Review of Environment and Earth Sciences
2019 Vol. 6, No. 1, pp. 1-13
ISSN(e): 2313-8440
ISSN(p): 2409-2150
DOI: 10.18488/journal.80.2019.61.1.13

HABITAT SELECTION AND THREATS OF RED FOX (*Vulpes vulpes*) IN RARA NATIONAL PARK, NEPAL

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Article History
Received: 5 February 2019
Revised: 12 March 2019
Accepted: 17 April 2019
Published: 30 May 2019

Keywords
Habitat selection
Ethnographic
Conflict
Perception
Wild animal
Awareness.

ABSTRACT

Habitat selection is an important aspect of ecology to understand the relationship between the animals, its habitat and its resources. In an effort to understand the habitat selection by red fox and to explore its threats in relation to the people, the present study was conducted in Rara National Park, Nepal. Habitat variables were recorded in presence and absence plot (based on the signs of scat) along the elevation transect walk with associated topographic features (elevation, slope, aspect, distance to water, distance to a village) and vegetation features (tree species, shrub species, herb species and canopy cover). Using the Principal Component Analysis and Partial Least Square Regression model it was found that habitat variables such as distance to water, distance to village, major trees and major shrubs explained the presence and distribution of red fox in the study area. Data were collected from Key Informant Interview and schedule survey employing a convenience sampling method to know the cause of conflict and people's perceptions towards red fox in the study area. Of the 35 respondents, 33 (94.2%) perceived that crop and livestock depredation was the major problem caused by the wild animals where most destructive wild animals were *Sus scrofa* (27.27%), *Presbytis entellus* (12.12%), *Hystrix brachyura* (15.15%) and *Canis aureus* (21.21%) followed by the red fox (12.12%). Threats ranking was conducted by questionnaire survey through purposive sampling method. Relative Importance Index (RII) technique was used to rank the threats.

Contribution/Originality: This study is one of the few studies which have investigated baseline information about its status, an important factor for habitat selection and threats in the higher altitude of Nepal. It contribute valuable Knowledge in the field of wildlife management to develop species strategic conservation plan.

1. INTRODUCTION

The red fox (*Vulpes vulpes*) is a common mesocarnivore that ranges widely across the grassland, semi-desert and desert steppe environments of Northern and Central Asia [1] and represent the widest ranging terrestrial member of the Carnivora [2]. Habitat selection by wildlife is an important aspect of ecology. Knowledge of habitat selection can contribute to the understanding of the relationship between the animals, its habitat and its resources and is central to the development of appropriate Management strategies [3]. Recently, habitat degradation, extinction of prey populations, and conflicts with and persecution by humans has led to a marked reduction in the red fox range. However, most studies have focused on populations in Europe and North America [4]. But remain largely

unstudied in Asia, In Nepal, this species occurs across the mid-hills and higher elevations of Nepal, including within the protected areas of Annapurna conservation area, Dhorpatan hunting reserve, Kanchenjunga conservation area, Khaptad national park, Langtang national park, Makalu Barun national park, Manaslu conservation area, Rara national park [5]. Despite conservation efforts implemented through the enactment of law and designation of protected areas, the species remains susceptible to likely negative impacts of poaching for fur, Human-wildlife conflict, and poisoning [6]. Very little research has been done in the study of habitat preference, population ecology, and behavior of red fox in Nepal. Some preliminary work has been done in Nepal focusing on its diet in Dhorpatan Hunting Reserve [7]. However, red fox distribution within other areas of the country is still unknown. So, because of the limited information, effective conservation measures are lacking to strengthen red fox conservation. Therefore, further research is needed to investigate habitat requirements and threats to develop a strategic conservation plan. Recent effort to address gaps in the study include exploration of red fox habitat selection and threats which has important implications for understanding resource needs and ongoing threats of red fox in the study area.

2. STUDY SITE

The study was conducted in Rara National Park (RNP) which is located in the Northern-Western high mountains of Nepal. The park was established in 1976 with the objectives of conserving biodiversity and maintaining the unique landscape. Its area is 106 sq. km. It is the smallest of all protected areas of Nepal and boosts by 10.8 sq. km [8].

Similarly, Park is rich in biodiversity having ideal habitat of nationally important species of mammals like Musk Deer (*Moschus chrysogaster)*, Himalayan Black Beer (*Ursus Selenarctos thibetanus*), Red panda (*Ailurus fulgens*), and a variety of avifauna, including Red-crested pochard (*Netta ragin*), Impeyan pheasant (*Lophophorus impejanus*) and Blood pheasant (*Ithaginis cruentus*). The fauna diversity in this park is 51 species of mammals, more than 272 species of birds, 3 endemic species of fishes [8].

