farmer's perception towards dhole conservation in rural and semi-urban?

1.4 Research objectives

Following objectives were determined to analyze the effect and status of human dhole interaction on farmer’s livelihood and their perception towards dhole conservation in two different village zones within buffer of JKSNR.

1. To evaluate the livestock depredation by dhole and other predators.
2. To analyze the extent of farmer’s income loss due to livestock predation by dhole and other predators.
3. To document occurrence and livestock depredation hot spot of dhole and other wild predators.
4. To understand the farmer’s perception towards dhole conservation

1.5 Content of the Chapters

1.5.1 Chapter One

This chapter explains the background information, problem statement of the study, research question driving this thesis and four research objectives for this thesis.

1.5.2 Chapter Two

It combines the literature review in context to this thesis. Literature review comprises of geographical distribution of dhole, threats to dhole, human-wildlife conflict and implication to farmers livelihood, perception of farmers towards wild animals conservation, people’s perception towards dhole conservation and human dhole conflict management intervention strategies.

1.5.3 Chapter Three

This chapter contains the materials and methods. Details of study area on its location, climate and vegetation with the research design explaining on the conceptual framework, area stratification, sampling design, pre-testing of questionnaires, household questionnaire interview, secondary data collection and data analysis details.

1.5.4 Chapter Four

This chapter is divided into seven sections, which tells you about the results and discussions. It tells you about the socio-demographic characteristics of the study, livestock depredation by dhole and other wild predators, depredation occurrence hot spot of dhole and wild predators, farmers income lost due to livestock depredation by dhole and other wild predators and farmer’s perception on dhole conservation and dhole conservation policy.

1.5.5 Chapter Five

This chapter provides the conclusions, limitations and the recommendation, which had resulted from this research.

Chapter Two

Literature Review

2.1 Geographical distribution and habitat of dhole

The dholes or Asiatic wild dogs (*Cuon alpinus*, Pallas, 1811) are one of the most remarkable carnivores in the Asian forest. The term 'dhole' was reported to have an ancient Asiatic origin signifying "recklessness and daring" (Acharya and Trust, 2016). Dholes are pack canids, in many ways resembling the wolves *(Canis lupus*), the African wild dogs (*Lycaon pictus*), and the South American bush-dog (*Speothos venaticus*) in their life history traits (Kamler et al., 2012). Once dholes occurred throughout South and East Asia to as far as southern part of Russian federation (Amur region and upper lena river north of Lake Baikal). Dholes had disappeared from more than 75% of the historic range (Nielsen et al., 2015). Geographically dholes were found stretching from Siberia in the north, India in the west, Java in the south, and China in the east (Acharya et al., 2016).

Dholes occurred in different types of vegetation including; tropical and moist deciduous forest; evergreen and semi-evergreen forest; temperate deciduous forest; grassland scrub forest; temperate steppe and alpine steppe with the elevation range from the sea level to as high as 5,300 masl (Thinley et al., 2011). Dholes in southern area were mostly found in tropical dry and moist deciduous forest (Nurvianto et al., 2015a). In Indian Sikkim, dholes were found up to sub-alpine zone (3,100 to 3,900 masl) and alpine zone up to 4,100 masl (Kamler et al., 2012).

Dholes consume a wide variety of prey species from small rodents and hares to gaur and they do kill livestock (Liu et al., 1999). The preferred prey ungulates body weight ranges from 40 to 50 kg, however if prey size were not available they were found to prey on any size of the prey (Thinley et al., 2011). The factors that influences the habitat use includes prey availability, level of human disturbance, water availability, tiger presence and suitability of the breeding sites (Kamler et al., 2012).

Dholes in Bhutan were reported from all districts with the exception from eastern district of Tashigang, Samdrupjongkhar and Pemagatshel (Wangchuk and Jackson, 2004). The global declines in the population of most of the mammalian predators were due to its conflict over livestock depredation and human livelihood with the farmers (Nurvianto et al., 2015b). Dhole population in Bhutan was classified as low number (250—750) and is found from the low land to the alpine meadows in the north (Thinley et al., 2011).

2.2 Threats to dhole

The dholes were one of top carnivore predator present throughout Indian subcontinent and the decline of this species were mostly linked with the anthropogenic factors (Nurvianto et al., 2015b). Over the last decades, the dhole conservation status has been assessed as endangered from vulnerable because of its mature individual population of less than 2,500. The current range of dhole was only the fraction of the former distribution (Nielsen et al., 2015). Threats towards dhole include depletion of prey base, habitat loss and transformation; disease and pathogens; competition with other species and persecution (Nielsen et al., 2015). Nurvianto et al. (2015b) assert that the confounding factor contributing towards dhole population decline is its conflict with human and persecution by human in form of retaliatory killing. Habitat disturbances due to over grazing, collection of forest produces, poaching and decline in prey species population is driving threat towards survival of top carnivores including dhole in Bhutan (Wang and Macdonald, 2006).

In Bhutan, dholes got nearly extirpated due to poisoning campaign by government of Bhutan, with intention to reduce livestock depredation by dhole in 1970s (Rajaratnam et al., 2016).

2.3 Human-wildlife conflict and implication to farmers livelihood

In many parts of the world, the conflict between human and wildlife is a significant problem and the influencing factors are increase in human populations, natural habitat loss and, in some regions, increase in wildlife populations from successful conservation programs (Alexander et al., 2015). Habitat deterioration due to over grazing and collection of forest produce, poaching and decline in prey population pose a serious threat to the survival of large carnivores including dholes in Bhutan (Wang and Macdonald, 2006).

In Jigme Singye Wangchuck National Park (JSWNP), the rates on reported livestock predation by wild animals have increased since the implementation of Forest and Nature Conservation Act of Bhutan, 1995 (FNCA) and the park's inception in 1993 (Wang and Macdonald, 2006). However, farmers in Bhutan have a clear understanding of wild animal's behavior and habits and they have learned to coexist with wild animals because of the Buddhist philosophy and culture people follow (Wangyel et al., 2006). But when they lose their livestock and crops to the wild animals, people perceive that damage by wildlife as a serious issue, whether the damage is huge or small and try to kill the wild animal. The short term measures recommended by Wang and Macdonald (2006) to reduce conflict between humans and predators is the livestock intensification including financial compensation while the long term measures include testing the feasibility of an insurance scheme, exploring the possibility of realizing the restrictions on resource use in the Forest and Nature Conservation Act of Bhutan (FNCA) 1995 and involving farmers in human-wildlife conflicts management by encouraging improved herding, guarding practices and making proper corralling facilities.

Due to the shift in balance of less natural prey and more livestock availability, can shift the predators preferences over livestock (Mir et al., 2015). Human dhole interaction was more predominant on area where there is very less prey. For instance, Lyngdoh et al. (2014) reported high livestock depredation by dhole in Northeast India where there were low prey density because of the hunting.

Study conducted by Katel et al., (2014) in Toebisa geog, Bhutan showed that dhole depredation was among the top with 82%, which caused loss of 2% of the total cash income of the farmers and 11% of the cash income from livestock. The mean annual livestock lost to dhole accounts to 0.19 heads of livestock per year and per household. Among the livestock killed by the dhole, 4% were killed inside village and 96% were killed in the forest. Similarly, study conducted by Lyngdoh et al. (2014) in Arunachal Pradesh, India, showed that, dhole livestock depredation accounted for 73.2% of the depredation among the carnivore predators. He also asserted that the number of livestock owned was positively correlated with the livestock depredation. Whereas, study conducted by Wang and Macdonald in year 2006 at JSWNP, Bhutan, showed that leopard and tiger were held responsibility for majority of livestock depredation with 53% and 26% of the total livestock lost respectively with US$ 10,095 of the total monetary loss. Bear (8%) and dhole (13%) were responsible for rest of 21% with monetary loss of USD$ 2,157. Wangyel et al. (2006) reported that dholes contributed to most frequent livestock depredation with 40% in Phobji, which were located in conifer forest. Whereas, in Athang black bear accounted the most livestock depredation with 50%, which was located in broad leave forest.

Farmers in Bhutan mostly rear livestock to supplement their household income and they graze their cattle in or near the forest. In addition to grazing, farmers in Bhutan are dependent on nearby forests for forest produces like fuel wood, non-wood forest products and timber (Sangay and Vernes, 2008). Wang et al. (2006) in a study carried out in JSWNP found that people suffered major financial losses annually from crop loss to wild animals like wild pigs, barking deer, sambars and macaques. According to Thinley (2010) crop damage by wildlife, wild pigs in particular, was a major problem for farmers in Bhutan. Farmers who were more concerned about the crop damage were those whose livelihoods were more dependent on agriculture (Sangay and Vernes, 2014). Perceptions of crop growers are important because it can influence the altitude of farmer’s towards wildlife (Bashir et al., 2014).

In JSWNP, the loss of domestic animals, in a period of one year, due to wild dog was 13 percent of the total loss. Out of the total livestock loss to wild predators valued at US$ 12,252, the loss due to dhole was US$ 1,117. The annual mean livestock loss from wild predators per household was found to be more than two-thirds of the annual cash income (Wang and Macdonald, 2006). The depredation of livestock by dhole compared to tigers and leopard were less but people perceive it as a threat and were ready to kill it to protect their livestock.

2.4 Perception of farmers towards wild animals conservation

The conservation of wildlife will depend on the perception of people towards the wild animals and policies. While involving local people in conservation planning and decision-making processes, it was found important to understand the feelings and perceptions of people on the conservation policies and wildlife conflicts which affect their behavior (Jenks et al., 2014). People's perceptions towards damage-causing predators were often negative and, therefore, without the support and co-operation of communities, efforts in conserving large predators or carnivores may fail (Khatiwada et al., 2011). While designing long-term conservation strategies for protected area management, it is very important to understand the human attitudes and the potential of wildlife conflicts (Carter and Allendorf, 2016). Dar et al. (2009) stated that conservation efforts can be influenced by farmer's opinions on wildlife and conservation, which are influenced by wildlife damage to property, danger to human life, benefit systems and land use patterns changes; and monitoring locals' concerns can provide a foundation for effective decision making that mitigates wildlife impacts.

The African wild dog, Lycaon pictus, was classified as vermin in Rhodesia from 1906 till 1975 and throughout Africa they were mercilessly slaughtered as putative cattle killers and eradicated from National Parks (Woodroffe et al., 2005). The support for wolves in the USA declined when its population increased and people directly experienced the cost of living with wolves (Liu et al., 1999). However, wild dogs were reintroduced in Bhutan in early nineties in an effort to solve the problem of wild pigs in the country and now it is getting reestablished and peoples are negatively responding towards its population increase (Wang and Macdonald, 2006).

2.5 People's perception towards dhole conservation

People's attitudes toward wildlife conservation can significantly affect the success of conservation initiatives (Mir et al., 2015). Involving the local people in conservation planning and decision making is pivotal and it is very paramount to understand the perceptions of the local people on the wildlife conservation and conservation policies (Jenks et al., 2014). Understanding the factors influencing the perceptions is important for designing the strategies to alleviate human wildlife conflict (Khan and Abbasi, 2015). People's perception towards damage causing herbivores and predators are negative and without the support and co-operation of the farmers for conservation of wildlife would fail (Borah, Deka, Dookia, and Prasad, 2009).

Dholes have been extirpated from certain areas because of the perception that they pose significant threat to livestock (Kamler et al., 2012). People keeping their livestock in free range were more exposed to livestock depredation and consequently it cases retaliatory killing and negative perception towards its conservation (Lyngdoh et al., 2014). The attitudes of the farmers towards wildlife conservation in Kashmir were significantly influenced by gender, extent of crop damage, extent of livestock depredation and the total livestock owned. Other factors such as occupation and age, number of family members, income and the amount of land owned did not play a significant role in predicting the perception of the farmers (Mir et al., 2015)

According to study conducted by Wangyel et al. (2006) at JSWNP states that 68% of the farmers perceived that problem wildlife should be eliminated and there was significant association between age, literacy, gender, livestock ownership and location with the perception towards elimination of problem wildlife. Household that owned more than 10 heads of livestock exhibited greater perception towards elimination of problem wildlife. Similarly, Sangay and Vernes, (2014) also reported that communities in western Bhutan also expressed their desire to eradicate problematic dhole. They also reported that farmers in western Bhutan ranked livestock predation by dhole as a serious threat to the community livelihood and perceive dhole as a nuisance predator and were not in support of its conservation.

2.6 Human dhole conflict management intervention strategies

Human dhole conflict were in a form of livestock depredation by the dhole and which influences the attitude and perception of local communities to kill and go against the dhole conservation (Mir et al., 2015). The perceived problem of considering dhole as pest to livestock and their irrational fear of livestock depredation by dhole influences the conservation attitude and perceptions towards dhole conservation. Therefore, we can improve the conservation effort by incorporating more ecology training into school curriculum, outreach educational conservation program towards local communities. This would dispel false notion of considering dhole as pest and it can enhance understanding of why dholes are important to ecosystem (Carter et al., 2012). Educating people about the needs and benefits of conserving wildlife is crucial for gaining support for conservation endeavors and to gain the public's participation in the conservation initiatives (Mir et al., 2015).

Another way to manage human dhole conflict is by initiating livestock compensation schemes through revenue generated by wildlife, whether through tourism or other activities (Wang and Macdonald, 2006). In Bhutan creation of conservation fund received strong support for initiation of management of human wildlife conflict (Sangay and Vernes, 2014). Integrated strategic approaches towards human wildlife conflicts were grouped into three components; Integrated Conservation Development Program (ICDP), Environmental education and Ecotourism initiatives (Sangay and Vernes, 2008).

Wang and Macdonald recommend that alternatives benefits from community based ecotourism, livestock intensification and sustainable use of forest products should be initiated, which in turn can develop positive attitude and perception of local community towards wildlife conservation (2006). Dholes depends largely on socio-cultural attitudes, hence, encouraging public tolerance towards dhole conservation through scientific as well as legal measures is crucial (Lyngdoh et al., 2014)

Chapter Three

Materials and Methods

3.1 Study area

3.1.1 Location

Study was conducted in buffer zone of Jigme Khesar Strict Nature Reserve of four geogs, which lies between latitude 27°22' N to 27° 1' N and longitude 89° 1'E to 89°23'E. It was located in western Bhutan covering 726.61 square kilometers (sqkm) (Figure: 3.1).

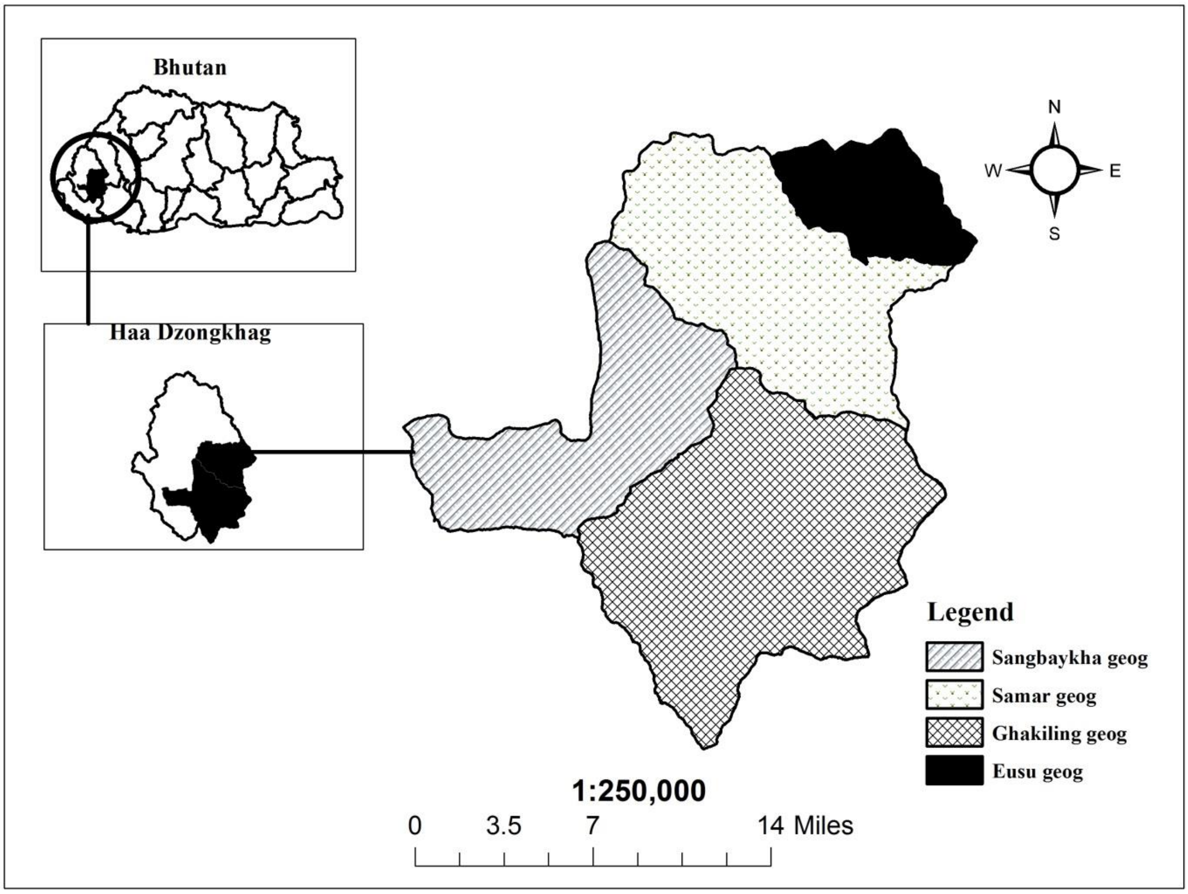


Figure 3.1: Study area location

3.1.2 Climate and vegetation

Study area covers wide range of vegetation zone stretching from warm broad leaved forest to alpine scrub in the north. Villages of two counties namely Gakiling and Sangbaykha falls within the broad leaved forest zone with elevation range from 491 to 2,183 masl. Villages of Sama and Eusu falls within conifer forest zone with elevation ranging from 2,476 to 4,597 masl. Dholes were found in wide range of vegetation zones from warm broad leave forest to alpine shrub (Thinley et al., 2011).

