



DECLARATION

I hereby declare that this study titled “Effectiveness of electric fences in reducing human-bear conflict in Pelgiri and Zongkha, JDNP and the basic ecology of Himalayan Black Bear” is an original research work done by me and I have not committed, to my knowledge, any academic dishonesty or resorted to plagiarism in writing this paper. All the sources of information and assistance received during the course of the study were duly acknowledged.

ACKNOWLEDGEMENT

The big funding help from the RSG was indeed a great help for me in particular and Bhutan in general to conduct this study on the effectiveness of electric fence which is installed as a mitigation measure to Human- Bear conflict in the two areas which are under the buffer zone of Jigme Dorji National Park. For this I sincerely extend my heartfelt gratitude to the management of the Rufford organization for the great help.

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ACRONYMS

CNR	College of Natural Resources
CBR	Cost-Benefit Ratio
DOFPS	Department of Forests and Park Services
FNCAB	Forest and Nature Conservation Act of Bhutan, 1995
GPS	Global Positioning System
HBC	Human Bear Conflict
HBB	Himalayan Black Bear
HWC	Human Wildlife Conflict
IUCN	International Union for Conservation of Nature
JDNP	Jigme Dorji National Park
MOAF	Ministry of Agriculture and Forest
PV	Present value
RCSC	Royal Civil Service Commission
WCD	Wildlife Conservation Division

ABSTRACT

The HBC became an issue and a concern for the conservationists and hermits after the series of bear appearances and raids in few areas in Jigme Dorji National Park in May, 2011. A pilot based project of the installation of electric fences was carried out in two conflict areas viz; Zongkha and Pelgir therefore, it is deemed essential to study its effectiveness. This study assessed the effectiveness of electric fences installed in these two areas and the cost benefit analysis of the electric fences and the total loss of property in the conflict. The study also aimed to understand the frequency of HBB sighting in terms of time and season. The survey covered the entire 19 household which were affected in the conflict. Primary data were collected through the face to face interview using the structured questionnaires and the secondary data were collected through the review of available books, reports and documents. The study showed a significant effect by the electric fences on the HBC. No incidences of bear appearances and raid reported since the day the electric fences were installed. The maximum HBB sightings and occurrences were found during the summer till early autumn. The cost- benefit analysis of the cost incurred on the installation of electric fences and total loss of property in the conflict showed the cost benefit ratio as 1.82 which far exceeded 1 which is considered beneficial. The electric fences proved to be 100% effective. The peak seasons for the HBBs sightings and raid were in the summer months and lean seasons were found to be in winter and late autumn months. The cost benefit ratio proved beneficial. Electric fences can be replicated in other conflict areas as a mitigation measures and timely monitoring and maintenance of the fences is required to ensure the effectiveness of the fences.

Key words: Cost-benefit analysis, effectiveness, electric fences, human bear conflict, peak season.

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CHAPTER ONE

Introduction

1.1 Background

Human wildlife conflict is defined as any event in which animals injure, destroy or damage human life or property, and also animals are killed, injured, captured or otherwise harmed. As a result both humans and animals suffer from the interaction. It is one of the growing concerns and complex challenges that are currently being faced by the conservationists all over the world (Shrestha, 2007). With the rapid increasing of human population and pressure on forest areas and wild life habitat, human-wildlife interaction and resultant conflict is also increasing (Zubiri & Switzer, 2001).

One such conflict is the Human Bear Conflict in Bhutan. High forest and Rocky Mountains have not only provided shelter to wild animals but provide a tranquil place for many hermits to pray and practice Dharma. During the author's four years of attachment at the Wildlife Conservation Division under the department of Forest and Park Services, the author and the wildlife rescue staffs were entrusted to manage the Human- Bear conflict. Starting 2011, May, Bhutan recorded the conflict between the Himalayan Black bear and the Hermits. The HBBs have started raiding meditation huts by breaking doors, windows and walls. There were even risks of bear attacking the human who are inside the huts. The huts are located inside and adjacent to the forest. As a mitigation measures, electric fences were installed in the conflict areas. The fences are designed like the barbed wire fences with 12 voltage regulated by an energizer (Dorji, n.d, unpublished).

According to Hoare, (2003), although the electric fences are one of the effective tools in mitigating the human-wildlife conflict, but the effectiveness depend on design, voltage and maintenance of fence.

1.2 Rationale

Human wildlife conflict is one of the challenges in the field of conservation in Bhutan like any other countries in the world. The wildlife in Bhutan enjoys the protection from any forms of threats and dangers. Unlike the other protected areas around the globe, Bhutan's protected areas have human settlements in the buffer zones (Wang 2004). Also there are many human settlements in and around the forested areas. These features have led to the increasing issues of human wildlife conflict in the country. One such conflict is the Human Bear Conflict. In the recent years, black bears have started raiding meditation huts by breaking doors, windows and walls. The huts are located inside and adjacent to the forest. As a mitigation measures, electric fences are installed in the conflict areas (Dorji, n.d, unpublished).

Conservationists, biologists and the concerned department in Bhutan have limited information about bears since limited comprehensive study on bear is done as of now. Therefore, this proposed study can answer the following questions.

- How effective is the electric fences in managing the Human- Bear conflict?
- Any necessary changes required in the design of the fence?
- Is there any negative or positive effect of fence on the bears?

1.3 Objectives

- To document the effectiveness of electric fences as human-bear conflict management.
- To document the frequency of bear sightings in terms of time and season in the two study areas.
- To produce a cost benefit analysis on the cost incurred on the installation of the electric fences and loss of property in the Human- Bear conflict and benefit of the electric fences.
- Basic ecology of the Himalayan Black Bears.

1.4 Expected outcomes

The key outcomes from this study would be;

- ✓ Understand the effectiveness of electric fences as a mitigation measure to solve Human Bear Conflict and changes required if any in the design of the fence.
- ✓ Understand the total cost incurred on installing the electric fences and loss of property in the Human- Bear Conflict.
- ✓ Basic ecology of the Himalayan Black Bear based on diet and behavior

Human Bear Conflict is a key concern both in terms of conservation and socioeconomic significance. Black bears are omnivores and can raid not only the huts and scattered settlements in the forest but also the apple orchards and livestock which are the main sources of income for the rural people (NCD, 2008). The knowledge gained from this study can be used to design and install electric fences in conflict areas to avoid the damage to property, people and the animals themselves. If this strategy is seen as a fruitful and effective measure, its replication can be carried out in other problem areas which will help enhance the conservation of natural flora and fauna. Understanding the cost and benefit of the electric fences and monetary value of the property lost in the Human- Bear Conflict can be used as an additional guide should the similar mitigation needs to be taken in other conflict areas. The project will be a source of inspiration for many young and aspiring researchers to work and explore more new findings about the black bears in Bhutan.

CHAPTER TWO

Literature Review

2.1 Background

Since time immemorial humans and wildlife have existed harmoniously, but intermittent negative interactions between the two are not uncommon either. The frequency of such interactions has increased manifold in recent times. This, to a great extent, is related to increased levels of human activities in wildlife areas (Chauhan 2003; Graham *et al.* 2005; Charoo *et al.* 2009).

Zubiri and Switzer, (2011) reported that with the increasing of human population and its pressure on forest areas, human-wildlife interaction and resultant conflict is also increasing. The causes of the conflicts are due to the negative effects that arise from the needs and behavior of both wildlife and human (Distefano, 2005).

The conflict can be more serious in areas where rural people live in close association with protected areas (Lamarque, 2008). Wang, (2004) reported that most protected areas in Bhutan support some form of land use, such as agriculture, livestock grazing and/or the harvesting of timber and non-timber forest products.

Choden and Namgay, (1996) reported that there was a pioneer issue of discussion at the local, regional meetings and national assembly on the crop damage by wild pigs in Bhutan. One of the major national issues in the wildlife conservation is the Human-wild pig conflict where farmers across the country consider wild pigs as the enemy (Penjor, 2010). In addition to this conflict, HBC has become another challenge in the field of wildlife conservation (Dorji, n.d, unpublished).