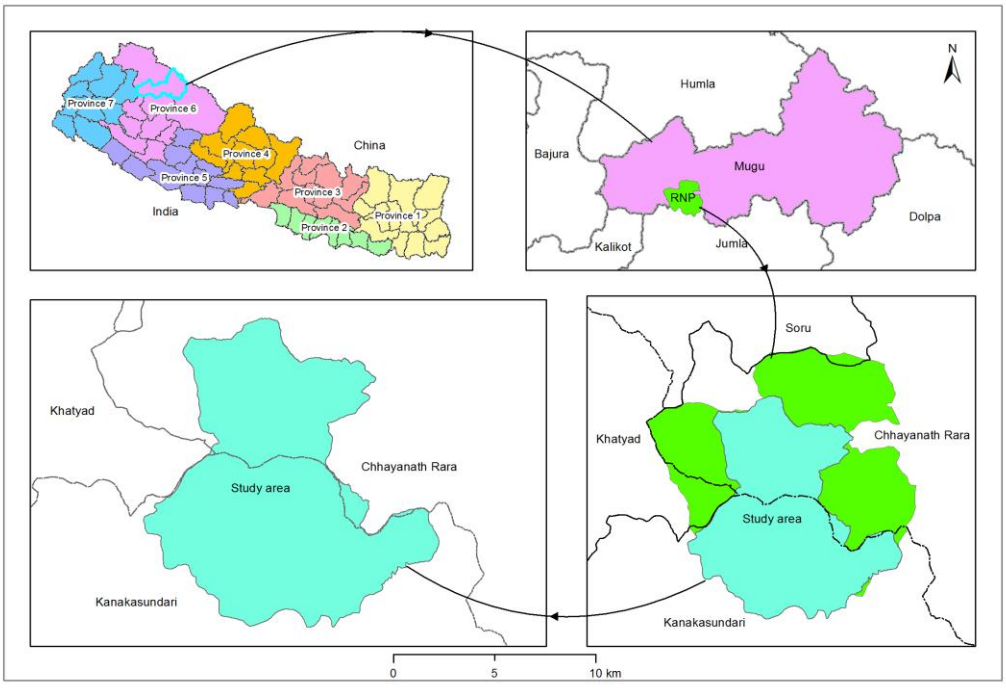

Figure-1. Location Map of Rara National Park.
Source: Arc GIS software version, 10.2, 2018.

3. METHODOLOGY

3.1. Data Collection and Analysis

A field survey was carried out from April 29 to May 12, 2017, throughout the possible habitat sites. Red fox presence was confirmed by searching through indirect evidence of their presence, such as scat, pugmark, and kills along wildlife made trails and in all accessible areas adjacent to trails. Scat of red foxes were identified on basis of certain characters such as relative size, long and final pointed tips, scats covered with grasses and fruit covered [7, 9]. During the study, presence plot was determined when signs were found or had an observation and available plots were laid out in a random direction 200 m from the presence plots [10]. In total, 26 presence points and 16 absence points were recorded during the study site. In each point, 10*10m quadrant was laid from where habitat variables information was collected as described in Table 1. Different habitat characteristics were recorded at each plot and variables were further categorized for analysis. The main data collection tool to be used for this study is a questionnaire where respondents were selected primarily working on wildlife conservation sector. Different conservationists were categorized into three groups; Government, NGOs and Intellectuals and a total of 45 respondents were mailed. An online survey was conducted using Google form, as the most appropriate method for sampling the population of the study [11].

Similarly, Relative Importance Index (RII) was used to analyze because it is best fitting the purpose of the study. In this study, the RII used to rank (R) the different statements of threats expressed by the respondents in 1-9-point scale. Threats ranking was done by the score express by the respondents for the order of priorities to their status or importance. For each statement, the RII was calculated by using the formula. $RII=\frac{\sum W}{N}$

Where,

W= weighting given to each statement by the respondents

N= Total number of respondents

RII value was arranged according to the ascending order for ranking the threats. The rank having the value 1 was considered as most important for the analysis.

Table-1. Habitat variables collected from a user and available plot of 10*10m in RNP.

Variables	Description and code used for analysis
Land feature	Gentle (1), moderate (2), step (3), very steep (4)
Slope degree	Slope per area
Elevation	Elevation from GPS point.
Aspect	A direction of a slope to the N (1), S (2), W (3), SE (4), SW (5), NE (6)
Cover type	Grass (1), tree (2), Grass -shrubs (3)
Ground Cover	Percentage
Crown Cover	Percentage
Major tree species	None (1), *Juniperus* spp., *Pinus wallichina* (2), *Abies*, *Quercus* spp., (3), *Betula*, *Abies pindrow* (4), *Pinus wallichina* (5).
Major shrubs species	None (1), *Juniperus indica* (2), *Rhododendron* spp. (3)
Major herbs	*Rumex* spp., i.e. Halhale (1), *Ariemisia* spp. (2), *Amricana Mexicana* (3)
Distance from village	Distance to nearest village (4 categories) : <2000 (1), 2000-3000 (2), 3000-4000 (3), >4000m (4).
Distance from water	Distance to nearest water source (4 categories) : <100 (1), 100-250 (2), 250-500 (3),>500 (4).
Sign of anthropogenic influences	Horse grazing (1), Horse & sheep grazing (2), no anthropogenic Pressure (3)
Fire presence/absence	yes (1), No (2)
Illegal hunting	No (1), yes (2)
Presence of prey	Pika (1), Wild boar (2), birds (3), Anthropoids (4)
disturbed/undisturbed	No (1), yes (2)

Source: SPSS.V.20, & Arc GIS software version, 10.2.

3.2. Data Interpretation

XLS-Tat software version 17 was used to study what factors affect the habitat selection of red fox. The data was analyzed by using appropriate statistical tools (SPSS.V.20, MS-excel, GIS software Arc View version 3.2.etc. and Data interpretation in this study was focused on the tools of PLS including Variable Importance Projection (VIP), Model Parameter (i.e. Regression coefficients), Goodness of Fit statistics and Standardized coefficients (95% C.I Chart). Similarly, a statistical correlation was also considered to study the correlation between dependent and independent variables.

4. RESULTS

4.1. Sing Survey

Total of 26 signs was encountered Figure 2. During the transect walk, scat signs were encountered in three land use i.e. cultivation land, grassland, and forest land whereas signs was mostly encountered in the edge of forest and grassland.