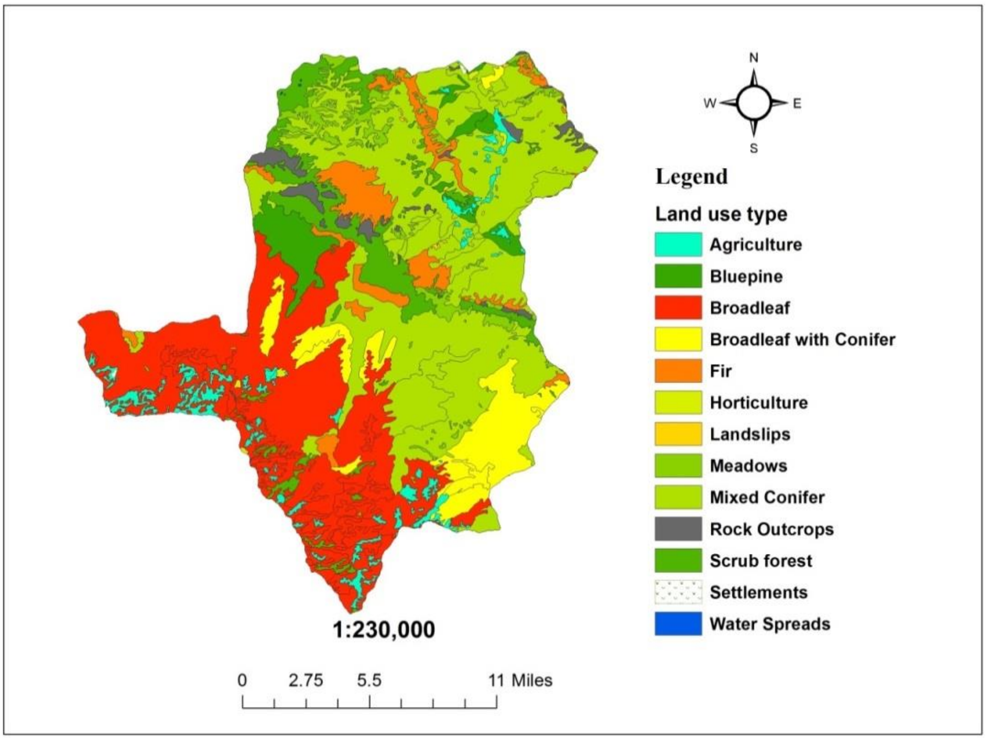


Figure 3.2: Land use type of the study area

Farmers within this area are agrarian and livelihoods of the local farmers are dependent on livestock rearing and agriculture. Several incidences of livestock depredation by dhole and other predators have been reported to office of Haa range forest and JKSNR. Presence of dhole in study site has been confirmed during systematic camera trap survey for tiger carried out in year 2015 by Wildlife Conservation Division (WCD). Hence, this area has been chosen for current study.

3.2 Research design

3.2.1 Conceptual framework

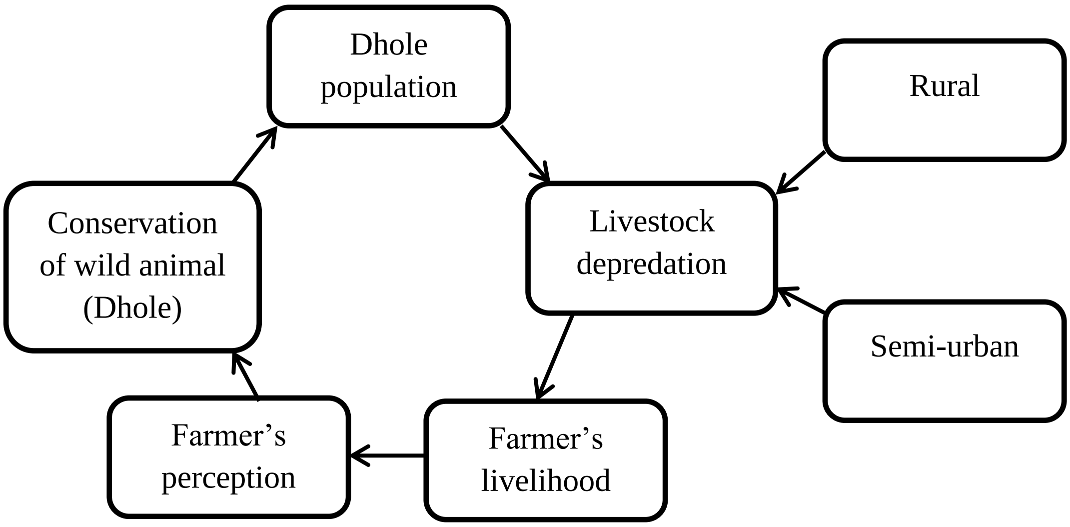


Figure 3.3: Conceptual framework

The increase in dhole population can have positive as well as negative impact to the livelihood of the farmers. Study conducted by Katel et al. (2014) in Toebisa Geog of Bhutan indicated that maximum livestock depredations were due to dhole. Dhole were found in wide range of ecological zones including subtropical forest, moist deciduous forest, evergreen forest, confer forest, scrub forest, grassland, and alpine steppe (Jenks et al., 2014). The extent of the depredation will be different based on the differences in vegetation type and different living standard of the farmers (Lyngdoh et al., 2014). Livestock depredation can happen due to lack of prey species in the location (Jenks et al., 2014). For example, Lyngdoh et al. (2014) reported high livestock predation by dholes in Northeast India where there are low prey. Livestock depredation by dhole had greater impact on the livelihood of the farmers. Katel et al. (2014) stated that dhole depredation of livestock accounted for majority of the farmer's income lost to wild predators.

Depending upon the extent of livestock depredation by dhole and its role in reducing the problem wild herbivores will determine farmer's perception towards dhole conservation (Mir et al., 2015). Study conducted by Wangyel et al. (2006) reported that majority of the responded expressed their desire to exterminate dhole from the wild. Similarly, Gusset et al.(2008) stated that majority of the respondent expressed negative perception towards dhole conservation where there were incidences of livestock depredation by dhole.

In Bhutan, huge number of livestock depredation by dhole occurred during 1970s and there was mass poising of the dhole, which lead to extirpation of dhole but in 1990s, population of wild pig increased, causing damage to farmer's agriculture products and government initiated reintroduction of dhole, which again will have impact on human livelihood and its conservation effort. Aforementioned statements influence the conservation of the dhole and thus determine dhole population.

3.2.2 Area stratification

Four counties were stratified into two strata based on the ecological zone, altitude, vegetation type and proximity of the village to urban zone. The principle criteria for the stratification of the survey area were the proximity of the settlements to the forest and national highway and town. Strata I was located in the subtropical zone dominated by broad leaved forest, moreover, it is far away from the motor roads, which is stratified as rural area. Strata II was located in the cool temperature zone dominated by the conifer forest and they are within the periphery of motor road which was stratified as semi-urban area (Table 3.1).

Table 3.1: Study area stratification

Strata	Agro ecological zone	Vegetation type	Counties	Category	Elevation range (masl)
Strata I	Subtropical zone	Broad leaved forest	Gakiling and Sangbaykha	Rural area	491-2,183
Strata II	Cool temperate zone	Conifer forest	Samar and Eusu	Semi-urban area	2,476-4,597

The idea behind stratification of the survey area was to compare the significance, intensity and prevalence of human dhole interaction in different ecological zone and within rural and semi-urban area with the hypothesis stating that dhole population will be more with increasing distance from the national high way or in the rural area (Figure: 3.3). This hypothesis was based on the assumption that the dholes avoid areas where there is high changes of human encounter and thus, will result in less livestock depredation (Borah et al., 2009). Stratification would help in identification of human dhole interaction status, livestock depredation extent, local farmer’s perceptions and different mitigation measures that need to be under taken in different ecological zones or two category of villages (Sangay and Vernes, 2008).

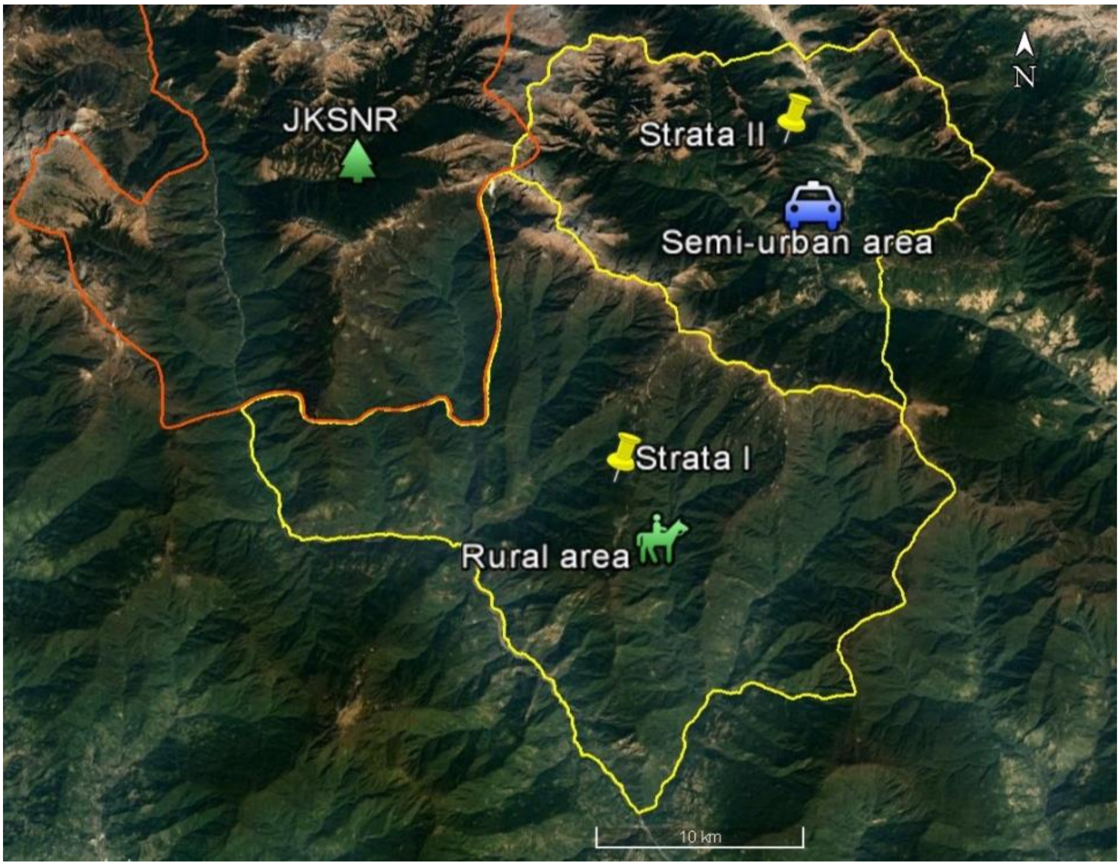


Figure 3.4: Study area stratification

3.2.3 Sampling design

Stratified random sampling was executed (Wangyel et al., 2006). Target population were households rearing livestock within past five years because not all the households were rearing livestock (Alexander et al., 2015). Villages within each stratum were treated as the sampling frame of the target population and 50% of the household rearing livestock within last five year, from each village were randomly selected, which were treated as sampling unit (Khan and Abbasi, 2015). Random selection of households were executed based on the random number generation against total households in the village using Microsoft excel.

3.2.4 Pre-testing of questionnaires

Pre-testing of the questionnaire is pivotal in enhancement of required and quality data collection (Woodroffe et al., 2005); therefore, pre-testing was carried out for six households, three each from two strata. Few unwanted questions were removed and few needy questions were included after pre-testing. Data collected during the pre-testing of the questionnaire were not included for analysis.

3.2.5 Household questionnaire interview

Questions were focused on the livelihood living, livestock holding, livestock predation by dhole and other predators. It also included the type of livestock lost to dhole, their response to livestock kill and site locations of the livestock kill. Perception of local peoples on dhole including their knowledge on dhole like “how they came to know dhole”, “how they perceive dhole” and “what is their knowledge on the trend of dhole population” were asked. Moreover the details of livelihood sources of farmers with their income lost due to livestock depredation by wild animals were also collected. All these information were embedded into the semi-structured questionnaire which comprised of both closed and open ended questions (Jenks et al., 2014).

Figure 3.5: Questionnaire interview with the farmer

Questions were also focused on demography, perception on the dhole conservation and its conservation policy. To assess the livestock depredation extents of wild predators, the respondents were asked to report all their livestock killed by wild predators during last five years with its kill predator, total value lost and time of kill with season.

Interviews were carried out by visiting the household identified (Wangyel et al., 2006). It was conducted away from other people nearby to avoid the override information by the other respondent and equal composition of sex and the age composition were given the priority during the interview (Katel et al., 2014). Head of the households were target to interview assuming that they have more knowledge and experiences about the household activities. This method has been widely used to evaluate predation patterns, perceptions and human carnivore interactions in Trans-Himalayan mountain ranges (Jackson, 1996; Khan etal.,2017).

Enumerators were trainee before going to the field for questionnaire survey. They were given inputs on the research proposal objectives, survey protocols, participatory rural appraisal techniques and social data collection methods (Rajaratnam et al., 2016). Enumerators were from Jigme Khesar Strict Nature Reserve and Haa Forest Range office.

3.2.6 Secondary data collection

Secondary data includes livestock holdings and income generated from livestock for last five years (2010—2016). This information was collected from Renewable Natural Resources extension office of Haa Livestock section.

3.3 Data analysis

Data was statistically analyzed using Statistical Package for Social Science (SPSS) Ver.23, ArcGIS 10.2 and Microsoft excel. Coding of the questions and the responses were done before analyzing the data. Both the descriptive and inferential statistics were used for data analysis.

Descriptive analysis includes the demographic characteristics of respondents like mean age of the respondent, percentage of livestock holdings, average total members per household, mean livestock holding per household, average annual income of the farmers and average income lost to predation by dhole and other predators. It also includes the percentage of respondent's information on the trend of dhole population, percentage of livestock lost to dhole in past five years, percentages of kill in different seasons and percentage of farmer's perception towards dhole conservation policy.

Data were tested for normality using histogram with its normal curve and Kolmogorov normality test. Normally distributed data includes age of respondent and number of member's in the living at household. Therefore, One-way ANOVA was executed to see the significant difference between the age of the respondents and the members per household between two strata.

Number of livestock holdings per household, income of the farmers and income lost due to depredation by dhole and other wild predators, numbers of livestock depredation by the wild predators and livestock population trend in last five years, kill distance of livestock type and wild predators and age category of livestock kill by the wild predators were non-normally distributed. Therefore, Mann-Whitney U test was used to see the significant difference in mean annual income between two strata, average annual income from different income sources between two strata, mean annual income from livestock between two strata, mean livestock kill between two strata, mean livestock kill between four season, day and night kill preference of common leopard, mean income lost due to dhole in two strata and mean income lost due to wild predators between two strata.

Kruskal-Wallis test was used to test the significant difference in mean yak population trend during last five years, livestock holding between years from 2012 to 2016, mean livestock holding per household in last five years, mean income from agriculture between two strata, age category of livestock kill by dhole, mean livestock kill by dhole between four seasons, livestock depredation by dhole in last five years, age category of livestock depredation by common leopard, age category of livestock depredation by black bear, mean horse depredation by common leopard during last five years, kill distance between livestock type and income lost due to wild predators excluding dhole.

Spearman's correlation was used to test the relationship between the mean annual income from livestock and agriculture to the mean annual income of the respondents. Pearson's correlation was executed to see the relationship between numbers of livestock killed between years.

Pearson's Chi-Square test was used to test the significant relationship between the categorical data like gender and their perception on dhole population trend, age category and their perception on current presence of dhole, gender and their perception on the solution to reduce dhole conflict, gender and their reaction when their livestock killed by dhole, respondents perception of whether dhole are beneficial or not to human between the strata, respondents perception on dhole conservation policy with number of livestock kill of the respondents and respondents perception towards dhole conservation policy between two strata.

Livestock depredation hot spot of wild predators were analyzed using ArcGIS 10.2 with the optimized hot spot analysis tool and Inverse Distance Weighting (IDW) tool. Livestock depredation hot spot areas were mapped with hot spot analysis tool and the hot spot depredation was extrapolated within the study area and livestock depredation hot spot distribution was mapped.

Chapter Four

Result and Discussion

4.1 Socio-demographic characteristics of study area

4.1.1 Demographic characteristic of respondents

Data were collected from 160 respondents, which comprises of 50 respondents from four geog. Out of 160 respondents, 47.5% (*n* = 76) were men and 52.5% (*n* = 84) were women. Respondents from strata I comprises of 75.4% (*n* = 44) male and 43.6% (*n* = 34) female and strata II comprising of 40% (*n* = 32) male and 60% (*n* = 50) female (Table: 2).The mean age of the respondents was 45.11(*SD* ± 14.09) with oldest respondent age of 82 and youngest of 19. The number of respondents with age less than 46 was 56.9% (*n* = 91), age from 47 to 64 was 31.9% (*n* = 51) and ages more than 64 was 11.3% (*n* = 18), which were significantly different, *F* (2,158), =4.54, *p* <.05 (Annexure 2.1).

The average household member living at home was 5 (*SD* ± 2.25) and household member's living at home in strata I (*M* = 4.910, *SD* ± 2.07) was lower than in strata II (*M* = 5.22, *SD* ± 2.15) with both the strata having minimum of two and maximum of 12 members but difference was not significantly different, *F* (1,158), =.858, *p* >.05. The study conducted by Johnsingh et al., 2007 at Toebisa geog also found that the mean family members size living in semi-urban area (right bank) (*M* = 8.42) was higher than in the rural area (*M* = 5.78).