The HWC ranges from crop damage to livestock predation to property damage to attack on people and sometimes the animals are killed, injured and harmed and vice versa (Wang, 2004). Ogra and Badola, (2008) reported that numerous studies carried out in India and other parts of the globe have shown that when residents of nearby areas are forced to absorb the costs of living with wildlife, local support for conservation may be seriously undermined.

2.3 Ecology of Himalayan Black Bear and Human- Bear Conflict

Asiatic black bear (*Ursus thibetanus*) is one of the two bear species found in Bhutan. It has been recorded from 18 countries throughout southern and eastern Asia (Garshelis and Steinmetz 2008). This carnivore is known to inhabit tropical, subtropical, temperate broadleaved and conifer forests. Altitudinal range of Asiatic black bears may extend up to 4300 m and on rare occasions they may venture into alpine meadows, beyond the tree line. Individual bears, however, are known to change their habitats and altitude seasonally (Izumiyama and Shiraishi 2004; Yiqing and Xiaomin 1998; Sathyakumar 1998, 2001; Hazumi 1998; Garshelis and Steinmetz 2008).

Himalayan black bears belong to the family Ursidae. The black bear (*Ursus thibetanus*) is also known as moon bear and white chested bear. It is a medium sized bear species and largely adapted to arboreal life (Heptner & Naumov, 1998).

Black bears are largely herbivorous and usually are not aggressive toward humans. They tend to be aggressive towards human who frequently kill them, and have frequently attacked people without first suffering provocation (Garshelis & Steinmetz, 2008)

Although the Himalayan black bears are diurnal but near human habitation they are nocturnal. This species of bear is good climbers and therefore, half of their lives are spend on trees. They climb to feed, rest, sun bath, escape/hide from the enemies and hibernate. Black bears hibernate in northern ranges or some move down to lower elevation. All pregnant sows hibernate (Hwang, 2003).

The Himalayan black bears are generalist and feed on different food in different seasons. They feed on succulent vegetation in spring, insects and variety of tree and shrub borne fruits in summer and nuts and acorns in autumn. At times, their diet may contain a good proportion of meat which they either kill or scavenge (Bromlei 1965; Reid *et al.* 1991; Hwang *et al.* 2002; Huygens *et al.* 2003; Hwang *et al.* 2010).

Himalayan black bears have a wide home range varying from three km² to 158 km² and occasionally they wander into human territory (Charoo *et al.* 2009; Sharma *et al.* 2010; Huang *et al.* 2010; Dr. Sathyakumar, 2006.). Therefore, black bear end up competing with human beings, directly or indirectly, for food and other resources within its probable home range in a given locality. This has been the prime cause behind the conflicts associated with black bears throughout its range. According to Chauhan (2003) ; Sathyakumar and Choudhury (2008); and Charoo *et al.* (2009) depredation of crops, killing of livestock and in extreme cases fatal attacks on humans are the main conflict issues related to this species. The Himalayan black bears are protected under schedule I of FNCAB and listed as endangered in IUCN red listing. The conservation threats of the Himalayan Black Bear are habitat loss and fragmentation, retaliatory killing, hunting, and bile farming like countries in China (Sathyakumar and Choudhury, 2008).

In fact Bhutan is the only country in the world which has a policy allowing people to continue residing in the protected areas like National Parks, Wildlife sanctuaries and Strict Nature Reserves. This unique policy of letting people continue to co-exist with the wild sometimes unfortunately leads to human wildlife conflicts. The attitudes and feelings of people concerning conservation policies and wildlife conflicts affect their behavior and understanding. This is important in involving local people in conservation planning and decision-making processes (Wang, 2004).

In the olden days, Bhutanese farmers used to fear black bears more than any other pest. To drive or frighten away the bears, farmers erect platforms in the fields where watchmen would be posted at night and would beat drums. However, some black bears have grown accustomed to the sound and encroached anyway (Stirling, 1993).

Out of 1,375 livestock kills examined in Bhutan, black bears accounted for eight percent of attacks (Montgomery, 2002). Serious problems of bear raid apart from predation started occurring in the western part of the country in 2011. More than 18 meditation huts were destroyed and the food stuffs of the hermits were eaten and destroyed in places called, Zongkha, Tokchu, Nimtasa, Chari and Pelgiri (WCD, 2011). The problem was still at large till 2014 until the electric fences were installed in conflict/ affected areas.

2.4 Electric fences.

An electric fence according to the definition of oxford English dictionary is a barrier that uses electric shocks to deter animals or people from crossing a boundary. Electric fencing technology was first developed in the United States and New Zealand and was used to control livestock in the United States (Maartje, 2006). “Electric Fence” Hand Book of Texas online, (n.d), states that electric fences are designed to create an electrical circuit when touched by a person or animal. A component called a power energizer converts power into a brief high voltage pulse. One terminal of the power energizer releases an electrical pulse along a connected bare wire about once per second. Another terminal is connected to a metal rod implanted in the earth, called a ground or earth rod. A person or animal touching both the wire and the earth during a pulse will complete an electrical circuit and will conduct the pulse, causing an electric shock. The effects of the shock depend upon the voltage, the energy of the pulse, the degree of contact between the recipient and the fence and ground and the route of the current through the body; it can range from barely noticeable to uncomfortable, painful or even lethal (Maartje, 2006).

Electric fences have been adopted in many parts of the globe where there is a human-wildlife conflict (Gunaratne & Premarathne, 2005). Electric fence is a winner, saving huge amount of crops and property not to mention the significant reduction in number of nights spent on guarding (Wildlife Conservation Division, Bhutan, 2013). However, according to Hoare, (2003), electric fences need higher investment in both establishment and maintenance and are not therefore easily accessible to farmers in resource-limited communities especially in developing countries.

Although the electric fences need higher investment in both establishment and maintenance as compared to the damage caused by problem animals, it should not be judged solely by the success they have in reducing crop raiding. In the long term, they also have an important role to play in saving human lives and valuable animals (Gunaratne & Premarathne, 2005).

Electric fences are considered the most effective HWC mitigation measure if they are strategically located and well implemented. Such fences also appear to be the people's favorite solution to the problem since they physically separate human and wildlife territories. This method is a very economically efficient way to conserve the valued animals (IUCN, 2000).

The residents of Thinleygang and Limbukha under Punakha district and Rubesa and Bjena under Wangdiphodrang district where the electric fences are installed expressed the electric fences as 100% effective in resolving the Human-Wildlife Conflict (Wangmo & Lekzom, 2016).

2.5 Cost Benefit Analysis.

A study analyzing the cost effectiveness and efficacy of fencing for conservation was carried out in the eastern sector of Chitwan National Park, Nepal. Their study analysis suggested that total net present value of the cost of electric fence in Kagendramalli User Committee (KMUC) and Mrigakunja User Committee (MKUC) was 21 685 USD and 50 429 USD respectively up to the fiscal year 2009/10. Net present benefit in KMUC and MKUC were 232, 872 USD and 547, 208 USD respectively up to 2009/10. The cost-benefit ratio of electric fence up to base fiscal year 2009/10 in KMUC is 10.73, whereas MKUC is 10.85. These results illustrate that the electric fencing program is economically and socially beneficial in reducing human-wildlife conflict (crop damage and livestock depredation) around the protected areas where large mammals occur (Hayward and Raubenheimer, 2014).

2.6 Property damage and Compensation.

The major poverty in Bhutan today is perceived as due to HWC and as such the issue was given the top priority in the 10th Five Year Plan (MOA, 2004).

Nyhus and Tilson (2004) have recommended the use of monetary compensation for farmers who have been affected by elephant crop damage. The unexpected part of the monetary compensation is whenever such compensation is involved, even in the form of revenue sharing, the programs become vulnerable to corruption and the people may feel a sense of entitlement rather than an appreciation for the wildlife areas (Archabald and Naughton-Treves, 2001).

According to Gadd (2005), conservation has lots of benefits to both wildlife and people by providing habitat for at-risk species and developing economic benefits derived from the wildlife resource, such as tourism. One of the potential mitigation instruments in reducing HWC is the community development program that concentrates on sharing the revenue from Tourism (Archabald and Naughton-Treves, 2001).