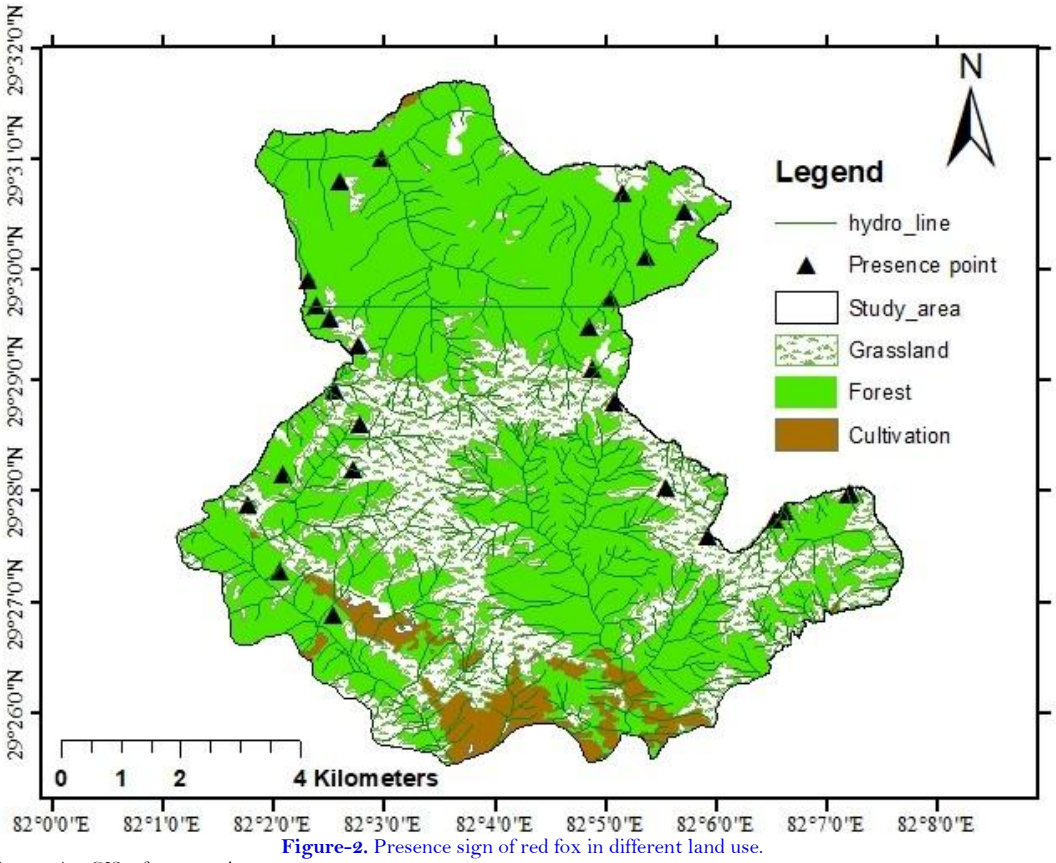

Figure-2. Presence sign of red fox in different land use.

Source: Arc GIS software version, 10.2, 2018.

4.2. Factors Affecting Habitat Selection of Red Fox

As shown in Figure 3 (correlation circle), the variables like fire presence, major trees, elevation, aspect, illegal hunting and forest product collection which is displayed near the center of the circle but little close to each other; it shows that correlation is low, i.e. little correlated with explanatory variables. The result shows that they have only the little influence in the habitat selection. Similarly, there is a positive correlation between land feature's and slope degree and a negative correlation between distance from water and distance from the village which is far from the center and close to each other. Such a relationship shows that it has a strong influence on the rate of habitat selection.

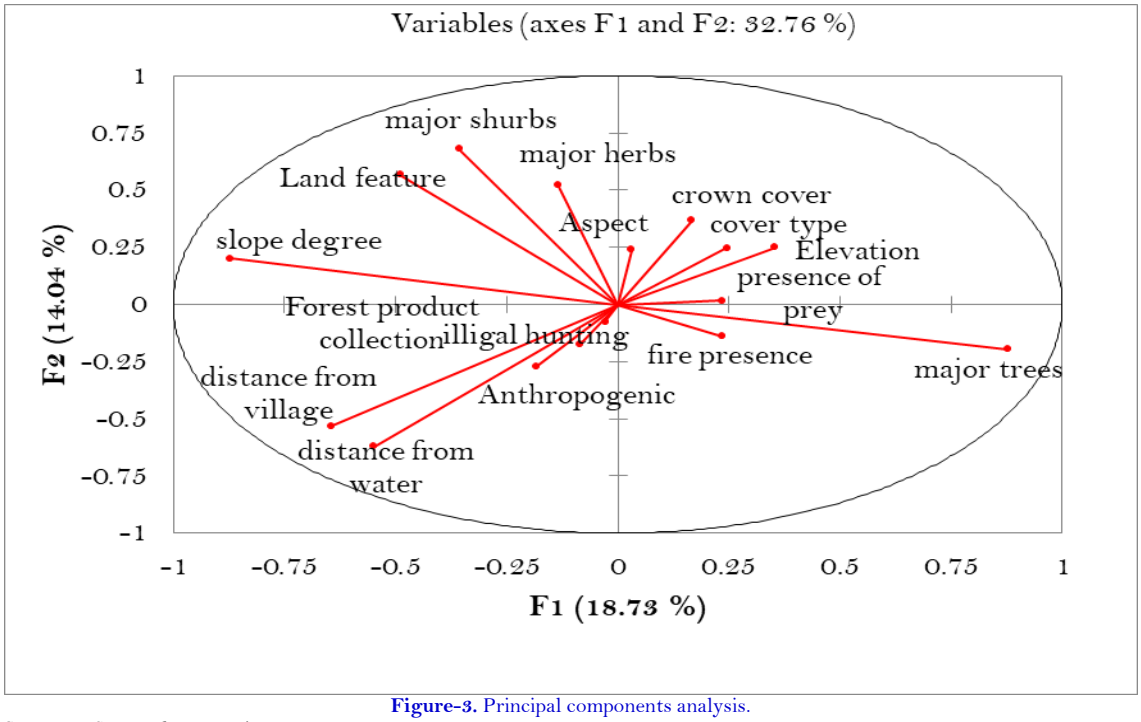

Figure-3. Principal components analysis.

