HUMAN-WILDLIFE CONFLICT: SUSTAINABILITY OF ELECTRIC FENCING AS MITIGATION MEASURE IN PARO DZONGKHAG.

THINLEY TSHERING

A Thesis Submitted to the Graduate School of Naresuan University
in Partial Fulfillment of the Requirements
for the Master of Science in (Geographic Information Science)
2019

HUMAN-WILDLIFE CONFLICT: SUSTAINABILITY OF ELECTRIC FENCING AS MITIGATION MEASURE IN PARO DZONGKHAG.

THINLEY TSHERING

A Thesis Submitted to the Graduate School of Naresuan University
in Partial Fulfillment of the Requirements
for the Master of Science in (Geographic Information Science)
2019

Thesis entitled "Human-wildlife Conflict: Sustainability of Electric Fencing as mitigation measure in Paro Dzongkhag."

By THINLEY TSHERING

has been approved by the Graduate School as partial fulfillment of the requirements for the Master of Science in Geographic Information Science of Naresuan University

Oral Defense Committee

..... Chair
(Assistant Professor Suphatphong Ruthamnong, Ph.D.)

..... Advisor
(Associate Professor Pathana Rachavong)

..... Internal Examiner
(Assistant Professor Kampanart Piyathamrongchai, Ph.D.)

Approved

.....
(Professor Paisarn Muneesawang, Ph.D.)

for Dean of the Graduate School

Title HUMAN-WILDLIFE CONFLICT: SUSTAINABILITY OF ELECTRIC FENCING AS MITIGATION MEASURE IN PARO DZONGKHAG.

Author THINLEY TSHERING

Advisor Associate Professor Pathana Rachavong

Academic Paper Thesis M.S. in Geographic Information Science, Naresuan University, 2019

Keywords Human-wildlife conflct, Maximum Entropy Model, habitat distribution, Representative Concentration Pathways, bioclimatic variables, Mitigating

ABSTRACT

This participatory research have been conducted to understand the perception, level of tolerance and attitude towards HWC and overall wildlife conservation policies, assess type and extent of damages caused by human-wildlife conflict in Paro, to study the distribution probability of wild pig (*Sus scrofa*) using MaxEnt & impact of climate on the its habitat distribution in Bhutan, and finally to understand the effectiveness of Electric Fencing in mitigating Human-wildlife conflict. The data was collected in a face-to-face interview with household members through snowballing methods of sampling 105 households.

The overall mean age of the respondents was 47.97 with age ranging from 18 to 78 years old. All 100% of the respondent has been in conflict with the wild animal and majority of the conflict 98.1%was related to crop raiding while 1.9% faced conflict related to cattle predation. According to the study it was found that whopping 97.1% of the respondent experienced conflict with the wild pig, while 73.3% experienced conflict with deer. 65.7% of them named wild pig as the most destructive wild animal, while 20% and 14.3% named deer and white capped langur respectively as the most destructive animal in the study area.

The respondents saw increase income from minimum of Nu.7000/- to the maximum of Nu.315000/- after electric fencing. After electric fencing, 20% of the

respondent lost their crops to the wild animal while 80% did not lose any crops after electric fencing of their land. Potatoes was the main crop that was lost after electric fencing, the total valuation of crops lost among 21 household after EF is around Nu.369550/-. After electric fencing, 83 Household or respondent saw increase in production of potatoes, while 38 households saw and increase in production of paddy and cabbage crop. 99% were satisfied with the performance of the electric fencing and similarly 100% of the respondent were willing to recommend electric fencing as mitigation measures in combating human-wildlife conflict in Paro Dzongkhag.

Majority of the respondent 98.1% were aware of the Rules while only 2.9% of the respondent were ignorant of the Forest & Nature Conservation Rules, 2017. 58.1% of the respondent felt that the HWC situation in Bhutan was moderately severe, while 39%of the respondent felt the HWC cases was very severe. 100% chose for Electric Fencing materials to be provided at subsidized and did not opt for other 4 option such as compensation, kill problem animals, catch and relocate wild animals etc. Using the MaxEnt model it was found that the bioclimatic factor precipitation and temperature played a significant role in the habitat distribution of wild pigs in Bhutan.

ACKNOWLEDGEMENTS

Firstly I would like to thank The Royal Government of Bhutan for giving me this opportunity to pursue my Master in Naresuan University, Thailand. I am unequivocally indebted to Thailand International Cooperation Agency (TICA) for their generous scholarship funding for my study without which this study would not have been possible.

I would also like to extend my deepest gratitude to my advisors Associate Professor Pathana Rachavong and Miss Tanyaluck Chansombat who not only has courage to mentor me but also devoted endless hours patiently listening to me and guiding me. They have not only been my mentor or guided me but also critiqued me and coerced me to maintain high standards of writing. Gratitude to Assistant Professor Dr. Kampanart Piyathangrongchai for his support and guidance during thesis writing.

Special acknowledgement goes to Chief Forest Officer, Paro Forest Division for his help and logistical support during my data collection. Heartfelt thanks to Mr. Lobzang, Unit In-charge, Bitekha FMU , Mr. Jamyang Zangpo Geog In-charge, Dogar Geog, Mr. Phub Thinley & Mr. Kezang Wangchuk, Shaba Geog, Mr. Tenzin Zangpo of Shari Geog, Mr. Choney Rangdol of Lamgong Geog & lastly Mr. Dorji Tshewang of Paro Division Office for their help during data collection.

I would also like to extend my deep gratitude to Naresuan University, staffs at the Faculty of Agriculture, Natural Resources & Environment, my colleagues, and all those who has helped me one way or the other to make my stay in Naresuan University a memorable experience.

Finally, to my partner, Yeshi Pelden and my boys Thinley Dhendup & Sonam Tshering for their patience love and support provided throughout my study period. I would like to dedicate this thesis to my family of what good may come out of it.

THINLEY TSHERING

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

ACRONYM

DoFPS	Department of Forest & Park Services
Dzongkhag	District
EF	Electric Fencing
FNCR	Forest & Nature Conservation Rules of Bhutan
Geog	Sub-district
HH	Household
HWC	Human wildlife conflict
MaxEnt	Maximum Entropy Model
MoAF	Ministry of Agriculture & Forests
Nu	Ngultrum (Bhutanese Currency 1$ =71.58 Ngultrum)
RCP	Representative Concentration Pathways
RGoB	Royal Government of Bhutan
WCD	Wildlife Conservation Division
WWF	World Wildlife Fund

CHAPTER I

INTRODUCTION

1.1 Background

Human-wildlife conflict (HWC) is defined as any interaction between humans and wildlife that results in negative impacts on human social, economic or cultural life, on the conservation of wildlife populations, or on the environment (WWF, 2008). HWC is a growing problem in today's world, threatening the survival of wild animals and the livelihoods of the rural farming communities. Conflicts can take many forms ranging from damage to crops, livestock or property by wild animals to injury or death of humans/wild animals. Direct contact with wildlife occurs in both urban and rural areas, but it is generally more common inside and around protected areas, where wildlife population density is higher and animals often stray into adjacent cultivated fields or grazing areas (Distefano, 2005).

Millions of people across the world are affected. The loss of life, crops or livestock to wildlife has significant consequences for people's livelihoods, their food and agricultural security. Conservation and provision of livelihoods should therefore go hand-in-hand. Human–wildlife conflict, by compromising people's livelihoods, seriously impedes these goals (Barua, 2012).

Whereas conflicts between people and wild animals have always occurred throughout history, population growth and increased demand for natural resources as well as the decrease in natural habitat have aggravated the problem in many places. Wildlife species invade human settlements and raid crops, cause damage to personal belongings, injure or kill livestock and in some regrettable instances even injure and kill people. Humans respond by retaliation killings, indiscriminate poisoning and increased poaching of wild animals. The causes of the conflict cannot be eliminated easily or quickly, and human-wildlife conflicts are among one of the main threats to the survival and conservation of various wild species (Africa, 2014).

Direct costs to humans are the financial, social and cultural losses suffered because of human-wildlife conflict. The indirect costs of human-wildlife conflict are generally associated with the physical threat of living with large mammals. This has the effect of restricting people's freedom of movement, for fear of running into such animals, or restrict their access to resources such as water, firewood and grass for thatching (WWF, 2008).

Farmers' poor understanding of the ecological role of predators may also inadvertently exacerbate resentment against predator conservation. Livestock loss may consequently lead to retaliatory killings of large apex predators, such as tigers (Panthera tigris), leopards (Panthera pardus), and dholes (Cuon alpinus). Negative human-predator interactions have overshadowed potential benefits to the extent that the extirpation of carnivore species has been advocated (Thinley, 2018). Thinley *et.al* (2018) has shown that there is ecological benefit of apex predator conservation program to farmers in reducing crop and livestock losses in Eastern Himalaya region. The study found that when tiger was present in forests surrounding villages, leopards and dholes occupied areas closer to village croplands and preyed on a higher relative abundance of wild herbivore crop raiders, thereby significantly reducing crop and livestock damages. In contrast, leopards and dholes occupied areas in deep forests farther from croplands when a tiger was absent in the village vicinity, leading to increased predation on a higher abundance of untended free-ranging livestock.

1.2 Problem Statement

Bhutan is recognised as one of the top ten biodiversity hotspots in the world, the country has 5114 species of animals, 5369 plants, 690 fungi, 55 Chromista, 18 Eubacteria and two species of Protista (Wangmo, 2019). Though small, Bhutan is a primary steward of some of the world's most exceptional mega- fauna, many of which are endangered elsewhere in the Hindu Kush Himalayas. Bhutan has steadily gained international recognition for its organized conservation efforts, including the establishment of an extensive network of protected areas, and interconnecting biological corridors. Indeed, about 51% of the country's total land area of 38,394 Km^2 (DoFPS, 2018) has been set aside for conservation, and 60% of the country is mandated

by the Constitution of Bhutan to remain in forest cover for all times (NCD, 2008). However, this recognition has come at a cost, as all our conservation areas have people living inside or adjacent to these areas.

Every year, human-wildlife conflict in the rural areas is reported in the media. The conflict are varied in nature and includes livestock predations, house raiding and even human attack. This has caused serious threat and challenge to farmers living in rural Bhutan. In most cases, farmers who have experienced threats from wild animal in attempt to combat the challenge by killing the species and as a result, conservation effort of such species is challenging.

1.3 Rationale

While Bhutan is globally reputed for richness in biodiversity and for promoting sound conservation policies, the human wildlife conflicts has been recognized as one of the biggest challenges for conservation in Bhutan. Conflict between people and wildlife has been recognized as serious issue that confronts the rural communities around the country and huge investments has been made in implementing measures to combat the issue. In order to address the increasing incidence of human wildlife conflict, the Ministry of Agriculture & Forest have implemented numerous intervention programs throughout the country. The Department of Forests and Park Services, Royal Government of Bhutan has developed the National Human Wildlife Conflict Management Strategy in 2008. The focus of this National strategy was mostly towards alleviating poverty and improving livelihoods for rural Bhutanese while protecting the mega-fauna that characterize this kingdom (NCD, 2008). Since then, various mitigation measures has been adopted throughout the country based on the prescription/ recommendation of this strategy.

This research intend to study the impact of electric fencing on reducing the conflicts between wild animals and human, which is one of the mitigation measures adopted by the Ministry of Agriculture and Forest of Bhutan. The geographical habitat distribution of wild pig (*Sus scrofa)* which is one of the main pest resulting in loss of crops was be examined using current and future climatic conditions in Bhutan using MaxEnt. The study was conducted based on qualitative research using public

participation geographic information system (PPGIS) to understand the types of damage caused during human wildlife conflict, effectiveness of electric fencing as well as understand the public perception, attitude and tolerance level of public towards human-wildlife conflict.

1.4 Objectives of the Study

The study on human wildlife conflict in Paro Dzongkhag, Bhutan was undertaken mainly in line with these objectives:

1. To understand the perception, level of tolerance and attitude towards HWC and overall wildlife conservation polices.
2. To assess type and extent of damages caused by human-wildlife conflict in Paro.
3. To study the distribution probability of wild pig (*Sus scrofa*) using MaxEnt & impact of climate on its habitat distribution in Bhutan.
4. To understand the effectiveness of Electric Fencing in mitigating Human-wildlife conflict.

1.5 Expected Outcome

This research consists of 4 expected outcomes which are as follow:

1. Understand the perception, level of tolerance and attitude of the respondent to human wildlife conflict and on the overall conservation policy of the Royal Government of Bhutan.
2. Assess type and extent of damages caused by human-wildlife conflict in the study area.
3. Understand the distribution probability of wild pig's habitat in Bhutan under different climatic scenarios
4. Understand the effectiveness of electric fencing in mitigating human wildlife conflict.

CHAPTER II

HUMAN-WILDLIFE CONFLICT

2.1 Human-wildlife Conflict

Conservation conflicts are widespread and are damaging for biodiversity, livelihoods and human well-being. Conflict management often occurs through interventions targeting human behavior (Herd, 2018). Conservation conflicts are increasing and needs to be managed to minimize negative impacts on biodiversity, human livelihoods, and human well-being (Redpath, 2013). Paradoxically, farmers in developing and biodiversity-rich countries often experience economic loss through negative interactions with wild predators and herbivores (Thinley, 2018). 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 (S. W. Wang, Lassoie,James P. & Curtis,Paul D. , 2006). Biodiversity conflicts and human–wildlife conflicts (HWC) in particular, are predicted to increase. Understanding drivers of these conflicts is a prerequisite for developing strategies to achieve conservation goals. People are a part of all HWC problems meaning social research methods are essential for finding solutions (Kansky, 2014).

HWC has a long historical existence, its increasing severity and complex nature has made it a central issue to wildlife management. The increase in severity of HWC has been attributed to a number of factors, such as expansion of human activities into wildlife habitats, recovery, and expansion of a few wildlife populations and large scale environmental changes(Ananad, 2017). Human–wildlife conflict is one of the most critical threats facing many wildlife species today, and the topic is receiving increasing attention from conservation biologists. Direct wildlife damage is commonly cited as the main driver of conflict, and many tools exist for reducing such damage. However, significant conflict often remains even after damage has been reduced, suggesting that conflict requires novel, comprehensive approaches for long-term resolution. Although

most mitigation studies investigate only the technical aspects of conflict reduction, people's attitudes towards wildlife are complex, with social factors as diverse as religious affiliation, ethnicity and cultural beliefs all shaping conflict intensity. Moreover, human–wildlife conflicts are often manifestations of underlying human–human conflicts, such as between authorities and local people, or between people of different cultural backgrounds. Despite evidence that social factors can be more important in driving conflict than wildlife damage incurred, they are often ignored in conflict studies. Developing a broader awareness of conflict drivers will advance understanding of the patterns and underlying processes behind this critical conservation issue. Variety of case studies shows how social factors strongly influence perceptions of human–wildlife conflict, and highlight how mitigation approaches should become increasingly innovative and interdisciplinary in order to enable people to move from conflict towards coexistence (Dickman, 2010).

The evolution of the arsenal of HWC mitigation methods suggests that currently relevant developments fall into three categories: biological, physical and governance. These broadly reflect new knowledge about problem animals themselves, better application of fencing and olfactory deterrents, and evaluation of options for damage compensation and land-use policy (Hoare, 2012). HWC involves a wide range of occurrence environments and species from the grain poaching rodents to the man eating tigers (Panthera tigris) of the world. For instance, in the Sanjiangyuan region of China, the brown bears are reported to raid villages and damage foods stores and kill sheep. It is estimated that the cost of addressing the damages ranges from $700 to $2800, which exceeds most family's annual income (Worthy, 2008). In the United States of America (USA), found out that vehicle collisions with the white-tailed deer (Odocoileus virginianus) was injuring up to 29,000 people and damaging properties worthy more than $1 billion annually in rural counties (Storm, 2007). In Manitoba Canada, conflict between elk (Cervus elaphus) and the farmers had been documented since 1880. However, the creation of the Riding Mountain National Park in 1930 and a ban in hunting increased the elk population and intensified elk-farmers conflicts. Elks damage fences and crops estimated to be over $ 24,000 annually and they are also associated with the spread of bovine tuberculosis to dairy cattles (Brooks, 2009).

HWC has been considered as a global problem occurring both in developed and developing world. The conflict is rapidly becoming a key issue to the wildlife conservationist and managers with increased interest by more people to actively participate in wildlife management decisions. Evidence-based decision-making is critical for implementing conservation actions, especially for human-wildlife conflicts, which have been increasing worldwide. Conservation practitioners recognize that long-term solutions should include altering human behaviors, and public education and enforcement of wildlife-related laws are two management actions frequently implemented, but with little empirical evidence evaluating their success (Baruch-Mordo, 2011).

2.2 Electric Fencing

The history of the fencing is closely tied to the history of human civilization and fences arose to resolve social conflict. Fencing for conservation is an acknowledgement that we are failing to successfully coexist with and, ultimately, conserve biodiversity (Hayward, 2009). Despite these problems, fencing for conservation is likely to become increasingly utilized as biodiversity becomes increasingly threatened and methods of ameliorating threats lag behind. In the long-term, fences may ultimately prove to be as much a threat to biodiversity as the threats they are meant to exclude, and a new research agenda should arise to ensure that conservation fences do not remain a permanent part of the landscape (Hayward, 2009).

Fences implemented to achieve a conservation benefit are not necessarily physical barriers, but can also include ‘metaphorical’ fences of sound, smoke and smell, or even actual islands. Fences provide defined units for managers and separate biodiversity from threatening processes including human persecution, invasive species and disease. Conversely, they are costly to build and maintain; they have ecological costs through blocking migration routes, restriction of biodiversity range use which may result in overabundance, inbreeding and isolation; restriction of evolutionary potential; management; amenity and ethical costs (Hayward, 2009).

An electric fence is a barrier that uses electric shocks to deter animals and people from crossing a boundary. The voltage of the shock may have effects ranging from discomfort to death. Although various options for crop protection are available, most are not effective or not opted as it involves killing of animals. Study shows that electric fencing was the most useful measure for reducing crop and property damage due to large mammals, especially elephants and rhinos. It was, however, not completely effective in controlling small mammals and ungulates (Sapkota, 2014). Electric fencing have proved to be successful in addressing the crop damage by wild animals in countries like India, Sri Lanka, Kenya, Namibia, Australia, was tested in the country and found to be effective in preventing crop damage by wild animals (Kioko, 2008).

Simply erecting a fence is not sufficient to achieve the goals of its creation and ensure conservation success. Fences must be maintained and this can be expensive. The cost of fencing varies between countries, however the key issue is that it is expensive and it requires continued maintenance. Modern electric fence designs in South Africa are solar powered to reduce on-going costs, however they still require frequent monitoring to ensure their operability. Although these costs are staggering, it is not the world's wealthiest countries constructing these conservation fences. Indeed, Australia can afford to build and maintain thousands of kilometers of rabbit and dog fence to protect the viability of pastoralism in marginal lands, yet cannot afford to fence out introduced predators from national parks despite having the world's highest extinction rate over the past 200 years (Hayward, 2009).