To address the concerns raised in the objectives for conservation and local livelihood needs, the Integrated Conservation and Development Program (ICDP) was implemented. This is evident from a number of conservation and development initiatives such as cash compensation program for livestock depredation that has reduced the notable issue of human-wildlife conflicts. This has helped reduced the retaliatory killings of wild animals particularly tigers and snow leopards by local communities (Wangchuk, n.d).

CHAPTER THREE

Materials and methods

3.1 Methods

3.1.1 Sampling

The sampling were drawn from the whole population of both the areas since all the household in the conflict areas are affected. There are only nineteen households in the study area viz; eleven households in Zongkha and 8 households in Pelgiri. Since nineteen is not a huge number for the study to be carried out, all the households were included in the sample.

3.1.2 Primary Data Collection

Forestry colleague students of the College of Natural Resources were deployed as enumerators. Prior to data collection, enumerators were trained and questionnaires pretested. The primary data were collected using the questionnaires (Annexure). Other data concerning the bear behavior and diet were collected through the installation of camera traps and sign surveys.

All cameras were numbered serially and GPS coordinates of every camera noted. Cameras were stationed in areas like the daily route taken by the bears, in areas where there are more animal signs and near water/ stream areas. Camera trapping is widely recognized as a very effective tool in the investigation of presence, morphology, behavior and movements of individuals and populations of animals (De Luca and Mpunga 2005). According to WWF, India, it is a cost effective way of detecting the presence of fauna in an area and also for some nocturnal or retiring species, it provides an edge in non-intrusive detection. Tammy, (2015), reported that few studies testing the effectiveness of electric fences for excluding black bears have used video surveillance to support their conclusions and their results suggest that properly designed, erected, and maintained portable electric fences effectively deter bear access to an attractant.

Sign surveys were carried out along the daily routes and most frequent places visited by the bear as of now. This was based on snow ball sampling method.

3.1.3 Secondary Data Collection

Secondary data were collected from the various field reports submitted by the field staffs to the office of the Wildlife Conservation Division, Department of Forest and Park Services.

Internet, journals on wildlife and human-wildlife management, books on wildlife ecology, wildlife census, wildlife study design and official reports and print media were used to gather other necessary secondary information (data).

3.2 Data Analysis

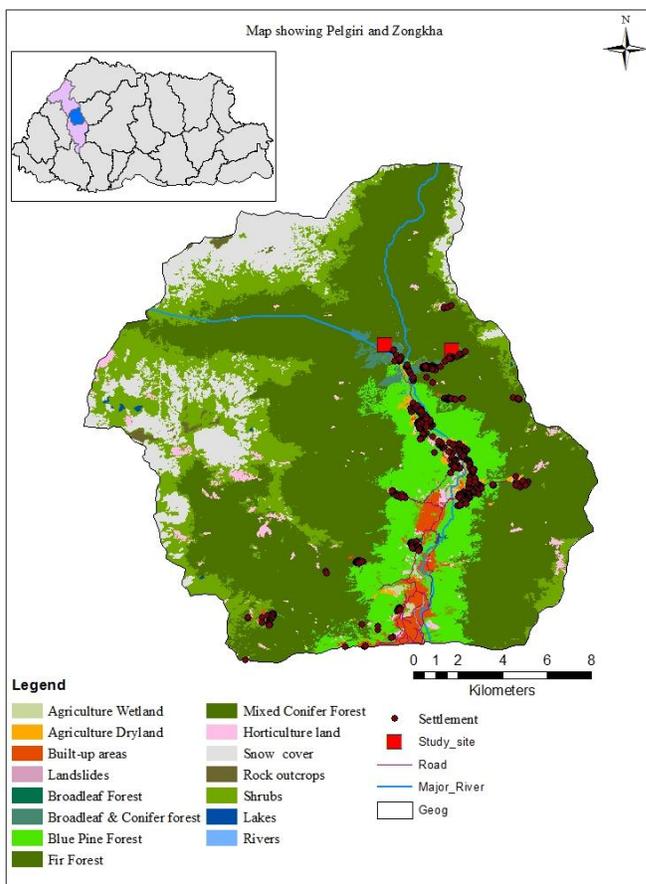
The combination of descriptive as well as statistical tools was employed to analyze the data. The data were processed using Statistical Package for the Social Sciences (SPSS, version 17) software, and MS-Excel. Cost Benefit analysis was used to find the cost of the electric fences, loss of property in the HBC and cost benefit ratio. The analysis of data was done through cross-tabulations, frequency tables, pie diagrams and graphical presentations. The descriptive statistical analysis was used to transform raw data. The techniques like simple tabulations were used for frequency tables, determination of mean, median and mode.

3.3 Materials and Tools required.

The following equipment were used for the smooth and accurate functioning of the research.

1. GPS
2. ARC GIS 10.2
3. Camera traps
4. Digital camera
5. Datasheets
6. Pen & Pencil
7. Scat collection tools viz; hand gloves and zip lock plastic bags.

3.4 Study area



Zongkha and Pegiri areas both fall in the buffer zone of the Jigme Dorji Wangchuk National Park at GPS reading N27°35'54.0'', E89°39'04.0'' and N27°36'00.9'', E89°37'27.0'' respectively in the northern part of Thimphu district. These forest areas provide shelters not only to the wild fauna but also these areas are peace and tranquil places for the hermits to undergo silent meditation without any human disturbances. The areas are just above the forest dominated by *Quercus semicarpifolia* mixed with shrubs and herbs.

According to the park officials of the JDNP, the areas are home to giant predators like the Royal Bengal tiger, common leopard, snow leopard on rare incidences and Himalayan black bears.

Figure 3.1 Map showing the study sites

CHAPTER FOUR

Results and discussions

This chapter shows the results of the study such as the qualification of the hermits, the start of HBC in Zongkha and Pelgiri, reasons for HBC in these areas, the preparedness of the residents in defending the HBBs from raiding and the different methods used in guarding the huts during the conflict. The chapter also shows the challenges for guarding the huts during the conflict and the responsibilities for managing the conflict. The main objectives of the study such as the effectiveness of the electric fences, frequency of bear sighting in different timing and season and the cost and benefit analysis of the electric fences are the essential components that are discussed below under this chapter.

4.1 Qualification of the hermits.

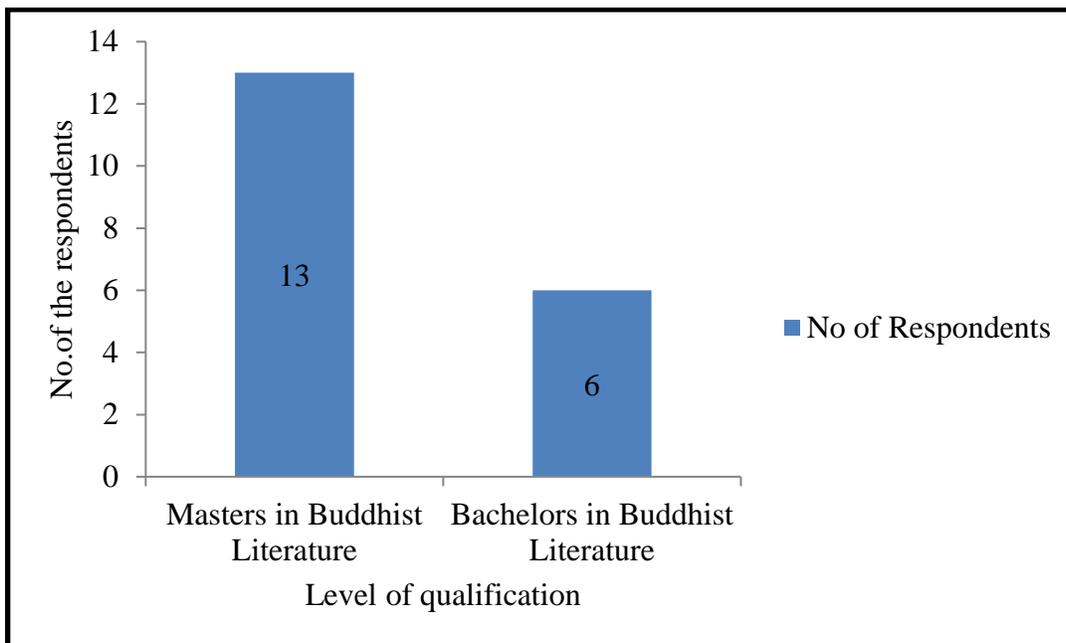


Figure 4.1 Qualification of the hermits who were the interviewee.