Source: XLS-Tat software version 17, 2018.

4.3. Partial Least Square Regression Analysis

As shown in Partial Least Square Regression circle Figure 4 the variables like distance to water-4, distance from village, Forest product collection 2, fire presence-1 have far from the center which lies in negative portion similarly cover type, forest product collection-2, Anthropogenic influence, major trees-1, distance from water-1 which lies in positive portion which shows influence in habitat selection of red fox.

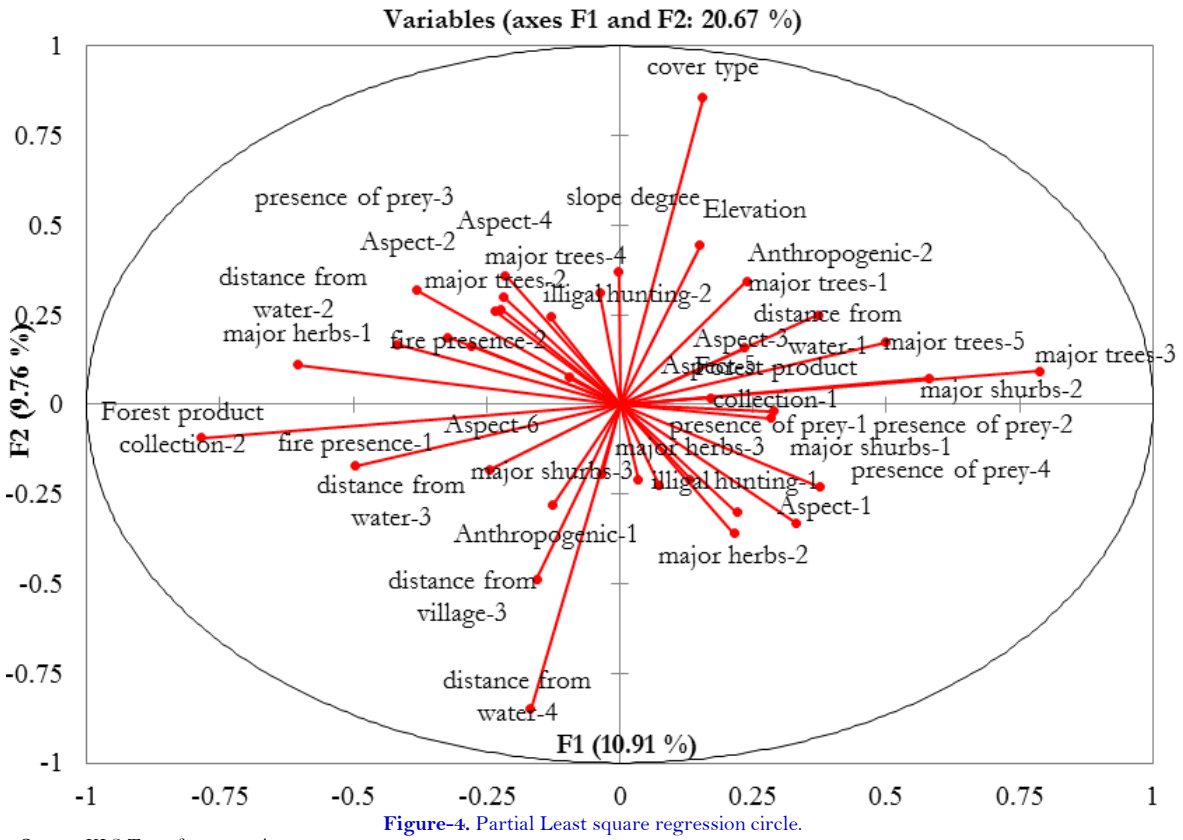

Figure-4. Partial Least square regression circle.

Source: XLS-Tat software version 17, 2018.

4.4. Variable Important Projection

VIP determines which factors to be eliminated from the analysis. In Figure 5, a variable having VIP score close to or greater than 0.08 (>0.08) considered as the most important factors for the model. VIP score of variables found to be high in distance from water-1, distance from village 4 and major trees 3 & 5, major shrubs-2 and presence of prey-2, i.e.3.644, 2.676, 1.439, 2.535, 1.248, 1.086. Similarly, variables having VIP scoreless in Aspect -1, 4, Fire presence 2, land feature 2, i.e. 0.081, 0.043, 0.064, 0.286.