Similar proportion of gender were selected for interview with the maximum of mid age class from both the strata. Both the strata were having similar number of members per household.

4.1.2 Livestock holding and population trend

Farmers in the study area are dependent on livestock and agriculture for their livelihood sustenance. The mean annual livestock holding per household was 17.29 (*SD* ± 17.97), including cat, dog and poultry, which was 17.2% more than farmers in JSWNP Wang and Macdonald, 2006). This was because farmers in JSNWP were rearing majority of improved breed than in current study site. Farmers in Kashmir were having lower of 28.9% of livestock per household when compared with current study site; it was because they never kept wide variety of livestock, majority were sheep and goat (Mir et.al, 2015). Both the strata were having similar numbers of livestock holding in year 2016 (Strata I; n = 1,378, Strata II; n = 1,389). Farmers in northern part of Nepal which were proximity to the developmental zones holds 20% of livestock less than the farmers living further away from the urbanization, where in, livestock and agriculture were main means of rural livelihood sustenance (Thapa, 2015). The mean number of livestock holding per household in strata I was 17.6 (*SD* ± 14.7) and in strata II was 16.9% (*SD* ± 13.3). Cow was highest among other livestock type in both the strata (Strata I 37.4% n = 516, Strata II 60%, n = 834) (Table: 4.1).

Table 4.1: Type of livestock holding of the respondents

	Strata I	Strata II
Livestock type	Total (%)	Total (%)
Yak		160 (11.5)
Horse	90 (6.5)	67 (4.8)
Cow	516 (37.4)	834 (60)
Ox	238 (17.3)	174 (12.5)
Goat	9 (0.7)	1 (0.1)
Poultry	410 (29.8)	31 (2.2)
Cat	55 (4)	43 (3.1)
Pig	17 (1.2)	3 (0.2)
Dog	43 (3.1)	76 (5.5)

Only nine households from strata I and three households form strata II reported rearing of pigs, the reason was that, it has been 10 year that most of the household had stop rearing pig because of the increase in sanctity of life and those who were rearing pig are blamed as evil person and moreover the pork were easily available in the market. Pig population in study was 169 in 2012 and it has increase to 205 in 2013, however, in the subsequent years it showed decreasing trend (2014, 80; 2015, 41, 2016, 40). Pig rearing trend had also decreased by 50% in the northern village of Arunachal Pradesh (Lyngdoh et al., 2014) whereas there was no significant decrease of pig population in Karakoram Mountains of Pakistan (Khan, 2016).

The trend of livestock holding by farmer in the last five years (2012—2016) showed varying result. There was no constant sequential exponential decreasing or increase in the livestock population trend except number of yak population in strata II showed decreasing trend, this was because the number of households rearing yak decrease from 12 to five households during last five years, which was significantly different (H (4) =339.67, p<.05) during last five years in strata II (Figure 4.1) (Annexure 2.2). The decrease in numbers of yak rearing household was because of the increase in literacy rate and children were not interested in herding yak (Tshering and Thinley, 2017).

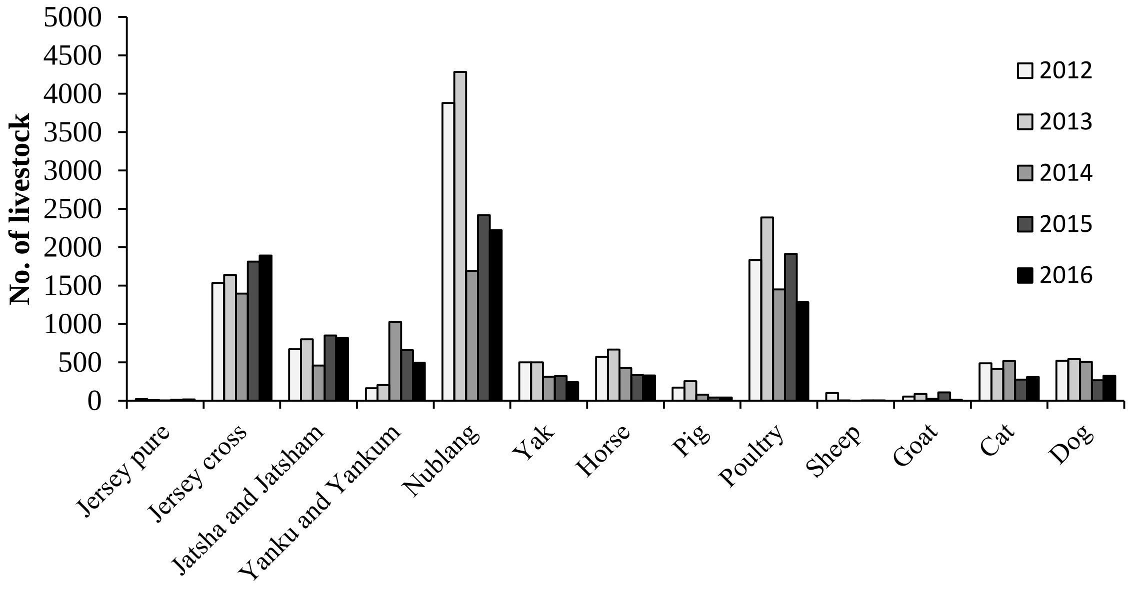


Figure 4.1: Livestock population of two strata (Source: RNR Office, Haa, 2017)

There was no significant difference in livestock holding between 2012 and 2013, *H* (1) =.487, *p*>.05 and 2015 and 2016 *H* (1) =.953, *p*>.05, however, there was significant different between in mean livestock holding per household from 2013 and 2014, *H* (1) =17.164, *p*<.05 and 2014 and 2015 *H* (1) =4.089, *p*<.05 (Annexure 2.3). The total livestock population recorded in 2013 was 11,794 and in 2014 it was 7,891. Therefore, this shows that there was decrease in livestock population from 2013 to 2014 (Annexure 2.4).

The mean livestock holding in year 2012 was 17.10 (*SD* ± 16.7, *n* = 10,501) per household, which constitutes 37.8% (*n* = 3,969) from strata I and 62.2% (*n* = 6,532) from strata II. The overall mean livestock holding decreased to 15.1 (*SD* ± 13.98, n = 7,985) in 2016 (Figure 4.2), which constitute of 42.7% (*n* = 3,409) from strata I and 57.3% (n = 4,576) from strata II. Livestock holding per house hold during last five years were significantly different *H* (4) =19.633, *p*<.05 (Annexure 2.5), indicating decrease in the average livestock holding per household from 2012 to 2016.Similiar findings were found by Khan (2016), where farmers nearer to the modern development and urban areas showed significantly decrease in livestock due to change in their income source from livestock to urban non-farm activities.

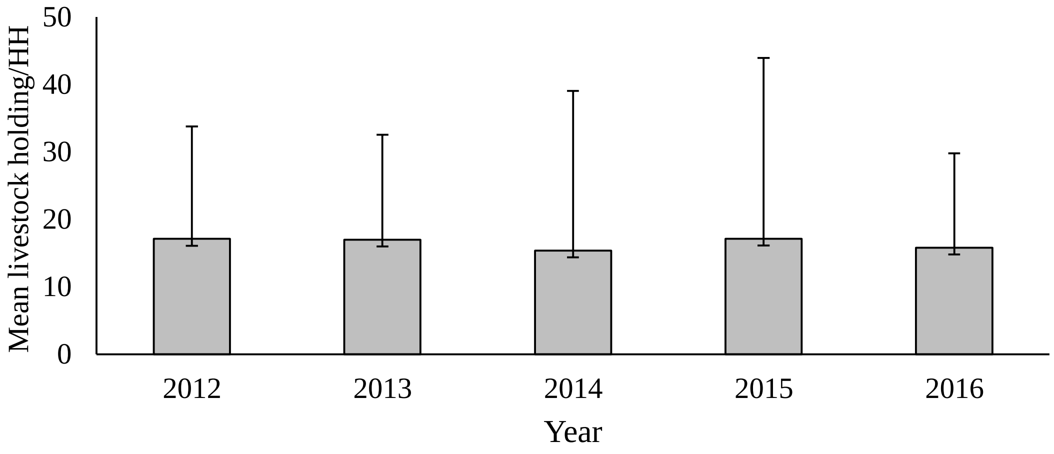


Figure 4.2: Mean livestock holding per household trend

4.1.3 Income source and livelihood of the farmers.

All the households interviewed practices subsistence agriculture which contributed towards main source of income for their livelihood. Livestock rearing also contributed to the livelihood source of income with other non-farm activities like business, support from their employee, forest produce collection and casual labor at villages. Approximately 69 % of Bhutan's population are farmers, practicing a combination of small-scale cropping and animal husbandry with livestock integral towards their socio-economy (Rajaratnam et al., 2016) .

The average annual cash income of household from all sources including livestock was Nu.111833.3 (*SD* ± 45,533.5) which was 91% higher than that of farmers in JSWNP (Wang and Macdonald, 2006) and 71% higher than farmers in Toebisa geog (Katel et al., 2014) and the reason could be because in strata I farmers were growing cardamom as their main cash crop and in strata II farmers mean annual income was contributed by combined force of agriculture, livestock, business, forest produce collection and casual labor, which provided better opportunities than farmers in Toebisa geog and JSWNP.

The average income holding of the respondents from strata I was Nu.117,549.90 (*SD* ± 42,116.3) and strata II was Nu.119,941.8 (*SD* ± 48,793.38) (Table: 4.2). There was no significant difference in mean annual income per household between strata I and strata II U = 3180, z = -.061, p>.05 (Annexure 2.6), because in strata I the average annual income from agriculture contributed 77.6% (M = 91,293.3, *SD* ± 28,467) by cultivation of cardamom as their main income source, whereas in strata II both agriculture (M = 54,711.97, *SD* ± 27,763.4) and livestock (M = 34,227.8, *SD* ± 40,055.9) contributed equally to the overall mean annual income per household followed by income from other non-farm activities

(Annexure 2.7). Katel et al. (2014) found that average income of the farmer decreases as they move further away from the national highways and it contradicts with the current finding because of the lucrative cardamom cultivation in rural area in the current study site.

Table 4.2: Mean annual income of the respondents

Stratum	Mean annual income per capita	Std. Error of Mean	Std. Deviation	Total
Strata I	117549.9	4768.73	42116.32	9168892
Strata II	119941.84	5388.33	48793.38	9835231
Whole area	118775.77	3599.74	45533.49	19004123

Average annual income from agriculture (U = 961.5, z = -7.64, p<.05), livestock (U = 1,801.5,z = -4.78, p<.05),forest produce collection (U = 1,340, z = -7.41, p<.05), business (U = 2,813, z = -2.52, p<.05), and casual labor (U = 2582.5, z = -3.27, p<.05) between two strata were significantly different, but it showed no significant difference in average annual income from employee support between two strata (U = 3,088,z = -.67, p>.05) (Annexure 2.8).The average income from agriculture was Nu.72,545.4 (*SD* ± 33,489.9), however livestock contributed only Nu.25,985.6 (*SD* ± 37,566.1) towards average annual income per household of the farmer. Therefore, in both the strata income from agriculture contributed maximum to the mean annual income (Table 4.3). The result was consistent with the farmers in Arunachal Pradesh, where 66% of the household depends in the subsistence agriculture (Lyngdoh et al., 2014). This is because farmers of these study sites shared similar economic zone.

Income of the farmers from agriculture in two strata were significantly different, H (1) =22.81, p<.05 (Annexure 2.9), this was because the higher income from agriculture in strata I was highly contributed by cash from lucrative cardamom because of the agro-ecological zone. Sale of potato and vegetables were the main cash crop that contributed towards income from agriculture in strata II, which was minimal when compared to the cardamom. Farmers in conifer zones of JWSNP were contributed maximum by the sale of potatoes and in the lower elevations were contributed by sale of livestock products and oranges (Wang and Macdonald, 2006).

Livestock contribution was only 14.73% towards farmers livelihood in strata I and 28.5% in strata II. The mean annual income from livestock between two strata were significantly different, U = 1,801.5, z = -4.776, p<.05 (Annexure 2.10). This was because farmers in the strata II has the easy excess to the market and in the semi-urban there are demands for livestock product, whereas farmers in the strata I are keeping livestock mostly for their household consumption and not for income because there was no market for their livestock products. Non-farm activities contributed only 6% of the total average income in strata I and in strata II, it contributed 25.9%, this was because in the semi-urban areas peoples were engaged in business, which alone contributed to 10% of the average annual cash income. Spearman's correlation shows no significant relationship between the total average cash income per household and the total average income from livestock, r_s = .177, p>.05, (Annexure 2.11) this was because the overall average income was contributed by agriculture and Spearman's correlation of average total income per household with average agriculture cash income showed significant positive correlation r_s = .811, p<.05, (Annexure 2.12), which indicates that increase in income from agriculture leads to increase in total income of the farmers. Katel et al. (2014) also found similar result, were the farmers nearer to the national highways were having higher income that those that were further away from the national highways.

Table 4.3: Mean annual income contributors (%)

	Strata I		Strata II	
Income contributor	Mean	%	Mean	%
Agriculture	91,293.3± (28467.4)	77.7	54,712 ± (27763.4)	45.6
Livestock	17,320.7 ± (32830.5)	14.7	34,227.8 ± (40055.9)	28.5
NTFP collection	1,072.7 ±(6074.7)	0.9	6,965.5 ± (8636.6)	5.8
Employee support	3,611.1 ± (9479.3)	3.1	4,471.5 ±(14705.3)	3.7
Business	2,606.8 ± (13209.9)	2.2	12,012.2 ±(32981.5)	10
Casual labor	1,645.3 ± (6565.8)	1.4	7,552.9 ±(15372.4)	6.3

4.1.4 Livestock holding characteristics and their protection measures

Farmers in the study area has different mechanism for rearing their livestock like stables or enclosure feeding, tethered in the field, send in the natural pasture or forest and itinerant herding. Out of 160 households more than half (58.1%, n = 93) send their cattle in the forest during day time and 25% (n = 40) of households tether their livestock in enclosure or field. The reason for those who send their livestock in the forest and never look after was because 57.1% (n = 114) of households reported labor shortage as their problem for looking after the cattle, where as in Toebisa geog, maximum (57%) of the farmers never leave or keep their livestock in the forest. The difference in herding practices between two study sites could be explained by availability of labor to look after the cattle (Katel et al.,2014).

Relatively strata-wise livestock rearing mechanism showed that 76.9% (*n* = 60) of households in strata I send their livestock in the natural pasture or forest during the day time and never look after the livestock for whole day. They were engaged only in sending their livestock to natural pasture or forest in the morning. In strata II, 40.2% (*n* = 33) of households were engaged in sending their livestock in the natural forest during day time followed by 34.1% (*n* = 28) tethering their livestock in their fields. Whereas farmers in Eyamoo village under Toebisa geog never kept their livestock in the forest; they took animal to forest with cattle herder for grazing at day and stall fed at night in village, the difference was because farmers in Eyamoo were driven by the traditional system of livestock rearing passed on to them by their grandparents (Johnsingh et al.,2007) and it was no more practiced in the current study site.

Stall feeding and keeping (3.8%, *n* = 3) in enclosure was least practiced in strata I and even in strata II (9.8%, *n* = 8) (Table 4.4). Farmers in both the strata reported fodder shortage as one of the livestock rearing challenges and they could not stall feed the livestock.

Table 4.4: livestock rearing mechanism

		Stables or enclosure	Natural pastures or forest	Tethered in the field	Herding in forest
Strata I	No. of HH (%)	3 (3.8)	60 (76.9)	12 (15.4)	3 (3.8)
Strata II	No. of HH (%)	8 (9.8)	33 (40.2)	28 (34.1)	13(15.9)
Whole area	No. of HH (%)	11 (6.9)	93 (58.1)	40 (25)	16 10)

4.2 Livestock depredation by the wild predators

Total of 443 numbers of livestock were lost to wild predators in last five years, which was caused by six numbers of predators belonging to 108 households. 64.6% (*n* = 286) were killed in strata I and 35.4% (*n* = 157) were killed in strata II, which were significantly different, (U = 1,927.00, z = -4.428, p<.05) (Annexure 2.13). Livestock depredation by wild predators involved six types and cow was highest with 36.6% (*n* = 162), followed by ox with 26.2% (*n* = 116) (Table 4.5), which were proportionally to their relative abundance. Cow (*n* = 430) killed in Bhutan during 2003 to 2005 by the wild predators was highest among the other livestock types (Sangay and Vernes, 2008). So farmers in Bhutan own major proportion of their livestock as cow and they are vulnerable to predation based on their abundance.

Table 4.5: Livestock type kill number by the wild predators

	Pig	cow	Ox	Dog	Horse	Yak	Poultry
Total kill no (%)	6 (1.4)	162 (36.6)	116 (26.2)	11 (2.5)	50 (11.3)	30 (6.8)	68 (15.3)

Maximum numbers of livestock were killed during the spring season (36.3%, n = 161), during which the farmers were busy with their peak agriculture activities and livestock were left in the forest. Only 14.4% (n = 64) were killed in winter but there was no significant difference of kill between four seasons, (U = 980, z = -.310, p>.05) (Annexure 2.14), where as in Tibet, kills were mostly common in autumn which corresponds to livestock being moved to higher elevation to graze pasture during those periods (Li et al., 2013) The inadequate herding practices was contributor to livestock kill by wild predators in the Himalayan region (Bagchi and Mishra, 2006), including Bhutan (Wang and Macdonald, 2006). More than half of the livestock predation were of adult (57.3% n=254).

The overall livestock depredation by wild predators increased from 2012 with 68 kill and 110 livestock kill in 2016 but the relationship was not significantly different (r_s = .091, p>.05) (Annexure 2.15).