The efficacy of electric fencing to protect other economically and ecologically important areas, such as orchards, livestock, and wetland habitats, from wild animal damage needs scientific evaluation. Furthermore, long-term and multi season evaluations of electric fence should be pursued. More study is needed on different electric fence designs and their integration into wild animal damage control programs. combining electric fencing with other damage control methods in an integrated management program may be the best method for alleviating wild animal damages and controlling population (Reidy, 2008).

2.3 HWC Scenario in Bhutan

Bhutan is largely an agrarian economy with large population engaged in crop and livestock farming. It contributes up to 16.08% of GDP and account for 4.3% export (MoAF, 2014). Sector directly employ about 58% of total population (LFS, 2015) and continues to play important role in reducing poverty and bringing prosperity for Bhutanese. The increasing scenario of HWC has put many farming communities under serious threat in recent decades (NCD, 2008).

HWC scenario is widespread all over the country and cases have been reported from all the Dzongkhag. Conflicts between people and wildlife in Bhutan comprises of various situations viz. human predator conflicts for livestock herding community mostly in the central and eastern Bhutan, human elephant conflicts for the southern farmers and conflicts with wild pigs, monkey and other ungulates almost throughout Bhutan. The impact is felt mainly by predominantly poor rural farmers who depend on agricultural farming and livestock rearing for their livelihood. The huge financial and labor costs (guarding and other measures) incurred due to HWC and wild pest attacks lead to revenge killing and hatred toward wildlife. Most of the rural communities in Bhutan suffer due to damages from wildlife such as losing crops and domestic stock and have destabilized the livelihoods of the people in the rural communities around Bhutan. With the rapidly increasing human population and pressure on forest areas and wild life habitat, human-wildlife interaction and resultant conflict is also increasing (NCD, 2008).

It is reported that total of 2.3% of domestic cattle are lost to wild predators over a period of 12 months which equates to an average financial loss of 17% ($44.72) of their total per capita cash income (S. W. M. Wang, D.W. , 2006). However, there is no report on actual loss of crop by wild animals as most of the crop raiding by wild animals occurs in rural areas which is very far from the office Center, moreover since there is no compensation for crop loss by wild animals from the Government, the residents do not feel obligated or consider it worth the trouble to report the incident to Government officials incurring travel expenses.

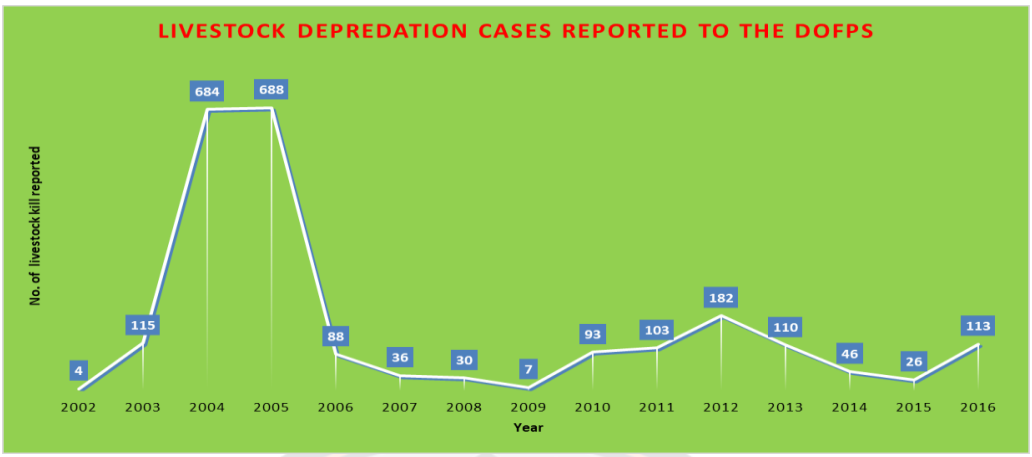


Figure 1 Livestock Depredation cases reported to DoFPS

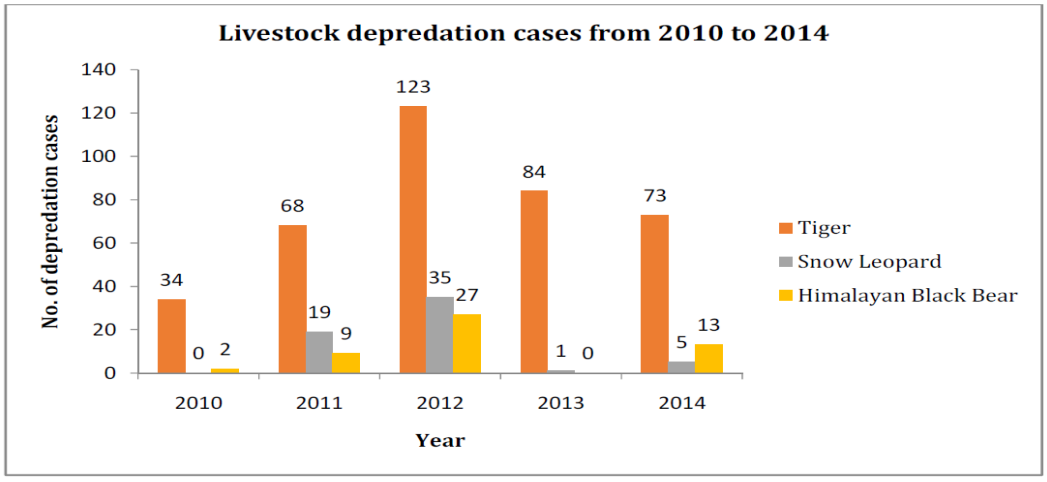


Figure 2 Livestock killed by various predators in Bhutan

In order to address the increasing incidence of human wildlife conflict, the Ministry of Agriculture & Forest of Bhutan have implemented numerous intervention programs throughout the country. The Department of Forests and Park Services, Royal Government of Bhutan has developed the National Human Wildlife Conflict Management Strategy in 2008. The focus of this National strategy was mostly towards alleviating poverty and improving livelihoods for rural Bhutanese while protecting the mega-fauna that characterize this kingdom (NCD, 2008). Since then, various mitigation measures have been adopted throughout the country based on the prescription/ recommendation of this strategy.

The model of electric fencing which includes imported IEC certified energizer and locally fabricated fencing materials has proven to be successful after it has been tested for more than 5 years in different locations targeting different problem species of animals. This technology is not only found to be an effective control but also cost effective and socially acceptable for the Bhutanese farmers (NPPC, 2019).

These fencing which are quite expensive have been repeatedly experimented on pilot scale to address the ever increasing HWC incidences in Bhutan in early 2000 and the incidences of conflict has drastically reduced in the fenced areas.

Table 1 Table showing various Electric Fencing Projects in Bhutan

Dzongkhag	Fence length (Km)	Dryland fenced (Acre)	Wetland fenced (Acre)	Total land fenced (acre)	Total beneficiaries
Bumthang	186.25	1136.70	71.97	1208.67	986
Chukha	61.05	1424.65	340.62	1765.27	497
Dagana	220.80	1788.71	1196.48	2985.19	1116
Gasa	74.83	268.31	169.75	438.06	152
Haa	144.77	1055.08	0	1055.08	801
Lhuntse	225.79	921.30	223.90	1145.20	768
Mongar	199.24	1355.86	274.62	1630.48	1138
Paro	127.86	647.08	515.34	1162.42	354
Pemagatshel	117.75	2451.12	0	2451.12	828
Punakha	213.39	344.42	419.14	763.56	619
S/jongkhar	204.7	590.20	666.00	1256.20	1178
Samtse	75.80	867.31	508.88	1376.19	803
Sarpang	234.499	4491.19	5228.20	9719.39	3114
Thimphu	116.54	715.81	126.25	842.06	570
Trashigang	165.76	2712.07	715.13	3427.20	951
Trashiyangtze	304.23	1695.80	108.10	1803.90	1001
Trongsa	276.31	1232.00	1640.62	2872.62	1166
Tsirang	165.66	820.00	833.20	1653.20	788
Wangdue	295.81	207.59	897.75	1105.34	983
Zhemgang	147.66	792.60	770.40	1563.00	878
Total	**3558.699**	**25517.80**	**14706.4**	**40224.15**	**18691**

Source: NPPC,DoA,MoAF : Bhutan RNR Statistics, 2017 Report

During the 11Five Year Plan, the MoAF (as shown in Table no. 1) through various funding support (RGoB & donors) have installed 3558 Km of SEF, protecting 40224.14 acres of registered agricultural land, benefiting 18691 households in the country (Bhutan RNR Statistics, 2017).

Royal Government has invested significant effort and resources in this initiative, pioneering and legalizing this new technology. Valuable technical assistance is provided through training and monitoring. However, till date there has been few studies or research undertaken to demonstrate effectiveness of electric fencing in deterring wild animals from raiding crops under Paro Dzongkhag nor was the benefit of electric fencing ever quantified with empirical evidence.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Conceptual Framework

Conflicts involving species are commonly referred to as 'human–wildlife conflicts', defined as those occurring when an action by either humans or wildlife has an adverse effect on the other. This term is problematic in part because it suggests that wildlife species are conscious human antagonists, so we partition such conflicts into their two components: (i) impacts that deal with the direct interactions between humans and other species; and (ii) conflicts that centre on human interactions between those seeking to conserve species and those with other goals (Redpath, 2013).

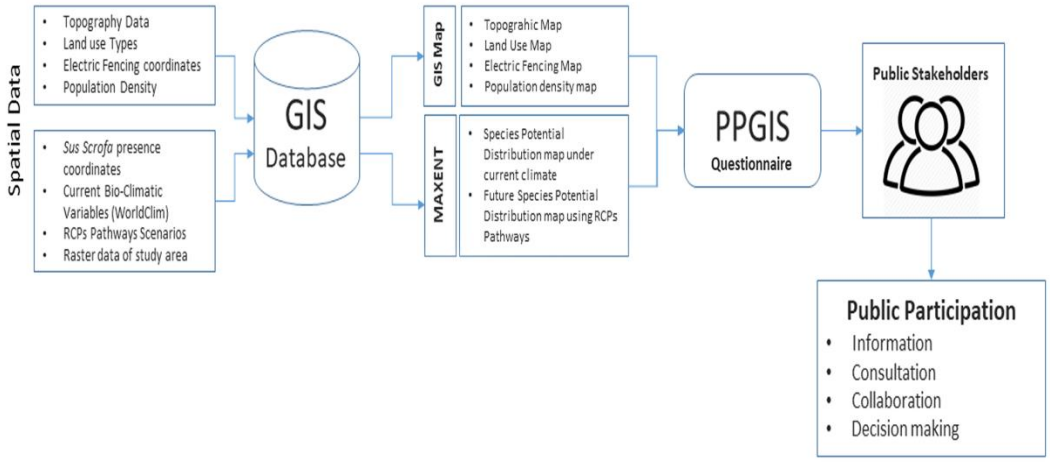


Figure 3 Conceptual framework for HWC in study area.

Conceptual framework for understanding Human-Wildlife conflict as shown in Figure 3. represents two main factor which are 1) spatial data for mapping distribution of wild pig in Bhutan and the impact of bioclimatic variables on the future population of wild pig and 2) Public Participatory GIS for collection of qualitative data through

face to face interview with the respondent to understand their perception, attitude and level of tolerance towards human wildlife conflict in Paro District.

3.2 Area description

Paro is located on the western part of Bhutan with an area of 1,293 Km², 10,274 households and a local population of 46,316 people (NSB, 2019). The bountiful and fertile Paro Valley is the entry point for all visitors flying into Bhutan and is one of the top destination for tourist visiting Bhutan and has the only airport of Bhutan. Paro District is located between 27°13'7.88"N, 89°31'11.10"E to 27°35'4.97"N, 89°21'31.35"E with an elevation ranging from 2500 masl till 4000 masl (shown in Figure 4).

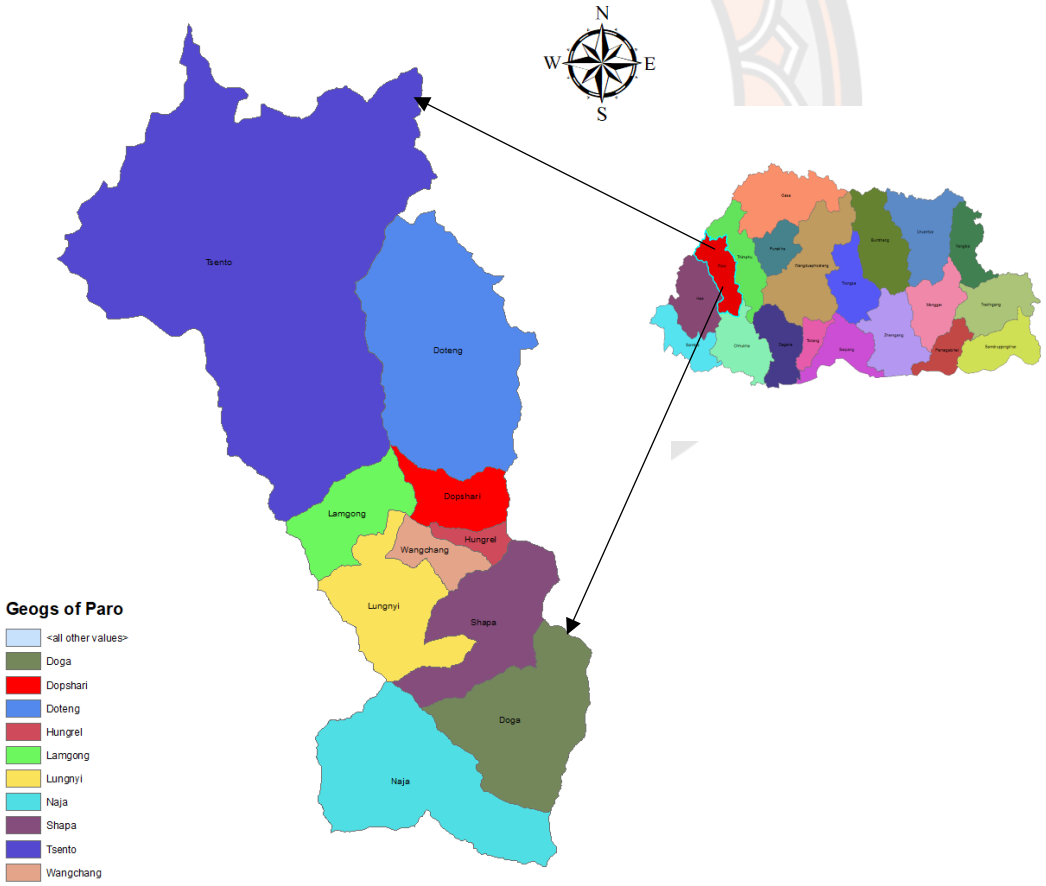


Figure 4 Map showing study area

Paro Dzongkhag has 10-sub district and 2 Municipal town and 2 towns identified as satellite towns with 100% coverage of roads connectivity health facilities and other basic amenities. Dzongkhag due to its vicinity to capital city Thimphu, has experienced unprecedented development since 1990s as compared to other districts of Bhutan. Figure 5 showing land use land cover map of Paro Dzongkhag. The details of land use classification under Paro is shown in table no.2 below

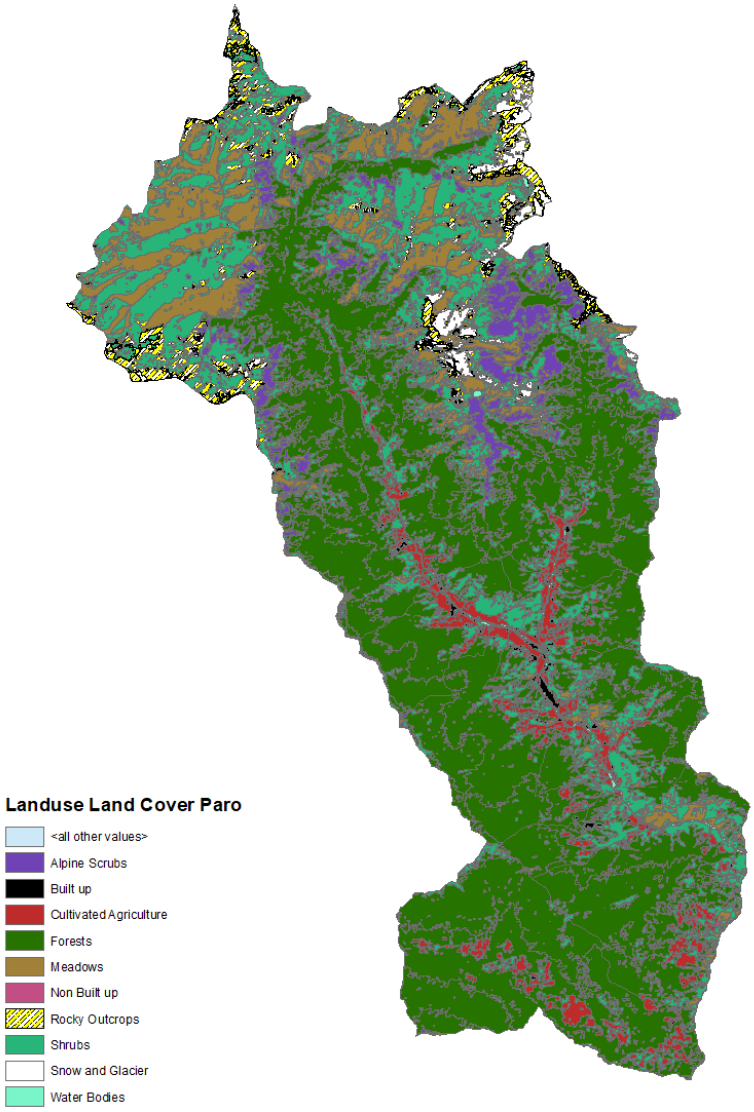


Figure 5 Land Use Land Cover Map of Paro Dzongkhag (Study Area)

Agriculture is still the main source of livelihood and majority of the farmers follow integrated subsistence farming system. Paro is blessed with fertile alluvial plains perfect for agriculture and is irrigated by meandering Pachu river fed by the eastern Himalayan glaciers, glacial lakes, snowmelts, and rain in summer. Farmers grow a wide range of temperate crops. Paro is one of the first Dzongkhag in the country where improved paddy cultivation technologies was introduced in the late 1970s including farm mechanization.