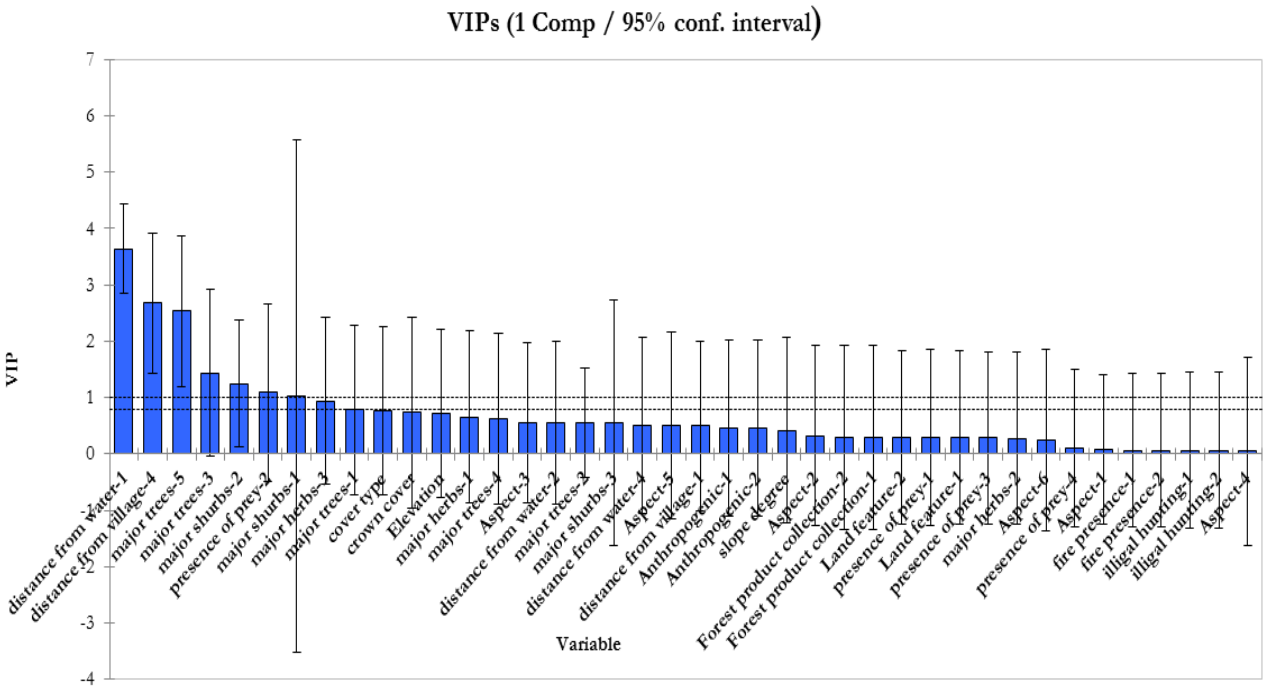

Figure-5. VIP in component 1 of PLS regression mode.

Source: XLS-Tat software version 17, 2018.

4.5. Problematic Wild Animals

As shown in Figure 6, Bear and wild boar rank among the locals as dangerous problematic animals Figure 6. The wild boar (27.27%), jackal (21.21%) and porcupine (15.15%) was the animal most mentioned as being problematic, followed by the red fox (12.12%) causing some sort of loss for respondents.

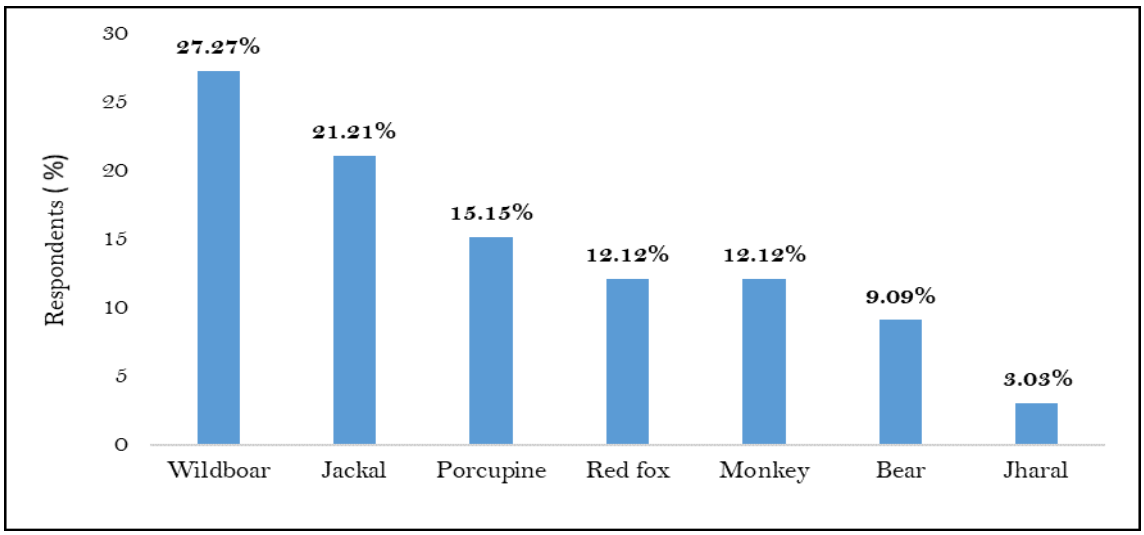

Figure-6. Problematic wildlife in the study area.

Source: MS-excel, windows 13, 2018.

4.6. Types of Loss

A human-wildlife conflict was found to be high in the study area with 33 (94.2%) of the respondents reporting to have some problem due to wildlife.