4.3 Livestock depredation by dhole

4.3.1 Type of livestock depredation by dhole

Livestock depredation by dhole comprises of 52.6% (n = 233) belonging to 88 households (Table 4.6). This result was in conformity of the number of livestock killed by dhole with 34.7% (n = 51) in Toebisa geog as highest kill, as reported by Katel et al. (2014) but the result contradicts the result of the study conducted by Wang and Macdonald (2006) in JSWNP, where they found leopard (53%) and tigers (26%) killing more domestic animals than dhole (13%) followed by bear (8%), the reason could be due to difference in the corridors of other wild predators. However the finding was consistent with the study conducted by Tshering and Thinley in 2017, who also found that dhole as the major predator for livestock depredation (49.9%, n = 177) among other three predators in JDNP during period of three years (2012—2014). The reason for the more loss of livestock to the dhole could be due to cattle herding practices (Send to the forest during day time without herding, 68.1%, n = 109) and also due to forest destruction and habitat encroachment by the human. Dholes were also top predator in the neighboring regions like Arunachal Pradesh (70%) (Lyngdoh, 2014).

Table 4.6: Total cattle lost to wild predators from 2012-2016

Predators	Total livestock kill (no)	Total livestock kill (%)	Total HH affected (no)
Dhole	233	52.6%	88
Common leopard	83	18.7%	51
Snow leopard	27	6.1%	3
Black bear	50	11.3%	27
Leopard cat	15	3.4%	8
Yellow throated marten	35	7.9%	8

From total of 233 livestock depredation by dhole, 54.2% (n = 134) were cow followed by ox with 40.1% (n = 89), this result was consistent with the findings of Katel et al. (2014), who reported that local cattle kill by dhole was highest (89%, n = 141) in Toebisa geog. Livestock predation by dhole was maximum in strata I with 72.9% (n = 170) kill and in strata II with 37.1% (n = 63). The mean livestock lost to depredation by dhole in strata I was 3.7 (SD ± .59) numbers per household per year and in strata II it was 1.9 (SD ± .62). In both the strata dhole depredation was highest among the other predators with maximum depredation on cow in both the strata (Strata I, 55.9%, n = 95, Strata, II 61.9%, n = 39) and followed by ox (strata I 39.4%, n = 67, strata II 34.9, n = 22) (Table 4.7).

Table 4.7: Number of livestock kills by dhole in five years

	Strata I				Strata II			
	Total kill	Mean	SE	SD	Total kill	Mean	SE	SD
cow	95 (55.9)	1.36	.08	.68	39 (61.9)	1.50	.15	.76
Ox	67 (39.5)	1.31	.07	.47	22 (34.9)	1.10	.07	.31
Horse	8 (4.7)	1.00						
Yak					2 (3.2)	1.00		
Total	170 (72.9%)	1.44	0.07	1.05	63 (37.1%)	1.50	0.09	0.92

From the overall proportion of livestock kill by the wild predators dhole alone contributed 52.6% (n = 233) and other predators together contributed 47.4% (n = 210), indicting dhole as a top predator for livestock depredation. Dhole caused maximum number of livestock depredation with cow and ox as the highest victim, which were more in strata I compared to the strata II but in both the strata dhole depredation was highest.

4.3.2 Age category of livestock depredation by dhole

From the total livestock kill by dhole, 55.8% (n = 130) were adult (>2 years) and 44.2% (n = 103) were young (<3 years) (Figure 4.3). The kill age category of livestock by dhole showed no significant difference, H (1) =.2210, p>.05 (Annexure 2.16) which indicates that dholes has no preferences over the age of the livestock for kill.

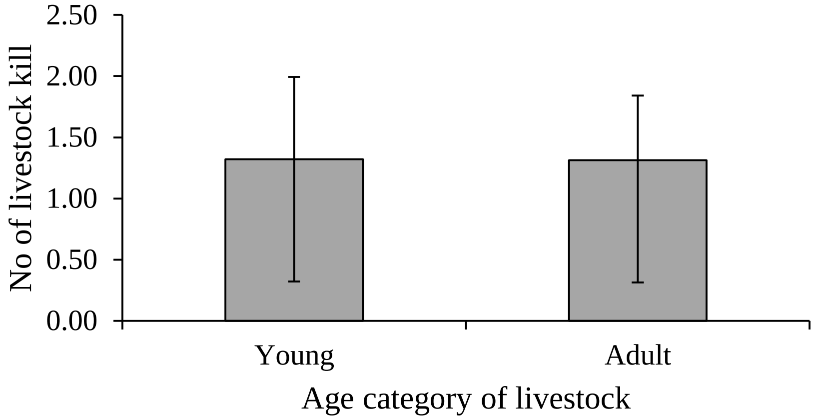


Figure 4.3: Age categories of livestock kill by dhole

4.3.3 Seasonality and time of livestock depredation by dhole

The maximum depredation of livestock by dhole occurred during spring season (31.8%, n = 74) and there was no much percentage variation with the lowest (winter=15.9%, n = 37) (Figure 4.4).Therefore, number of livestock kill by dhole in four seasons were not significantly different (H (3) =2.975, p>*.05)* (Annexure 2.17).

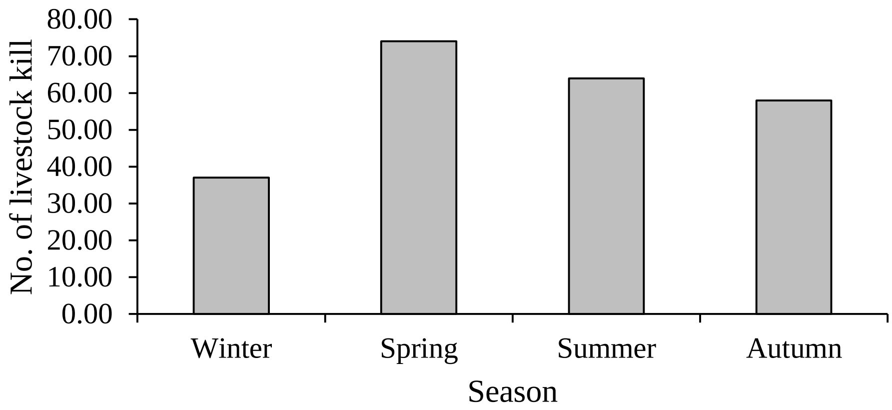


Figure 4.4: Month of livestock depredation by dhole

Livestock depredation season of dhole was similar to the findings of the study conducted by Thinley et al. (2011) at JDNP, where they found that livestock depredation by the dhole were more in the wet season (Spring and Summer) and also similar cases of depredation by dhole in summer was found by Sangay and Vernes (2008).

Out of 177 incidences of livestock kill by dhole, 99.4% (n = 176) were made during day time and only 0.6% (n = 1) at night. Therefore, we conclude that the dholes were more active during day time. Similarly, livestock depredation by dhole was not reported during the night in study by Tshering and Thinley (2017) in JDNP, this was because dholes were normally active during the day time (Selvan et al., (2013).

4.3.4 Livestock depredation trend of dhole

The maximum livestock depredation by dhole was made in 2013 with 54 kills and the lowest kill was made in 2016 with 41 kill (Figure 4.5) and the livestock kill was not significantly different (*H* (4) =4.063, *p>.05)* (Annexure 2.18), indicating similar livestock kill numbers by dhole in last five years.

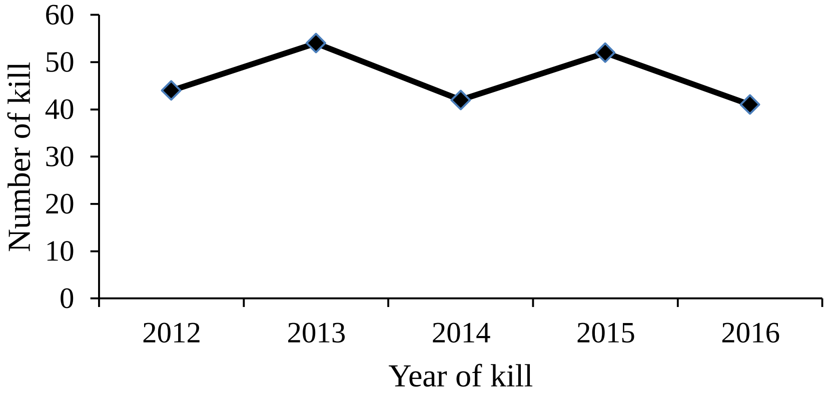


Figure 4.5: Livestock depredation trend of dhole

Dhole depredation on cow and ox were reported in every year from 2012 to 2016. In 2012 only cow and ox were lost to dhole but in 2013 dhole depredation includes horse, cow and ox. Horses were lost to dhole every year except in year 2012 and the number of horse kill by dhole in five years was 8, which indicates that horses are less depredated by dhole. Ox showed increasing trend from 2012 to 2016 (Figure 4.6) but the trend was not significantly different *H* (4) =3.171, *p>.05* (Annexure 2.19). Cow depredation was not constant in last five year; it was highest in 2013 with 36 numbers of kill with lowest in 2016 with 15 numbers of kill.

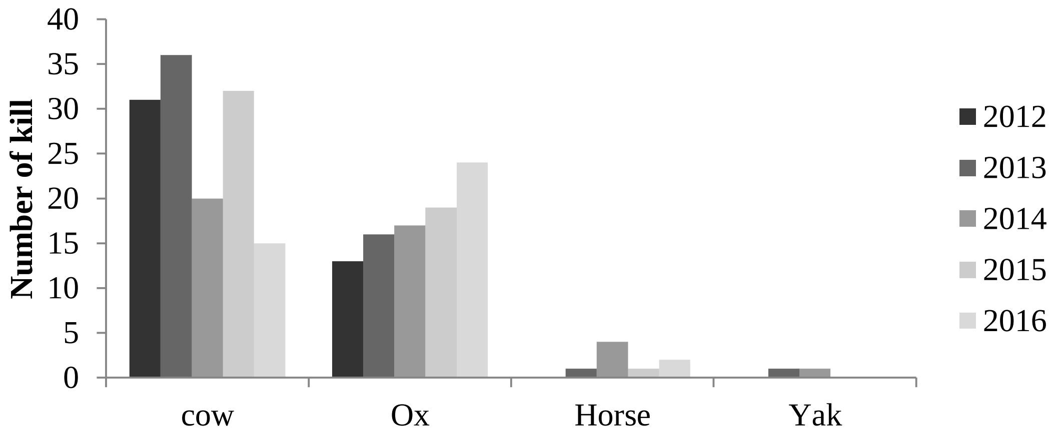


Figure 4.6: Livestock type kill trend of dhole

4.4 Livestock depredation by other wild predators

4.4.1 Type of livestock depredation by other wild predators

Common leopard, Snow leopard, black bear, leopard cat and yellow throated marten were other predators that caused livestock depredation. Common leopard killed 18.7% (*n* = 83) of the livestock next to dhole belonging to 51 households (Strata I, *n* = 29, Strata II, *n* = 22) in last five years. From 83 numbers of livestock kill, maximum (60.2% *n*=54) were reported from strata I and less (34.8%, *n* = 29) were reported from strata II (Annexure 2.20). The reason could be because the rural villages were nearer to the forest than the semi-urban villages connected with motor road. The result of livestock depredation by common leopard is conformity with the findings of the study conducted in Bhutan by Sangay and Vernes (2008), which showed that next to dhole, common leopard contributed 70% of the livestock depredation.

Livestock depredation preferences of common leopard constitute cow with 22.4% (*n* = 15), ox 17.9% (*n* = 15), dog 14.9% (*n* = 11), horse 37.3% (26) and poultry 7.5% (*n* = 13), which indicates that common leopard depredates almost all type of livestock and maximum kill was with horse (52%, *n* = 26). This could be because horses were normally sent in the forest and collected only when they were need for transportation, this results in increase their in their vulnerability to predation (Lyngdoh, 2014). This result contradicts with the finding of the study conducted by Wang and Macdonald (2006) in JSWNP, where they found that evidences of domestic dog in common leopard scats which agreed with the findings of the questionnaire interview. The difference was because farmers in the study site kept dog as pet at home and never left free roam as like in JSWNP. 60% of the horse kill were from strata I and 40% from strata II, this was because horses were used as mode of transportation in strata I. Similarly, villages without motor roads reported more horse losses than those where motor transportations were more common in Bhutan (Sangay and Vernes, 2008).

Black bear was next to common leopard with 11.3% (*n* = 50) kill, where 40% (*n* = 20) of the kill were from strata I and 60% (*n* = 30) were from strata II. This was because in strata II there were maximum forest produce collectors (93%, *n* = 53) and it could have imbalanced the bear habitat and the bear could have come to the village. Maximum kill of black bear were on horses with 31.6% (*n* = 16), followed by ox 28.9% (*n* = 12) and least with yak 2.6% (n = 1) (Table 4.8).

Other predators include leopard cat and yellow throated marten which killed only poultry. Snow leopard depredation on yak was reported from Strata II with 27 kills. There were significant difference in number of livestock kill by common leopard and snow leopard

(U = 76, z = -5.024, p<.05) but difference between common leopard and black bear was not significant (U = 1143.5, z = -1.20, p>.05), which indicates that depredation intensity of common leopard and black bear were similar (Annexure 2.21). This result contradicts with the findings by Sangay and Vernes (2008) where they found that black bear caused less livestock kill than common leopard in Bhutan (8%).

Table 4.8: Livestock kill composition among wild predators

	Pig No (%)	cow No (%)	Ox No (%)	Dog No (%)	Horse No (%)	Yak No (%)	Poultry No (%)
Dhole		134 (54)	89 (40)		8 (5)	2 (1)	
C leopard		18 (22)	15 (18)	11 (15)	26 (37)		13 (8)
S leopard						27 (100)	
black bear	6 (11)	10 (21)	12 (29)		16 (32)	1 (3)	5 (5.3)
Leopard cat							15 (100)
Y T marten							35 (100)

C, Common; S, Snow; Y T; Yellow Throated

4.4.2 Age category of livestock depredation by other predators

Maximum number (61.4%, n = 51) of livestock kill by common leopard were of adult and only 38.5% (n = 32) were of young. Thus, it indicates that common leopard normally depredates on adult livestock than the young but the age preferences for livestock kill was not significantly different, H (1)=2.192, p>.05 (Annexure 2.22).The age category of livestock kill by black bear comprises of 54% (n = 27) adult and 46 %(n = 23) (Figure 4.7) of young livestock, which was not significantly different H (1)=.058, p>.05 (Annexure 2.23) and it indicates that black bears has no choices over the age of livestock for kill, which was similar to the bear livestock depredation in JSWNP (Wang and Macdonald, 2006)

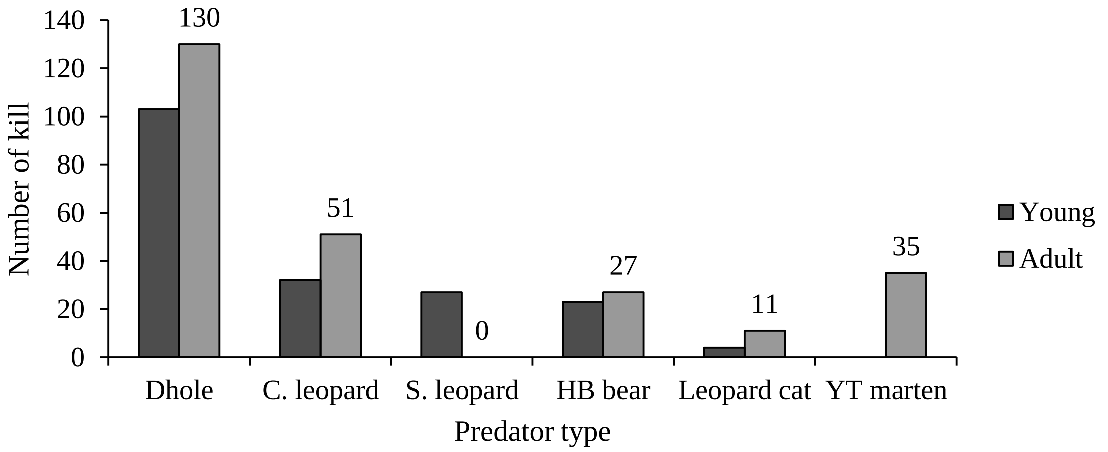


Figure 4.7: Age categories of livestock kill by wild predators

4.4.3 Time of livestock depredation by other wild predators

The significantly (*U* = 302, *z* = -1.985, *p*<.05) (Annexure 2.24) maximum kill incidences of livestock by common leopard were made during day time (77.7%, *n* = 52) and only 22.4% (*n* = 15) were killed at night. This indicates that common leopards are more active during day time for the livestock kill, whereas kill timing of the black bear was opposite to common leopard, where 84.2% (*n* = 32) of the kill by black bear were made at night and only 15.85% (*n* = 6) in the day time. A similar result, where 80% of the black bear kill was reported during the night by Tshering and Thinley (2017). All the 10 incidents of livestock kill by snow leopard were reported during day time. All 35 incidents of poultry kill by yellow throated marten were killed at night, similarly 73.3% (*n* = 11) of the poultry kill by leopard cat were also at night and only 26.7% (*n* = 4) was killed during day (Table 4.9).

Table 4.9: Wild predators kill timing of livestock (Numbers).