Table 2 Table showing classification of land in Km^2

CLASS	Area in SqKm	Percentage
Alpine Scrubs	55.03	4.28
Built up	6.06	0.47
Cultivated Agriculture	54.85	4.26
Forests	669.34	52.00
Meadows	128.28	9.97
Non Built up	0.37	0.03
Rocky Outcrops	56.53	4.39
Shrubs	292.23	22.70
Snow and Glacier	19.16	1.49
Water Bodies	5.28	0.41
Total	**1,287.13**	**100**

3.3 Sampling Method

Snowball sampling method was used to collect data from the study area and only the registered household (gung) numbers was considered for this study. The list of household has been obtained from the National Statistics Bureau website (NSB, 2019) as shown in Table no.3 below. There are total of 10,274 listed households in Paro Dzongkhag of which the households that falls under municipal town area of Bondey and Tshongdue Town area has been excluded.

Table 3 Table Showing Population & Number of household in study area

Name of Geog	2016			Number of Household
	Male	Female	Total	
Dogar	1,099	1,174	2,273	683
Doteng	602	547	1,149	395
Hungrel	1,141	875	2,016	617
Lamgong	1,710	1,626	3,336	855
Lungney	1,263	1,280	2,543	752
Naja	1,632	1,622	3,254	834
Shaba	2,050	2,022	4,072	1,044
Shari	1,590	1,590	3,180	965
Tsento	3,171	2,082	5,253	1,347
Wangchang	3,363	3,062	6,425	1,647
Bondey Town	309	261	570	296
Tshongdue Town	1,364	998	2,362	839
Grand total			**36,433**	**10,274**

Source : (NSB, 2019)

Paro Dzongkhag consists of one Park Range Office, two Forest Management Unit Offices (FMU) and ten geogs. Out of ten, five geogs were selected for the study (Dogar, Lamgong, Naja, Shari & Shaba) and total of 105 Household was selected for interview. The selection was done based on altitudinal, vegetation representation and living style of the people in the Dzongkha mainly rural (35 household), semi urban (35 household and urban area (35 Household) of the Dzongkhag. Each geog was treated as one stratum or one study area. The idea behind stratification of the survey area was to compare the intensity and prevalence of conflict in the locality for each ecological zone. This had helped in identifications of conflict types and different mitigations measures that needed to be under- taken in different locations. The nature and type of conflict were all different from location to location. Further, justifications for stratifying the area was firstly, Paro Dzongkhag has a large area and is impossible to cover within the short period of 1 month time, secondly all ecosystems were well represented in five selected geogs and thirdly those selected areas had past evidences of conflict.

3.4 Data Collection

3.4.1 Primary Data collection

Prior to data collection from the field, staffs from the Divisional Forest Office, Paro was familiarized with the objective of the study and the survey questionnaire (Annexure 1).The survey questionnaire was prepared in consultation with my advisor and cross checked by Faculties of Naresuan University. Single household interview was conducted primarily with the head of the household, using question asking household demographic, age, education, employment, land holdings, agricultural production and livestock ownership. All the questions are close ended for simplicity in qualitative analysis. Interview with each respondent, depending on the respondent's ability to address the question lasted about approximate 30 minutes to 45 minutes.

Figure 6 Household interview with farmers in Shari Geog

To investigate and understand the HWC, questions such as "Did you face any conflict with wild animal?" was asked. To assess the types of conflict in the particular areas, people was asked to list types of conflicts face such as crop raiding, livestock depredation, house raiding or attack on humans. Question such as the frequency of conflict in a week was also asked and to list down the conflict animals in the particular area. To understand the severity of HWC, people was also asked to list and rank the most destructive

wild animals. To understand the perception of people pertaining to state of population of wild animals by asking questions such as “Compared to last 5 years, what do you think about the population of wild animals listed by you”.

Attempts was also made to know about the effect of electric fencing by asking questions such as “Have you lost any crops/livestock after electric fencing?” and to list the types of crops lost to wild animals after electric fencing with approximate value in terms of money. Questions was also asked to list the animals that has been successful in breaching the electric fencing and assess the frequency of electric fencing breach. Questions such as “Has the electric fencing benefited you economically in terms of increased production of crops?” and listing of crops and monetary profit reaped because of EF. Questions such as “After introduction of electric fencing, has there been any changes in farming practices, such as change in crops” and listing of changes in farming system as per the format provided in the annexure. Questions such as “Are you satisfied with the performance of electric fencing? and “Would you recommend electric fencing as mitigation measures for HWC?” was asked to the respondents.

Besides HWC, questions such as “Are you aware that killing of certain wild animals like tiger, snow leopard and elephants are totally protected as per Forest & Nature Conservation Rules, 2017?” and “How do you feel about severity of HWC cases in Bhutan?” was asked to understand the knowledge and awareness of the respondent. To understand the farmer’s opinion on socially inclusion strategy, question like “How would you like the government to intervene if the HWC continues unabated?” The respondent was asked to record and rank the intervention option listed. Respondent’s opinion regarding the RGoB’s conservation and protection policy and whether they would support any new conservation programs related to wild animals was also asked and recorded.

3.4.2 Secondary Data collection

The secondary data related to HWC was obtained from the office of the Chief Forestry Officer, Paro Forest Division. In addition, data on HWC occurrence, rescue and relocation of wild animals was also collected from field offices of Range Office & FMUs as shown in figure no.. The data pertaining to electric fencing was obtained from the office of the District Agriculture Officer of Paro Dzongkhag. Wild pigs are considered one of the most destructive, free roaming pest that pillage the crops of Bhutanese farmers. Wild pigs presence data that was collected by Wildlife Conservation Division, Department of Forest & Park Services, Bhutan during the National Tiger Survey (2014). The data available for wild pigs are a set of geographic coordinates (462 points throughout Bhutan) where the species has been observed and recorded during the camera trapping exercise for National Tiger Survey.

In addition, Bioclimatic variables are derived from Worldclim Project Version 1.4. The bioclimatic variables represent annual trends (e.g., mean annual temperature, annual precipitation) seasonality (e.g., annual range in temperature and precipitation) and extreme or limiting environmental factors (e.g., temperature of the coldest and warmest month, and precipitation of the wet and dry quarters (WorldClim). In addition to the current bioclimatic variable, attempt is also made to use the georeferenced data with high spatial and sectoral resolutions. The data available are the IPPC5 climate projections from global climate models (GCMs) for four representative concentration pathways (RCPs). These are the most recent GCM climate projections that are used in the Fifth Assessment IPCC report. The GCM output was downscaled and calibrated (bias corrected) using World Clim 1.4 as baseline 'current' climate.

3.5 Data Analysis

3.5.1 Statistic description

Descriptive statistic would be used to summarize the data which is the representation of entire or sample of a population. Therefore using Statistical Package for Social Science (SPSS version 19) to measure central tendency and measures of variability. Measures of central tendency will include mean, median and mode, while measures of variability will include the standard deviation, variance, the minimum and maximum variables of the population.

3.5.2 Inferential Statistic & Correlation

Similarly, inferential analysis of the data will also be carried out using SPSS. Inferential statistic such as Spearman's Correlation test to analyze relationship between income and land holding will also be carried out. The distribution probability, comparing means, cross tabulation etc… will also be carried during the analysis .

3.5.3 Maxent

The habitat distribution probability of wild pig in Bhutan and in Paro specifically will be analyzed using Maximum Entropy Model (MaxEnt) and climatic variable data. The spatial georeferenced data along with bioclimatic variables which was extracted from www.worldclim.org was imported into MaxEnt Model software (Version 3.4.1) in order to calibrate species distribution model. The algorithm is designed to use presence only data for the analysis.

3.5.4 PPGIS

PPGIS will be used to analyze the impact and performance of EF in the study area, attempts are also made to understand and analyze the attitude, tolerance and perception of the respondents in the study area. Attempts was also made to understand HWC in the study area, especially varieties of conflicts and the impacts of HWC.

CHAPTER IV

IMPACT OF CLIMATE CHANGE ON DISTRIBUTION PROBABILITY OF WILD PIGS

4.1 Background

Bhutan is grappling with human-wildlife conflicts and wild boar or wild pig is one of the most commonly found pest that causes insurmountable loss to Bhutanese farmers. In Bhutan, the wild pig (*Sus scrofa*) is often described as farmer's "enemy number one." An entire chapter in Bhutan National Human-Wildlife Conflict Management Strategy 2008, has been devoted to human-wild pigs conflict management due to its significance to farming in Bhutan. Farmers all over Bhutan lose crops to wild pigs, some as high as 18% or more of their annual staple crops, thereby causing huge impacts on food security (NCD, 2008).

Accurate modeling of geographic distributions of species is crucial to various applications in ecology and conservation. Maxent or Maximum Entropy Model is a recently introduced modeling technique, achieving high predictive accuracy and several additional attractive properties (M. D. k. Steven J. Phillips, 2013). MaxEnt typically uses the information about spatial environmental characteristics of an area such as land cover type, temperature range, precipitation and any other spatially explicit variables that can best describe physical anthropogenic environment of the location to determine how the occurrence of the species are affected by these characteristics and then makes spatial prediction on potential habitat for species in question (R. P. A. Steven J. Phillips, Miroslav Dudík, Robert E. Schapire and Mary E. Blair, 2017).

Earlier species distribution model that evaluates the association between bioclimatic environment variables and known species occurrences and uses that information to identify space/regions or predict where the particular populations could occur. This research used MaxEnt model in an attempt to find out the distribution

probability of wild pig's habitat in Bhutan and the role of environmental/climatic variables on the population and distribution of the wild pigs in Bhutan.

Till date very few attempts has been made to study the distribution probability of wild pigs in Bhutan and how the environmental or climatic variables will have an impact on the habitat of wild pigs in Bhutan considering the climate change phenomenon. The results from this research can be used to map out the potential habitats of wild pigs in Bhutan. This research was undertaken with the following objectives. The first objective is to study the habitat distribution of wild pigs in Bhutan and the second objective is predict the impact of bioclimatic variables on the wild boar habitat distribution in Bhutan.

4.2 Wild pig's distribution analysis

The analysis of 462 georeferenced points representing locality for wild pigs presence with current bioclimatic condition (19 variables) as shown in figure 1 below. The asc file from MaxEnt was converted to tiff file-using ArcGIS and the area is reclassified into 3 broad categories. Figure 7 below which shows the least habitat (green area) distribution of wild pig habitat with an area of 11,945 Km², and moderate (yellow) habitat probability distribution with an area of 13,842 Km² and a very high (red area)probability habitat distribution map of wild pig with an area of 13,007 Km².

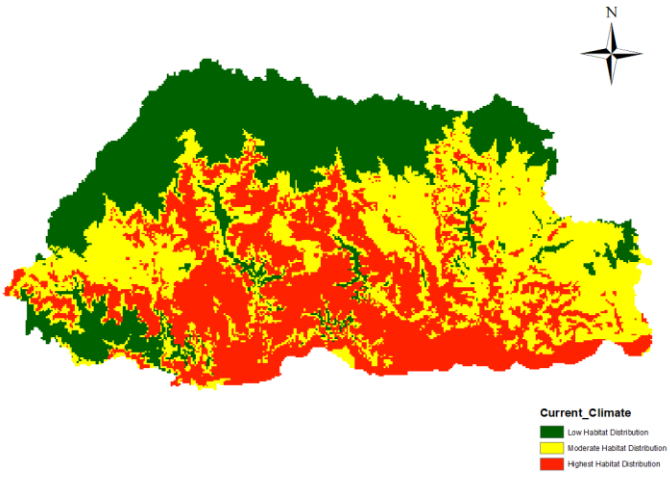


Figure 7 Wild Pig's Habitat current climatic variable WorldClim version 1.4

The Analysis of variables contribution shows that the Bioclimatic factor 12, 14, 17 & 19 (precipitation) and bioclimatic factor 02 &4 (temperature) plays a significant role in the distribution of wild pig's habitat in Bhutan.

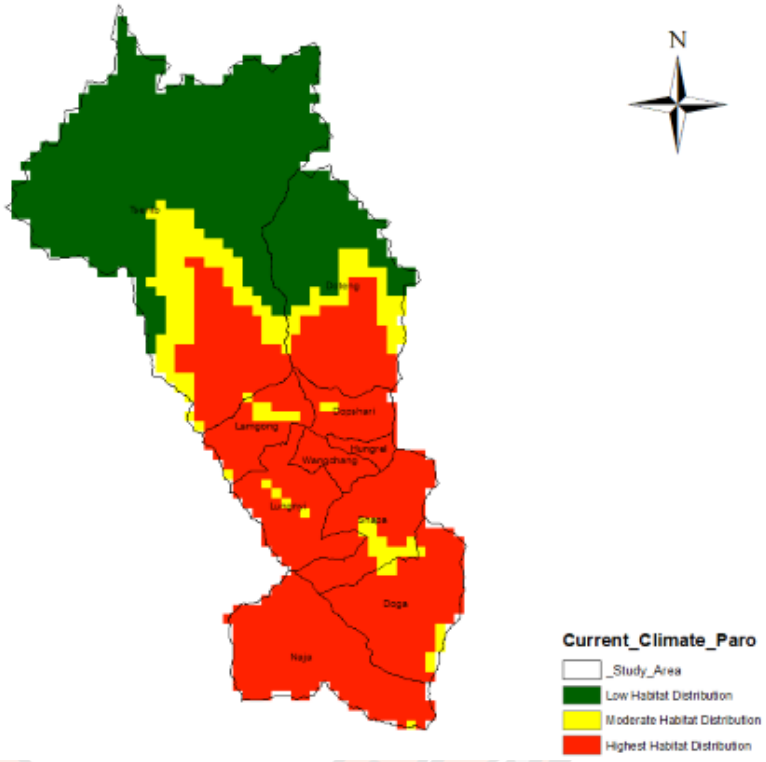


Figure 8 Wild Pig's Habitat in Paro current climatic WorldClim version 1.4

Similarly, model was also performed on the 462-georeferenced points using with high spatial and sectoral resolutions. The result of wild pig's habitat using different RCP condition is shown in Figure no.9 for RCP 2.6.

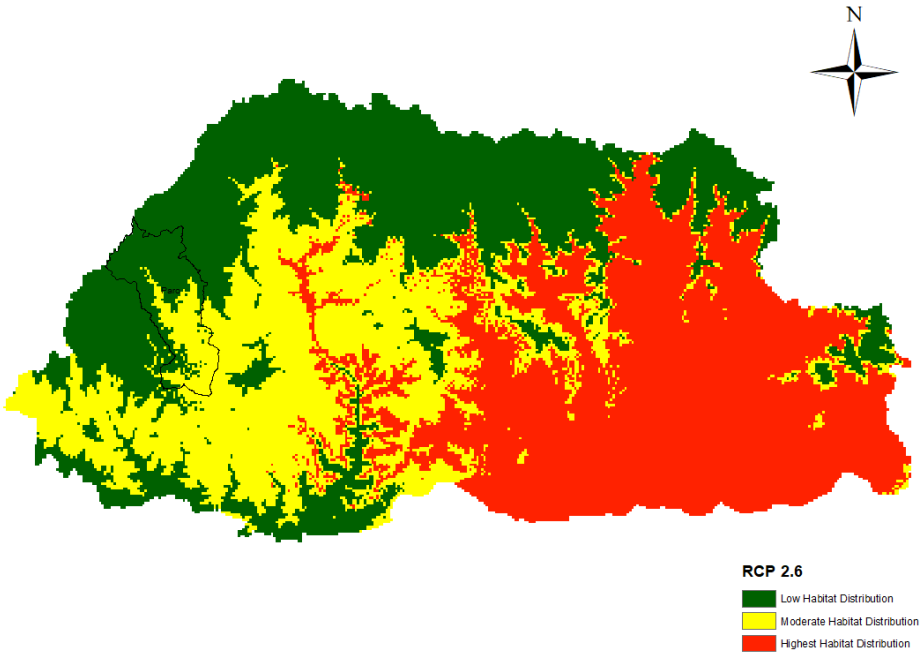


Figure 9 Wild pig's habitat using RCP 2.6

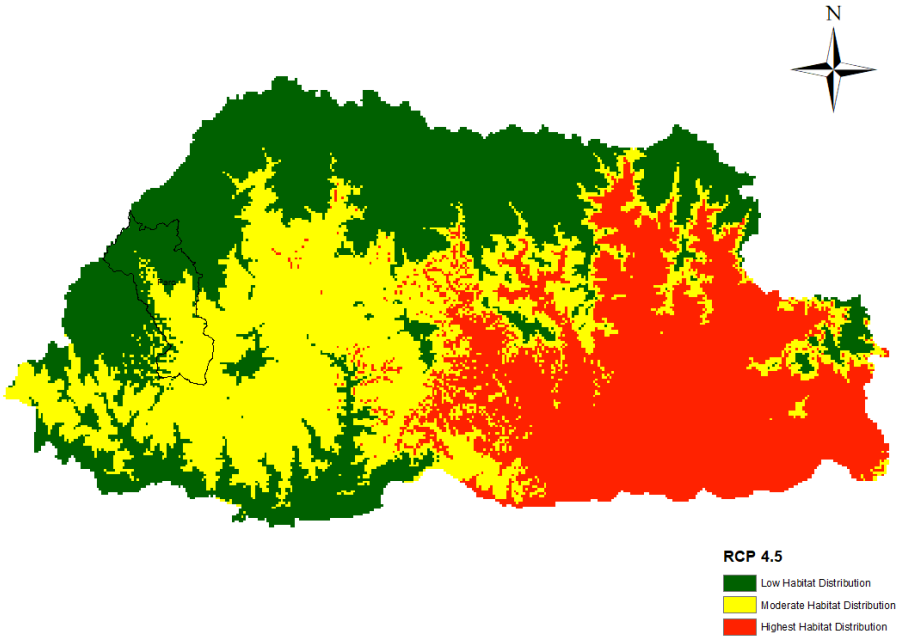


Figure 10 Wild Pig's habitat using RCP 4.5

The low habitat distribution (green) area increased by 1,464 Km², and the moderate habitat distribution area decreased by 3,020 Km² while highest habitat distribution area (red color) increased by 1,494 Km² (as shown in Figure 9.) when compared with same data using current bioclimatic variables.

Whereas the wild pigs habitat distribution in Bhutan also showed some slight variation (shown in figure no. 10) in the total area while using the RCP 4.5 Model. The lowest habitat distribution showed minimal increase by 671 Km², the moderate habitat distribution area showed an increase of 2,047 Km² while the highest habitat distribution area showed significant decrease of 2,657 Km as compared to RCP 2.6 model.