Understanding the qualification of the hermits who are the main stakeholders of the HBC is deemed necessary. A person with high education background is easier to educate on the importance of wildlife conservation. Literate people have right understanding with which they can be easily netted as conservation partner. During the Author's tenure in Human- Wildlife Conflict management, the author found easy to deal with clients who were literate and therefore, a lot of time and resources were saved which could be spent on other conservation activities. The above figure 4.1 shows the qualification of the hermits who were interviewed for the study. Out of the 19 respondents, 13 respondents have Masters Qualification in Buddhist literature and 6 have bachelors in Buddhist literature. In other words 68% of the respondents have Masters Qualification and 32% of the respondents have Bachelors Qualification.

4.2 Start of HBC in Zongkha and Pelgiri

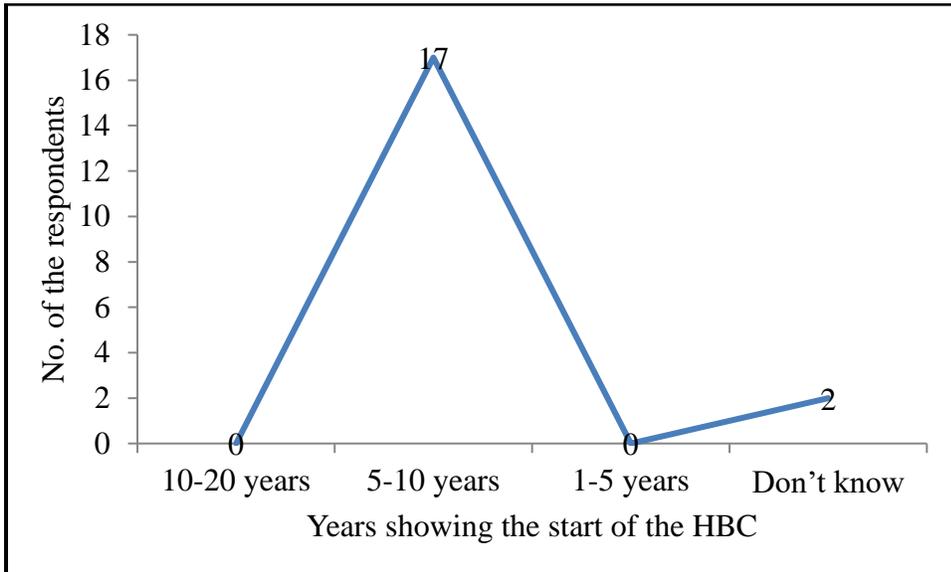


Figure 4.2 The start of HBC in Zongkha and Pelgiri

No sooner did the WCD received the HBC case in May, 2011, the DoFPS with extra concern had instructed the WCD, a functional Division which is in charge of the HWC throughout the country. WCD then entrusted the management of the conflict works to its section called HWCS. The section with the man power help from the field staffs of JDNP carried out the conflict management works such as help to guard the hermitage, carried out awareness campaign on bear ecology and snaring and translocation of the nuisance bear in which three HBBs were translocated from Chari, a place just below Pelgiri. Since the above mentioned management works could not help solve the HBC, the WCD then with the fund from World Bank carried out the installation of electric fences in two areas (Pelgiri and Zongkha) as a pilot project (Dorji, unpublished). The figure 4.2 given above shows the start of HBC in Zongkha and Pelgiri which are under the Jurisdiction of JDNP. The HBC started in 2011 which was five years from now according to 89.5% of the respondents.

4.3 Reasons for HBC in Zongkha and Pelgiri

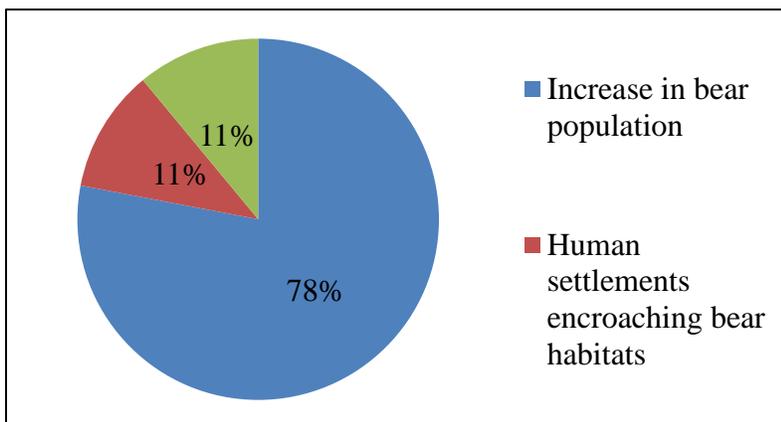


Figure 4.3 Reasons for HBC in Zongkha and Pelgiri

WWF- India, (n.d), reported HBBs as the crop and livestock depredation agent in Lhabda and Rampuria. The respondents were asked the reasons for the HBC. In the above figure 4.3, 78% of the respondents expressed the increased population of HBB as the cause of the conflict and 11% of the respondents attribute the conflict to the human settlement encroachment in the bear habitats and 11% of the respondents have the view of scarcity of food in the bear habitats. However, there is limited data on population of HBB of Bhutan to validate the information.

4.4 Preparedness and different methods of the Hermits to defend the bears.

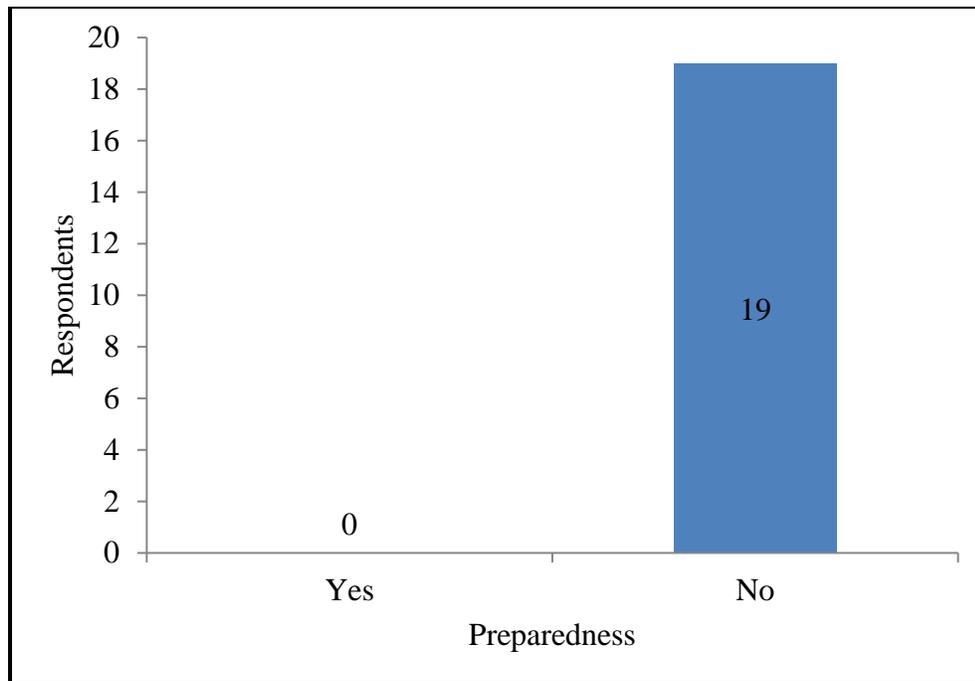


Figure 4.4 Preparedness to defend the HBBs

Respondents were not prepared in any way to defend the bears from raiding their hermitage. The figure 4.4 shows all the 19 respondents from the study areas unprepared to defend the HBBs. This is because as per some of the hermits, the forestry rules are very strict and they may be fined and put behind the bars if they defend the bears. Many of the hermits expressed the religious sentiments as a barrier in defending the bears.