	Day						Night						
Predators	cow	Ox	Dog	Horse	Yak	Poultry	Pig	cow	Ox	Dog	Horse	Yak	Poultry
Dhole	133	89		8	2			1					
C leopard	17	11	9	21		1		1	4	2	5		12
S leopard					27								
B bear	3			3			6	7	12		13	1	5
L cat						4							11
YT marten						28							7
Total	153	100	9	32	29	33	6	9	16	2	18	1	35

C, Common; S, Snow; B, Black; L, Leopard; Y T; Yellow Throated

4.4.4 Seasonality of livestock depredation by other wild predators

Livestock depredation by common leopard were maximum in spring (54.2%, *n* = 45), followed by summer (27.7%, *n* = 23), winter (12%, *n* = 10) and least in winter (6%, *n* = 5). Similarly, majority of livestock killed by leopard in Pakistan's Machiara National Park occurred during the summer months of May and July (Dar et al., 2009). Snow leopard kill was reported in summer with 96.3% (*n* = 26) and spring with 3.7% (*n* = 1). The result contradicts with the study conducted at Sanjiangyuan Region of the Tibetan Plateau where they had reported that maximum number of yak was killed during the spring and season (Li et al., 2013). The reason for the difference could be because they move within the same elevation range for all seasons whereas itinerant yak herders in strata II come down to low lands during autumn season and only at end of spring they move to high mountains. Black bear depredation on livestock were maximum in summer with 54 %(n = 27) and spring with 36% (n = 18) and only 8% (n = 4) were reported in winter and 2% (n = 1) in autumn. The reason could be because maximum numbers black bears go for hibernation during the winter months (Johnsingh et al., 2007). Poultry kill by leopard cat and yellow throated marten were reported only in winter (leopard cat 53.3%, n = 8, yellow throated marten 54.3%, n = 19) and summer (leopard cat 46.7%, n = 7, yellow throated marten 45.7%, n = 16) (Figure 4.8).

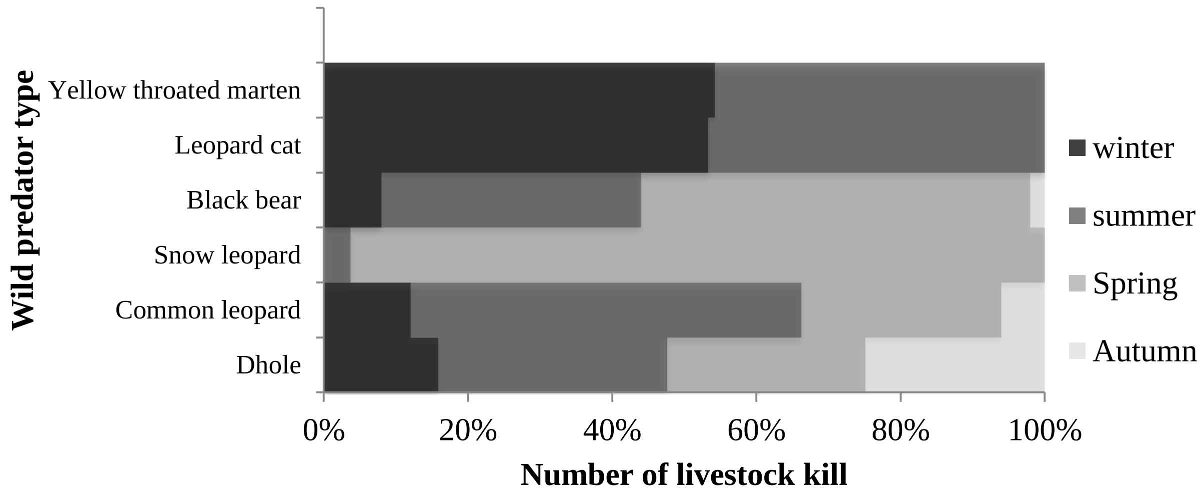


Figure 4.8: Livestock depredation seasonality of wild predators

4.4.5 Livestock depredation trend of other wild predators

Numbers of livestock depredation by common leopard showed increasing trend from 2012 with 7 kill and 28 killed in 2016. Common leopard depredations on horse increased from 4 kill in 2012 to 8 kill in 2016, but the difference was not significant (H (4) =1.423, p>.05) (Annexure 2.25).

Snow leopard depredation on yak was reported every year in last past years from strata II. Only one number of pig kill by black bear was reported in 2012 and not reported in rest years, this is because the number of households rearing pig decreased in both the strata over last five years.

Cow and ox kill by black bear were reported in every last five years, this was because cow and ox were the major component of their livestock composition. Horses killed by wild predators were reported in four years and it was not recorded in 2012. Poultry killed by black bear were reported in 2015 and there were no records in other years. Leopard cat and yellow throated marten kill on poultry were reported in year 2015 and 2016 (Table 4.10). Farmers were not aware of the poultry farming until 2015 and in year 2014 dzongkhag agriculture section initiated promoting poultry farming and farmers took poultry farming from 2015.

Livestock kill by common leopard in strata I was reported every year for the last five years and in strata II it was not reported in 2012.

Table 4.10: Livestock depredation trend of wild predators

	D kill (No)	C L kill (No)	S L kill (No)	BB kill (No)	L C kill (No)	YTM kill (No)
2012	44	7	8	9		
2013	54	8	2	8		
2014	42	14	5	7		
2015	52	26	3	20	7	17
2016	41	28	9	6	8	18
Total	233	83	27	50	15	35

D, Dhole; C L, Common leopard; SL, Snow Leopard; HHB, black bear; L C, Leopard cat; TYM, Yellow throated Marten.

4.5 Livestock depredation occurrence and hotspot

4.5.1 Livestock depredation distance from village

The livestock depredation pattern and the kill distance of the wild predators occurred at varying distance from the herd or village. Relatively 52% (n = 229) were killed within one kilometer (km) from the village and 33% (n = 145) were killed inside the village or herd followed by 12% (n = 54) within one to two km from the village and only 3% (n = 15) were killed at distance more than 2 km away from the village (Figure 4.9).

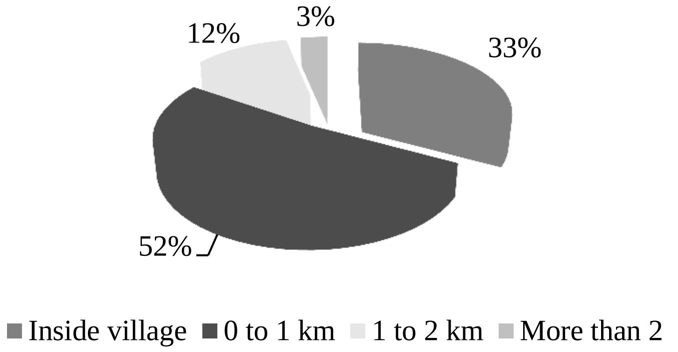


Figure 4.9: Livestock kill distance of wild predators from the village

Maximum dhole depredation took within one km (52%, n = 167) from the village (Figure 4.10), because farmers free range their livestock in the nearer forest and never look after the cattle. They were engaged in sending in the morning and cattle come back to their shed in the evening, in which livestock become easy prey for the dhole within proximity to the village without attended (Johnsingh et al., 2007).

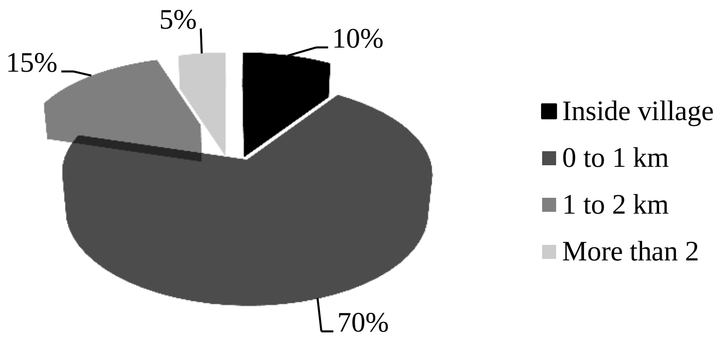


Figure 4.10: livestock kill distance of dhole from the village

The other predators include, common leopard with relatively 39.8% (*n* = 33) kill inside the village and 84% (*n* = 42) of depredation by black bear were also killed inside the village. Therefore, common leopard and black bear normally hunt livestock inside the village. Tshering and Thinley (2017) also found that the livestock kill by common leopard were mostly (78%) inside the village for the dog hunt in JDNP and Katel et al. (2014) also reported that 70% (*n* = 20) of the leopard kill were inside the village and 29% (*n* = 8) were in the forest in Toebisa geog. The livestock kill reported by leopard cat (*n* = 15) and yellow throated marten (*n* = 35) were all made within the village because they hunt for poultry, which were kept within the village.

There was significant difference in kill distance among the livestock type killed *H* (3) =16.458, *p<.05* (Annexure 2.26), where maximum cow was killed within 1 km with 71% (*n* = 115) and only 14.2% (*n* = 23) were killed inside the village. There was no much kill distance variation of horse (Inside village=32%, 1 to 2 km=38% and >2=20%) (Table 4.11). Yak kill was maximum within the 1 km (96.7%, *n* = 29) of the herd. All six pig killed were confined inside the village.

Table 4.11: Livestock type kill distance by wild predators

	Inside village	0 to 1 km	1 to 2 km	More than 2 km
Pig	6 (100)	0	0	0
cow	23 (14.2)	115(71)	19 (35.2)	1 (33.3)
Ox	25 (21.6)	61 (52.6)	25 (46.3)	1.25 (33.3)
Dog	6 (54.5)	5 (45.5)	0	0
Horse	16 (32)	19 (38)	10 (18.5)	1 (33.3)
Yak	1 (3.3)	29 (96.7)	0	0
Poultry	68 (100	0	0	0

4.5.2 Depredation hot spot of wild predators

Depredation of the livestock by wild predators are driven by the location of the village in proximity to the forest, population structure of the wild predators and the livestock rearing pattern of the farmers (Acharya et al., 2016). Livestock depredation hot spots were more in strata I because it was located in a remote location without modern developments and has intact natural forests, which are viable for predator's survival, moreover, the farmers never, look after their livestock during the day time (Johnsingh et al., 2007).

Nine villages from the strata I falls within the significant depredation hotspot zones (p<.01), which indicates that these villages were having a major livestock depredation problem and future depredation vulnerability were also sensed. Eight villages from the strata II falls within the significant cold spot livestock depredation zones (p<.01), which indicates that these villages are having a negligible livestock depredation by the wild predators and it is less likely to livestock depredation in future. The degree of livestock depredation hot spot increases as we move further away from the economic zone and national highway (Figure 4.11).

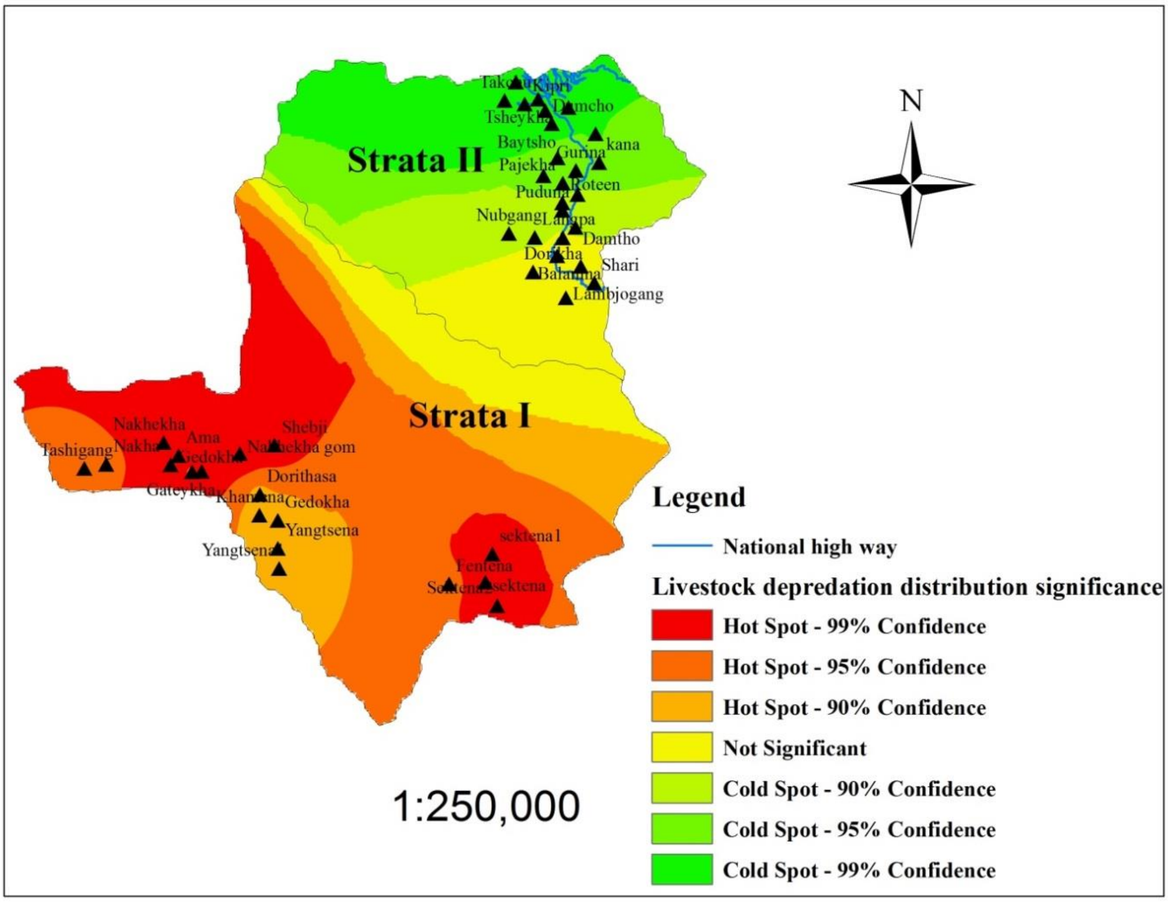
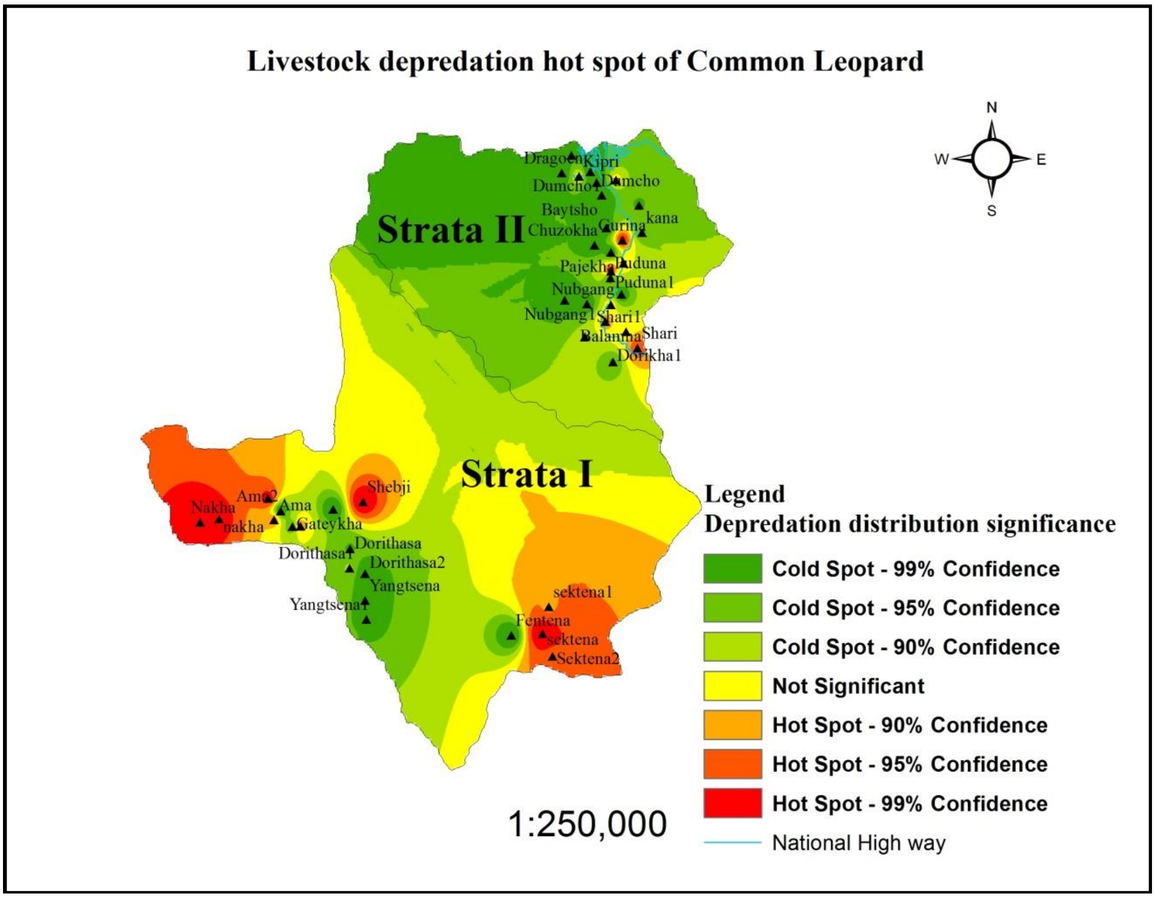
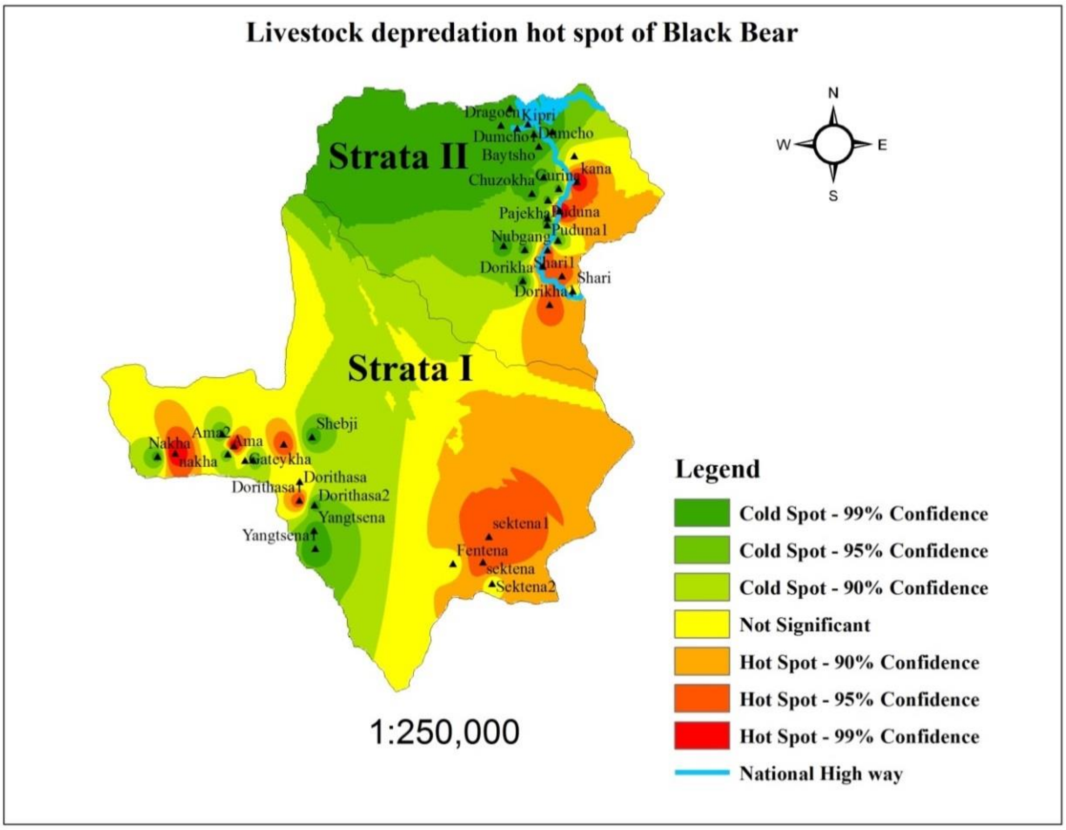