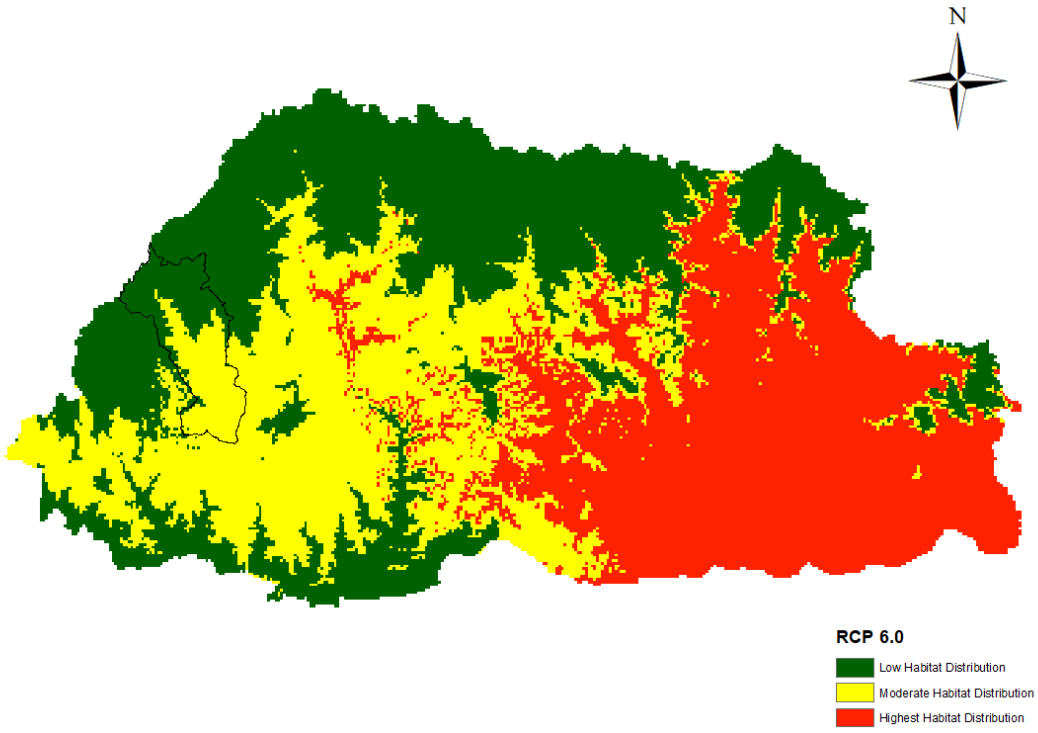


Figure 11 Wild Pig's Habitat using RCP 6.0

The overall population of wild pigs in Bhutan seems to shift toward eastern side of Bhutan in these 4 RCP models.

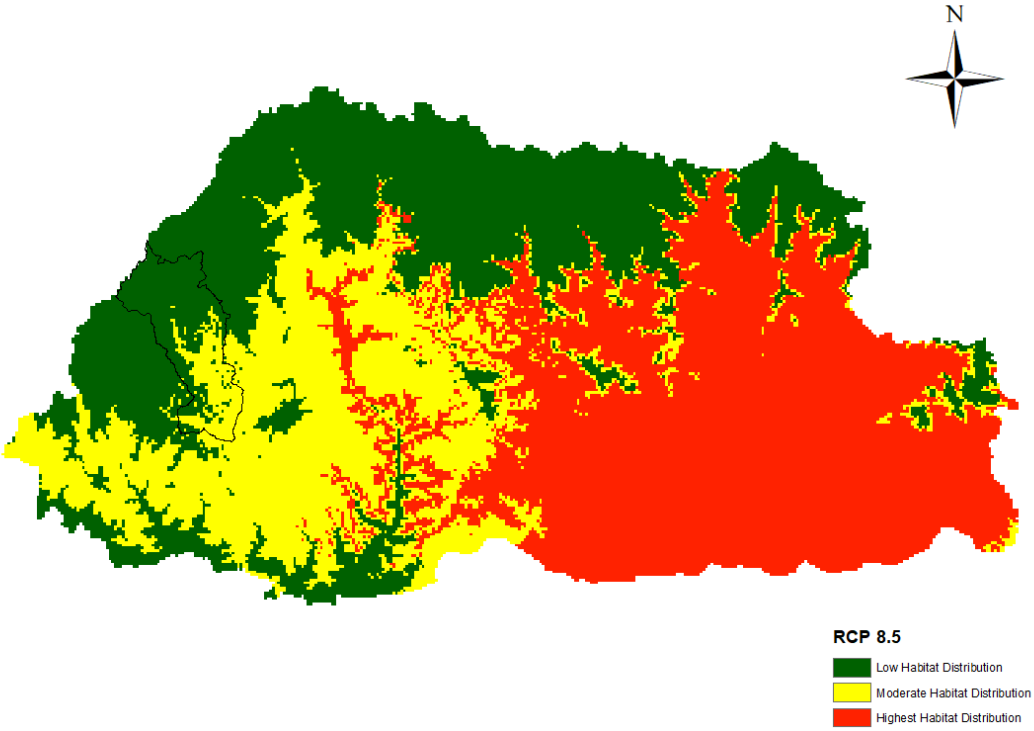


Figure 12 Wild Pig's Habitat using RCP 8.5

Regarding the result calculated from RCP 6.0, the lowest habitat distribution area seems to have decreased by 436 Km², and the moderate habitat distribution area also saw reduction in area by 884 Km² while the highest habitat distribution area showed significant increase in area by 1,299 Km² when compared with RCP 4.5 model as shown in Figure 11.

Figure no.12 shows that the low habitat distribution area showed decrease in area by 799 Km², the moderate habitat distribution area showed significant decrease in area by 1,787 Km² and the highest habitat distribution area increased drastically by 2, 606 Km² as compared to RCP 6.0 model. The overall wild pig habitat comparison using current and 4 RCPs are shown in Table. 4.

Table 4 Attribute table for overall Wild pig's habitat comparison (Area in Km²)

Habitat	Current climate	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
Low distribution	11,945.1	13,409	14,080	13,644	12,845
ModerateDistribution	13,841.6	10,822	12,869	11,985	10,198
HighestDistribution	13,006.8	14,501	11,844	13,143	15,749

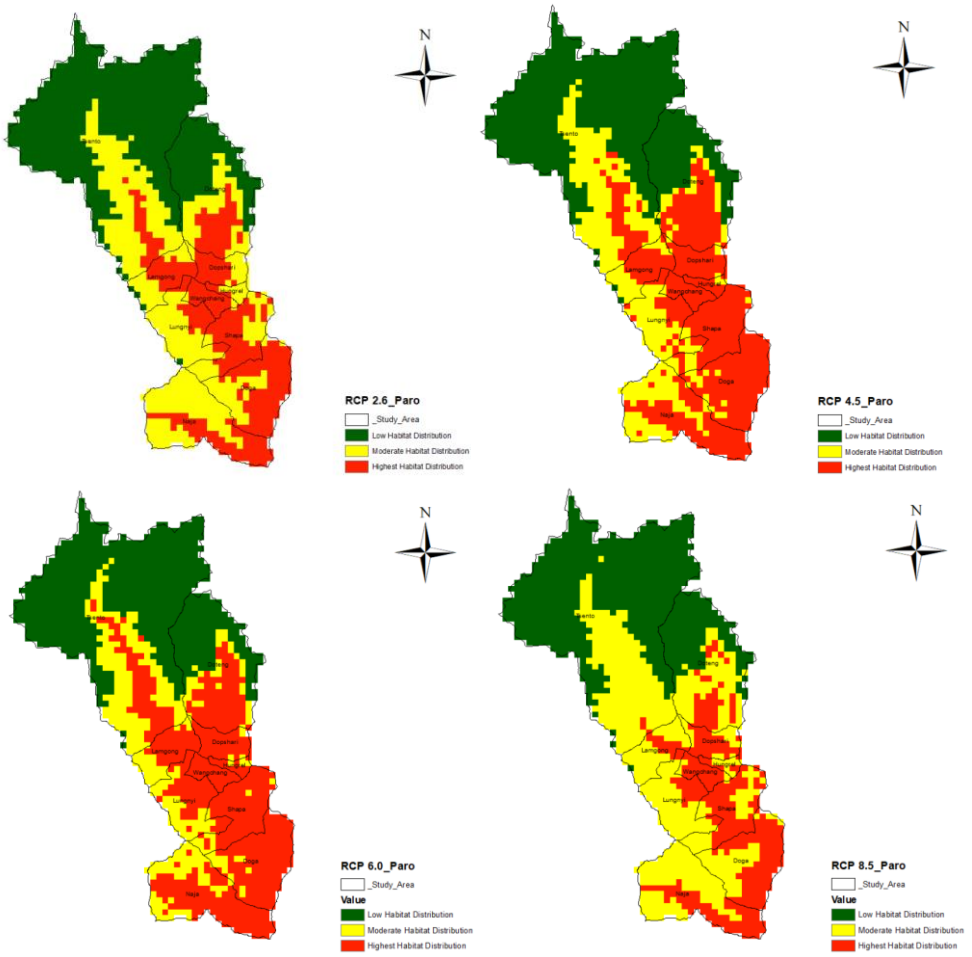


Figure 13 Wild pig's Habitat under different RCP in Paro

Figure 13 shows the wild pig's habitat under different RCP scenarios under Paro Dzongkhag. The details of wild pig's habitat under different RCP scenarios under Paro Dzongkhag is shown in Table 5.

Table 5 Attribute table for wild pig's habitat comparison under Paro Dzongkhag

Habitat	Current climate	RCP 2.6	RCP 4.5	RCP 6.0	RCP 8.5
Low Habitat	510.33	530.46	313.63	268.72	269.49
ModerateHabitat	137.07	432.11	463.09	501.04	511.10
High Habitat	639.65	324.47	510.33	517.30	506.46

This research has used the presence only (geo-referenced points) data to study the population distribution of the wild pig in Bhutan. From the analysis of the data and the result from Maximum Entropy Model it is fairly accurate to state that the Bioclimatic factor annual precipitation (12), precipitation of driest month (14), precipitation of driest quarter (17) & precipitation of coldest quarter (19) and bioclimatic factor mean diurnal range which is the mean of monthly maximum and minimum temperature (factor 02) & temperature seasonality (biofactor 04) played a major significant role in the habitat distribution of wild pig in Bhutan.

The Representative Concentration Pathways also contributes significantly in terms of spatial distribution to the habitat of wild pigs in Bhutan. It is clearly shown in the maps that the RCP models shifts the current homogenous wild pig habitat drastically towards the eastern part of Bhutan.

CHAPTER V

PUBLIC PARTICIPATORY GIS

5.1 Demographic characteristic of respondents

Figure 14 Household Interview with farmer in the field.

The questionnaires was completed among 105 respondents within five geogs of study area. Among the geogs listed Naja and Dogar geog are located furthest from the Dzongkhag Headquarter therefore representative for extreme rural area while Shaba and Lango geog has been chosen as the representative for semi urban areas while Shari geog which is located in the proximity of town area has been selected as representative of urban area. Out of the total respondents, 42.9% (n = 45) were male and 57.1% (n = 60) were female (Table 6).

Table 6 Gender of respondent

	Frequency	Percent
Males	45	42.9
Females	60	57.1
Total	**105**	**100.0**

The overall mean age of the respondents was 47.97 with age ranging from 18 to 78 years old. The total average members registered per household in the study area was 9.21 but the actual mean members living and doing daily household activities in the village was 4.55 as shown in Table 7.

Table 7 Demography of respondent

Geog	Mean Age of respondent (years)	Mean of total listed HH members (Nos)	Means of Actual members living in HH(Nos)
Naja	40.80 (±8.04*SD)*	9.40 (±4.39*SD*)	5.60 (±2.83*SD*)
Shari	50.83 (±11.71*SD*)	8.29 (±3.47*SD)*	4.83 (±1.79*SD)*
Dogar	47.00 (±12.68*SD)*	10.97 (±4.67*SD)*	4.80 (±1.79*SD)*
Shaba	44.40 (±17.44*SD)*	8.92 (±3.97*SD)*	3.56 (±1.26*SD)*
Langa	53.40 (±12.96*SD*)	7.80 (±4.26*SD*)	4.70 (±1.83*SD*)
Total	**47.97 (±13.72*SD*)**	**9.21 (±4.17*SD*)**	**4.55 (±1.82*SD*)**

When compared with other geogs in terms of total members listed, Dogar Geog the had highest members of 10.97 and but Naja Geog had the highest actual members 5.60 living in daily H/H activities of 5 geog (Table 6) and Langa geog had the lowest listed HH member with 7.80 while Shaba Geog had the lowest means of actual member living in the household with 3.56.

Among the respondents, 70.5 % (n = 74) were head of the household which comprised of 40 female and 34 male, where as 29.5 % (n =31) respondents were non-head of the household (Male = 11, Female = 20). During the survey, 92.4% (n=97) of

the respondent were farmers while, 5.7% (n=6) of the respondents were student, and there were each person from business and service sector as shown in figure no. 15.

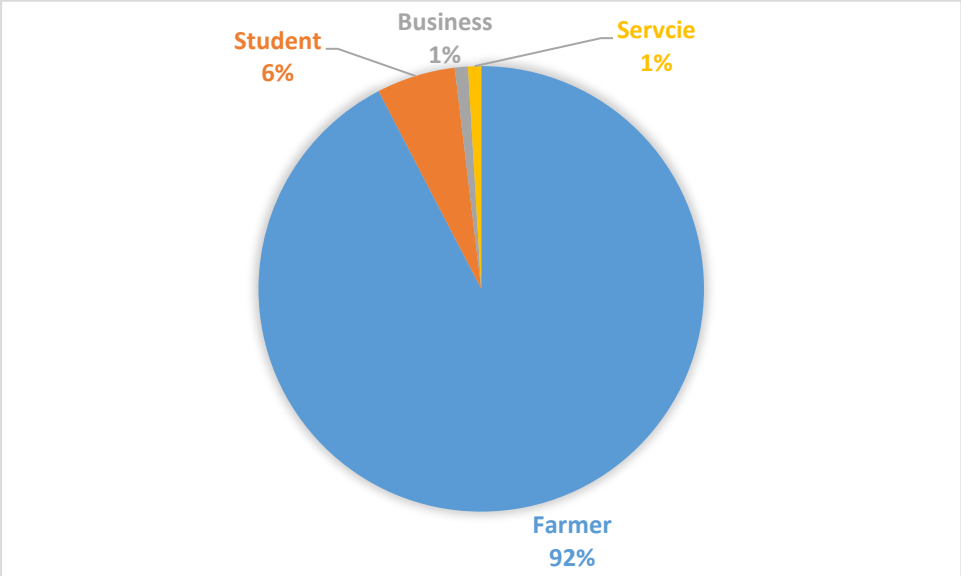


Figure 15 Pie chart showing different occupation of the respondent.

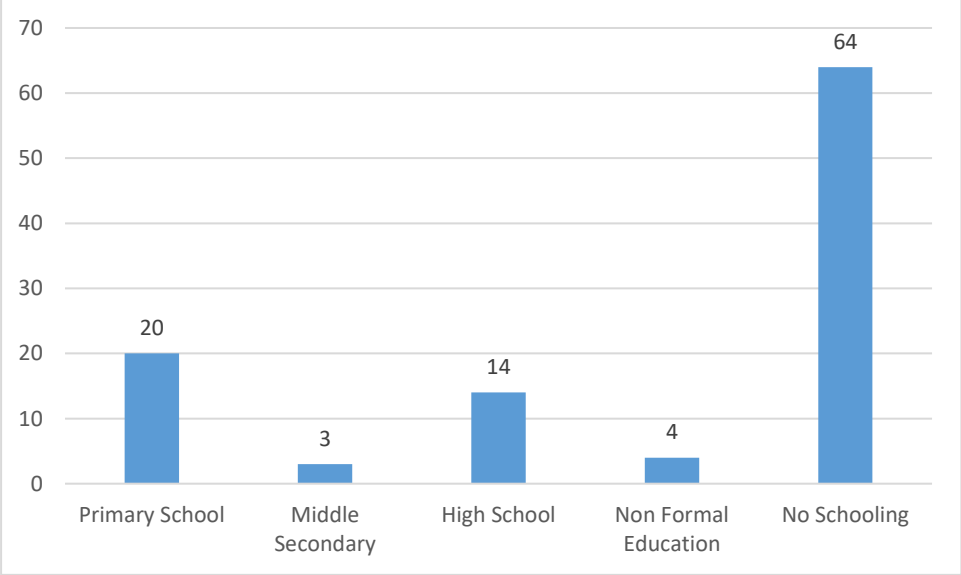


Figure 16 Graph showing qualification of the respondent

Among the respondent, 61% (n=64) of the respondents never received any schooling while 19% (n=20) of the respondent had studied in Primary School while 13.35 % (n=14) had attended High Schools, 3.89% (n=4) received Non-Formal Education while 2.9% (n=3) had attend Middle Secondary School as shown in Figure 16.

Among the respondent the average dry land holding is 2.40 acres (± 2.6 SD) while the average wet land holding of the respondents in the study area were 0.60 acres (± 0.91 SD) and the average livestock holding of the respondents was 4.71(± 3.12 SD) as shown in table no.8 below. 10.5% (n = 11) of the respondent did not own any livestock or cattle during the survey.

Dogar geog has the highest average dry land holding in the study area with 3.95 Acre (SD±2.28) while Lango geog had the highest average wet land with 2.01 acre (SD±1.40). With regards to livestock, Shaba geog had the highest livestock among study area with 6.16 (SD±3.09) livestock per household.

Table 8 Land & Livestock Holdings of the respondents in study area.

Geog	**Dryland holding of respondent (Acres)**	**Wetland holdings of respondent (Acre)**	**Livestock holdings of respondent(Nos)**
Naja	3.90 (±2.46*SD)*	0	5.00 (±3.32*SD*)
Shari	0.76 (±0.49*SD*)	1.18 (±0.71*SD)*	3.68 (±2.39*SD)*
Dogar	3.95 (±2.28*SD)*	0	5.33 (±3.46*SD)*
Shaba	3.34 (±2.12*SD)*	0.06 (±0.15*SD)*	6.16 (±3.09*SD)*
Lango	0.42 (±0.39*SD*)	2.01 (±1.40*SD*)	2.70 (±2.58*SD*)
Total	**2.40 (±2.60*SD*)**	**0.60 (±0.91*SD*)**	**4.71 (±3.12*SD*)**

5.2 Livelihood and Income of the respondents

As reported in Table 9, the respondents in the study area are mostly subsistence farmer dependent mostly on agriculture, livestock and at times supplemented by off farm activities such as business, contract works etc. The average income of the respondents in study area was Nu.283347.62 (Ngutrum Two Hundred Eighty Three Thousand Three Hundred Forty Seven) with standard deviation of ± Nu. 141192.88. Lango geog had the highest mean income of Nu.319150 (±99175.50) while Naja Geog showed the lowest mean income of Nu.184000.