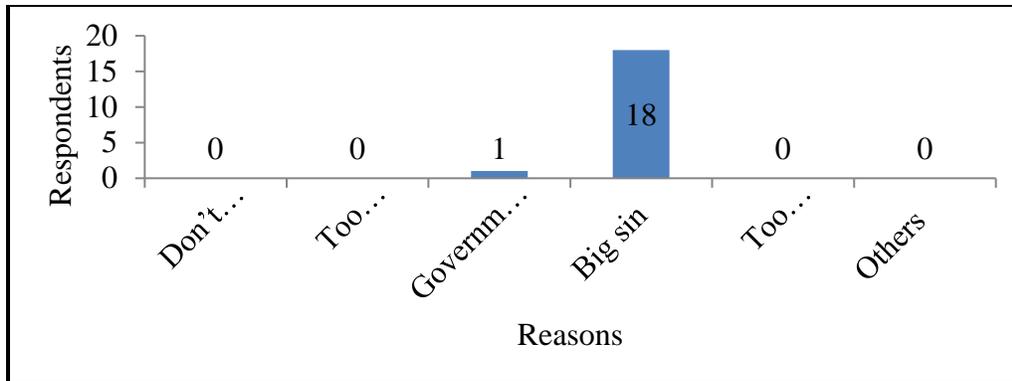


Figure 4.5 Various reasons for failing to defend the HBBs

As shown in the figure 4.5 above, the eighteen respondents (99%) expressed the guarding as a big sin according to Buddhist teaching and 1 respondent (1%) viewed it as the obstruction from the Government Rules. Being hermit, the residents are all religious minded and guarding or defending the bears are not at all at the back of their mind.

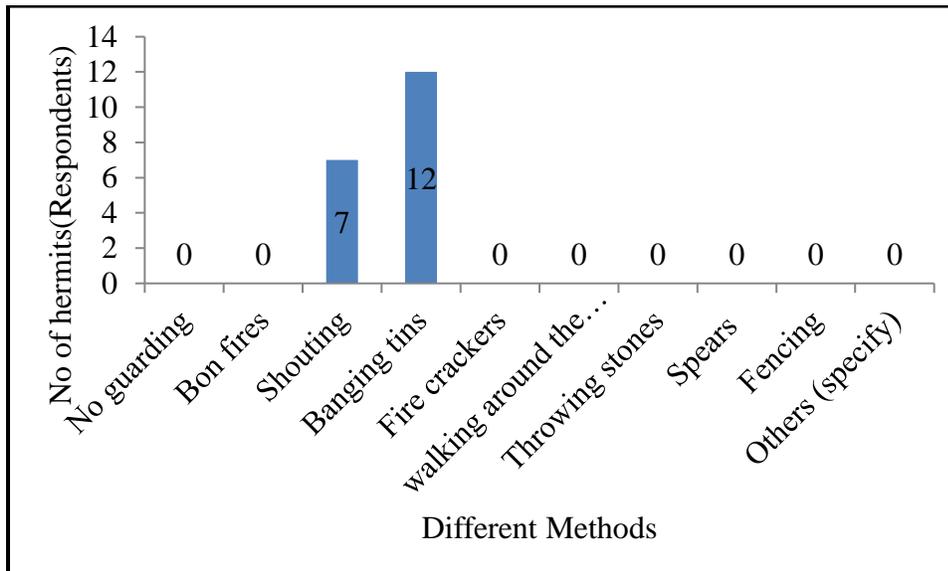


Figure 4.6 Methods used in guarding the hermitage.

The most popular methods of guarding the hermitage from the HBBs were Banging tins and shouting. Twelve respondents (63%) used the method of banging tins to keep away the HBBs from raiding and 7 respondents (37%) used the traditional method to keep away the HBBs as shown in the figure 4.6 above. This is because those were the only methods that the hermits could adopt to little ease the problems of conflict. Other methods like bon fires, throwing stone, traditional fences and walking around the huts proved futile. After the installation of the electric fences, none of the hermits in either of the study areas used the traditional methods to drive away the HBBs. This indicates that the electric fences were found 100% effective to solve the problem of HBC.

4.5 Challenges for guarding the hermitage.

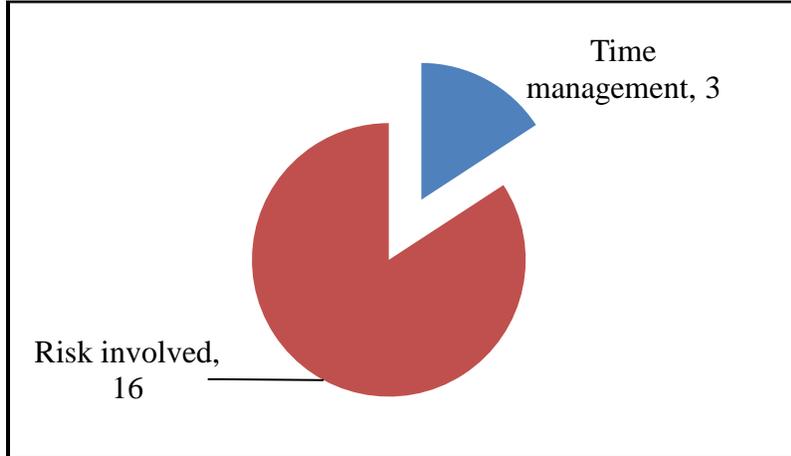


Figure 4.7 Challenges for guarding the hermitage

The biggest challenges associated with guarding the hermitage are the risk involved and the time management. 16 respondents said the risk involved as the problem as there are chances of being mauld by bears. HBBs can be very aggressive towards human who frequently trap/hunt/kill them and have frequently attacked people without first suffering provocation (Garshelis & Steinmetz, 2008). Three respondents said time management as the problem in guarding since maximum of their time have to be spent in praying and chanting. Hermits have daily schedule of prayers and other religious chores starting from early dawn till dusk.

4.6 Responsibility for solving HBC.

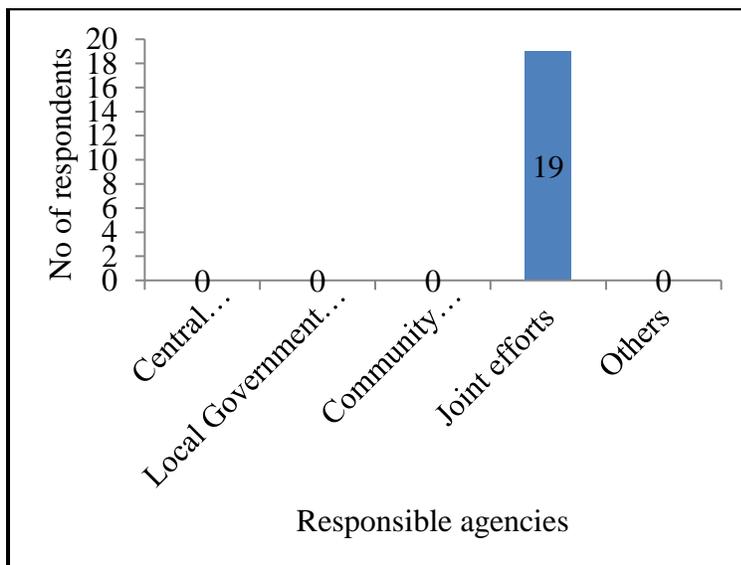


Figure 4.8 Responsibilities of solving the HBC

The respondents feel the responsibility of solving the HBC as the joint responsibility of the Forestry Officials and the hermits themselves. (See figure 4.8). Hundred percent of the

respondents feel the need to conserve wild fauna and flora for the lasting good of men as stated by Gifford Pinchoit (Thinley,2015) . The hermits feel the job of managing the HBC as a joint responsibility because of being themselves guided by the philosophy of Dharma which focuses on peaceful co-existence of all sentient beings for all time to come.