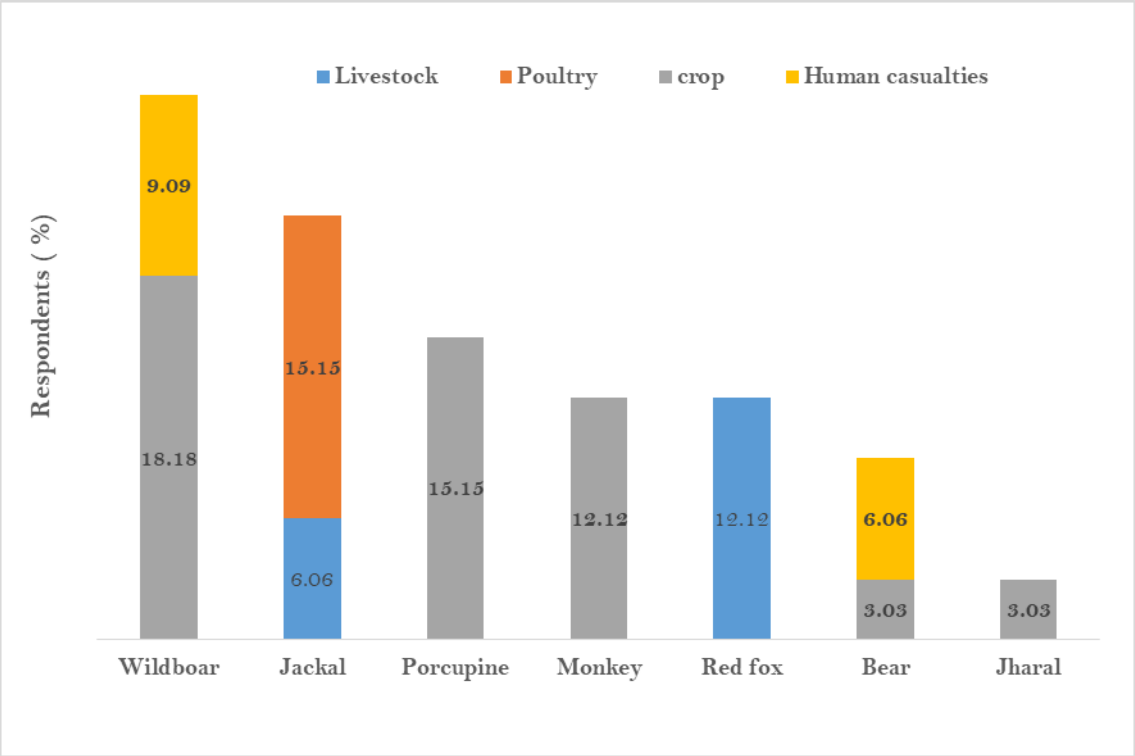

Figure-7. Types of loss caused by wildlife in the study area.

Source: MS-excel, windows 13, 2018.

Livestock depredation, poultry riding, crop damaged and human casualties were found as a loss by wildlife in the study area. Among them, crop Riding was found to be high (51.51%), followed by livestock depredation (18.18 %), poultry Riding (15.15%) and human casualties (15.15%).

4.7. Measures to Reduce Conflict

Most of the respondents were unsatisfied with wildlife management. Concerning how a problem with wild animals should be managed, questions were asked like, how can you minimize the human-wildlife conflict. As shown in Figure 8, where 44.90% of the respondents said that conservation education should be there to Educate people about the conservation value of wildlife and its behavior while 23.61% of the respondents said that protective measures should be there to mitigate the wildlife induced damage where they adopt technologies such as sound producing, fencing with stones, guarding the farm as a major protective technique to reduce way of conflict and 31.53% respondents said that acceptable compensation should be provided to victims or their family to reduce human-wildlife conflict.

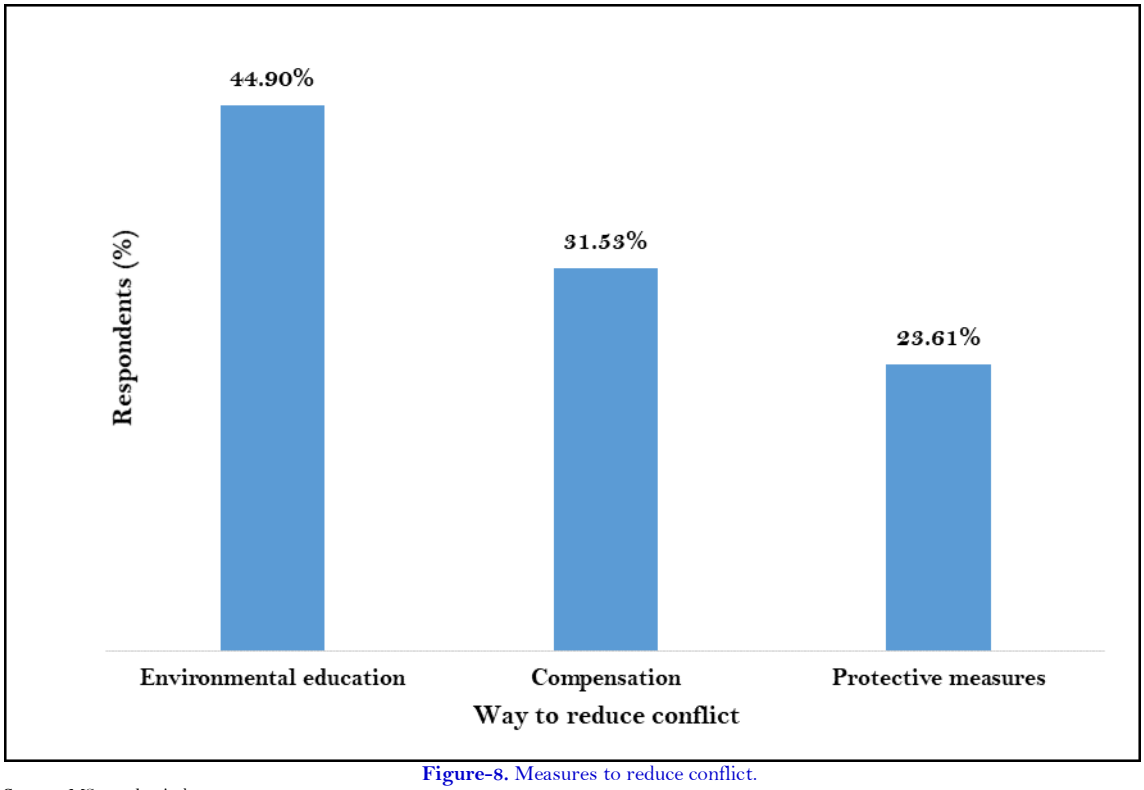

Figure-8. Measures to reduce conflict.

Source: MS-excel, windows 13, 2018.

4.8. Threats of Red Fox

From the questionnaire survey, altogether n= 23 respondents had responded for the survey where the respondents have expressed their opinion according to threats status of importance. As shown in Figure 9, RII and Ranking score of all threats have placed according to their importance. most of the respondents have ranked the threats viz. habitat loss and transformation, depletion of prey base, human-wildlife conflict and livestock depredation in the first, second, third and fourth order of priority according to their status or importance in comparison to the other threats.