Table 9 Mean Annual Income of the respondents of study area (2019)

Geog	**Mean Income/year/Hh(Nu)**	**SD(±)**	**Minimum**	**Maximum**	**Total**
Naja	184000.00	185013.51	70000	500000	92000
Shari	306114.29	145743.69	30000	522000	10714000
Dogar	271800.00	125386.41	50000	620000	8154000
Shaba	270880.00	155659.17	80000	90000	6772000
Lango	319150.00	99175.5	190000	468000	3191500
Total	**2,83,347.62**	**1,41,192.88**	**30,000**	**900,000**	**2,97,51,500**

*** Note: 1 US Dollar = Ngultrum 71.58 (at the time of writing this report)

As reported in Figure 18, majority of the respondent 98.1% (n=103) depended on agriculture as their livelihood while 1.9% (n=2) did not depend on agriculture for their livelihood, 51.4% (n=54) of the respondent derived income from livestock and animal husbandry activities while 48.6% (n=51) respondent did not depend on income from livestock, similarly 30.5% (n=32) supplemented their income through non-farm activities such as business, contract works and from rental of their property. Meanwhile only 3.1% (n=4) of the respondent supplemented their income through forestry activities such as logging and weaving of bamboo baskets and selling them in market as shown in figure 16.

Figure 17 Farmer weaving bamboo baskets to supplement their income

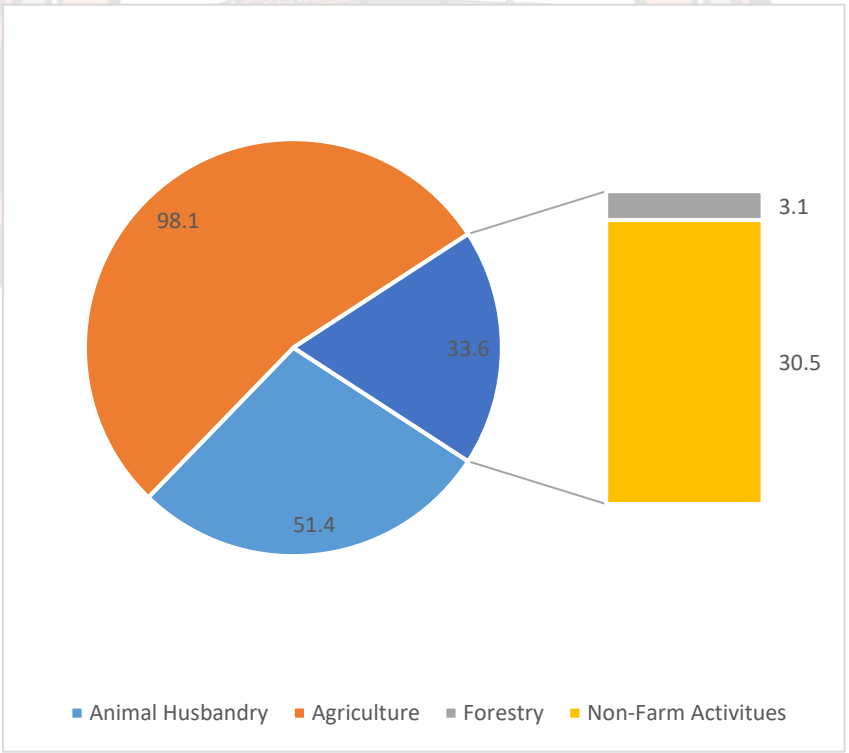


Figure 18 Pie chart showing different income sources of the respondent.

A Spearman's Rank Order correlation (Two-tailed) was applied to determine the relationship between the total annual income and the total acreage of wet land holdings of the respondent. There was strong correlation between these two variables, which was statistically significant at $r_s = .288$, $p < .001$. This showed that the amount of income in the household level directly depends on the acreage of wetland holding of the household, which mean more wet land you possess, higher the annual income of the household. Table 10, which shows that having wetland contributed significant amount of income to the rural famers in study areas.

Table 10 Spearman's rho Annual income vs wet land holding

Correlation				
			Wetland holding	Annual Income
Spearman's rho	Wet Land holding	Corelation Coefficient	1.00	.288**
		Sig (2 Tailed)		0.003
		N	105	105
	Annual Income	Corelation Coefficient	.288**	1.00
		Sig (2 Tailed)	0.003	
		N	105	105

**Correlation is significant at 0.01 level (2 tailed)

5.3 Wildlife and Conflicts

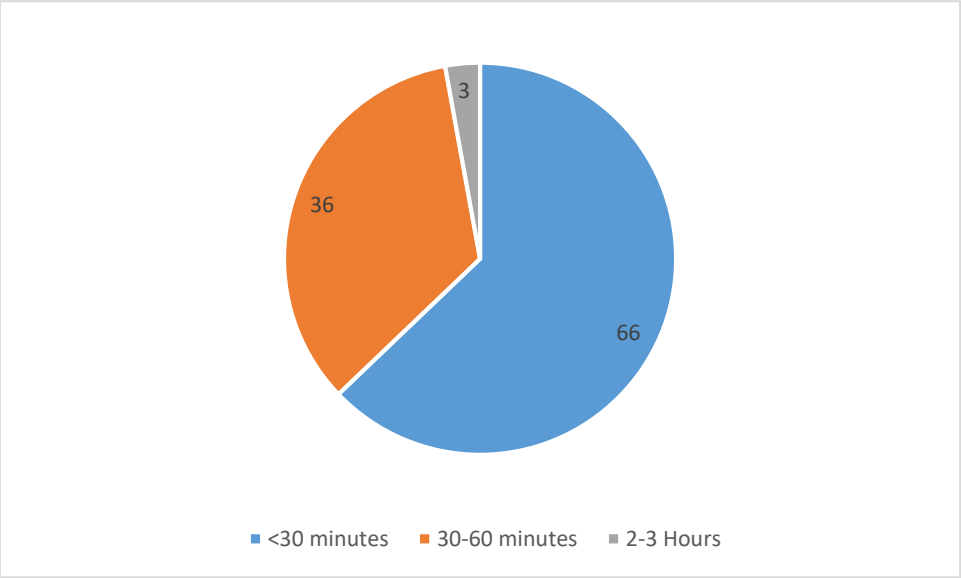


Figure 19 Pie chart showing the walking distance of the respondent to nearest forest

Among the respondents 62.9% (n= 66) them had their house within <30 minutes from nearest forest, while 34.3% (n=36) of the respondent had their house within 30-60 minutes' walk and mere 2.9% (n=3) had their house within 2-3 hours walk. The distance to the nearest forest from the respondent's house is found to be significantly related with the human-wildlife conflict figure 19.

100% (n=105) of the respondent has been in conflict with the wild animal and majority of the conflict 98.1% (n=103) was related to crop raiding while 1.9% (n=2) faced conflict related to cattle predation. Fortunately, till date there was no report of loss of human lives due to HWC in the study area.

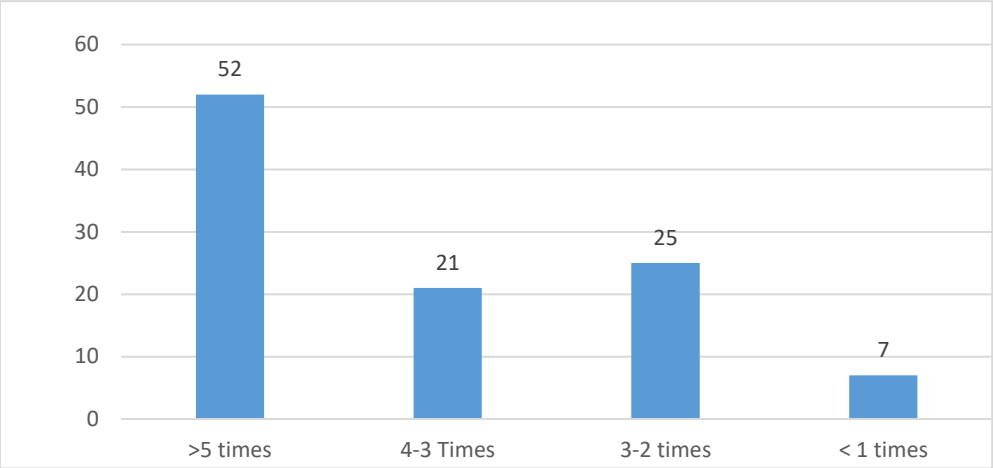


Figure 20 Graph showing the frequency of conflict experienced by the respondent.

49.2% (n=52) of the respondent experienced conflict more than 5 times in a week, while 20% (n=21) experienced conflict 4-3 times a week and 23.8% (n=25) experienced conflict with wild animals about 3-2 times in a week and 6.7% (n=7) experienced less than 1 times in a week as shown in figure 20.

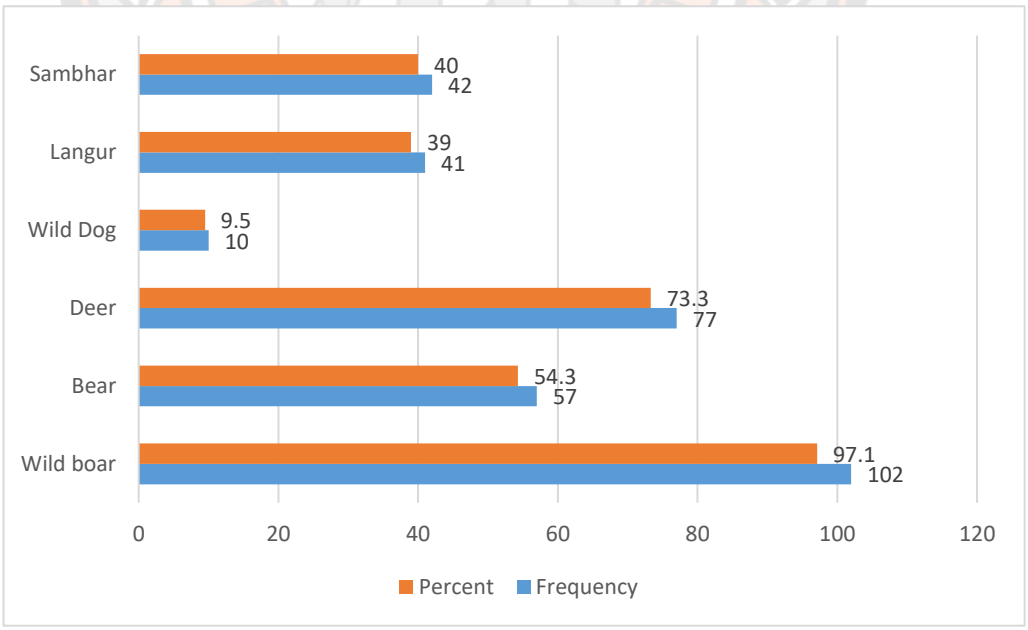


Figure 21 Graph showing conflict with different wild animals.

As shown in figure no. 21 it was found that whopping 97.1% (n=102) of the respondent experienced conflict with the wild boar, while 73.3% (n=77) experienced conflict with deer. And 54.3% (n=57) experienced conflict with bear and 40% (n=42) had encounters with sambhar and 39% (n=41) encountered conflict with white capped langur and lastly 9.5% (n=10) had conflict with the wild dog. The geog wise breakdown of HWC is shown in table.11.

Table 11 Table showing most destructive wild animal in study area.

Wild Animal	Geog					Total
	Naja	Shari	Dogar	Shaba	Lango	
Wild boar	5	34	30	23	10	102
Bear	5	16	20	15	1	57
Deer	5	22	30	16	4	77
Wild Dog	0	1	0	9	0	10
Langur	5	2	11	23	0	41
Sambhar	5	4	20	13	0	42

Among the respondents, 65.7% (n= 69) labelled wild boar as the most destructive wild animal while 20% (n=21) found deer as most destructive and 14.3% (n=15) found white capped langur as the most destructive wild animal as shown in figure 22.

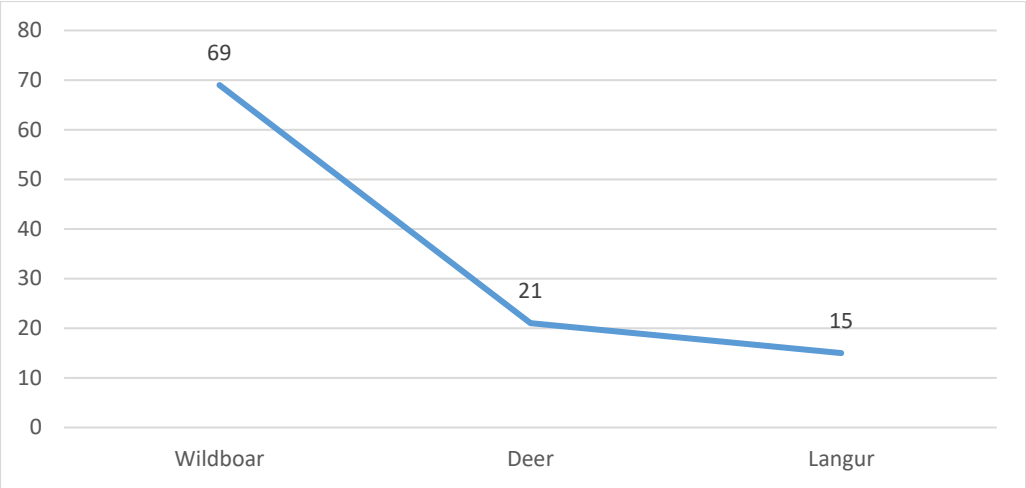


Figure 22 Graph showing most destructive animal in the study area

Table 12 Opinion of respondent regarding population of animals in the wild

	Increased very much	**Increased slightly**	**Remained same**	**Decreased slightly**	**Decreased drastically**	**Total**
Male	7	6	17	15	0	45
Female	7	4	21	27	1	60
Total	**14**	**10**	**38**	**42**	**1**	**105**

As shown in table 12, majority of respondent 40% (n=42) felt that the population of wild animals has decreased slightly followed by 36.2% (n=38) who perceived the population of the wild animals to have remained same. While 13.3% (n=14) felt that the population has increased very much and 9.5% (n=10) felt that the population in the wild has increased slightly during the last 5 years.

Table 13 Opinion about HWC incidences in study area.

Geog	Increased very much	Increased slightly	Remained Same	Decreased slightly	Decreased Drastically	Total
Naja	3	1	1	0	0	5
Shari	4	2	10	19	0	35
Dogar	0	1	2	26	1	30
Shaba	0	0	1	20	4	25
Lango	1	0	2	6	1	10
Total	8	4	16	71	6	105

Similarly, regarding the trends of Human-wildlife conflicts in the areas as compared to last 5 years, the majority of respondent 67.6% (n= 71) felt that the HWC incidences has decreased slightly. While 15.2% (n=16) felt the HWC incidence has remained same and 7.6% (n=8) felt the HWC incidences has increased very much and 5.7% (n=6) felt that the HWC has decreased drastically as shown in table no.13.

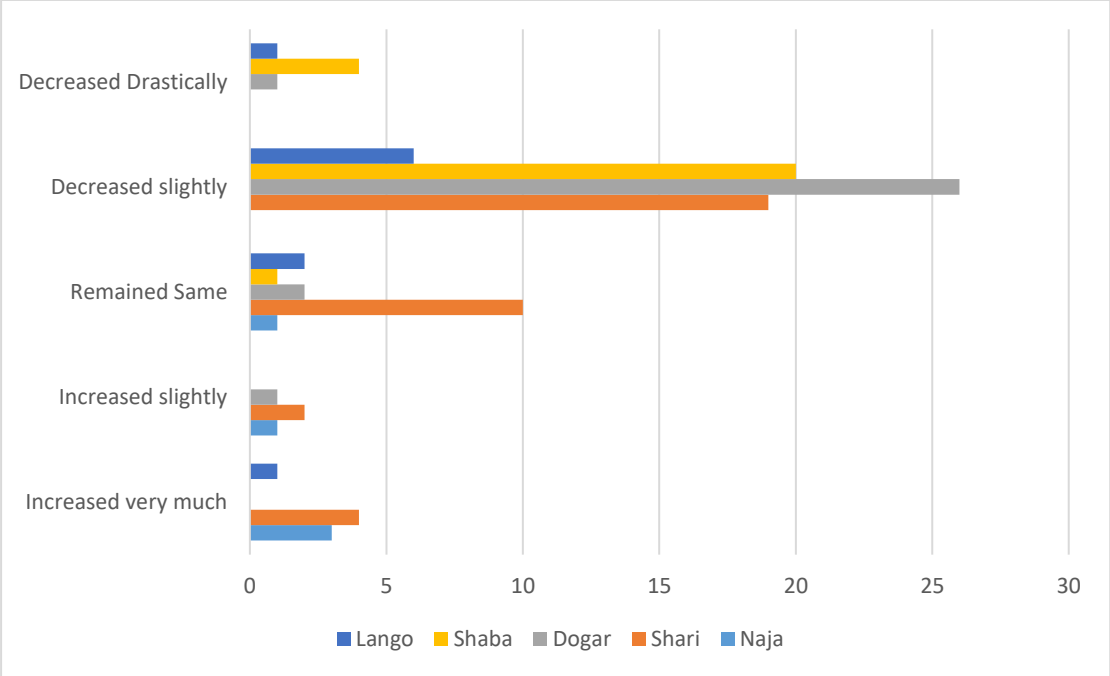


Figure 23 Graph showing the opinion regarding HWC incidences in past 5 years

The geog wise break down on opinion regarding HWC incidences in past 5 years. 26 respondents out of 30 respondents of Dogar geog felt that the HWC incidences in the country has decreased slightly, while 20 respondent out of 25 respondent of Shaba geog also felt that the HWC incidences has decreased slightly as shown in figure no. 23.