4.7 Effectiveness of electric fences.

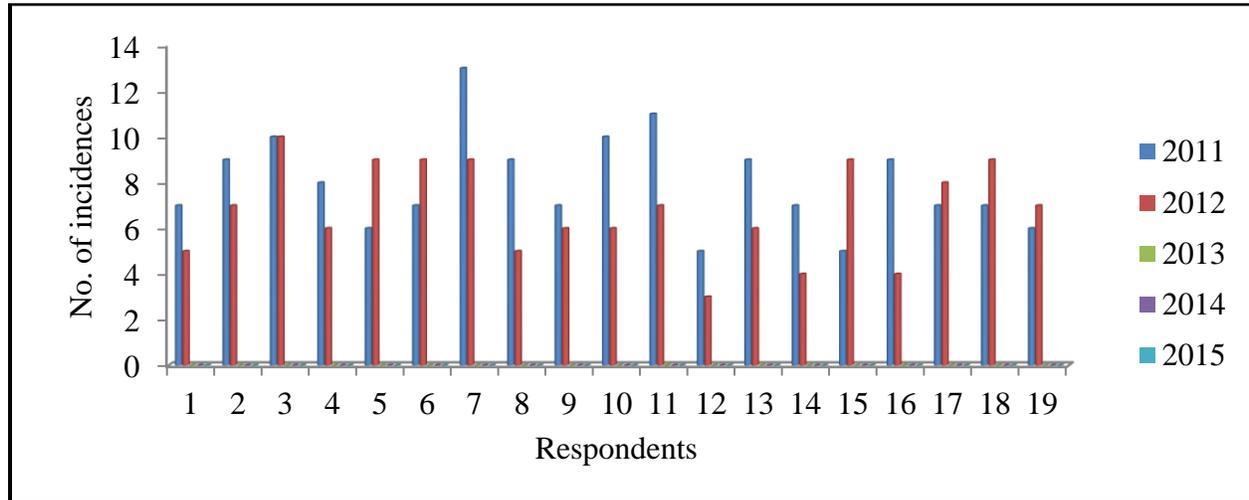


Figure 4.9 Number of HBB appearances/incidences.

On an average there were at least eight cases of raid in 2011 and seven cases in 2012 .But after the installation electric fences in 2013, the number of cases dropped down to nil. The figure 4.9 given above shows the number of bear raid incidences in the two study areas for the last five years (2011 till 2015).

A paired samples t-test was conducted to compare the incidences of bear raid before and after the installation of electric fences. There was a significant difference in the scores before and after the installation of electric fences ($M=14.78$, $SD =3.11$, $N=19$); $t (18) = 20.666$, $p = 0.00$. These results suggest that the electric fence is effective in preventing the bear raiding the huts. The number of cases dropped down to zero in both the conflict areas right after the installation of electric fences.

4.7.1 Perception on electric fences.

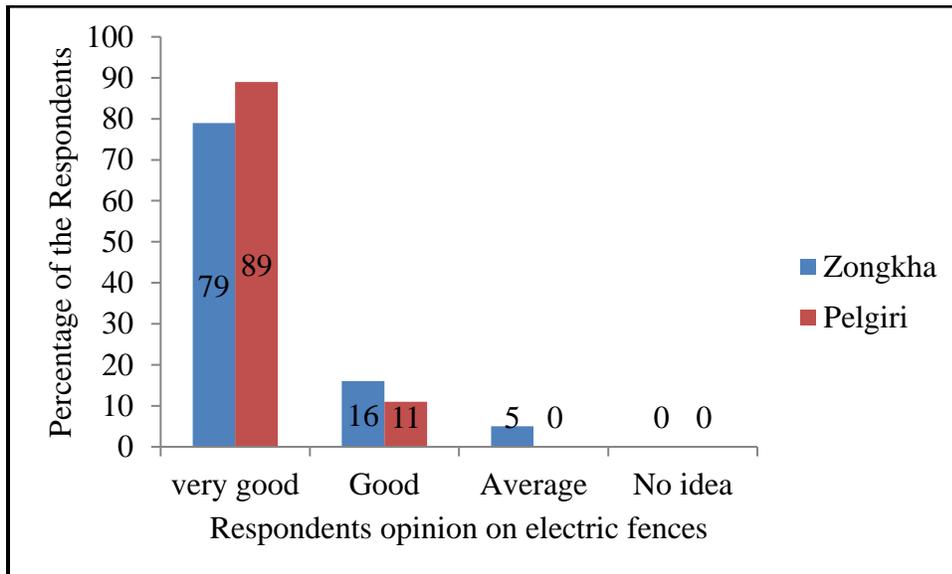


Figure 4.10 Perception on electric fences.

Community support is the key to the success of the solar fence (Gyeltshen, 2013). Therefore, to rate the effectiveness of the electric fences, an opinion based question was asked to the respondents in both the study areas. Respondents expressed various opinions about the electric fences (Figure 4.10). In Zongkha, 79 % rated very good, 16 % rated good, and 5 % rated average. Likewise in Pelgiri, 89 % of the respondents rated very well, 11 % rated good, 0 % rated average and 0 % rated no idea in both the areas. In general, 84 % of the respondents rated very good, 14 % rated well and only 2 % rated average. Hence it is vividly clearly that there is a very good community support from both the study areas which backs up to the statistical effectiveness test of the electric fences. This community support will also help enhance the effectiveness of the electric fences in the long run.

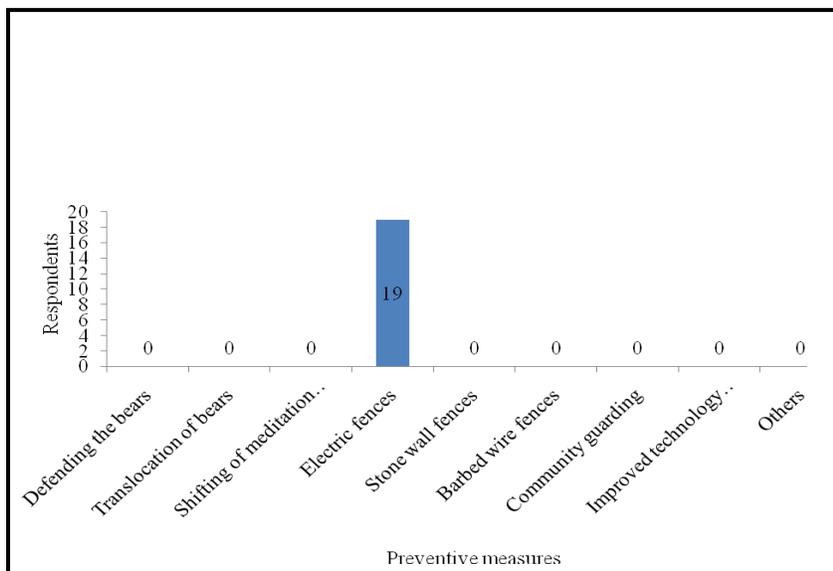


Figure 4.11 The most effective preventive measures to resolve HBC.

Figure 4.11 shows the electric fences as the most effective preventive measures. All the respondents have expressed the electric fences as the most effective measures to resolve the HBC among the many measures like defending the bears, translocation of the bears, shifting of meditation huts, electric fences and stone wall fences. Their like and preference for the electric fences is backed by the peaceful night that they have been able to enjoy right after the installation of the electric fences. Many of the respondents were able to fully concentrate on their daily religious chores like chanting prayers, meditations and performing rituals.