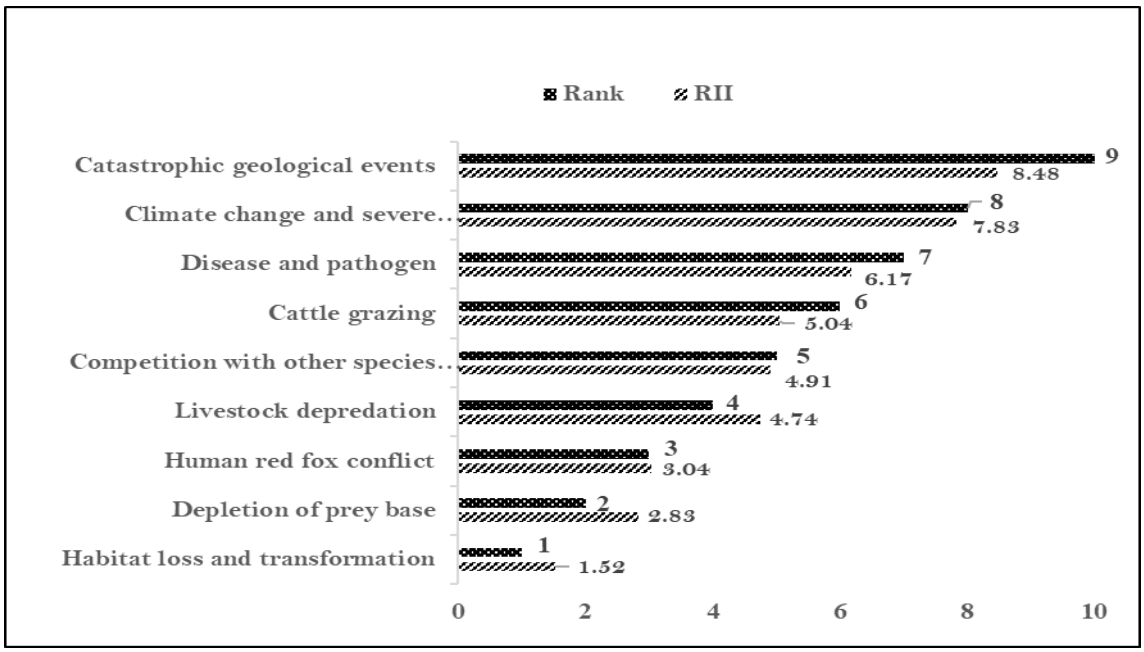

Figure-9. Threats ranking according to ascending order.

5. DISCUSSION

5.1. Habitat Selection

Red fox signs were mostly encountered within the edge of the forest followed by agriculture and grassland in all possible habitats where elevation ranges 2800 to 4039 m. which encompasses temperate, sub-tropical and sup alpine zone. Altogether 26 presence signs (points) and 16 absence points were recorded in 10 opportunistic surveys of 55 hrs. and 60 km distance. This shows that red fox signs were distributed in all possible land use types. It is, however, known that foxes are opportunistic animals not only in terms of the food that they consume but also in terms of den-site selection and therefore preferences may change based on geographic location [12].

From schedule survey, it was also found that sighting of a red fox was found to be high in an edge of the forest followed by the grassland and cultivation land. This might be due to the fact that the edge of this area may contain essential resources for the animal such as shelter, diurnal resting sites, den sites, and food sources, therefore these are the areas in which the animal spends most of its time and also extensively use it for cover, reproduction and also to protect from other predators. Similarly, grassland could be used for hunting the rodents, mice. The result is similar to a study conducted in the Sierra Nevada, where red fox prefers forests interspersed with meadows or alpine fell-fields. Open areas for hunting, forested habitats for cover and reproduction. Edges are utilized extensively [13]. Similarly, red fox signs in cultivation areas may also reflect prey abundance as they are known to house large populations of several rodent species [14] as well as features such as hedge rows bordering fields, which may offer optimal resting sites. This reflects that red fox is an opportunistic omnivore that consumes a variety of food items, including fruits, berries, small mammals, insects and invertebrates, fish, amphibians, human waste and carrion [12].

5.2. Principal Component Analysis (PCA)

PCA was used for the data dimension reduction where it confirmed that very few components of variation influenced the habitat selection. Analysis has suggested four variables viz. major tress, major shrubs, distance from water and distance from the village were sufficient to influence habitat selection by a red fox. Only these components are likely to have practical significance. This is also revealed by the correlation matrix where the major tress, distance to water, distance from the village and major shrubs were found to be 0.322, -0.855, -0.07 and 0.208 respectively. Distance from water and distance from the village were found to be negatively correlated to habitat selection and major trees and major shrubs were found to be positively correlated.

5.3. Partial Least Square Regression (PLSR)

PLSR was applied to study the inter-class variance for classification which was not possible through principal component analysis. Q^2 cumulated index to measure the global goodness of fit and predict the quality of the model. For each model, PLSR displays the goodness of fit coefficients, the standardized coefficients, and Variable Importance Projection. The analysis of the model corresponding to habitat selection allows concluding that the model is well fitted (R^2 equal to 0.76). It implies that 76% of the explanatory variables have been accounted for and explained in the habitat selection (response) of the model.

5.4. Variable Importance Projection

It estimated the importance of each variable in the projection and was often used for variable selection. A variable with a VIP score close to greater than 0.8 was considered to be important in a model. On the contrary, variables with VIP scores significantly less than 0.8 (VIP<0.8) were less important and might be candidates for exclusion from the model [15]. In the VIP table, five variables had a high level of importance in their relationship to habitat selection which include distance from water-1, distance from village-4, major trees-5 (*Pinus wallichiana)*,

major tress-3 (*Abies*, *Quercus* sp.); major shrubs-2 *(Juniperus indicia)* and presence of prey -2 were of highest importance in the model for habitat selection.