Figure 4.11: Livestock depredation hot spot

Livestock depredation hotspot of dholes were concentrated in strata I and eight villages from this strata falls within the significantly ($p<.01$) depredation hot spot zone and only small area of hot spot zones were detected in strata II with one village falling within it, which indicates that dholes depredations were more concentrated in rural villages than in semi-urban villages (Figure 4.12 C). Common leopard depredation hot spot were detected more in strata I and four villages were found to be within common leopard depredation hot spot zones in strata II (Figure 4.12 A). Black bear depredation hot was similar in two strata, six villages from each strata falls within the significant ($p<.01$) livestock depredation hot spot zones of black bear (Figure 4.12 B)



(A)



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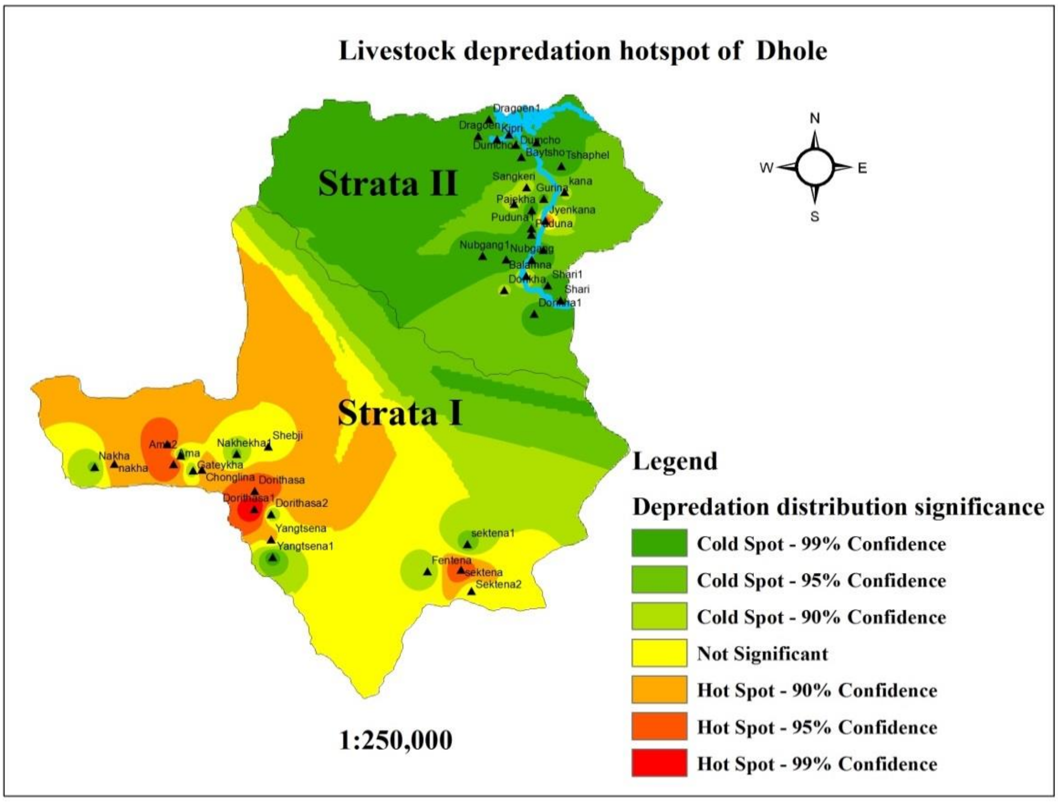

(C)

Figure 4.12: Livestock depredation hot spot of wild predators

4.6 Farmers income lost due to depredation by wild predators

4.6.1 Farmers income lost due to depredation

The total monetary value lost due to livestock depredation by wild predators in last five years was Nu.95,7290, which was 5.04% of the total income (Nu.19,004,123) earned by the respondents in last five years. The average value of livestock lost per annum per household due to livestock depredation by wild predators combined was Nu.5,983.1 (*SD* ± 3,938.9). The value of livestock lost due to depredation by wild predators per annum in comparison with the average annual cash income per house hold is comparatively lower (32.9%) than in Toebisa geog (Katel et al., 2014), it was because of the difference in income from the agriculture contribution due to different agro ecological zone.

The average mean annual cash income per household lost due to depredation by wild predators in strata I was Nu.6,959.5 (*SD* ± 3,898.5), which was 5.9% of the mean annual cash income (MAI=117,549.9) per household of the strata I and average annual income lost to depredation in strata II was 5,054.3 (*SD* ± 3,909.6, which was 4.2% (MAI=1,199,941.8) of the mean annual income per household of the strata II (Table 4.12). The variation in average annual cash income lost to wild predators between two strata was significantly higher in strata I (U = 8,119.00, z = -3.199, p<.05) (Annexure 2.27).

Table 4.12: Total income value lost to wild predators (*in Nu*)

	Income Lost to wild predators		
	Whole area	Strata I	Strata II
Mean	5,983.06	6,959.49	5,054.27
Std. Error of Mean	325.91	276.36	381.54
Median	4,800	5,600	4,800
Std. Deviation	3,938.92	3,898.5	3,909.58
Total value (Nu)	957,290	542,840	414,450

4.6.2 Farmers income lost due to depredation by dhole

The average monetary value lost due to livestock predation by dhole for last five years were Nu.576,720, which was 3% of the total annual income holding (Nu.19,004,123) of the respondents. The mean average income lost due to livestock depredation by dhole was Nu.3,605.50, which was 60% of the income lost due to wild predators (Figure 4.13). The mean annual income lost due to dhole (60%) was more in comparison with the mean annual income lost due to dhole (32.9%) in Toebisa geog (Katel et al., 2014) and the mean annual income loss due to dhole (13%) by the farmers in JSWNP (Wang and Macdonald, 2006).

This was because in these two areas tiger also added to the livestock depredation, whereas no record of tiger kills was reported in the current study site.

The average value of livestock lost to dhole in strata I (Nu.5,162) was much higher than in strata II (Nu.2,122.4) (Figure: 4.13) and in both the strata dhole contributed maximum to the income lost due to depredation (strata I=74.2%, strata II=41.9%). When we compared the income lost due to livestock depredation by dhole in two strata, dhole contributed 69.2% in strata I and only 30.2% in strata II, which was significant higher in strata I (*U* = 2,964.00, *z* = -.436, *p*<.05 (Annexure 2.28).

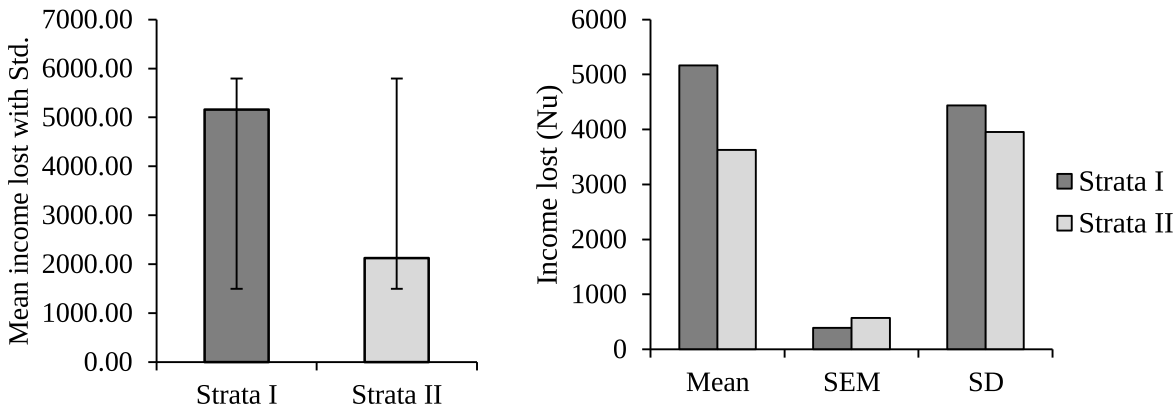

Figure 4.13: Mean income lost due to livestock depredation by dhole

4.6.3 Farmers income lost due to depredation by other wild predators

The average annual income lost due to livestock depredation by common leopard was 1,260.25 (*SD* ± 3,538) per household, which was next to dhole depredation. It caused 1.1% of the average annual cash income per household of the respondents. Mean annual income lost due to dhole was significantly different with the mean annual income lost due to common leopard depredation, *U* = 4,916.00, *z* = -2.061, *p*<.05 (Annexure 2.29). There was a significant difference in income lost due to livestock depredation by other predators excluding dhole, *H* (4) =27.295, *p*<.05 (Annexure 2.30), where among the other predators, common leopard caused 21.1% followed by black bear with 12.3% and rest of the predators caused negligible income lost when compared to the average annual income per household. The average annual income lost due to depredation by common leopard in strata I was 1,380.77 (*SD* ± 2,882.8), which caused 19.8% to the total income lost due to depredation by wild predators and it was followed by black bear with 5.5%. Whereas, Common leopard caused 22.7% of the average annual income per household in strata II followed by black bear with 21.2%, and snow leopard with 14%. So in both the strata, common leopard was next predator that caused major income loss, followed by black bear (Table 4.13).

Income lost due to dhole (Nu.576,720, 60.3%) alone was comparatively higher than the income lost due to all other wild predators (Nu.380,570, 39.7%).

Table 4.13: Income lost due to livestock depredation by wild predators in last 5 years

		Dhole	Common leopard	Black bear	Leopard cat	Yellow throated marten	Snow leopard
Strata I	Total income lost (%)	402,680 (74.18)	107,700 (19.84)	2,9840 (5.5)	940 (0.17)	1,680 (0.31)	
Strata II	Total income lost (%)	174,040 (41.99)	93,940 (22.67)	58,190 (14.04)	87,800 (21.18)	60 (0.01)	420 (0.1)

4.7 Farmers perception and tolerance towards dhole conservation

4.7.1 Perception of farmers on dhole and its population trend

Out of 160 respondents, 99.3% (*n* = 159) respondents knew dhole, where 90.6% (*n* = 145) of the respondent have sighted dhole and 3.7% (*n* = 6) have seen only in television. 38.1% (*n* = 61) of respondent believes that the dhole population was increasing followed by 36.9% (*n* = 59) with decreasing, 10% (*n* = 16) believes that the population trend is not changing and 14% (*n* = 24) of the respondents are not sure about the population trend of dhole (Figure 4.14). However, finding contradicts with Jenks et al. (2016) research around the protected areas in southern Thailand, who found only 5% of the respondents (*n* = 8) reported seeing dhole. When they were given the photo of dhole to identify, 32% labeled the photograph as Asiatic jackal and out of 133 respondents only 10% perceived that dhole population were increasing compared to last 10 years. The reason of difference could be because of the difference in geographical location of the two study site (Tropical vegetation-Thailand, subtropical and temperate zone-current study site).

There was no significant relationship between the gender of the respondents and their perception on dhole population, χ^2 (3) = 1.804, $p > .05$(Annexure 2.31), indicating that perception of respondent on dhole population is not driven by the gender (Table 4.14), which was similar to the farmers of JDNP (Tshering and Thinley, 2017).

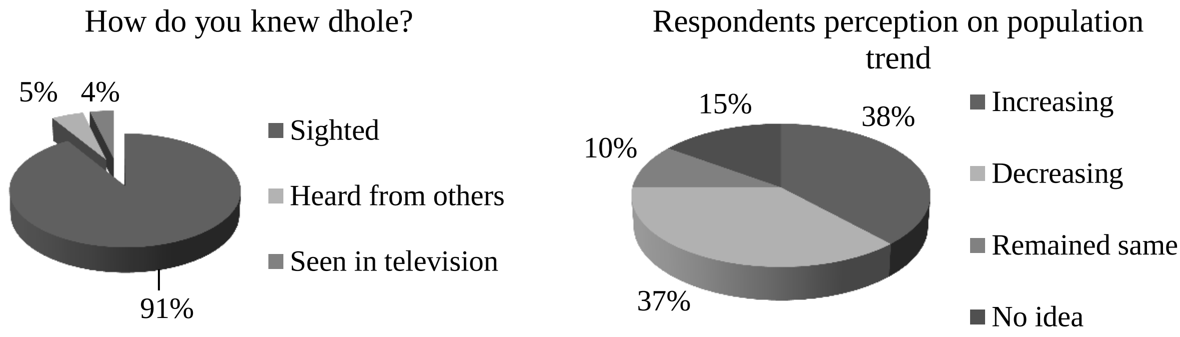

Figure 4.14: Respondents perception on dhole and it population trend

Table 4.14: Genders perception of dhole population trend (% in parenthesis)

	Increasing No.	Decreasing (No.)	Remained same (No.)	No idea (No.)
Male	33 (54.1)	25 (42.4)	7 (43.8)	11 (45.8)
Female	28 (45.9)	34 (57.6)	9 (56.3)	13 (54.2)
Total No.	61 (38.1)	59 (36.9)	16 (10)	24 (15)

The reason for the change in population trend as per respondent's opinion was that 17.5% (*n* = 28) of the increase were due to reintroduction of dhole by government in 1970s, followed by 8.8% (*n* = 14) claiming for more breeding and no predator to kill dhole. 4% (*n* = 4) of the respondents reported that habitat destruction and encroachment by human were the cause for decrease in dhole population and 5% (*n* = 8) were not sure of the reason for population change. Respondent with the incidents of livestock kill seems to be reporting for increase in the population and vice versa for those who have not lost their livestock to dhole.

Farmers have their different perception on the presence of dhole in their locality. Maximum number of respondents from both the strata (strata I, 48.7%, *n* = 37; Strata II, 52.4% *n* = 43) believed that currently present dholes were native to their locality while 32.9% (*n* = 25) from strata I and 17.1% (*n* = 14) from strata II believes that both the native as well as introduced are present in their locality. 17.7% (*n* = 28) respondents from the study site comprising 14.5% (*n* = 11) from strata I and 20.7% (*n* = 17) from strata II believes that government had reintroduced dhole and reintroduced dholes are currently present in their locality (Table 4.15). This was supported by the statement made by Johnsingh et al. (2007) asserting that poisoning of dhole in 1970s nearly extirpated the dhole existence and subsequently for last thirty years dhole problem was forgotten and absence of dhole bought enormous damage to agricultural crops by wild pig and dhole reappeared in most part of the

Bhutan in late 1990s, which was assumed to be reintroduced and again started causing damage to livestock. There was no significant relationship between the age category and their perception on the current presence status of dhole $\chi2$ (3) = 7.372, $p > .05$ (Annexure 2.32).

Table 4.15: Respondents perception on present dhole presence (% in the parenthesis)

	Strata 1	Strata 2	Total
Native	37 (48.7)	43 (52.4)	80 (50.6)
Introduced	11 (14.5)	17 (20.7)	28 (17.7)
Both present	25 (32.9)	14 (17.1)	39 (24.7)
No idea	3 (3.9)	8 (9.8)	11 7)

4.7.2 Farmers opinion on dhole problem and control measures

Out of total respondent 25.6% (n = 41) said that dhole problem in their village was severe and from this 92.7% (n = 38) was from strata I and only 7.3% (n = 3) from strata II. This indicates that villages located near the forest and away from the motor roads are more exposed to livestock depredation by dhole. Therefore, it confirms that the dholes do not cause much problem inside the semi-urban settlements because 52.4% (n = 43) respondents said that dhole problem is negligible in their locality (Table 4.16).