4.8 Occurrence and raid by the HBB in different season and timing.

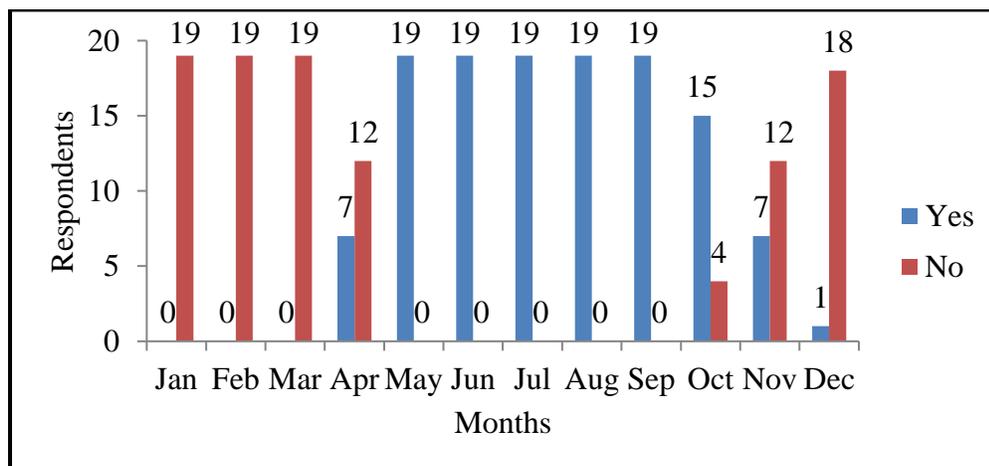


Figure 4.12 Frequency of HBB sighting/raid in different months

The figure 4.12 given above shows the maximum occurrence and raid by the HBB in the months of May, June, July, August and September. All the nineteen respondents reported of HBB sightings and incidences during those five summer months. In other words the peak season of the HBB starts from May till September. The HBBs are least sighted from the months of November till April. According to Hwang and Garshelis, (2007), HBB of both sexes sleep from October till

the end of May in the northern latitude and in the tropics only female giving birth hibernates. Therefore, the findings of the research match with those of the literatures.

4.9 Cost benefits analysis.

Year	Project cost	Project benefit	Discount factor (5%)	PV cost	PV benefits
1	1997793	360257 (558050- 197793)	0.952	188298(PCXDF)	342964 (PBXDF)

Table 4.1 Cost benefit analysis

The most common method of comparing costs with benefits is the Cost-Benefit Analysis (CBA). Cost-Benefit Analysis compares alternatives based on the monetized advantages and disadvantages. Two main issues are important in Cost-Benefit Analysis; the time factor and the principle of discounting (Moktan, 2015). The formula and the statement given below were used to calculate the cost benefit ratio.

$$\text{Cost Benefit Ratio} = \text{PV benefit} / \text{PV cost} = 342964 / 188298 = 1.82$$

CBR \geq 1 Accept (beneficial)

CBR \leq 1 Unacceptable (Not beneficial)

The study showed that the total net present value of the electric fences in Zongkha and Pelgiri was Nu 197,793.00 and the total value of losses in the HBC was Nu 558,050.00. The total net present benefit is Nu 360,257.00 and the cost benefit ratio of the project is 1.82. Therefore, the project proved feasible as the cost benefit ratio exceeded 1. (Refer Table 4.1). The loss of Nu 558,050.00 or more would still be continuing every year had the electric fences not installed in these conflict areas. The project can be replicated in other conflict areas where the total loss of property is more or equal to that of the loss in the HBC in Zongkha and Pelgiri maintaining the cost benefit ratio at 1.82.

4.10 Basic ecology of the Himalayan Black Bears.

The bears are found as generalist in feeding. Their diet contains different food in different seasons. The dietary analysis showed that they feed on succulent vegetation in spring, insects and variety of shrubs and fruits in summer and nuts and acorns in autumn. They also feed on meat whenever they come across meat throughout the season. The fecal analysis of the bears showed the hairs of rodents in their faeces.

The data from the cameras traps shows the maximum number of Himalayan Black Bears sightings from the areas of thick vegetation.

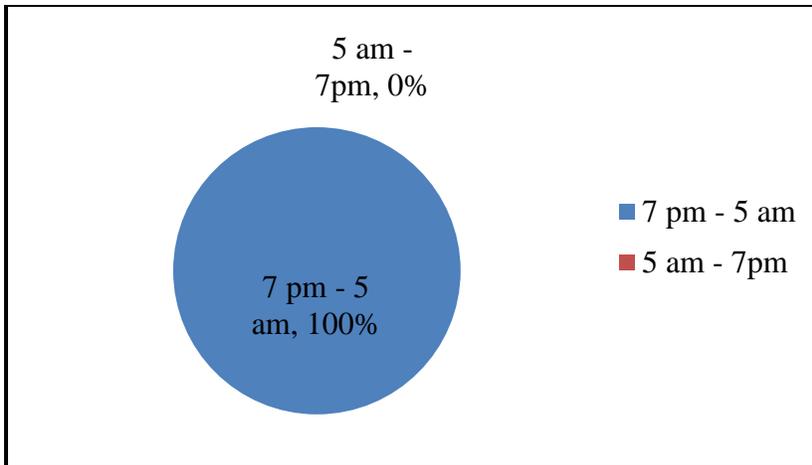


Figure 4.13 Bear raid timing

According to Garshelis and Steinmetz, (2008) although the HBBs are diurnal but they become nocturnal near human habitations. 100% of the respondents reported that the appearance and raid timing by the HBBs took place between 7 pm till 5am (Figure 4.13). During the summer months, dusk starts at 7 pm and gets dawn at 5 am. So, therefore, it is very clear that the HBBs are active during night near human habitations.

CHAPTER FIVE

Conclusion

Human bear conflicts in general are very complex requiring highly successful intrusions that are sensitive to the needs of ecosystem and society at large. Polarizing this need will lead to either ecological disaster which may bring upsetting impact on the continued existence of humans and other animals or not receive enough community support for the intrusion to succeed (Gunaratne & Premarathne, 2005). This study on the “effectiveness of electric fences as a mitigation measures to Human- Bear Conflict in Pelgiri and Zongkha under the Jigme Dorji National Park” showed that the effectiveness of the electric fences is unquestionable. The electric fences proved 100% effective. Before, the installation of the electric fences, every hermit faced the problem of raid by the HBBs and had to spent sleepless nights because of the fear of being raided and attacked by the HBBs. The sleepless nights had disturbed the hermits in performing their daily rituals and prayers. The conflict not only disturbed the tranquility of the hermits but the hermits had lost lots of ration and property. This has disturbed the hermits mentally too. Hermits were not only the victims in the conflict but the HBBs too. Few bears were trans-located and during the course of sedation and translocation, the bears had to undergo unnecessary handling by humans and suffered stress.

Starting 2013 till 2015, there was not even a single case of HBC reported from both the study areas although there were few sightings and signs of HBBs around the electric fences in both the study areas. The installation of the electric fences in the two conflict/study areas proved to be a blessing both for the HBBs and the hermits.

The highest and the frequent sightings/ incidences of HBBs were usually in the hot and warm seasons and the HBBs were least sighted during the winter months. The active hours of the HBBs were reported from Dusk till dawn.

The difference between the total costs of installation of the electric fences and the property damage in the HBC is significant. The cost of installation of the electric fences is far less than the total property damaged and lost in the HBC.

During the course of the study, the following points were found worthy to be included in the recommendation.

1. Electric fences which are carried out as a pilot project in these study areas is found to be the most effective method in mitigating the HBC and this method can be replicated in other areas like in Tangsibi in Trongsa and Soe in Paro where the HBC is still rampant and reported in media time and again.
2. To make use of the electric fences in the long run and for the sustainability of the effectiveness of the electric fences, regular cleaning in and around the fences need to be carried out.

3. At least five strands with a minimum of 10 cm in between the ground and the lower strand and the same gap between the strands is recommendation given the body size of the HBBs.
4. An energizer is must to regulate the flow of the current for the safety of both the animals and people.

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Annexures

Annexure 1.1 Pictures



Pic 1. HBB breaking the house in Zongkha



Pic 2. Hermits on visit to their friend's damaged huts



Pic 3. Damaged windows by HBB



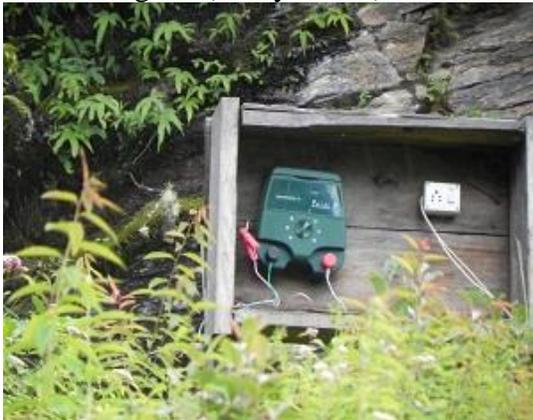
Pic4. A hermit moving out of his damaged hut



Pic 5. Zongkha (Study area 1)



Pic 6. Pelgiri (Study area 2)



Pic 7. Energizer that regulates the flow of current in electric fence.