5.4 Electric Fencing

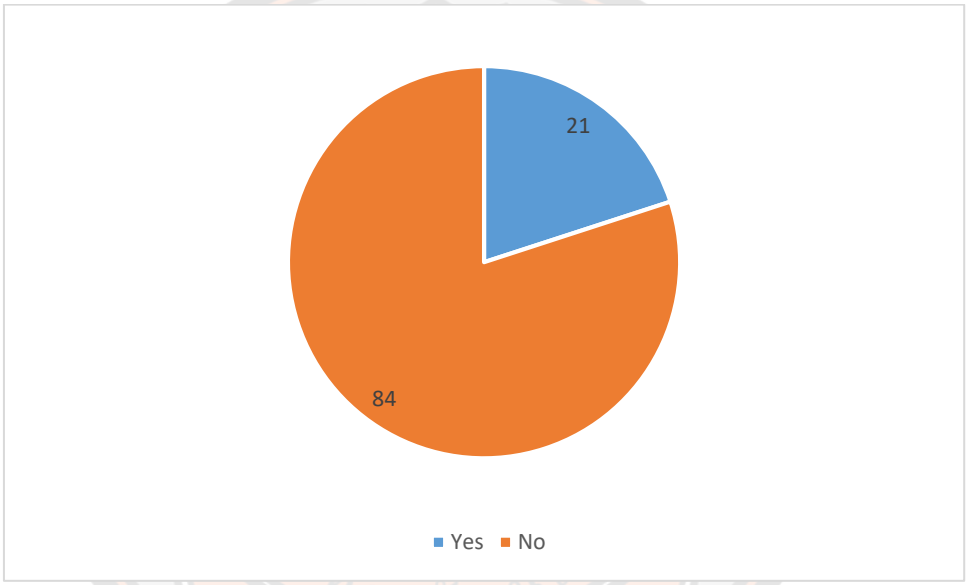


Figure 24 Pie chart showing breach of EF in the study area

According to the survey, it was found that 100% of the respondent had their field covered by Electric Fencing provided by the RGOB. After electric fencing, 20% (n=21) of the respondent lost their crops to the wild animal while 80% (n=84) did not lose any crops after electric fencing of their land figure 24. Potatoes was the main crop that was lost after electric fencing. The total valuation of crops lost among 21 household after EF is around Nu.369550/-.

Table 14 Table showing the EF breach by wild animals

Geog	No Breach	wild boar	Langur	Total
Naja	5	0	0	5
Shari	32	3	0	35
Dogar	21	9	0	30
Shaba	16	7	2	25
Lango	10	0	0	10
Total	**84**	**19**	**2**	**105**

As shown in table 14, among the 21 household that lost crops after electric fencing, majority (n=19) of the electric fencing breach was caused by wild boar and only 2 household lost crop to white capped langur. 12 household experienced the breach of fencing 3-2 times in a week while 5 household experienced the breach of fencing 4-3 times in a week.

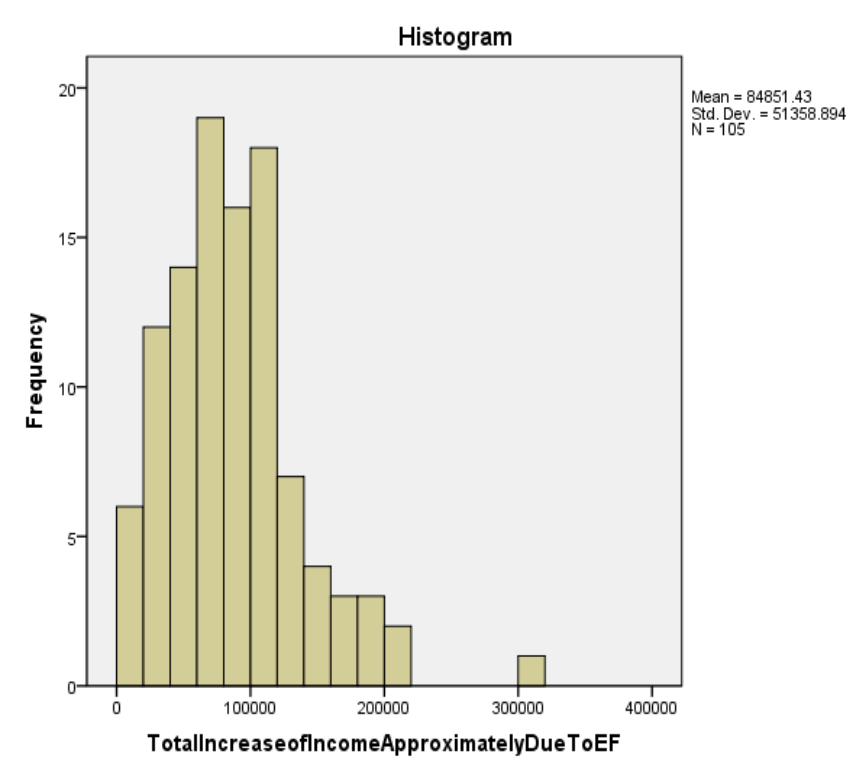
Among the reported breach of 21 household, 9 household of Dogar geog experienced breach of electric fencing by wild boar, 7 household of Shaba Geog experienced breach of EF by wild boar and 2 household experienced breach of EF by langur and finally 3 household of Shari geog household saw their EF being breached by wild boar as shown in Table 13.

All 105 respondent economically benefitted and saw increase in production of their agricultural crops after electric fencing of their field. The respondents saw increase income from minimum of Nu.7000/- to the maximum of Nu.315000/- after electric fencing as shown in table 15. Overall mean increase in income after EF was Nu.84851.43 (SD±51358.89) as shown in figure 25.

Table 15 Increase of income after EF

Number of respondent		
	Valid	**105**
Minimum		7000
Maximum		3,15,000
Total		**89,09,400**

Figure 25 Graph showing increase in income after EF



Concerning increase in in crop production after electric fencing, 83 Household or respondent saw increase in production of potatoes, while 38 households saw and increase in production of paddy and cabbage crop. 31 household saw increase in chili, 28 household experienced increase in production of carrot while 17 of the respondents saw increase in pea and beans. Only 9 household saw increase in apple production after electric fencing as shown in Table 16.

Table 16 Table showing increase in different crops production after EF

Crops	Frequency	Percent
Paddy	38	36.2
Potatoes	83	79.0
Chilli	31	29.5
Cauliflower/cabbage	38	36.2
Pea/bean	17	16.2
Carrot	28	26.7
Apple	9	8.60

Majority of the respondent 99% (n=104) were satisfied with the performance of the electric fencing and similarly 100% of the respondent were willing to recommend electric fencing as mitigation measures in combating human-wildlife conflict in Paro Dzongkhag as shown in figure 26.

Only 1 respondent from Dogar geog was not happy with EF as she had conflict with white capped langur, EF is basically useless against monkeys as they (monkeys) can easily climb from wooden post (to avoid electric shock) over into the field. Moreover, if there is any trees in the periphery of the field, the monkeys are easily able to cross over into field using the trees as bridge.

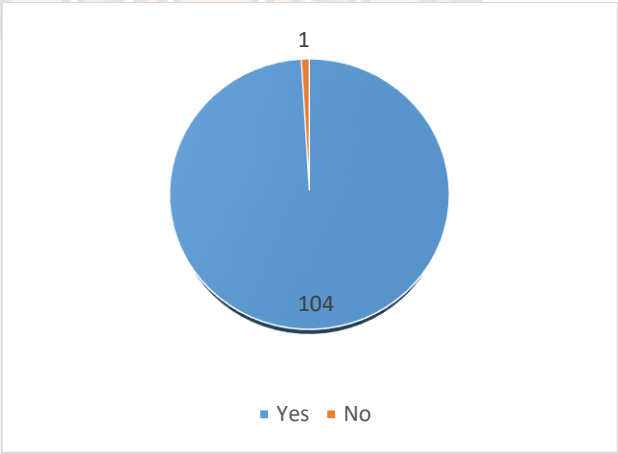


Figure 26 Pie-Chart showing opinion of respondent on performance of EF

Table 17 Cross tabulation satisfaction of EF vs awareness

		Awareness of FNCR		
		Yes	No	Total
Satisfaction with EF performance	Yes	102	2	104
	No	1	0	1
Total		**103**	**2**	**105**

5.5 People's perception, awareness and tolerance about conservation policies.

Regarding awareness on Forest Nature Conservation Rules, 2017, majority of the respondent 98.1% (n=103) were aware of the Rules while only 2.9% (n=2) of the respondent were ignorant of the Forest & Nature Conservation Rules, 2017 as shown in figure 27.

Upon further inquiry, it was found that these 2 respondent who was not aware was of FNCR, were 2 ladies who has not attended any school and were not the head of family, therefore, they did not get any opportunity to attend any awareness training held by Department of Forest earlier.

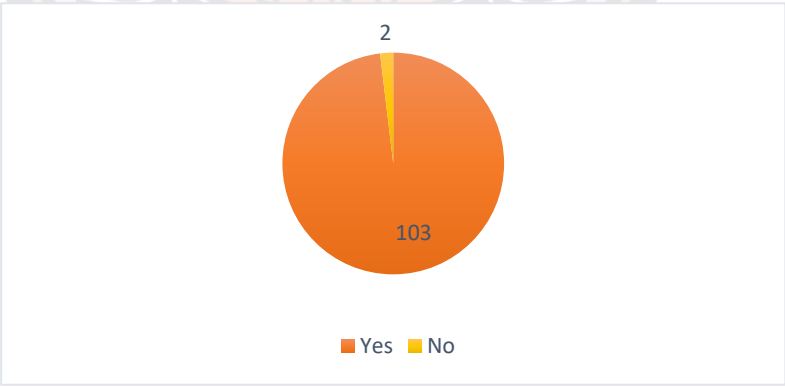


Figure 27 Pie-chart showing people's awareness regarding FNCR

On the subject of the severity of human-wildlife cases in Bhutan, 58.1% (n=61) of the respondent felt that the HWC situation in Bhutan was moderately severe, while

39% (n=41) of the respondent felt the HWC cases was very severe, while 2.9% (n=3) does not feel HWC is a problem in Bhutan as shown in figure 28.

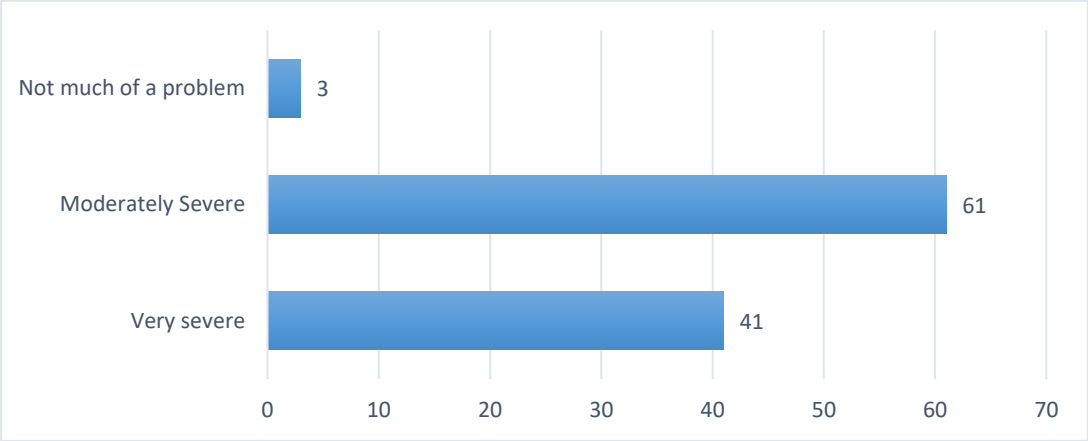


Figure 28 Graph showing respondents opinion regarding HWC severity in Bhutan

On the issue of intervention measures by the Royal Government of Bhutan, the respondent overwhelming 100% (n=105) chose for Electric Fencing materials to be provided at subsidized and did not opt for other 4 option such as compensation, kill problem animals, catch and relocate wild animals etc.

About 54% (n=57) of the respondent felt good about the current Government's Conservation and Protection policy while 32% (n=33) felt very good and 14% (n=15) were not exactly sure or had any opinion regarding the conservation and protection policy of the Royal Government of Bhutan as shown in figure 29.

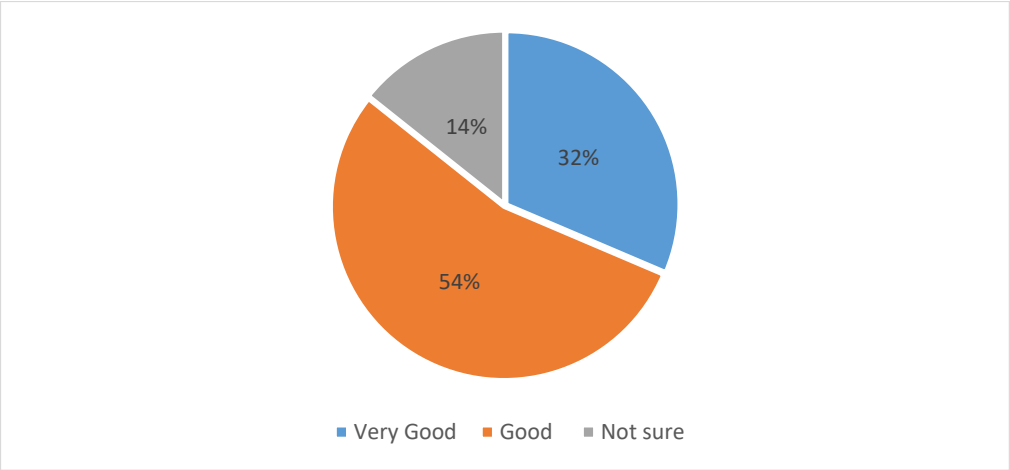


Figure 29 Pie chart showing the respondent's opinion regarding current Governments Conservation Policy

On the subject of support for future conservation programs, 81% (n=85) of the respondent has expressed willingness to support any future conservation program, while 17.1% (n=18) were not sure of supporting but 1.9 % (n=2) respondent refused point blankly to support any future conservation programs initiated by the Royal Government of Bhutan as shown below in figure 30.

Upon further inquiry into these 2 respondents who refused to support any future conservation program, it was found that they were once fined heavily by concerned authorities for illegal fishing without any approval from the authorities, hence they were reluctant to support any conservation programs.

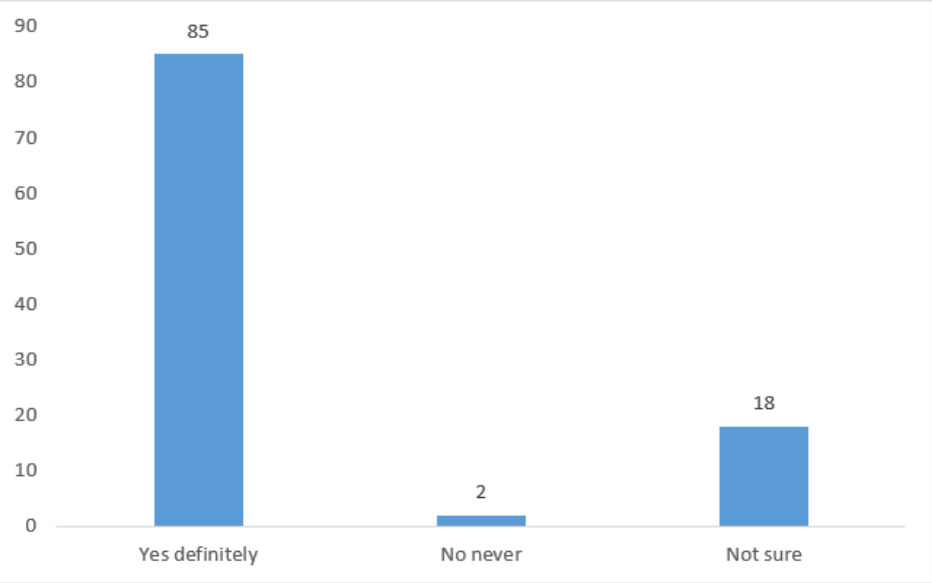


Figure 30 Graph showing support for future conservation programs

The list of electric fencing under Paro Dzongkhag was obtained from the office of the Dzongkhag Agriculture Officer. The GPS location of the current electric fencing was obtained though field personnel and the data was processed in Arc GIS for plotting of the map. There is 37 electric fencing projects currently under Paro Dzongkhag running 141.41 kilometer protecting 2264.41 acres land belonging to 1545 households of Paro Dzongkhag shown in figure 31.

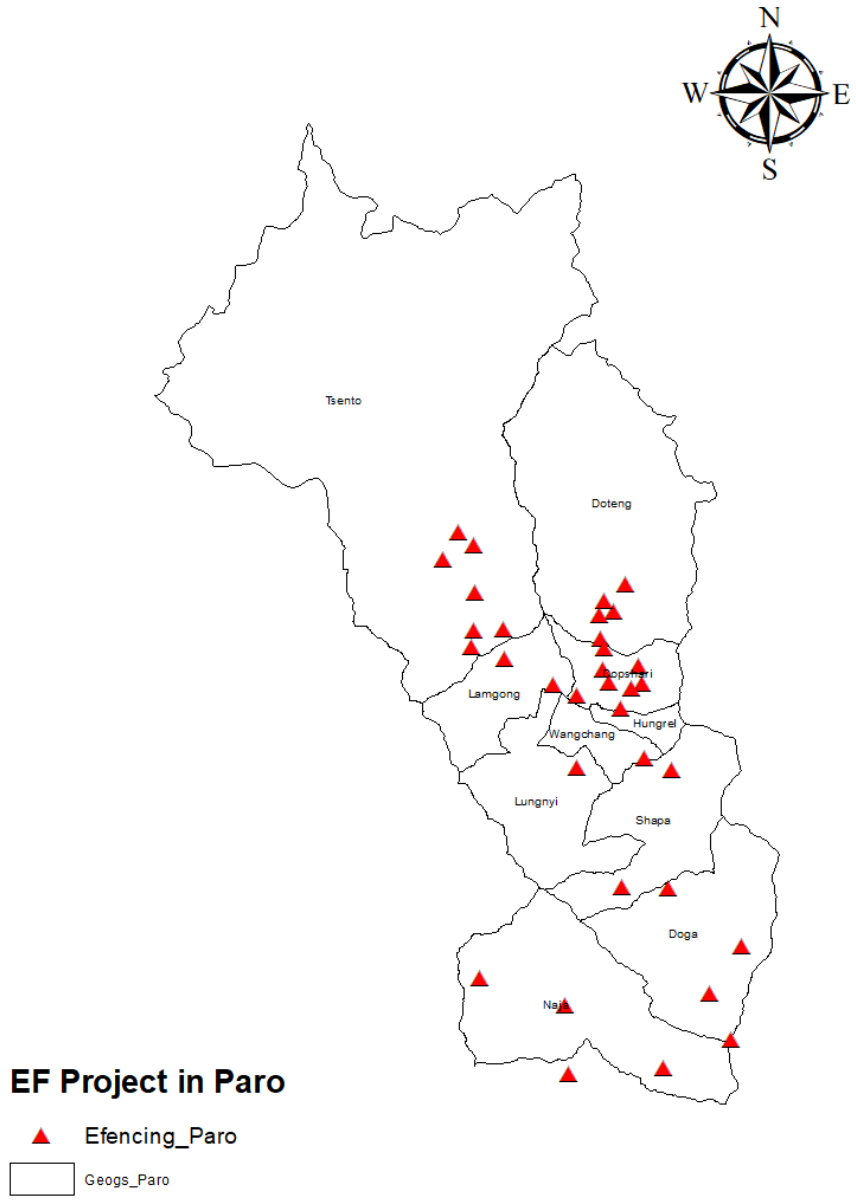


Figure 31 Showing current EF projects in Paro as per Dzongkhag Agriculture Office

The data on number of HWC conflict that has occurred and observed in Paro Dzongkhag was obtained from the Office of the Chief Forest Officer of Paro Dzongkhag. The detailed GPS coordinates of the conflict was then processed in Arc GIS to obtain point density and point statistic of the conflict that occurred in Paro Dzongkhag as shown in the map below in figure 33. The GPS coordinates on the presence of wild boar throughout the country was also obtained for Maximum Entropy Model.