Table 4.16: Respondents perception on dhole depredation problem (% in parenthesis)

	Severe	Moderate	No idea	Negligible
Strata I	38 (48.7)	36 (46.2)	4 (5.1)	
Strata II	3 (3.7)	25 (30.5)	11.4 (13)	43 (52.4)
Total	41 (25.6)	61 (38.1)	13 (8.1)	43 (26.9)

Respondents in strata I preferred compensation schemes with 46.2% (n = 36) for livestock killed and in strata II farmers would prefer electric fencing around the village with 41.5% (n = 34), therefore, it proves that farmers in the semi-urban areas are more exposed to modern techniques then the farmers located in remote areas. From the total respondent, 14.4% (n = 23) said that they would kill the dhole to reduce livestock depredation, where 82.6% (n = 19) was from strata I and 17.4% (n = 4) from strata II. Only 17.9% (n = 14) of the respondents were willing to look after their cattle to curve the dhole problem in strata I and 26.8% (n = 22) were willing to look after their cattle to minimize the dhole depredation. There was no significant relationship between gender and their perception on the solutions to reduce human dhole conflict χ^2 (4) = 7.539, $p > .05$ (Annexure 2.33) but there was significant relationship between the strata and the respondents solution to reduce human dhole conflict, χ^2 (4) = 35.930, $p < .05$ (Annexure 2.34)

Respondents were asked how they have reacted when their livestock were killed by dhole and 60.3% (*n* = 47) of respondents from strata I said that they could do nothing when their livestock were killed by wild predators and 23.1% (*n* = 18) had chased away the dhole away from their livestock and no depredation kill was officially reported to any concern offices from strata I. 29.4% (*n* = 47) respondents never loss their livestock to dhole in past five years. 87.2% (*n* = 68) of the respondents from strata I have lost their livestock to wild predators and from strata II only 54.9% (*n* = 45) lost their livestock to wild predators. 17.1% (*n* = 14) of respondent from strata II said that they could do nothing to the dhole, 11% (*n* = 9) chased away the dhole and 6.1% (*n* = 5) respondents have reported their depredation case to concerned offices (Figure 4.15). Therefore, we can say that the settlements nearer to the urban areas were not too far distance from offices and they report the depredation cases to concern offices for mitigation measures and help. There was no significant relationship between the gender of the respondent and their reaction during the incidences of livestock kill by dhole (χ^2 (4) = 1.660, $p > .05$) (Annexure 2.35).

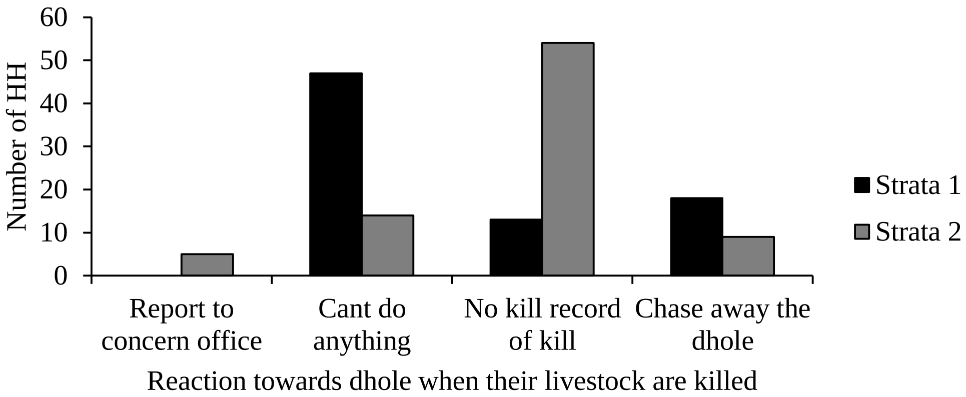

Figure 4.15: Respondents reaction towards dhole when their livestock were killed

4.7.3 Farmers perception on Dhole conservation

Farmer's perceptions on benefits of dhole conservation were mostly driven by the livestock being killed by the dhole and dependency on agriculture. There was significant relationship between two strata with respondents perception on whether dholes are beneficial to human or not (χ^2 (2) = 26.665, $p < .05$) (Annexure 2.36). Relatively 70% (*n* = 49) of the respondents from strata I and 30% (*n* = 21) from strata II said that dholes are not beneficial to human (Figure 4.16). The reason could be because higher number of respondents in strata I have lost their livestock to dhole than strata II and farmers in strata II are more dependent on agriculture than livestock. Thus, the farmers dependent more on agriculture perceive dhole as a beneficial because dhole helps to regulate the herbivores population and minimize the loss of crops damage by the pest herbivores (Johnsingh et al., 2007).

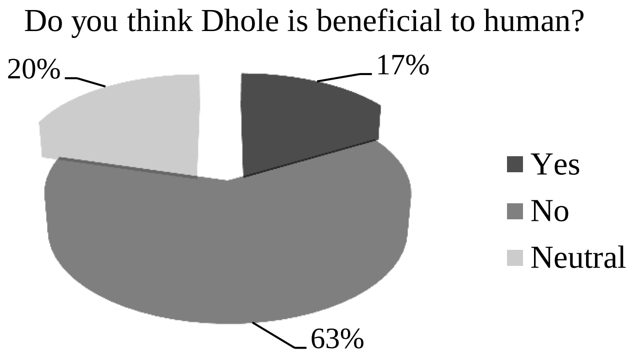

Figure 4.16: Farmers perception towards benefit of dhole conservation

Respondents were asked about their degree of willingness to conserve dhole and 46.9% (*n* = 75) respondent, i.e.74.7% (*n* = 56) from strata I and 25.3% (*n* = 19) from strata II, said that there are not willing to support dhole conservation. Thus, we conclude that farmer's degree of willingness to support dhole conservation were also driven by livestock loss to dhole because strata I (*n* = 170) has maximum number of livestock losses to dhole than strata II (*n* = 63).

4.7.4 Farmers perception towards dhole conservation policy

People were asked whether they were aware about the dhole being protected by conservation policy and the rules, 96.9% (*n* = 155) of the respondents were aware that the dholes were protected by conservation policy and rules of Bhutan. Thus, we conclude that farmers in both the rural and semi-urban area were aware about the dhole protection by law and policy.

Farmers were asked on how they feel about the current conservation policy and rules on dhole and 55% (*n* = 88) respondents reported that current conservation policy on dhole was good and it should be maintained. From the 55%, 69.3% (*n* = 61) were from strata II and only 30.7% (*n* = 27) were from strata I. Farmers from strata I have maximum loss of their livestock to dhole and respondents perception of current dhole conservation policy had significant relationship with number of livestock kill by the dhole χ^2 (2) = 34.4, $p < .05$ (Annexure 2.37).

Farmers from strata II were more dependent on agriculture and they reported less livestock lost to dhole and only 8.5% (*n* = 7) reports current conservation policy as bad and there was a significant relationship between the strata with the respondents feeling towards current conservation policy of the dhole χ^2 (2) = 39.455, $p < .05$ (Annexure 2.38).

Chapter Five

Conclusions

The major source of income in the study area was cropping and livestock rearing. The depredation by dhole and other predators not only made significant impact on farmers' livelihood but also changed peoples' attitude towards wildlife and conservation effort. The extent of livestock depredation was significantly more in rural areas comparing to in semi-urban area, however, there was no significant difference in income lost, which was attributed due to high livestock value in semi-urban than in rural villages.

Dholes were the principal predator responsible for livestock depredation, followed by common leopard and black bear. Dhole depredation incidences were recorded highest in the rural villages with cow being highest killed compared to semi-urban area. In both the strata, dhole attributed highest depredation among the other predators. The average income lost due to livestock depredation by wild predators were significantly higher in strata I with proportion to its depredation numbers. Incomes lost due to dhole were also higher in strata I, where in both the strata, dhole caused maximum income lost from depredation.

Dholes showed no preferences over the age category of the livestock for kill, which was similar with common leopard and black bear in both the strata. Livestock depredations by dhole were more in spring in both the strata; however minimal depredation was made in winter in semi-urban area. Maximum depredation by common leopard and black bear were made in spring in both the strata. Majority of livestock depredation by dhole, snow leopard and common leopard were made during day time and black bear was significantly more at night considering in both strata.

Over all livestock depredation hot spots were located in rural area. Dhole and common leopard depredation hot spots were concentrated in rural area but black bear depredation hot spots were equally distributed in two strata.

Livestock depredation incidences by dhole in the study area have created mixed perceptions on dhole conservation. In strata I, maximum numbers of household lost their livestock to dhole, obviously respondents showed negative perceptions towards its conservation. Similarly, people in strata II have lost less livestock to dhole, so they were in favor of dhole conservation and further recommend controlling it due to added merits of controlling wild animals that are pest to agriculture. Majority of the respondents from semi-urban area percepts current dhole conservation policy as good and majority of the respondents from rural area were not in favor for being protected by policy, this could be because their livestock are more vulnerable to predation and prefer to kill it.

One of reason for not tethering the livestock in farm was shortage of fodder; this could be managed through providing fodder seeds and planting of fodder trees in their unproductive agriculture lands. Rural villages are opts for compensation schemes and semi-urban villages prefer electric fencing as a measure to reduce human dhole conflict, which are currently not in place. Therefore, it is recommended that human dhole conflict would be minimized though livestock compensation schemes, electric fencing around the village, education, sensitization and awareness outreach campaigns of conservation and policies. Moreover, initiating better alternative livelihoods such as improved agriculture, Integrated Conservation Developments Programs (ICDP) and ecotourism initiatives can create a better livelihood in the village, where they don't have to depend on livestock for their livelihood. Reducing the livestock depredation risk and creating a harmonic co-existence of dhole with farmers, in long run, would achieve one pillar of Gross National Happiness of Bhutan, which otherwise could be weakened if farmers perceive conservation of wildlife at current pace.

This is the first result of its kind in the current study site, so more research on dhole habitat; dietary composition, prey preferences, distribution and abundance are highly recommended to validate the cause and impact of human dhole interaction.

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Annexures

Annexure 1: Questionnaire survey form for household interview

Survey Questionnaire for Human Dhole Interaction

Serial no.________________________

Name of Interviewer:-

____Date:____________________

I. Background Information:

Name of Interviewee:		Age:	Sex:
Village:	Gewog:	Dzongkhag:	
Total members in household:			

II. livestock

1. Type and number of livestock owned:

Type	Number
Yaks	
Horeses	
Cows	
Ox/bull	
Others (Pl. specify)	

2. Rank importance of livestock (1 greatest importance and 5 least importance)

☐ Source of income

☐ Source of food

☐ Draught power

☐ Manure

☐ Means of transportation

☐ Others (Specify)

3. What are the most common problem faced with livestock (*rank in ascending order from 1-5, 1 being most important and 5 being least important)*

☐ Predator kill

☐ Insufficient fodder

☐Weak livestock services by extension agents

☐Diseases

☐Others-------------

☐Others--------------

4. Where are livestock kept during the year?

☐Stables/enclosures

☐Tethered in fields

☐Pastures/forest

Other-----------------------------

5. Do you assign/send household member to look after livestock when it is in the grazing ground/forest?

☐YES

☐NO

5.1. If yes, tick one of the following

☐Stay with the livestock all day

☐Engaged just for sending in the morning and bring back during evening

5.2. If No, Why?

6. Which of the wild predator you have most conflicts with (*Tick in rank of severity, 1 being most destructive and 5 being of least concern)?*

☐Common Leopard

☐Dhole

☐Himalayan Black Bear

☐Snow Leopard

☐………………

7. How many livestock did you lose to wild predator in the last five years?

Type of livestock killed	No of Livestock killed	Age (Young, Heifer, Adult)	Year of Kill	Month of Kill	Time of Kill (Day/Night)	Cost	Animal health	Dist. from village	Predator	Evidence
			2016							
			2015							
			2014							
			2013							
			2012							

7.1 Why do you think the depredation trend is changing?

III. Household source of income

What are the sources of income? *(rank in ascending order 1-5. I being the most important and 5 being the least important)*

	Estimated qty (2014)	Estimated qty (2015)	Estimated qty (2016)
Agriculture			
Livestock			
NTFP collection			
Trade/business			
Support from employee			
Casual labor			

IV. Agriculture

4.1 (a) What are the main crops grown by the household? *(rank in ascending order in order of importance 1 being most important followed by 2,3,etc)*

Crops	**Yes**	**Qty (2014)**	**Qty (2015)**	**Qty (2016)**
Maize				
Wheat				
Barley				
Buckwheat				
Mustard				
Turnip				
Raddish				
Peas				
Potato				
Apple				

4.1 (c) Does HH have other, special crop or livestock activities *(if yes, tick)*

□ grow mushrooms □ keep silk worms □ keep bees □ _ _ _ □ _ _ _ _

4.1 (d) what were the main problems for agriculture? *(Rank in ascending order in order of magnitude,1 being most problematic followed by 2,3,etc)*

□ Damage by wild animal □ insufficient labour □ bad road □ other

□ Insufficient irrigation water □ pests and diseases □ road/market far □ other _

□ Insufficient funds to invest □ poor soil □ unreliable transport □ other

□ Insufficient land □ erosion

4.1 (e). Rank the species of wild animal coming to your agriculture field and damaging crops *(1 being the most destructive and 5 being least)*

Predators	Crops	Estd kg or amount (Nu)	Are a damaged	Year	Sea son
Common leopard					
Wild pig					
Himalayan Black bear					
Sambar Deer					

HYT marten					
Leopard cat					
Porcupine					
Barking Deer					
Serow					

V. Information about Dhole

1. Do you know Dhole?

☐Yes ☐No

2. How did you come to know about Dhole? Sighted (Follow next question)

☐Heard from others ☐Others (pl. specify)

☐Seen in Television

Detail of sighting

Place	**When**	**Distance and direction from your village**

3. Where can we generally see Dhole?

Name of place:					
Direction from village:					
Distance from village (Km or M, No. of days or hours by walk):					

4. What do you think is the trend of the Dhole population?

☐Increasing (Why?________________________________)

☐Decreasing (Why?________________________________)

☐Remained same (Why?____________________________)

☐No idea

5. Is present Dhole native or introduced to our natural forest?

☐Native ☐Both present

☐ Don't Know ☐Introduced

6. What do you think of the Dhole problem in your village today?

☐Severe ☐No idea

☐Moderate ☐Negligible

7. What do you think of the black bear problem in your village today?

☐Severe ☐No idea

☐Moderate ☐Negligible

8. During which season do you usually have conflict with Dhole and Why?
   - Season:

   - Why:

9. How do you normally respond when your livestock is being killed by Dhole?

☐Hunt ☐Report to concern offices

☐Kill ☐No reaction

☐Poison ☐Other if specify

12. Are you aware that the Dhole is protected by the FNCR 2006 and act 1995?

☐Yes

13. NoIf yes, what is your opinion on the current conservation policy of Dhole in the country?

☐Good ☐Bad

☐Very good ☐Very bad

☐Neutral ☐No idea

14. If there is no restriction of killing Dhole, would you kill the Dhole, if yes, why?

☐Yes ☐No

15. Have you ever heard of people being fined for killing Dhole in your village in last three years, if yes, how many people?

☐Yes ☐No

16. Do you think Dhole is beneficial to human?

☐ Yes ☐ No

17. Do you agree that Dhole needs to be conserved?

☐ Strongly agree ☐ Do not agree

☐ Agree ☐ No idea

18. What are the possible solutions to reduce livestock depredation by Dhole?

Thank you for your time********************************

Annexure 2: List of Tables

Annexure 2.1: One-Way ANOVA for Age and Household members

Source		Sum of Squares	*df*	MS	*F*	*Sig.*
Age	Between Groups	882.038	1	882.038	4.538	.035
	Within Groups	30709.937	158	194.367		
	Total	31591.975	159			
House hold members	Between Groups	3.823	1	3.823	.858	.356
	Within Groups	704.421	158	4.458		
	Total	708.244	159			

Annexure 2.2: Kruskal-Wallis test- Yak population trend

Ranks

	Year	N	Mean Rank
Yak total	2012.0	165	447.12
	2013.0	9	865.28
	2014.0	346	430.61
	2015.0	356	431.60
	2016.0	5	863.50
	Total	881	

Test Statistics[a,b]

	Yak total
Chi-Square	339.672
df	4
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Year

Annexure 2.3: Kruskal-Wallis test- Livestock holding trend

Livestock holding in 2012 vs 2013

Ranks

	Year	N	Mean Rank
Total livestock holding	2012.0	614	647.24
	2013.0	695	661.85
	Total	1309	

Test Statistics[a,b]

	Total livestock holding
Chi-Square	.487
df	1
Asymp. Sig.	.485

a. Kruskal Wallis Test

b. Grouping Variable: Year

Livestock holding in 2013 vs 2014

Ranks

	Year	N	Mean Rank
Total livestock holding	2013.0	695	640.75
	2014.0	514	556.66
	Total	1209	

Test Statistics[a,b]

	Total livestock holding
Chi-Square	17.164
df	1
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Year

Livestock holding in 2014 vs 2015

Ranks

	Year	N	Mean Rank
Total livestock holding	2014.0	514	501.46
	2015.0	526	539.10
	Total	1040	

Test Statistics[a,b]

	Total livestock holding
Chi-Square	4.089
df	1
Asymp. Sig.	.043

a. Kruskal Wallis Test

b. Grouping Variable: Year

Livestock holding in 2015 vs 2016

Ranks

	Year	N	Mean Rank
Total livestock holding	2015.0	526	507.14
	2016.0	505	525.23
	Total	1031	

Test Statistics[a,b]

	Total livestock holding
Chi-Square	.953
df	1
Asymp. Sig.	.329

a. Kruskal Wallis Test

b. Grouping Variable: Year

Annexure 2.4: Livestock holding population trend

		Livestock holding population trend (whole area)					
		Mean	Sum	%	Total N	SD	%
Year	2012.0	17.10	10501.00	22.3%	614	16.67	21.5%
	2013.0	16.97	11794.00	25.0%	696	15.57	24.3%
	2014.0	15.35	7891.00	16.7%	514	23.72	18.0%
	2015.0	17.13	9012.00	19.1%	526	26.81	18.4%
	2016.0	15.81	7985.00	16.9%	509	13.98	17.8%

Annexure 2.5: Kruskal-wallis test-livestock holding trend

Ranks

	Year	N	Mean Rank
Total livestock holding	2012.0	614	1461.86
	2013.0	695	1495.98
	2014.0	514	1297.26
	2015.0	526	1402.00
	2016.0	505	1450.60
	Total	2854	

Test Statistics[a,b]

	Total livestock holding
Chi-Square	19.633
df	4
Asymp. Sig.	.001

a. Kruskal Wallis Test

b. Grouping Variable: Year

Annexure 2.6: Mann-Whitney U test- mean annual income per HH

Descriptive Statistics

	N	Mean	*SD*	Minimum	Maximum
Average annual total income	160	118775.7688	45533.48848	9000.00	283333.33
Area stratum	160	1.5125	.50141	1.00	2.00