Pic 8. Electric fences around the huts



Pic 9. A cautionary sign.

Annexure 1.2 Questionnaires

Research Questionnaire to determine the effectiveness of electric fence in reducing human-bear conflict in Pelgiri and Zongkha, JDNP”.

1. BASIC INFORMATION.		
1.1 Meditation hut information		
Village:	Geog:	
Date:	Interview no:	
GPS reading:	Interviewee’s work:	
Age of the interviewee:	Number of monks in interviewee hut:	
1.2	What is the highest level of education that you have completed?	
1.3 Type of meditation huts.		
<input type="checkbox"/> Mud plastered hut	<input type="checkbox"/> off cut made huts	
<input type="checkbox"/> stone built huts	<input type="checkbox"/> Others	
1.4 Type of hut where the bears mostly raid (Rank from 1 to 4 from most raid to least raid)		
<input type="checkbox"/> Mud plastered hut	<input type="checkbox"/> off cut made huts	
<input type="checkbox"/> stone built huts	<input type="checkbox"/> Others	
2 HUMAN BEAR CONFLICT RELATED QUESTIONS.		
2.1 Hut damaged:	1.Yes	2. No
2.2 Food items damaged:	1. Yes	2. No
2.3 Damage to other property	1.Yes	2. No
2.4 Other	1.Yes:	2. No
2.5 Tick () the stuff that is preferred and damage by the bear(s) (Rank in order)		
Tick	Food items	Rank
	1.Rice	
	2.Dried beef	
	3.Dried pork	
	4.Dalda	
	5.Wheat flour	
	6.Biscuits	
	7.Roasted Rice (Zow)	
	8. Others	
	Note: Give ranking from 1 to 8 (Highly preferred to least preferred).	
2.6 Tick () the properties damaged and rank in the damages beyond repair		
Tick	Property	Rank
	1.Meditation huts	
	2.Pots	
	3.Rice cooker	
	4.Curry cooker	

	5. Water boiler										
	6. Flask										
	7. Mugs										
	8. Plates										
	9. Religious texts										
	10. Statues										
	11. Wall paintings										
	12. Drums										
	13. Blankets										
	14. Mattress										
Note: Rank from 1 to 14 from Highly damaged to least damaged.											
2.7 During which month the bear raid your meditation site. (Tick) the month											
JAN -1	FRB -2	MAR -3	APR-4	MAY- 5	JUN-6	JUL-7	AUG -8	SEP -9	OCT -10	NOV -11	DEC -12
2.8 At what time does the bear usually raid the huts? (Tick and mark)											
1. At dark-1											
										Time	
2. Midnight-2											
3. Early morning-3											
4. Day-4											
2.9 Trend of bear raid in your area (within Last 3 years)											
<input type="checkbox"/> 1. Increase						<input type="checkbox"/> 2. Decrease					
<input type="checkbox"/> 3. Same						<input type="checkbox"/> 4. No idea					
Any other comments											
.....											
.....											
.....											
2.10 How many times did the bear appear and raid in your place during the last 5 years.											
Year			No. of incidences								
2011											
2012											
2013											
2014											
2015											
2.11 What method do you use for guarding your meditation huts against the Himalayan Black Bear? (Tick)											
1. No guarding						2. Bon fires					
3. Shouting						4. Banging tins					
5. Fire crackers						6. Walking around the huts shouting					
7. Throwing stones						8. Spears					
9. Fencing						10. Others (specify)					

	
2.12 Do bears raid when guarding the huts?		
Yes -1 <input type="checkbox"/>		No -2 <input type="checkbox"/>
3. ECONOMIC		
3.1 What is the average annual ration (Nu.) that the hermits get from the Central Monastic body?		
1. <5000		
2. 5000-10000		
3. 10000-15000		
4. 15000-20000		
5. >20000		
3.2 What are the other sources of ration?		
1. Alam		
2. From Relatives		
3. From friends		
4. From Jindas		
3.3 Damage to property (Huts and any material goods in the last 5 years)		

Type of damage	Value of the damage (Nu)	Attack by single bear/ No. of bears	Occurrence: Night/Day	Damage assessment/ Done/not done	Compensation paid: Yes/No (If yes specify amount and by whom)

3.4 Human casualty in the last 5 years.				
Year	Human death/attacks	Child/Adult	Attack time	Reason for encounter

3.5 Encounter with human				
Year	Name of the person who encountered	Age	Encounter time	Where encountered

3.6 Bear death in the last 5 years				
Place	Year	Age	Sex	Cause of the death
3.7 Did the concerned department take action on the conflict?				
Yes -1 <input type="checkbox"/>			No -2 <input type="checkbox"/>	
3.8 What did the concern department do? Please tick				
1. Awareness campaign on bear ecology		2. Help to guard the huts		
3. Snaring and translocation of the bear		4. Other strategies Specify.....		
3.9 How many bears relocated in the last 5 years?				
Year	How many bears	Relocated re-located		
4. PERCEPTION ON HUMAN BEAR CONFLICT IN THE AREA.				
4.1 When do you think HBC began in your area? (Tick)				
<input type="checkbox"/> 1. 10-20 years		<input type="checkbox"/> 2. 5-10 years		
<input type="checkbox"/> 3. 1-5 years		<input type="checkbox"/> 4. Don't know		
4.2 What do you think would be the reason for increase in Human bear conflict in your area?				
<input type="checkbox"/> 1. Increase in bear population		<input type="checkbox"/> 2. Human settlements encroaching bear habitats		
<input type="checkbox"/> 3. Due to scarcity of food in their habitats.		<input type="checkbox"/> 4. Due to the careless disposal of leftover food and other stuffs in and around the monastery and huts.		
<input type="checkbox"/> 5. Any other reasons (Please specify)				
4.3 How severe is the HBC situation today (Now)?				
1. Very severe		2. Moderate		
3. Severe				
4.3 Would you be prepared to defend any wild animal if it damages/raid your huts? Tick				
<input type="checkbox"/> 1. Yes		<input type="checkbox"/> 2. No		
If no, why? Tick				
<input type="checkbox"/> 1. Don't know how to defend		<input type="checkbox"/> 2. Too many to defend		
<input type="checkbox"/> 3. Government rules prohibit defending		<input type="checkbox"/> 4. Big sin		
<input type="checkbox"/> 5. Too dangerous		<input type="checkbox"/> 6. Others		
4.5 Which preventive measure do you think will be most effective to resolve HBC?				

1. Defending the bears	2. Translocation of bears
3. Shifting of meditation huts	4. Electric fences
5. Stone wall fences	6. Barbed wire fences
7. Community guarding	8. Improved technology or tool (specify).....
9. Others	
4.6 In what ways would the affected communities be willing to participate and cooperate in the efforts to initiate mitigation approaches?	
<input type="checkbox"/> 1. Contribute labour	<input type="checkbox"/> 2. Contribute cash
<input type="checkbox"/> 3. Forming societies	<input type="checkbox"/> 4. Any other support
4.7 Who do you think is responsible for solving HBC problem in your area?	
<input type="checkbox"/> 1. Central Government ministries/Departments (Forest)	<input type="checkbox"/> 2. Local Government Dzongkhags/Geogs
<input type="checkbox"/> 3. Community themselves	<input type="checkbox"/> 4. Joint efforts
<input type="checkbox"/> 5. Others	
4.8 Which is a bigger problem for guarding the bears?	
<input type="checkbox"/> 1. Time management	<input type="checkbox"/> 2. Risk involved
4.9 Are you aware of the Forest and Nature Conservation Act of Bhutan, 1995 and Forest and Nature Conservation Rules of Bhutan, 2003?	
<input type="checkbox"/> 1. Yes	<input type="checkbox"/> 2. No
4.10 How are forestry officials approachable in dealing with Human- Bear Conflict	
<input type="checkbox"/> 1. Very approachable	<input type="checkbox"/> 2. Approachable
<input type="checkbox"/> 3. Not approachable	<input type="checkbox"/> 4. Not at all approachable