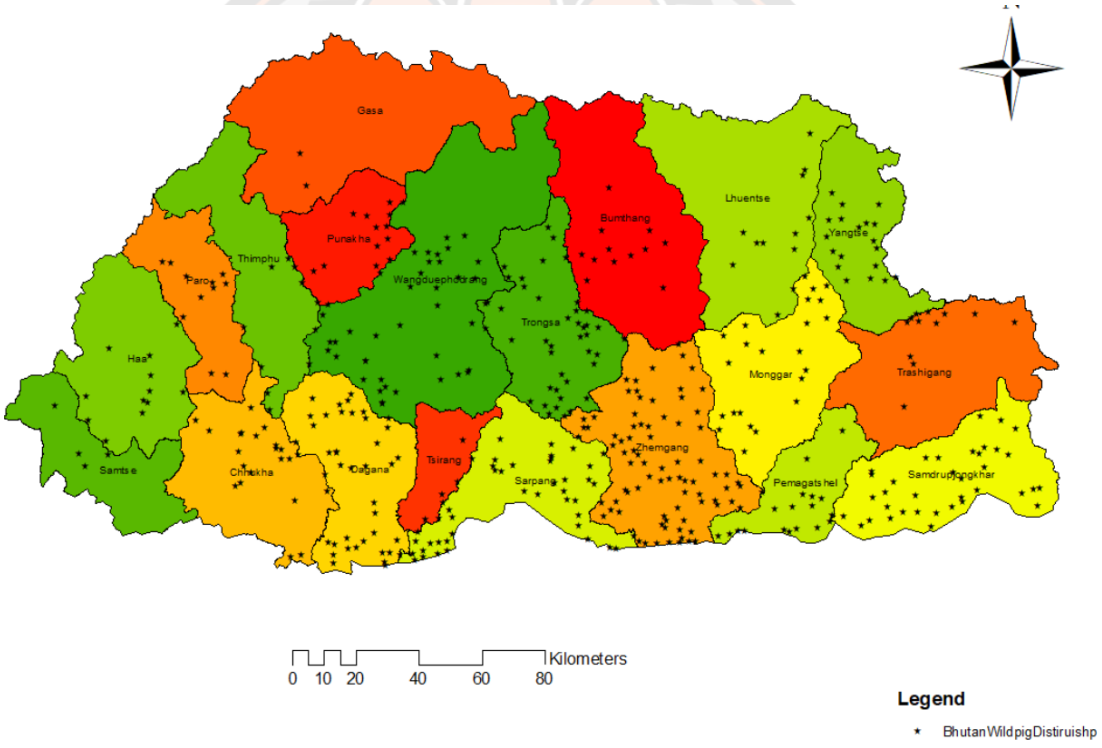


Figure 32 Map showing presence of wild pig in Bhutan (Courtesy WCD, 2018)

The Forest Division Office of Paro Dzongkhag has recorded 83 incidences of wildlife conflicts in various geogs under Paro Dzongkhag. The Office typically encountered 10 problem animals in the area as shown in the figure 32.

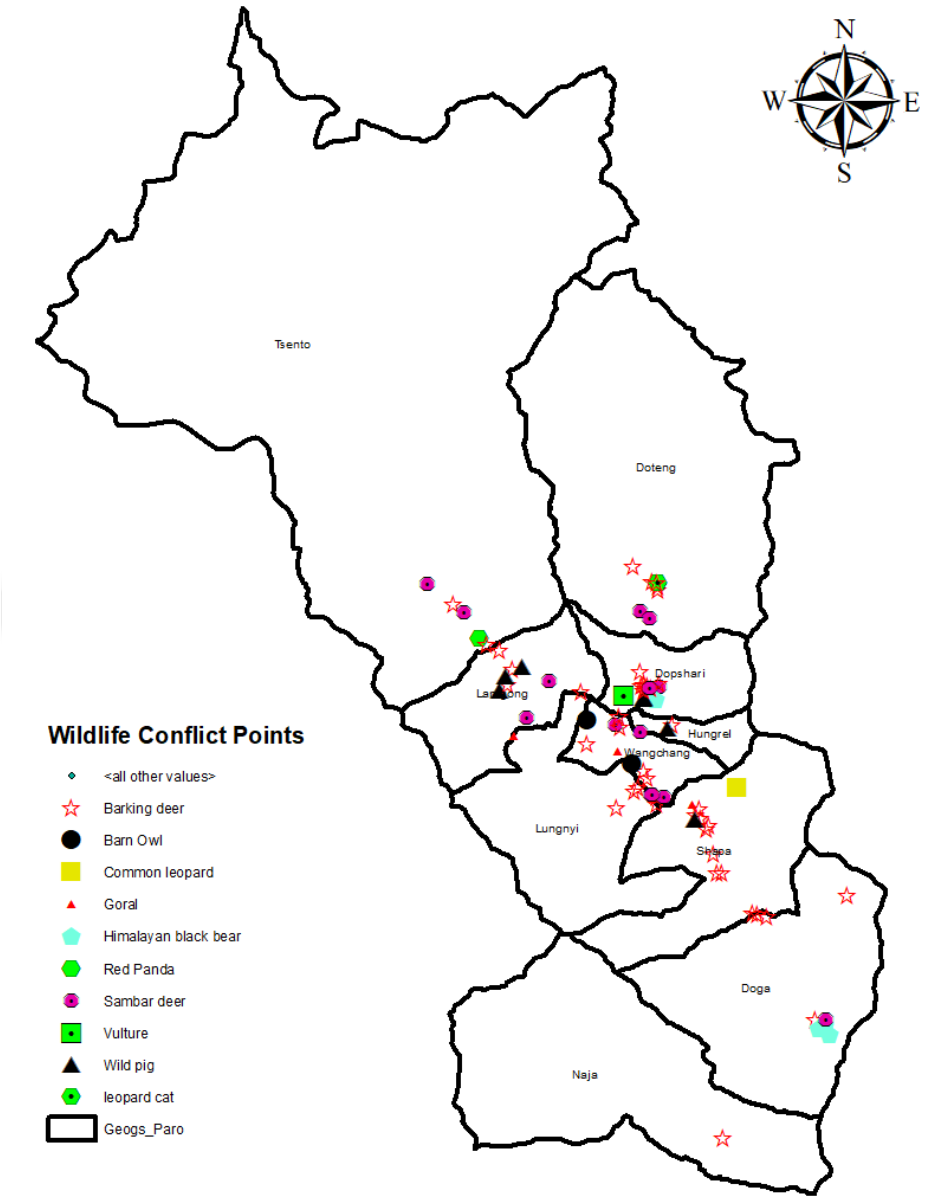


Figure 33 Map showing recorded wildlife conflicts in study area

Point statistics analysis was carried to assess the hotspot and diversity/ variety of human wildlife conflict in the study area. The GPS coordinate of HWC incidences recorded by Divisional Forest Office, Paro was used for assessment of conflict diversity in the study area.

As shown in figure 34 below, the result of point statistics analysis of the data, each shades of color represents different frequency and diversity of wildlife conflict that has been observed within a radius of 1km from each other. Shari Geog one of my study area is the hotspot of HWC conflict as it has more than 5 variety of conflicts recorded and observed within 1 km radius.

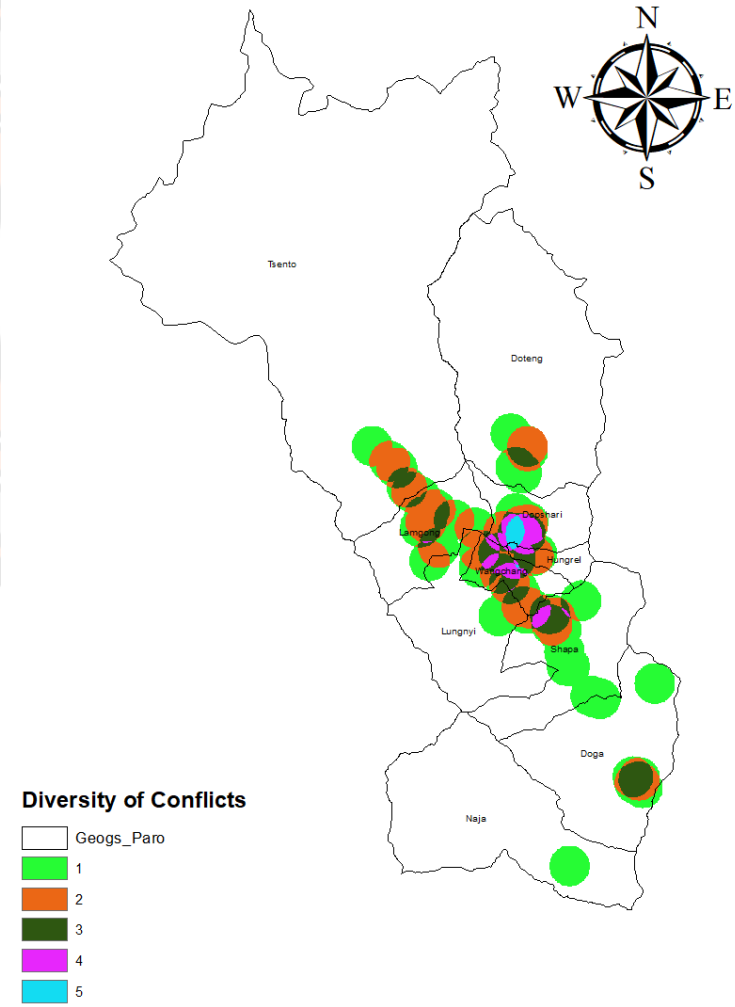


Figure 34 Map showing diversity of conflict recorded in Paro

CHAPTER VI

CONCLUSION, DISCUSSION & RECOMMENDATION

The study on the impact of electric fencing as mitigation measure in Paro Dzongkhag was challenging as well as interesting as it involved travelling wide and far, meeting people face to face and conducting the interview. However, I am fortunate that the task was completed in time due to unwavering support and co-operation received from various entities such as office of the chief forest office, village tshogpas and the respondents.

6.1 Conclusion

6.1.1 Perception, tolerance and attitude

As per the findings, it is reassuring to know that 98.1% (n = 103) of the respondents are aware of the Forest & Nature Conservation Rules of Bhutan, and 58.1 % (n = 61) of them perceive that the incidences of human-wildlife cases in the country to be moderately severe, while 39% (n = 41) feels that the HWC situation in our country to be very severe. More than half of the respondent 54.3% (n = 57) felt good about the current protection conservation policy of the Government while 31.4% (n = 33) feels very good about the current conservation policy of RGoB.

Majority of the respondent 81% (n = 85) has expressed willingness to support any future conservation program in the study area while 17.1% (n =18) of the respondent were not sure about supporting any future conservation programs and 1.9% (n = 2) flatly refused to extend support for any future conservation program. With regards to level of tolerance, all the respondents had very high level of tolerance and their willingness to co-exists with wild animal is evident from the fact that none of the 105 respondent opted for extreme measures such as culling of problem animals, capture and relocation of problem wild animal or even receiving compensation from RGoB as they feel that providing compensation will be a burden to RGoB. Their support for

conservation program is reassuring and a very positive indication of their desire to address the problem of human-wildlife conflicts amicably.

6.1.2 Damages caused by human-wildlife conflict.

The study also found that 98.1% of the respondent in the study depended on agriculture for their income, while 51.4% of them depended on livestock and animal husbandry activities, while 30.5 % of the respondent depended on Non-farms activities such as business, rental of property etc… for their livelihood. Majority of the respondents 62.9% (n = 66) lives <30 minutes from the nearest forest, while 34.3% (n =36) lives within 30-60 minutes from the nearest forest and since most of the respondents live in close proximity of the forest 100% (n=105) has experienced conflict with wild animals in various forms. 49.5% (n = 52) experienced conflict more than five times in a week, while 23.8% (n = 25) experienced conflict with animal 3-2 times in a week and 20% (n =21) experienced conflict with wild animals more than 4-3 times in a week.

Regarding the types of conflicts faced 98.1% (n = 103) experienced the conflict in the form of crop raiding by wild animals and 1.9% (n = 2) experienced conflict in the form of cattle predation by predators such as tiger, leopards and dholes. However, till date no mortal fatalities were recorded nor was there any incidences of house raiding by wild animals recorded in the study area.

As per record available, it is found that there are mainly 10 wild animals in conflicts with the respondents of the study areas, however as per the study it is found 6 of them are the major contributor to HWC in the study area. 97.1% (n = 102) of the respondents experienced conflict with wild boar, 73.3% (n =77) encountered problem with deer, 54.3% (n = 57) had encountered conflicts with bear, 40% (n = 42) with sambar, 39% (n = 41) with white capped langur and finally 9.5% (n = 10) had encountered conflict with wild dogs. Among the above listed 6 wild animals, the study found that 65.7% (n = 69) of the respondent pointed wild boar as the most destructive animal, while 20% (n =21) found deer to be a problem animal and 14.3% (n =15) named white capped langur as the most destructive animal.

6.1.3 Distribution probability of wild pig's habitat.

This study has used the presence only (geo-referenced points) data to study the habitat distribution of the wild pig in Bhutan. From the analysis of the data and the result from Maximum Entropy Model it is fairly accurate to state that the Bioclimatic factor annual precipitation (12), precipitation of driest month (14), precipitation of driest quarter (17) & precipitation of coldest quarter (19) and bioclimatic factor mean diurnal range which is the mean of monthly maximum and minimum temperature (factor 02) & temperature seasonality (biofactor 04) plays a major significant role in the habitat distribution of wild pig in Bhutan.

The Representative Concentration Pathways also contributes significantly in terms of spatial distribution to the habitat of wild pigs in Bhutan. It is clearly understood from the MaxEnt model maps that the RCP models shifts the current homogenous wild pig habitat drastically towards the eastern part of Bhutan if there is any increase in atmospheric temperature or due to unchecked global warming in the future.

6.1.4 Effectiveness of electric fencing in human wildlife conflict.

Electric fencing has taken a major role as a tool in addressing human wild life conflict throughout the world. However none of the manmade barriers are fool proof against the wild animal, however all the respondents (n = 105) had their field barricaded by EF, and 99% (n = 104) of the respondent was fully satisfied and happy with the performance of EF in mitigating the human wildlife conflict in the study areas

Despite electric fencing about 20% (n =21) of the respondent lost crop worth Nu.369550.00 in 2019 to various wild animal namely wild boar and white capped langur however the economic benefit of electric fencing far outweighs the loss of crops. It was found that after electric fencing, the respondents of the 5-study area had a cumulative profit of Nu.8909400.00 during 2019. The economic benefit of electric fencing ranges from Nu. 7000 to Nu.315000.00. The study found that 79% (n = 83) of the respondent saw increase in production of potatoes, which is one of the most important cash crop in the area. 36.2 % (n = 38) saw increase in paddy, 36.2% (n = 38)

respondent in cabbage and cauliflower, while 29.5 % (n = 31) respondent saw an increase in chili production and 26.7% (n = 28) saw increased carrot production.

On the perception and opinion about the trends of incidences of human-wild life conflict in the area, 67.6% (n = 71) of the respondent felt that the incidences has decreased slightly due to the electric fencing while 15.2 % of them felt the same while 7.6% felt that the HWC incidences has increased very much. Overall, the result from this study indicates that the electric fencing is economically and sustainably beneficial in reducing human-wildlife conflict in the study area.

6.2 Discussion

The result from the study indicates that the respondents were satisfied with the performance of electric fencing. After the installation of electric fencing, the respondents/household saw unprecedented economic growth in terms of increased crop production and decrease in crop damage by wild animal. The costs and benefits associated with living with wildlife, notably for people adjacent to highly forested areas, have generally been considered the primary determinants of attitudes towards wildlife, and conservation initiatives more broadly. Documenting and understanding stakeholder use of and reasons for implementing mitigation measures (or not) is important as mitigation measures have the potential to prevent or reduce the costs of living with wildlife (Kansky, 2014). Electric fencing significantly reduced the encounter rate between humans and ungulates such as deer and sambar.

Similarly, such fencing is effectively used by other countries, which has also been reported to minimize conflict, encroachments, poaching, crop damage, disease transmission and weed spreading (Hayward, 2009). The installation of electric fencing in the study areas has provided numerous benefits, in terms of increased income, times saved from guarding the crop and social security. Annual crop loss in Bhutan ranges from 0.3 to 18% of total household income (NCD, 2008). Before the installation of electric fencing, on average Bhutanese farmers used to spend about two months per year guarding their maize and rice from wildlife (Choden and Namgay, 1996). Overwhelming numbers of respondents in the study area has recommended electric fencing as the only means to mitigate the HWC in the area, the other options such as

compensation for crop damage, capture and culling of problem animals were not even considered by any of the respondents.

However, electric fencing is not a complete fool proof solution to HWC, as it is evident from the study that animals such has wild boar was able to breach the EF by burrowing underneath the electric fencing wire. White capped langurs were able to breach the EF by climbing from the poles thus avoiding electric pulses and sometimes they were able to jump over EF from nearby trees because of their agility. Nevertheless, electric fencing is a useful management strategy that not only reduces the conflict between humans and wildlife but also a cost effective measure to prevent wildlife entering to the surrounding settlement areas (Sapkota, 2014).

With regard to application of PPGIS methodology during the research, it is understood from the Conceptual Framework (figure 3), that there are 4 stages of PPGIS application, unfortunately due to some unforeseen problems all 4 stages of PPGIS was not completed. Only the first 2 stages of PPGIS i.e Information and Consultation could be carried out since it was not feasible to conduct collaboration and decision making due to shortage of time, resources and also due to bureaucratic procedures of the country.

6.3 Recommendation

Even though it is evident from the results of this study that EF is one of the best management strategies to mitigate HWC, however the current EF in Bhutan is not without problems, firstly it is recommended that the wooden fencing post should be replaced with RCC iron fencing. The current wooden posts has to be replaced time and again and moreover sometimes bigger animals are able to easily knock down the wooden poles and thereby disabling the EF. It is also recommended from the respondents to look into the possibility of replacing 5 strands of wire with wire mesh altogether. Usage of wire mesh in EF would be effective against wild boars and other small animals like civets, porcupine etc.