The results also show that red fox selects habitat having the distance nearest to a water source. It is because water is thought to influence den-site selection by foxes and another reason could be to reduce the cost of travelling to water sources in order to meet their water demands and also position them to close to key habitat for potential prey items such as water bird which is supported by many study [16, 17].

Similarly, from the result, it was found that red fox selects the *Quercus* sp. dominated forest. Previous research has also shown *Quercus* sp. to be a more preferred habitat for red fox from snow tracking method [18] this was contrary to finding where studies [19] shows red fox used broadly classified woodlands and croplands in proportion to their occurrence through radio-tracked method. Habitat selection by foxes in the study area is probably also a reflection of an intrinsic need of foxes for the protection cover against weather and possibly enemies.

Further in this study, it was also found that red fox select the low human disturbance area i.e. far from the human settlement area, the result are similar to a study conducted in the Charlottetown, Canada where study shows that red fox prefer to spend their time in land-use types that are less-disturbed by humans such as natural lands, agricultural areas, and regions of low human use, further suggesting that these areas may provide a greater abundance of resources such as food, space and vegetative cover. Similarly, a study in Melbourne also reported that areas of low-human disturbance were selected based upon the presence of certain resources such as thick vegetative cover which allowed for secure day-time rest sites [3].

5.5. Human-Wildlife Relation

Human and wildlife interactions are well known for several years, through this relation comes into view together both as pleasure and fear. The human animal interaction seems to play a significant role in modifying the attitudes and perception of the local communities residing nearby protected area or reserve. The results from this study revealed conflicting relation between human and wildlife which could be problematic for the survival of both wild animals and livelihood of local people in the long run. Most people have reported that they are facing the problems from the wild animal of the park and include loss of a variety of crops and livestock. During an interview, it was found that damages caused by wildlife are maize (Wild boar), buckwheat (Bear), pumpkin (Jharal), cauliflower (Monkey), potato (Porcupine), lambs, hen and chicken (Jackal). The red fox is often responsible for the predation of lambs in the study area. Wild boar, porcupine, and monkey were found to be high in local peoples list of problem animals not for their sizes but due to their ability to destroy large crops fields even in single raid. The next most rated problematic wild animals are bear and jackal based on the severity of damage. During the interview, it has been found that in the past year one adult man was injured by bear attack nearby forest area during fuel woods collection and has lost one side eye. Similarly, respondents also reported that they have a problem with wild boar because they have been frequently chase/injured by its attack in the human trail in the forest area. This shows that most of the conflict zone was occurred inside or nearby forest area. to mitigate the human-wildlife conflict, people usually use protective measure approaches to mitigate the wildlife induced damage. They adopt locally available techniques to mitigate crop and livestock depredation problems. The major techniques implied by the people were sound producing, fencing with stones, guarding the farm. This reflects that local people do not have sufficient knowledge and financial source to adopt modern means of mitigation measures.

Conservation education is an effective way to reduce human-wildlife conflict and change the attitude and behavior of people as well as to increase the tolerance of losses [20]. Conservation is a high priority in Nepal where people are generally impoverished [21] and also have a relatively low literacy rate [22]. From the results, it was found that conservation education should be a priority to reduce conflict. Many studies also highlighted that

conservation education should be there to enhance the understanding of environmental issues and affective commitment to the environment [23].

Compensation (relief) was found to be the second priority in the study area. Compensation of losses is a fundamental strategy to reduce the human-wildlife conflict through the increased tolerance level of the community towards wildlife [24]. The result shows that compensation is a way to mitigate human-wildlife conflict which has been expressed by most of the respondents. In many countries, already, this strategy is in full practice. The compensations are in the form of direct cash payments or stocks, implements, and grain, or other forms of incentives with a value such as community outreach programs. In the RNP, there exists a small compensation scheme. The program is run under the heading of "satisfaction relief" because it fails to compensate for the full value of the loss by paying for only a fraction of it.

Overall, the relationship between local people and the park management authority was found to be negative, the first reason could be the people are relying on natural resources, all through the local people are allowed to collect fuel wood from the forest for few days each year but the amount they gather is insufficient for them for an entire a year and second reason could be wildlife induced damage to the crops and livestock.

5.6. Threats Identification Using Relative Important Index (RII)

The results show that habitat loss and transformation, depletion of prey base, human red fox conflict, and livestock depredation were ranked as first, second, third and fourth order having the relative important index value 1.52, 2.83, 3.04 and 4.74. It reflects that this threat should be placed in high priority during species conservation action plan for the long term sustainability of the species. Other literature studies also show that this is the threats possess by the red fox in most of the landscape of the region [25, 26].

6. CONCLUSION

The present study depicts broad yet important pictures of habitat selection of red fox in the study area. It was confirmed that habitat variables such as distance to water, distance to village, major trees, major shrubs and presence of prey explained the presence and distribution of red fox in the study area. This research showed that human-wildlife conflict was the main cause of a problem in the study area which was mainly due to the damaged/loss caused by wild animals. So Incentive measures such as monetary compensation and materials support to increase the tolerance of them towards losses by a red fox are to be employed. Further detailed ecological research on red fox and their distribution patterns throughout Nepal should be undertaken.

6.1. Limitation of the study

- One-time data (seasonal) was collected due to time constraint.
- The samples were collected on Southern belt (Core area) area of Rara National park.

Funding: This study received no specific financial support.
Competing Interests: The authors declare that they have no competing interests.
Contributors/Acknowledgement: The authors thanks to the Central Department of Environment Science, Tribhuvan University, Department of National Park and Wildlife conservation/Rara National Park, Government of Nepal for their support and permission to conduct this study. We acknowledge Mr. Deepak Basnet and Mr. Bimal Shrestha for their constructive help.

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