Ranks

	Area stratum	N	Mean Rank	Sum of Ranks
Average annual total income	Strata I	78	80.73	6297.00
	Strata II	82	80.28	6583.00
	Total	160		

Test Statistics[a]

	Average annual total income 4
Mann-Whitney U	3180.000
Wilcoxon W	6583.000
Z	-.061
Asymp. Sig. (2-tailed)	.951

a. Grouping Variable: Area stratum

Annexure 2.7: Mean annual income sources

	Average annual cash income per household				
	Mean	SEM	SD	Sum	%
Agriculture	72545.38	2647.61	33489.86	11607260.00	61.07759
Livestock	25985.60	2969.86	37566.11	4157696.33	21.87786
NTFP	4092.71	635.41	8037.42	654833.33	3.445744
Employee support	4052.08	980.64	12404.24	648333.33	3.41154
Business	7427.08	2032.39	25707.98	1188333.33	6.253029
Casual labor	4672.92	968.36	12248.90	747666.67	3.934234

Annexure 2.8: Mann-Whitney U test- income from different sources

Ranks

	Area stratum	N	Mean Rank	Sum of Ranks
Average income from agriculture for past three years	Strata I	78	109.17	8515.50
	Strata II	82	53.23	4364.50
	Total	160		
Average income from livestock for past three years	Strata I	78	62.60	4882.50
	Strata II	82	97.53	7997.50
	Total	160		
Average income from NTFP past three years	Strata I	78	56.68	4421.00
	Strata II	82	103.16	8459.00
	Total	160		
Average income from employee support past three years	Strata I	78	81.91	6389.00
	Strata II	82	79.16	6491.00
	Total	160		
Average income from business past three years	Strata I	78	75.57	5894.50
	Strata II	82	85.19	6985.50
	Total	160		
Average income from casual labor three years	Strata I	78	72.61	5663.50
	Strata II	82	88.01	7216.50
	Total	160		

Test Statistics[a]

	Average income from agriculture for past 3 years	Average income from livestock for past 3 years	Average income from NTFP past 3 years	Average income from employee suport past 3 years	Average income from business past 3 years	Average income from casual labor3 years
Mann-Whitney U	961.500	1801.500	1340.000	3088.000	2813.500	2582.500
Wilcoxon W	4364.500	4882.500	4421.000	6491.000	5894.500	5663.500
Z	-7.637	-4.776	-7.407	-.668	-2.521	-3.271
Asymp. Sig. (2-tailed)	.000	.000	.000	.504	.012	.001

a. Grouping Variable: Area stratum

Annexure 2.9:Kruskal-Wallis test-Income from agriculture

Ranks

	Area stratum	N	Mean Rank
Average income from livestock for past three years	Strata I	78	62.60
	Strata II	82	97.53
	Total	160	

Test Statistics[a,b]

	Average income from livestock for past 3 years
Chi-Square	22.810
df	1
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Area stratum

Annexure 2.10: Mann-Whitney U test- Mean livestock income

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Average income from livestock for past 3 years	160	25985.6021	37566.10871	.00	230000.00
Area stratum	160	1.5125	.50141	1.00	2.00

Ranks

	Area stratum	N	Mean Rank	Sum of Ranks
Average income from livestock for past 3 years	Strata I	78	62.60	4882.50
	Strata II	82	97.53	7997.50
	Total	160		

Test Statistics[a]

	Average income from livestock for past 3 years
Mann-Whitney U	1801.500
Wilcoxon W	4882.500
Z	-4.776
Asymp. Sig. (2-tailed)	.000

a. *Grouping Variable: Area stratum*

Annexure 2.11: Correlation-income from livestock and total income

Correlations

		Total income for the household	Average income from livestock for past three years
Total income for the household	Pearson Correlation	1	.177*
	Sig. (2-tailed)		.025
	N	160	160
Average income from livestock for past 3 years	Pearson Correlation	.177*	1
	Sig. (2-tailed)	.025	
	N	160	160

**. Correlation is significant at the 0.05 level (2-tailed).*

Annexure 2.12: Correlation-income from agriculture and total income

Correlations

			Total income for the household	Average income from agriculture
Spearman's rho	Total income for the household	Correlation Coefficient	1.000	.811**
		Sig. (2-tailed)	.	.000
		N	160	160
	Average income from agriculture for past 3 years	Correlation Coefficient	.811**	1.000
		Sig. (2-tailed)	.000	.
		N	160	160

***. Correlation is significant at the 0.01 level (2-tailed).*

Annexure 2.13: Mann-Whitney U test-Livestock depredation by wild predators

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
total livestock kill	160	2.9375	3.17951	0.00	15.00
Area stratum	160	1.5125	.50141	1.00	2.00

Ranks

	Area stratum	N	Mean Rank	Sum of Ranks
total livestock kill	Strata I	78	96.79	7550.00
	Strata II	82	65.00	5330.00
	Total	160		

Test Statistics[a]

	Total livestock kill
Mann-Whitney U	1927.000
Wilcoxon W	5330.000
Z	-4.428
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Area stratum

Annexure 2.14: Mann-Whitney U test- Livestock depredation season

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Number of livestock kill	304	1.4572	1.00731	1.00	12.00
Month of livestock kill	304	2.4572	.91818	1.00	4.00

Ranks

	Month of livestock kill	N	Mean Rank	Sum of Ranks
Number of livestock kill	Winter	46	44.80	2061.00
	Autumn	44	46.23	2034.00
	Total	90		

Test Statistics[a]

	Number of livestock kill
Mann-Whitney U	980.000
Wilcoxon W	2061.000
Z	-.310
Asymp. Sig. (2-tailed)	.756

a. Grouping Variable: Month of livestock kill

Annexure 2.15: Pearson correlation-Year and number of livestock kill

Descriptive Statistics

	Mean	Std. Deviation	N
Year of livestock kill	2014.2237	1.36528	304
Number of livestock kill	1.4572	1.00731	304

Correlations

		Year of livestock kill	Number of livestock kill
Year of livestock kill	Pearson Correlation	1	.091
	Sig. (2-tailed)		.113
	N	304	304
Number of livestock kill	Pearson Correlation	.091	1
	Sig. (2-tailed)	.113	
	N	304	304

Annexure 2.16: Kruskal-Wallis test-Age category of livestock kills by dhole

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Dhole kill no	177	1.32	.595	1	5
Dhole kill age	177	1.56	.498	1	2

Ranks

	Dhole kill age	N	Mean Rank
Dhole kill no	Young	78	87.43
	Adult	99	90.24
	Total	177	

Test Statistics[a,b]

	Dhole kill no
Chi-Square	.221
df	1
Asymp. Sig.	.638

a. Kruskal Wallis Test

b. Grouping Variable: dhole kill age

Annexure 2.17: Kruskal-Wallis- Dhole livestock depredation among season

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Number of livestock kill	304	1.4572	1.00731	1.00	12.00
Month of livestock kill	304	2.4572	.91818	1.00	4.00

Ranks

	Month of livestock kill	N	Mean Rank
Number of livestock kill	Winter	46	156.12
	Spring	117	143.96
	Summer	97	156.92
	Autumn	44	161.68
	Total	304	

Test Statistics[a,b]

	Number of livestock kill
Chi-Square	2.975
df	3
Asymp. Sig.	.396

a. Kruskal Wallis Test

b. Grouping Variable: Month of livestock kill

Annexure 2.18: Kruskal-Wallis- Livestock depredation by dhole

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Dhole livestock kill	177	1.32	.595	1	5
Year	177	2014.02	1.350	2012	2016

Ranks

	Year	N	Mean Rank
Dhole livestock kill	2012	29	99.45
	2013	41	89.43
	2014	36	79.67
	2015	40	89.45
	2016	31	88.92
	Total	177	

Test Statistics[a,b]

	Dhole livestock kill
Chi-Square	4.063
df	4
Asymp. Sig.	.398

a. Kruskal Wallis Test

b. Grouping Variable: Year

Annexure 2.19:Kruskal-Wallis test –Ox depredation trend by dhole

Ranks

	Year	N	Mean Rank
Dhole ox kill no	2012	12	52.17
	2013	14	49.93
	2014	17	47.56
	2015	25	49.66
	2016	26	41.92
	Total	94	

Test Statistics[a,b]

	Dhole ox kill no
Chi-Square	3.171
df	4
Asymp. Sig.	.530

a. Kruskal Wallis Test

b. Grouping Variable: Year of kill

Annexure 2.20: Livestock kill by predators (strata wise)

Number of livestock kill in 5 years (strata-wise)						
		Mean	SEM	SD	Sum	%
Strata I	Dhole	3.7	0.05	0.59	170	59.40%
	Common leopard	1.23	0.1	0.64	54	18.90%
	black bear	1.25	0.14	0.58	20	7.00%
	Leopard cat	3.5	0.29	0.58	14	4.90%
	Yellow throated marten	4.67	1.5	3.67	28	9.80%
Strata II	Dhole	1.9	0.09	0.62	63	40.10%
	Common leopard	1.26	0.09	0.45	29	18.50%
	Snow leopard	2.7	0.37	1.16	27	17.20%
	black bear	1.36	0.1	0.49	30	19.10%
	Leopard cat	1	.	.	1	0.60%
	Yellow throated marten	7	.	.	7	4.50%

Annexure 2.21: Mann-Whitney Test- Mean livestock kill by wild predators

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Number of livestock kill	77	1.4286	.83396	1.00	5.00
Predator	77	3.1299	.33836	3.00	4.00

Ranks

	Predator	N	Mean Rank	Sum of Ranks
Number of livestock kill	Common leopard	67	35.13	2354.00
	Snow leopard	10	64.90	649.00
	Total	77		

Test Statistics[a]

	Number of livestock kill
Mann-Whitney U	76.000
Wilcoxon W	2354.000
Z	-5.024
Asymp. Sig. (2-tailed)	.000

a. Grouping Variable: Predator

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Number of livestock kill	105	1.2667	.55930	1.00	4.00
Predator	105	3.7238	.96571	3.00	5.00

Ranks

	Predator	N	Mean Rank	Sum of Ranks
Number of livestock kill	Common leopard	67	51.07	3421.50
	black bear	38	56.41	2143.50
	Total	105		

Test Statistics[a]

	Number of livestock kill
Mann-Whitney U	1143.500
Wilcoxon W	3421.500
Z	-1.200
Asymp. Sig. (2-tailed)	.230

a. Grouping Variable: Predator

Annexure 2.22: Kruskal-Wallis test-Livestock age category kill by C leopard

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Livestock kill no by CL	67	1.24	.580	1	4
Livestock kill age by CL	67	1.57	.499	1	2

Ranks

	Livestock age category	N	Mean Rank
CL kill	Young	29	31.31
	Adult	38	36.05
	Total	67	

Test Statistics[a,b]

	Common Leopard kill number
Chi-Square	2.192
df	1
Asymp. Sig.	.139

a. Kruskal Wallis Test

b. Grouping Variable: CL kill age of livestock

Annexure 2.23: Kruskal-Wallis test-livestock age category kill by BB

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
BB kill no	38	1.32	.525	1	3
BB kill age	38	1.53	.506	1	2

Ranks

	Livestock age category	N	Mean Rank
BB kill no	Young	18	19.14
	Adult	20	19.83
	Total	38	

Test Statistics[a,b]

	BB livestock kill no
Chi-Square	.058
df	1
Asymp. Sig.	.810

a. Kruskal Wallis Test
b. Grouping Variable: BB kill age

Annexure 2.24: Mann-Whitney U test-livestock kill time by common leopard

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
C Leopard kill no	67	1.24	.580	1	4
C Leopard kill time	67	1.22	.420	1	2

Ranks

	Leopard kill time	N	Mean Rank	Sum of Ranks
C Leopard kill no	1	52	32.31	1680.00
	2	15	39.87	598.00
	Total	67		

Test Statistics[a]

	C Leopard kill no
Mann-Whitney U	302.000
Wilcoxon W	1680.000
Z	-1.985
Asymp. Sig. (2-tailed)	.047

a. Grouping Variable: C Leopard kill time

Annexure 2.25: Kruskal-Wallis test-horse depredation trend by C leopard

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
C Leopard horse kill	45	1.11	.318	1	2
Year	45	2014.36	1.282	2012	2016

Ranks

	Year	N	Mean Rank
C Leopard horse kill	2012	4	20.50
	2013	8	23.31
	2014	12	22.38
	2015	10	25.00
	2016	11	22.55
	Total	45	

Test Statistics[a,b]

	C Leopard horse kill
Chi-Square	1.423
df	4
Asymp. Sig.	.840

a. Kruskal Wallis Test

b. Grouping Variable: Year

Annexure 2.26: Kill distance of livestock type

Ranks

	Kill distance from village	N	Mean Rank
Type of livestock kill	Inside village	84	181.35
	0 to 1 km	166	136.25
	1 to 2 km	40	156.44
	More than 2	14	160.86
	Total	304	

Test Statistics[a,b]

	Type of livestock kill
Chi-Square	16.458
df	3
Asymp. Sig.	.001

a. Kruskal Wallis Test

b. Grouping Variable: Kill distance from village

Annexure 2.27: Mann-Whitney U test- Mean annual income lost to depredation

Descriptive Statistics

	N	Mean	SD	Minimum	Maximum
Cost of livestock kill	304	13077.6316	15073.09669	300.00	95000.00
Area stratum	304	1.3454	.47628	1.00	2.00

Ranks

	Area stratum	N	Mean Rank	Sum of Ranks
Cost of livestock kill	Strata I	199	140.80	28019.00
	Strata II	105	174.68	18341.00
	Total	304		

Test Statistics[a]

	Cost of livestock kill
Mann-Whitney U	8119.000
Wilcoxon W	28019.000
Z	-3.199
Asymp. Sig. (2-tailed)	.001

a. Grouping Variable: Area stratum

Annexure 2.28: Mann-Whitney- Income loss due to dhole depredation

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Cost of livestock kill	177	12531.6384	13852.92118	1000.00	95000.00
Area stratum	177	1.2712	.44583	1.00	2.00

Ranks

	Area stratum	N	Mean Rank	Sum of Ranks
Cost of livestock kill	Strata I	129	87.98	11349.00
	Strata II	48	91.75	4404.00
	Total	177		

Test Statistics[a]

	Cost of livestock kill
Mann-Whitney U	2964.000
Wilcoxon W	11349.000
Z	-.436
Asymp. Sig. (2-tailed)	.023

a. Grouping Variable: Area stratum

Annexure 2.29: Mann-Whitney - Mean income lost due to dhole and C leopard

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Annual income lost to predator per year	304	3148.9803	3938.91827	60.00	45000.00
Predator	304	2.2599	1.68518	1.00	7.00

Ranks

	Predator	N	Mean Rank	Sum of Ranks
Annual income lost to predator per year	Dhole	177	128.23	22696.00
	Common leopard	67	107.37	7194.00
	Total	244		

Test Statistics[a]

	Annual income lost to predator per year
Mann-Whitney U	4916.000
Wilcoxon W	7194.000
Z	-2.061
Asymp. Sig. (2-tailed)	.039

a. Grouping Variable: Predator

Annexure 2.30: Kruskal-Wallis test- Income lost to kill by other predators

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Annual income lost to predator per year	304	3148.9803	3938.91827	60.00	45000.00
Predator	304	2.2599	1.68518	1.00	7.00

Ranks

	Predator	N	Mean Rank
Annual income lost to predator per year	Common leopard	67	61.88
	Snow leopard	10	96.75
	black bear	38	72.89
	Leopard cat	5	17.70
	Yellow throated marten	7	22.29
	Total	127	

Test Statistics[a,b]

	Annual income lost to predator per year
Chi-Square	27.295
df	4
Asymp. Sig.	.000

a. Kruskal Wallis Test

b. Grouping Variable: Predator

Annexure 2.31: Chi-Square-Gender and perception on dhole population

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.804[a]	3	.614
Likelihood Ratio	1.806	3	.614
Linear-by-Linear Association	.678	1	.410
N of Valid Cases	160		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 7.60.

Annexure 2.32: Chi-Square-Perception on current presence of dhole and gender

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.372[a]	3	.061
Likelihood Ratio	7.519	3	.057
Linear-by-Linear Association	.260	1	.610
N of Valid Cases	160		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.36.

Annexure 2.33:Chi-square-Gender's perception to reduce dhole conflict

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.539[a]	4	.110
Likelihood Ratio	7.798	4	.099
Linear-by-Linear Association	3.167	1	.075
N of Valid Cases	160		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 2.85.

Annexure 2.34: Chi-Square-Opinion on solution to reduce dhole conflict

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	35.930[a]	4	.000
Likelihood Ratio	38.480	4	.000
Linear-by-Linear Association	10.698	1	.001
N of Valid Cases	160		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 2.93.

Annexure 2.35: Chi-Square-Gender and respondents reaction during livestock kill

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.660[a]	4	.798
Likelihood Ratio	1.675	4	.795
Linear-by-Linear Association	.064	1	.800
N of Valid Cases	159		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.69.

Annexure 2.36: Chi-Square between strata and perception on dhole benefit

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	26.665[a]	2	.000
Likelihood Ratio	27.770	2	.000
Linear-by-Linear Association	7.390	1	.007
N of Valid Cases	160		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 17.06.

Annexure 2.37: Chi-Square-Conservation policy and no. of livestock kill

Test Statistics

	Total livestock kill	Conservation policy
Chi-Square	231.500[a]	34.400[b]
df	14	2
Asymp. Sig.	.000	.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 10.7.
b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 53.3.

Annexure 2.38: Chi-Square-Perception on dhole conservation policy

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	30.455[a]	2	.000
Likelihood Ratio	32.239	2	.000
Linear-by-Linear Association	29.530	1	.000
N of Valid Cases	160		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 15.60.