Loss of habitat and lack of food for wild animals in the wild is considered to be one of the main factors for human-wildlife conflict in the area. Therefore, habitat assessment should be undertaken in Paro Dzongkhag to understand habitat distribution, anthropogenic pressure on wild animal's habitat due to various developmental activities initiated in the area. Intensive study on human wildlife conflict need to be undertaken to understand conflict trends and population dynamic of wildlife in the area.

ANNEXURES

Annexure 1-Survey Questionnaire

Interview Date: ☐

Respondent ID No. ☐ Village ☐

SECTION 1: DEMOGRAPHY

1.1 Respondent's Information

Sex : Male ☐ Female ☐ Age ☐ Head of the Family a) Yes ☐ b) no ☐
Occupation of respondent: Farmer Service Student Monk
Student
Academic Qualification (Tick)

Pry. School ☐ MSS ☐ High School ☐ Bachelors &above

☐ NFE ☐ No schooling ☐ Religious School

Total Household (HH) members ☐ Actual members living in the HH ☐
Land holdings (Acres): Kamzhing (Dry Land) Chhuzhing (Wetland)

GPS reading ☐

1.2 Livestock holdings

Sl.#	Type of Livestock	Adult(>1 year)		Calf (<1 year)		Total
		Male	Female	Male	Female	
1	Local Cattle					
2	Jersey Cross					
3	Brown Swiss					
4	Yak					
5	Horse					
6	Pig					
7	Poultry					

SECTION 2: LIVELIHOOD

2.1 Main source of Annual cash income to the HH for 1 year (2018) Rank as per importance. (1 being most important and so on)

Sl. No.	Source of Income	Total Income (Nu.) Annual	Ranking
Animal Husbandry			
Agricultural crop/ horticulture			
Sale of Forest Products/Medicinal plant			
Non-farm activities			
1	Business/contract		
2	Remittance from relatives		
3	House rent/rental & hire of vehicle		
4	others		
	TOTAL CASH INCOME		

Section 3: Wildlife & Conflicts

3.1 Walking distance to nearest forest from your place? (Tick the most appropriate)

<30 minutes	30 min – 1 hour	2-3 hour	4-5 hour	>5 hour

3.2 Did you face any conflict with wild animal? Yes ☐ No ☐

3.3 If yes what types of conflicts do your face? Rank the following by giving 1-5 points, 1 being the least and 5 being the highest.

	1	2	3	4	5
a) Crop raiding	☐	☐	☐	☐	☐
b) Livestock predation	☐	☐	☐	☐	☐
c) House raiding	☐	☐	☐	☐	☐
d) Attack on humans	☐	☐	☐	☐	☐

3.4 Frequency of conflicts experienced in a week.

>5 times	4-3 times	3-2 times	<1 times

3.5 What types of wild animals do you come in conflict with? (Tick the wild animal answer could be more than 1).

a) Wild boar ☐ b) Bear ☐ c) Barking deer ☐ d) wild dogs ☐ e) Monkey ☐

f) Leopard ☐ g) sambhar ☐ h) wild cats ☐ i) Others ☐

3.6 Among the above listed wild animals, which one is the most destructive wild animal in your opinion? Rank them from 1-5, 1 being the least destructive while 5 being the most destructive.

	1	2	3	4	5
a) Wild boar	☐	☐	☐	☐	☐
b) Bear	☐	☐	☐	☐	☐
c) Barking deer	☐	☐	☐	☐	☐
d) Wild dogs	☐	☐	☐	☐	☐
					☐

e) Monkey ☐ ☐ ☐ ☐

f) Leopard ☐ ☐ ☐ ☐ ☐

g) Sambhar ☐ ☐ ☐ ☐ ☐

h) Wild cats ☐ ☐ ☐ ☐ ☐

3.7 Compared to last 5 year, what do you think about the population of wild animals listed above?

a) Increased very much ☐ b) Increased slightly ☐ c) Remained same/ no change ☐

c) Slightly decreased ☐ d) Drastically decreased ☐

3.8 Compared to last 5 year, what do you think about the frequency of human wildlife conflict in your area?

a) Increased very much ☐ b) Increased slightly ☐ c) Remained same ☐

d) Slightly decreased ☐ e) Drastically decreased ☐

4. Electric Fencing

4.1 Is your field protected by Electric Fencing? a) Yes ☐ b) No ☐ (If yes go to next question. If answer is "No" then go to question no. 4.12 directly.)

4.2 Was the electric fencing funded by Government or private? a) Govt. funded ☐ b) Private ☐

4.3 Have you lost any crops/livestock after electric fencing? a) Yes ☐ b) No ☐

4.4 If yes what amount of crops/ animals did you lose to wild animals?

Types of crop/livestock lost after fencing	**Approximate value in terms of money**

4.5 Frequency of electric fencing breached

>5 times	4-3 times	3-2 times	<1 times

4.6 List the wild animals that were able to breach the electric fencing and damage the crops. Rank from 1-5 based on frequency of breach, 1 being the least frequent while 5 being the most frequent.

	1	2	3	4	5
a) Wild boar					
b) Bear					
c) Barking deer					
d) Wild dogs					
e) Monkey					
f) Leopard					
g) Sambhar					
h) Wild cats					

4.7 Has the electric fencing benefited you economically in terms of increased production of crops?

a) Yes ☐ No ☐

4.8 If Yes please list down the crops that saw increase in production due to electric fencing.

List of crops, that increased production after fencing	**Increase in production (Kg)**	**Approximate value in terms of money**
1. Paddy		
2. Maize		
3. Potatoes		
4. Chilies		
5. Cauliflower		
6. Wheat		
7. Beans		
8. Radish		
9. Apple		
10. Peaches		
11. Plum		

4.9 After introduction of electric fencing, has there been any changes in farming practices, such as change in crops.

a) Yes ☐ No ☐

4.10 If yes, please list the change of crops after fencing.

4.11 Are you satisfied with the performance of electric fencing?

a) Yes ☐ b) No ☐

4.12 Would you recommend electric fencing as mitigation measures for HWC?

a) Yes ☐ b) No ☐

SECTION 5: PEOPLES PERCEPTION, TOLERANCE AND AWARENESS ABOUT CONSERVATION POLICY

5.1 Are you aware that killing of certain wild animals like tiger, snow leopard and elephants are totally protected as per Forest & Nature Conservation Rules, 2017?

a) Yes ☐ b) No ☐

5.2 How do you feel about severity of HWC cases in Bhutan?

a) Very Severe ☐ b) Moderately Severe ☐ c) Not a problem ☐

5.3 If very severe, how would you like Royal Government to intervene and help in HWC cases. Can be more than 1 options and rank from 1 -5, 1 being the least preferred option while 5 being the highest preferred option.

Intervention Option	**Tick whether the option is preferred or not**	**Rank the options from 1-5**
1. Provide Compensation for crop/livestock loss		
2. Provide Electric fencing at subsidized rate		
3. kill problem animals		
4. Capture & relocate wild animals		
5. Capture and keep wild animals in enclosure/zoo		

5.4 What do you think about Government's conservation and protection policy?

a) Very Good ☐ b) Good ☐ c) Not sure ☐ d) No comment ☐

5.5 Will you support any future Conservation Programs related to wild animals & environment?

a) Yes, definitely ☐ b) No never ☐ c) Not sure ☐

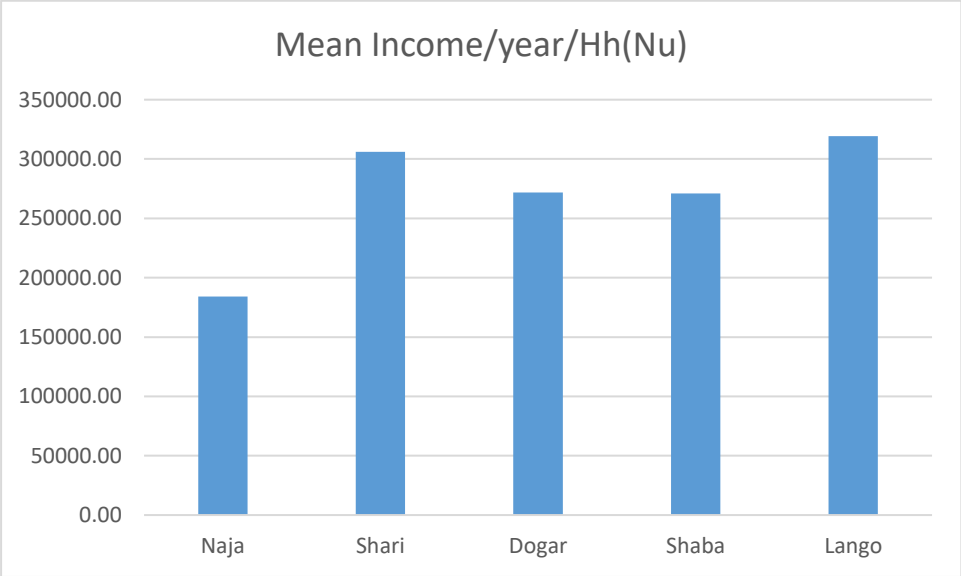
THANK YOU

Annexure 2

Report on Demography of Respondent

Geog		AgeOfApplicant	TotalHouseholdMemeberListed	ActualMembersLivingInTheHH
Naja	Mean	40.80	9.40	5.80
	Std. Deviation	8.044	4.393	2.864
Shari	Mean	50.83	8.29	4.83
	Std. Deviation	11.706	3.469	1.790
Dogar	Mean	47.00	10.97	4.80
	Std. Deviation	12.676	4.672	1.789
Shaba	Mean	44.40	8.92	3.56
	Std. Deviation	17.443	3.968	1.261
Lango	Mean	53.40	7.80	4.70
	Std. Deviation	12.963	4.264	1.829
Total	Mean	47.97	9.21	4.55
	N	105	105	105
	Std. Deviation	13.720	4.166	1.808

Annexure 3 Mean Income of Household



Annexure 4 Landholding & Livestock holding

Report

Geog		DryLandholdingOfRespondentInAcres	WetLandholdingofRespondentinAcres	LivestockHoldingofRespondent
Naja	Mean	3.9000	.0000	5.0000
	N	5	5	5
	Std. Deviation	2.45967	.00000	3.31662
Shari	Mean	.7611	1.1829	3.6857
	N	35	35	35
	Std. Deviation	.48615	.70963	2.38588
Dogar	Mean	3.9477	.0000	5.3333
	N	30	30	30
	Std. Deviation	2.27974	.00000	3.45746
Shaba	Mean	3.3400	.0592	6.1600
	N	25	25	25
	Std. Deviation	2.12446	.14927	3.09139
Lango	Mean	.4150	2.0100	2.7000
	N	10	10	10
	Std. Deviation	.38877	1.39240	2.58414
Total	Mean	2.4021	.5998	4.7143
	N	105	105	105
	Std. Deviation	2.26010	.91351	3.12470

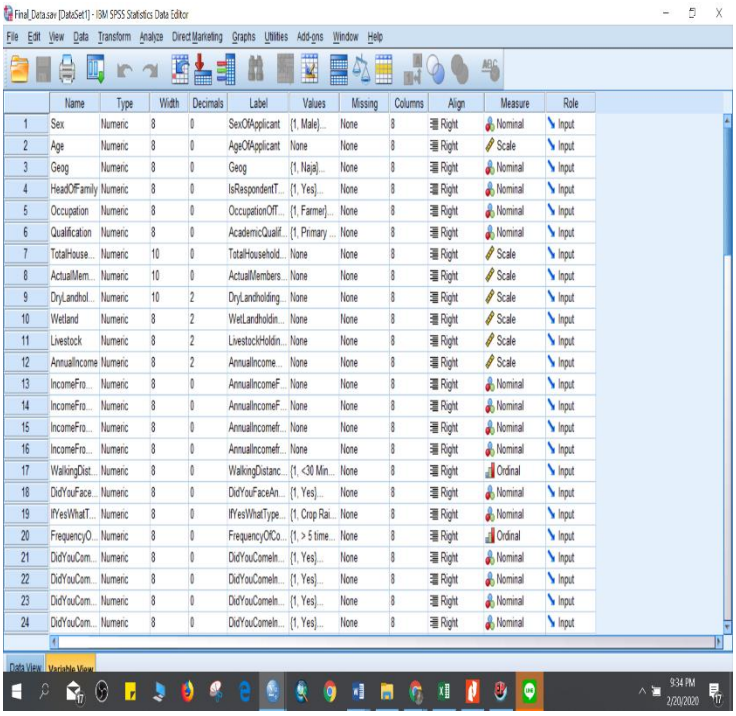
Annexure 5 : Spearman's Rho Correlation Test between Annual Income and wetland land holding

Correlations

			WetLandholdingofRespondentinAcres	AnnualIncomeOfRespondent
Spearman's rho	WetLandholdingofRespondentinAcres	Correlation Coefficient	1.000	.288**
		Sig. (2-tailed)	.	.003
		N	105	105
	AnnualIncomeOfRespondent	Correlation Coefficient	.288**	1.000
		Sig. (2-tailed)	.003	.
		N	105	105

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

Annexure 6 : Screen shot of data punched in SPSS



REFERENCES

Africa, F. (2014). Human- Wildlife Conflict. *Nature & Faune, 21*(2), 1-40.

Ananad, S., & Radhakrishna,Sindhu. (2017). Investigating trends in human-wildlife conflict: is conflict escalation real or imagined? *Journal of Asia-Pacific Biodiversity, 10*, 154-161.

Barua, M., Bhagwat,Shonil A. & Jadhav,Sushrut. (2012). The hidden dimensions of human-wildlife conflic : health impact, opportunity and transaction costs. *Biological Conservation, 157*, 309-316.

Baruch-Mordo, S., Breck,Stewart W. ,Wilson Kenneth R.,& Broderick,John. (2011). The Carrot or the Stick? Evaluation of Education and Enforcement as Management Tools for Human-Wildlife Conflicts. *PLoS One, 6*(1).

Brooks, R. K. (2009). Historical review of elk–agriculture conflicts in and around Riding MountainNationalPark, Manitoba,Canada. *Human Wildlife Interaction, 3*(1).

Dickman, A. J. (2010). Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. *Animal Conservation, 13*, 458-466.

Distefano, E. (2005). Human-Wildlife Conflict worldwide: collection of case studies, analysis of management strategies and good practices. *International Journal of Geographical Information Science*, 1-34.

DoFPS, B. (2018). Forest Facts & Figures 2018. Retrieved from www.dofps.gov.bt website:

Hayward, M. W., Kertley,Graham I.H. (2009). Fencing for conservation : Restriction of evolutionary potential or a riposte to threatening processes. *Biological Conservation, 142*, 1-13.

Herd, Z. B., Redpath,Steve., Bunnefeld, Nils., Molony,Thomas.,& Keane,Aidan . (2018). Conservation conflicts: Behavioural threats, frames, and intervention, recommendations. *Biological Conservation, 222*, 180-188.

Hoare, R. (2012). Lessons from 15 years of human–elephant conflict mitigation: Management considerations involving biological, physical and governance issues in Africa. *Pachyderm, 51*, 60-70.

Kansky, R., & Knight Andrew T. . (2014). Key factors driving attitudes towards large mammals in conflict with humans. *Biological Conservation, 179*, 93-105.

Kioko, J., Muruthi,Philip ., Omondi,Patrick & Chiyo, Patruc I. (2008). The performances of electric fences as elephant barriers in Amboseli, Kenya. *South African Journal of Wldlife Research, 38*(1), 52-58.

NCD. (2008). *Bhutan National Human -Wildlife Conflicts Management Strategy*. Retrieved from Thimphu:

NPPC. (2019). *Electirc Fencing Technical Reference Materials*.

NSB. (2019). Annual Dzongkhag Statistics.

Redpath, S. M., Young,Juliette., Evely,Anna., Adams,William M. , Sutherland,William J. , Whitehouse,Andrew.,Amar, Arjun., Lambert, Robert A. , Linnell,John D.C., Watt,Allan. & Gutierrez,R.J. . (2013). Understanding and managing conservation conflicts. *Trends in Ecology & Evolution, 28*(2), 100-109.

Reidy, M. M., Campbell, Tyler A., & Hewit,David G. . (2008). Evaluation of Electric Fencing to Inhibit Feral Pig Movements. *Journal of Wildlife Management, 72*(4), 1012-1018.

Sapkota, S., Aryal,Achyut ., Baral,Shanta Ram.,Hayward, Matt W. & Raubenheimer,David . (2014). Economic Analysis of Electric Fencing for Mitigating Human-wildlife Conflict in Nepal. *Journal of Resources and Ecology, 5*(3), 237-243.

Steven J. Phillips, M. D. k. (2013). Modeling of species distributions with Maxent: new extensions and a comprehensive evaluation. *Ecography, 31*, 161-175.

Steven J. Phillips, R. P. A., Miroslav Dudík, Robert E. Schapire and Mary E. Blair. (2017). Opening the black box: an open-source release of Maxent. *Ecography, 40*, 887-893.

Storm, D. J., Nielson,Clayton K., Shauber,Eric M. & Alan Woolf. (2007). Deer–human conflict and hunter access in an exurban landscape. *Human Wildlife Interaction, 1*(1).

Thinley, P., Rajaratnam,Rajanathan .,Lassoie,James P., Morreale, Stephen J. .,Curtis,Paul D., Vernes,Karls., Leki Leki, Phuntsho, Sonam.,Dorji,Tshering., & Dorji,Pema . (2018). The ecological benefit of tigers (*Pantehra tigris)* to farmers in reducing crops and livestock losses in the eastern Himalayas : Implication for conservation of large apex predators. *Biological Conservation, 219*, 119-125.

Wang, S. W., Lassoie,James P. & Curtis,Paul D. . (2006). Farmers attitude towards conservation in Jigme Singye Wangchuk National Park, Bhutan. *Environmental Conservation, 33*(2), 148-156.

Wang, S. W. M., D.W. . (2006). Livestock predation by carnivores in Jigme Singye Wangchuck National Park, Bhutan. *Biological Conservation, 129*, 558-565.

Wangmo, C. (2019). 11248 species found in Bhutan. *Kuensel National Newspaper*.

WorldClim. WorldClim-Global Climate Data. World Climate Data Retrieved 8/8/2019

Worthy, F. R. F., J.Mark. (2008). Conflicts between local villagers and Tibetan brown bears threaten conservation of bears in a remote region of the Tibetan Plateau *Human Wildlife Interaction, 2*(2).

WWF. (2008). *Common Ground : Solution for reducing human,economic and conservation costs of human wildlife conflict.* Retrieved from Switzerland: