1. INTRODUCTION

1.1 Background

Habitat use and preference of a species depends on the behavior of animals actively selecting where they live, or passively persisting in certain habitats (Southwood, 1997). Species select habitat based on availability of resources consisting of food, cover and water (Smith, 1974). Habitat of different species may be different according to their geographic range (Johnson, 1980). Study on habitat selection by the species compares the habitat parameters that used in their habitat (Thomas and Taylor, 1990).

Natural habitat in the Himalaya is degrading due to anthropogenic activities and global climate change causing threats to the biodiversity (Dorji *et al.*, 2011). Agriculture intensification and livestock herding remain the principal economic activities (79.85%) in mountain areas where nearly 95% of households depend on fuel wood as energy source for cooking and heating (CBS, 2014). Biodiversity loss of any habitat is related with the reduction in original habitat (Tews *et al.*, 2004). The Red Panda is an important species, information on this animal from Nepal is scanty and the insufficient information is major issues for its conservation (Yonzon *et al*., 1997).

1.1.1 General physical characteristics

The Red Panda is averages 100 cm in length including body length 60 cm and tail about 40 cm long having upper chestnut color fur and darker at abdomen. The tail is marked with approximately 12 alternating red and buff rings and is used for balance when in trees (Roberts and Gittleman, 1984). Adult Red Panda weights about 4kg in the wild and 4-5 kg in the captivity (Yonzon, 1989). They have distinct thumb allowing for better manipulation and handling the bamboos (Anton *et al.*, 2006). On the basis of colour or size, there is no sexual dimorphism between male and female (Roberts and Gittleman, 1984).

1.1.2 Behavior, activity and home range

Red Panda is an arboreal, crepuscular, solitary animal, especially during the non-breeding season.They form small group during the breeding season and are more active at dawn, dusk and during the night (Roberts and Gittleman, 1984). They show similar type of activity pattern in different season (Yonzon, 1989) and temperature, feeding regimes, and the presence of young affects seasonal activity. The average home range for male is 5.12 sq. km and 2.37 sq. km for female. Male home ranges tend to overlap but it occurs seldom in case of female (Yonzon, 1989). The home range size is influenced by habitat quality especially food availability and shelter.

1.1.3 Life cycle and reproduction

The average life span is 8-10 years in the wild (Robert and Gittleman, 1984; Johnson *et al*., 1988; Yonzon and Hunter, 1991b; Pradhan *et al*., 2001a). They mate between January and March (Pradhan *et al*., 2001b) and birth occurs during the monsoon in the months of June to August (Yonzon, 1989) after gestation period of 112 to 158 days (Robert and Gittleman, 1984). A litter may have 1 to 4 young (Dittoe, 1944; Roberts and Kessler,

1979). The mother shows maternal care by hiding newly born blind and helpless young in the nests to protect them from predation and inclement weather (Glatson and leus, 2005) and about 12 months of age cubs reach adult size (Bircher, 1989).

1.1.4 Geographic distribution

They are distributed throughout the Himalayan Mountain of Nepal, India, China, Bhutan and Myanmar (Figure 1) between 2,200- 4,800m altitude (Robert and Gittleman, 1984; Glatston, 1994; Reid *et al*., 1991; Yonzon *et al*., 1997; Wei *et al*., 1998; Wei *et al*., 1999; Wei *et al*., 2000; Choudhury, 2001; Pradhan *et al*., 2001a; Dorji *et al*., 2011; Ghose and Dutta, 2011). The potential habitat of Red Panda covers 47,000 km^2 globally (IUCN, 2011) while 2,653 km^2 in Nepal (PHVA, 2012).

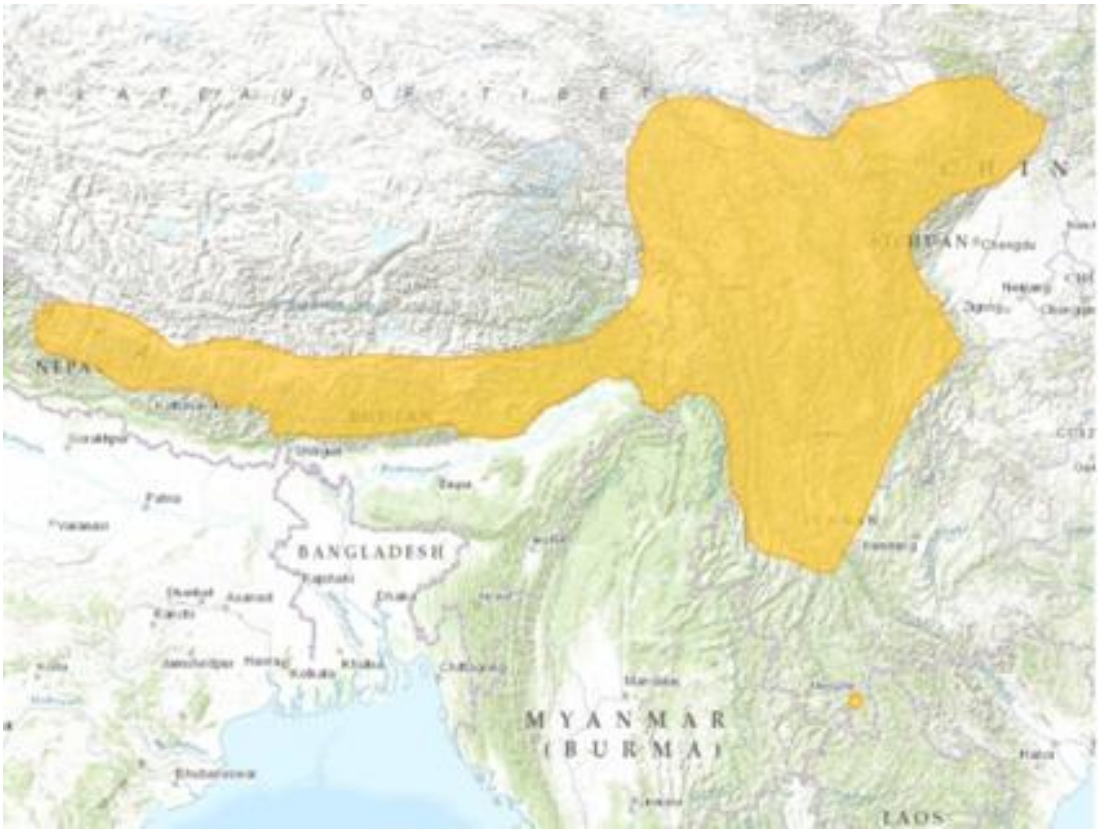

Figure1: Global distribution of Red Panda (Source: IUCN 2015)

In Nepal Red Pandas are patchily distributed from east to west within a narrow elevation range between 2,500-4,200 m in temperate and subalpine area (Yonzon *et al*., 1997). PHVA (2012) reported Red Panda from 24 districts: Taplejung, Panchthar, Ilam, Sankhuwasabha, Solukhumbu, Ramechhap, Dolkha, Sindhupalchowk, Rasuwa, Gorkha, Manang, Baglung, Myagdi, Rukum, Rolpa, Mugu, Darchula, Doti, Acham, Bajura, Bajhang, Therhathum, Nuwakot, Pyuthan (Figure 2).

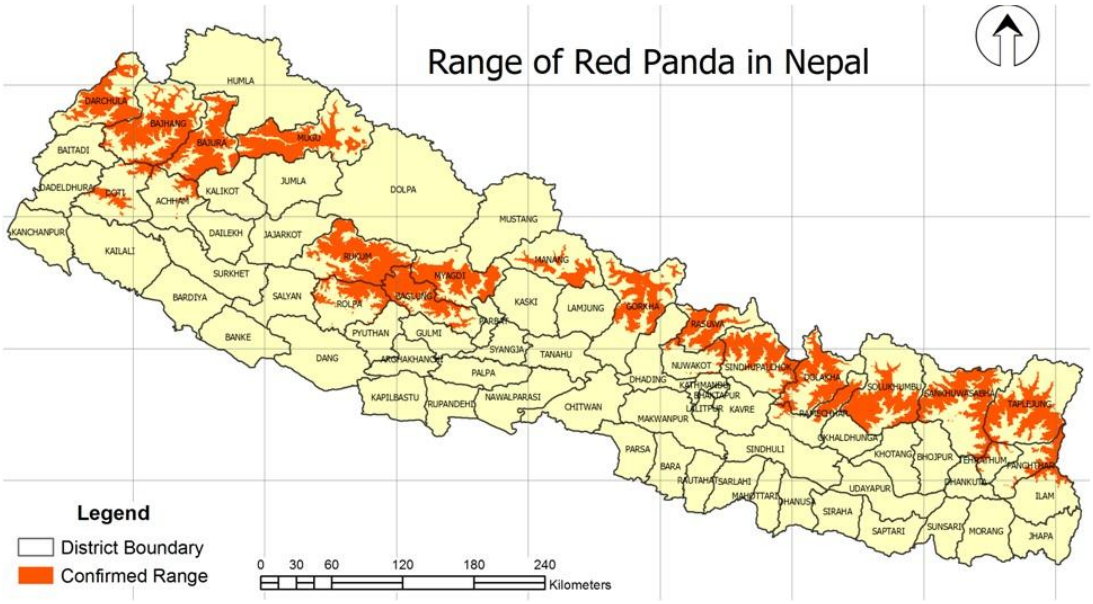

Figure 2: Districts with confirmed range of Red Panda in Nepal (PHVA, 2012)

In addition, 12 districts contained potential habitats: Bhojpur, Khotang, Okhaldunga, Dhading, Lamjung, Kaski, Mustang, Dolpa, Jajarkot, Humla, Jumla, Kalikot (PHVA, 2012) (Figure 3). Red Panda occurrence has been confirmed in eight protected areas: Khangchenjunga Conservation Area, Manaslu Conservation Area, Makalu Barun National Park, Sagarmatha National Park, Langtang National Park, Annapurna Conservation Area, Dhorpatan Hunting Reserve and Rara National Park (Yonzon, 1989; Jackson, 1990; Yonzon *et al*., 1991; Yonzon and Hunter, 1991a; Karki, 1999; Karki and Jendrzejewski, 2000; Shrestha and Ale, 2001; Mahato, 2003; Sharma and Kandel, 2007; Sharma, 2008).

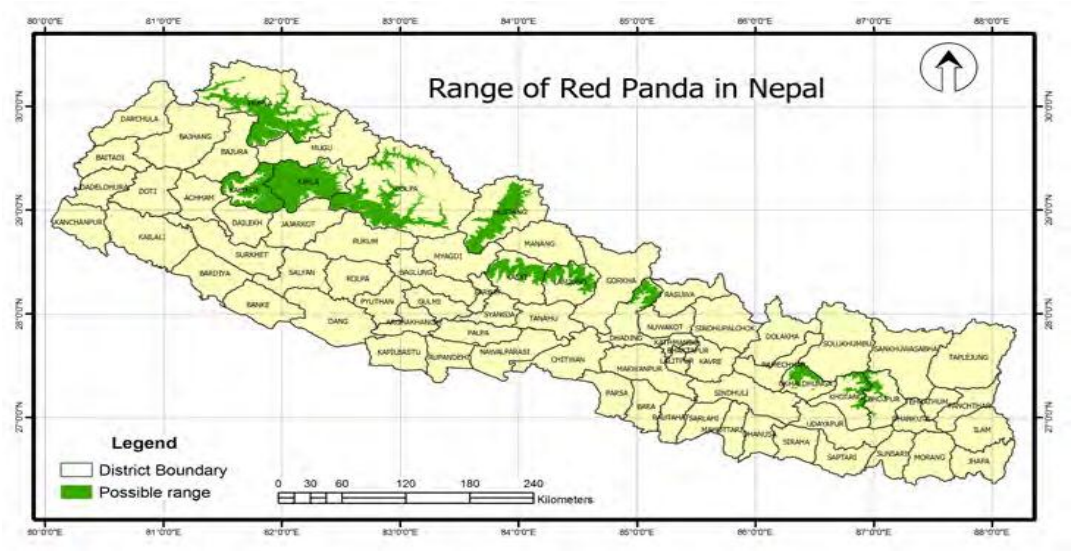

Figure 3: Districts with potential Red Panda habitats in Nepal (PHVA, 2012)

1.1.5 Habitat and food habit

The Red Panda mostly prefers subtropical, temperate, sub alpine and alpine forest between 1,500 and 4,800 m with the exception of Meghalaya, where it is found in tropical forests between 700m – 1,400m (Choudhury, 1997; Choudhury, 2001; Pradhan *et al*.,

2001a). Red Panda need mature forest (Yonzon, 1991) and prefer the bamboo-dominated understory in evergreen, deciduous, and mixed evergreen and deciduous forests (Roberts and Gittleman, 1984; Yonzon, 1989; Wei *et al*., 1999; Choudhury, 2001; Pradhan *et al*., 2001b). Other several microhabitat characters are required by them; a dense understory of fallen logs, fruiting shrubs, close proximity to a water source, canopy cover (Yonzon, 1989; Wei *et al*., 1999; Pradhan *et al*., 2001a). Red Panda prefers the habitat with proximity to water sources; tree canopy cover more than 30%; bamboo cover more than 37% and bamboo height 2.9 m (Yonzon *et al*., 1991; Pradhan *et al*., 2001a; Williams, 2004; Dorji *et al*., 2012). Similarly, habitat with gentle to steep slopes, tree stumps, snags and the north, north-west and south-west aspects are highly preferred by them (Yonzon *et al*., 1991a; Pradhan *et al*., 2001b; Zhang *et al*., 2008; Dorji *et al*., 2012). For defecation, Red Panda use tree most frequently followed by rocks, forest floor, fallen logs and cut stumps (Kandel, 2009). The required average temperature for the Red Panda is 10-25 ºc, and the average annual rainfall is 350 cm (Roberts and Gittleman, 1989). It indicates the overall health, associated with its upper layer of bamboos especially *Arundinaria maling* (Malingo) and *Arundinaria aristata* (Nigalo) (Chalise, 2009). Tall trees with hollow trunk such as *Rhododendron, Quercus*, and hardhood species such as *Viburnum erubescens, Symplocos pyrifolia, Magnolia campbellii, Quercus lamellosa, Lindera pulcherrima, Lithocarpus elegans, Machilus edulis, Eurya acuminate, Litsea salicifolia, Acer spp* etc are present in Red Panda habitat (Chalise, 2008).

The Red Panda primarily feeds on bamboo leaves and shoots, accounting for more than 83% of the total food types (Yonzon *et al*., 1991; Pradhan *et al*., 2001b; Thapa and Basnet, 2015). Common genera of bamboo consumed by Red Panda are *Arundinaria maling, Phyllostachys sp., Thamanocalamus sp., Oionobambusa sp., Semi arundinaria, Pseudostachyum sp.* (Warnell *et al*., 1989). They also feed on fruit, roots, succulent grasses, acorns, lichens, birds' eggs and insects (Hodgson, 1847; Sowerby, 1932). Red Panda show particular interests in sweet food and readily eat meat in captive condition (Choudhury, 2001).

1.1.6 Population, Threats and Conservation Status

The exact population size in the wild is unknown due to occurrence in the remote and rough terrain (Wei *et al*., 1999; Choudhury, 2001). However, estimated global Red Panda population to be around 10,000 (IUCN, 2011) and in Nepal ranges from 237 to 1,061 individual (Jnawali *et al*., 2012). Habitat loss, poaching, natural predation, inbreeding depression, parasitic infection are the threats associated with Red Panda (Choudhury, 2001; Wei *et al*., 1999; Dorji *et al*., 2011; Bista and poudel, 2013, Lama *et al*., 2015). Therefore Red Panda is listed as endangered species of IUCN Red Data List (Hilton and Taylor, 2000) and in Appendix I under CITES (BBP, 1995). Legally, it is protected by NPWC Act 1973 in Nepal.

1.2 Objectives

1.2.1 General objective

The general objective of the study was to determine the status, habitat selection and use of Red Panda in Ilam, Nepal.

1.2.2 Specific objectives

Specific objectives were:

1. To determine the distribution and relative abundance of Red Panda,
2. To assess the habitat characteristic and use by Red Panda.
3. To evaluate the threats particularly livestock grazing on Red Panda in Ilam.

1.3 Rationale of study

The population of Red Panda is decreasing because of habitat destruction, poaching, over exploitation of natural resources and lack of awareness (Bista *et al*., 2017). Despite it's legal protection in Nepal, detailed information on the status, ecology and causes of population declines is lacking particularly outside of protected areas (Panthi, 2012). Most of the researches have been conducted inside protected areas (Yonzon, 1997; Mahato, 2004; Mahato and Karki, 2005; Sharma and Belant, 2009; Subedi and Thapa, 2011; Panthi, 2011; Thapa *et al*., 2013; Bista *et al*., 2017) and a very limited studies have been carried out outside protected area (Williams, 2004; Chalise, 2009; Kandel, 2009; Mahato *et al*., 2011; Bhatta *et al*., 2014). Outside of the protected area may have higher risk due to human pressure (Yonzon *et al*., 1997). Eastern Ilam district is also a very important habitat for Red Panda and their ecological information is not adequate for conservation. This study has provided baseline information on the distribution, habitat characteristics, use and threats to Red Panda and such information could be useful to further investigate ecology and habitat of Red Panda and it is an important necessity for formulation of effective management and conservation strategies for the wild species.

1.4 Limitations of the study

During the present field studies following limitations were faced:

- The study was focused on smaller area including four community forests.
- Identification of many plants collected in the field was impossible because of absence of flower.

1.5 Research questions

Research question of the study was,

- What are the factors that affect on the distribution of Red Panda?

2. LITERATURE REVIEW

Literature review reveals that most of the research conducted on Red Panda in Nepal was inside the protected areas which cover only 30% of Red Panda habitat, nearly 70% of the Red Panda habitat remains outside the protected area (MoFSC 2016). Among the research conducted, most of them were found focused on the confirmation of Red Panda presence and distribution but only few were on habitat.

2.1 Distribution and abundance

Red Panda (*Ailirus fulgens fulgens)* is found in Nepal, northeastern India, Bhutan, part of western China and Myanmar in the temperate forest of Himalayas at elevation between 2,200 to 4,800m (Robert and Gittleman, 1984; Glatston, 1994; Yonzon *et al.*, 1997; Wei *et al.*, 1999; Chakrobarty, 1999; Choudhury, 2001; Pradhan *et al*., 2001a; Dorji *et al*., 2011; Ghose and Dutta, 2011) and another sub species *Ailurus fulgens styani* is found in south Western China in Sichuwan, Yunnan Provinces. These two sub- species are isolated by the Nujiyang River (Roberts and Gittleman, 1984; Glatston, 1994; Wei *et al*., 1999b).

Nepal is home to approximately 1.9% of the total global population of the Red Panda (Yonzon *et al*., 1997). They are patchily but widely distributed in Nepal. They are reported from Chaurikharka VDC of Sagarmatha area (Mahato, 2004), Marbu, Kalinchok, Chuchure and Fulpingkatti forests areas in Gaurishankar Conservation Area (Thapa *et. al*., 2013), Langtang NP and its buffer zone (Yonzon, 1997; DNPWC / MoFSC / GoN, 2010). Distribution of Red Panda has been described by RPN-Nepal (2010) at the altitude from 2,530 to 3,790 m with the highest encounter frequency between 2,700 and 3,220 m in Sacred Himalayan Landscape (SHL) and also revealed the higher Red Panda abundance in the east compared to the western part of the area. The presence of Red Pandas was recorded in five districts: Rasuwa, Nuwakot, Myagdi, Baglung and Dhading by Bista *et al*., (2017). Sharma and Belant (2009) observed it from 3,000 to 3,600 m elevation in Dhorpatan Hunting Reserve, with abundance of pellets increasing to 3,500 m and declining sharply at higher elevations. The evidence was not found at elevations >3,730 m. Four Red Pandas were encountered at elevations ranging from 3,220 to 3,610 m. Subedi and Thapa (2011) also found four small isolated groups of Red Panda from the same area and Panthi (2011) recorded it from lower belt including parts of Myagdi, Baglung and Rukum districts. Mahato and Karki (2005) reported distribution of Red Panda in Hellok and Lungthung up to Jaddak and Jaritar in Wolangchung Gola VDC of KCA.

Outside of protected areas Red Pandas occur in the districts of Dolakha, Ilam, Panchthar, Ramechhap, Sankhuwasabha, Solukhumbu and Taplejung (Jnawali *et al*., 2011). Williams (2004) recorded between 2,500m-3,000m with relatively abundant in the 2,600m - 3,000m in Jamuna and Mabu villages in eastern Ilam. Similarly Chalise (2009), Kandel (2009), Mahato *et al*. (2011), (DFO, 2012) also reported Red Panda in different parts of eastern Illam. Bhatta *et al*. (2014) recorded them from three forests namely Bahirepatan, Imilchadamar and Tyakot of Godhemahadev, Tamti and Malikathata VDCs of Jumla.

2.2 Habitat use

Habitats of Red Panda were characterized by the presence of dense growth of ringal bamboo (Pradhan *et al*., 2000; Mahato, 2004; Mahato and Karki, 2005; Chalise, 2009; Sharma and Belant, 2009; Panthi, 2011; Subedi and Thapa, 2011; Bista *et al*., 2017); mixed broad-leaved forest and coniferous forest (Mahato, 2004; Zhou *et al*., 2013) and undisturbed Montane oak and Eastern Himalayan mixed broadleaf forest (Williams, 2004)). The habitat is dominated by species of *Daphne bholua, Viburnum erubescens, Symplocos pyrifolia, Magnolia campbellii, Quercus lamellosa, Lindera pulcherrima, Lithocarpus elegans, Machilus edulis, Eurya acuminate, Litsea salicifolia Acer spp.* (Chalise, 2009). Red panda generally preferred diverse and mature forest with greater canopy cover and little livestock disturbance but some time they occurs open land with some bamboo grooves and forest with trees (Chalise, 2013). Dominant tree species in Red Panda habitat are *Juniperus sp*., *Rhododendron spp, Abies spectabilis, Betula utilis* (Sharma and Belant, 2009; Panthi 2011; Subedi and Thapa, 2011; Bista *et al*., 2017). They are found in tropical and subtropical forests on the Meghalaya of India, while elsewhere found in subtropical and temperate forests (Choudhury, 2001). Red Pandas were recorded from medium to dense bamboo cover area of *Arundinaria sp*., *Rhododendron sp*., *Sorbus sp.* and less understory in Pangchen Valley, Arunachal Pradesh India (Chakraborty *et al*., 2015). Their habitats extended till the higher mixed conifer forests dominated by *Abies sp.* In the Singhalila National Park also Bamboo species, *Arundinaria maling* and *Arundinaria aristata* were dominant. Red Pandas are most common in Fir, Abies, dense forests with an undergrowth of bamboo in Bhutan (Dorji *et al.*, 2011).

Trees were found to be mostly (86%) used as resting site including *Abies spectabilies* in summer and *Junipers, Betula spp, Rhododendron spp* and *Acer spp* trees in winter (Yonzon and Hunter, 1989). Mostly used substrate for defecation was tree branches in Singhalila National park (Pradhan *et al*., 2001b), Choyatar and Hangetham CF, Jamuna Ilam (Kandel, 2009) and CHAL (Bista *et al*., 2017). But the use of rocks and ground was found more frequently as scat site during the winter breeding month in Singhalila National Park (Pradhan *et al.*, 2000) and also in Jamuna and Mabu village during the end of the breeding season in late spring (Williams, 2004) whereas fallen logs were used mostly (39%) in Jumla (Bhatta *et al*., 2014). Habitat having water distance of 0- 100m was mostly preferred in LNP (Yonzon, 1989), Singhalila National Park (Pradhan *et al*., 2001b) and Ilam (Kandel, 2009). Bhatta *et al*. (2014) found preferred habitat of Red Panda having dense crown coverage (>20% - 100%) and (31% - 50%) ground cover in Jumla. Slope angle of 26-50%, 51-75% crown cover and 26-50% ground cover were preferred by them in DHR (Panthi, 2011). Steep northern slope having medium tree canopy cover was preferred by Red Panda in Ilam (Kandel, 2009). They have been reported mostly from south-facing slopes in Sichuan Province, China (Zhou *et al*., 2013) and Bhutan (Dorji *et al.*, 2011). Red Pandas were also observed from northeast and south facing slope in DHR (Sharma and Belant, 2009) and mostly preferred North- East aspect was followed by Northern and Eastern aspects in CHAL (Bista *et al*., 2017). Slope angle of (45-60)º was preferred on warmer southern aspect and (15-30)º slope angle was avoided by them in Meigu Dafengding National Nature Reserve (Zhou *et al*., 2013).

2.3 Conservation threats of Red Panda

Habitat loss and poaching are the biggest threats to Red Panda in India as legal and illegal felling of trees is common (Choudhury, 2001). In the Khast Hills of Meghalaya some of the best habitat is privately owned. Habitat are losing due to commercial logging, demand for firewood (especially in the cold Himalaya), clearing for habitation and farming, jhum (slash-and-burn shifting cultivation) by hill tribes, grazing of domestic stock, monoculture forest plantation, and various developmental activities. Similarly poaching and hunting are major threats in China and Myanmar (Wei *et al.*, 1999; IUCN, 2015). People from more than 10 villages in the Meigu Dafengding National Nature Reserve depend directly or indirectly on the Reserve for their livelihood. Red Panda pelts are found in many local markets (Glatson, 1994). Its' fur is often used in wedding in China. The 'good- luck charm' hats are used by Chinese newly- weds (Roberts, 1983). In Emaw Bum region of Myanmar more than 5,000 km^2 had been logged since 1999–2000 and many new roads were made into mountain areas (IUCN, 2015). Road construction, harvesting of timber, bamboo and minor forest products, livestock grazing, inefficiently managed tourism, and domestic dogs are causing threat for Red Panda in Bhutan (Dorji *et al.*, 2011). In Nepal Red Panda is one of the 27 protected species but their numbers are decreasing day by day due to Forest fire, rotational grazing, slash and burn cultivation, timber and fire wood collection, predation by dogs, natural dying of ringal bamboo species, inbreeding depression, drought, landslide, agriculture expansion, lack of awareness and development activities on the Red Panda habitat are identified as the major conservation threats throughout its habitat within the country (Wei *et al*., 1998; PHVA, 2012; Bista and Paudel, 2013, Bista *et al.*, 2017). Livestock grazing, habitat destruction and fragmentation, people's dependency on forest for firewood and construction materials, chasing and killing of panda by the locals are the main threats to Red Panda in Kanchanjanga Conservation Area (Mahato and Karki, 2005), DHR (Subedi and Thapa, 2011) ,Sagarmatha region (Mahato, 2004), in Central Himalaya (Acharya, 2018). Livestock rearing and tourism is causing threat in Langtang National Park (Yonzon and Hunter, 1991). Williams (2004) found greatest threat for Red Panda is Predation in Ilam. Two Red Pandas were killed by dogs during study. Red Pandas have been reported to carry high numbers of parasites like *Eimeria*, *Isospora*, *Toxoplasma gondii*, *Angiostrongylus spp*., *Crenosoma spp*. and unknown metastrongyloid nematodes (Grondahl *et al.*, 2005; Patterson-Kane *et al.*, 2009) which suggests a possible link between these endoparasites and the morbidity and mortality of the pandas. Lama *et al*. (2015) found positive result of having gastrointestinal parasites in all the fecal samples. The occurrence rates for different groups of parasites were: protozoa 100.0%, nematodes 52.2%, trematodes 13.0%, and cestodes 4.3%. Bista *et al*. (2017) also found parasitic prevalence in 90.80% (247) out of 272 samples examined. The parasites included seven different species along with three genera of parasites belonging to Protozoans (3 species), Cestodes (1 genus, 1 species) and Nematodes (2 genera, 3 species).

3. MATERIALS AND METHODS

3.1 Study area

Ilam (26º 40' – 27º08' N, 87º40'- 88º10' E) is the eastern district of Nepal which is bordered by Panchthar in the North West, Morang in the South West, Jhapa in the South East and India's Darjeeling District in the East. The district covers mountain terrain and rises from 140m above sea level at Setibeni to 3,636m at Sandakpur covering an area of 1,714 km^2 (DFO Ilam, 2010). Cultivated land of the district covers 54,676 Ha and 49,101 Ha is classified as forest land. There are number of rivers running through the district, the main ones being the Mechi, and Mai khola. The study area extends from Suryodaya municipality- 1, Gorkhe to Mai Jogmai rural municipality-2 (88º04'- 88º58' E, 26º 54'- 27º15'N) Ilam. This area is important for Red Panda mainly because this provides a biological linkage between Kanchenjunga Conservation Area in Nepal and Singhalila National Park in Darjeeling India.

The core study area consists of five different blocks of four community forests: Singhadevi (2,100-2,400m) and Chitre-Hile (2,300-2,500m) of Suryodaya municipality and Chhipchhipe (2,200- 2,700m) and Kalikhop dadheli 1st and 2nd blocks (2,200-2,600m) of Mai-Jogmai rural municipality having area of 13.42 km^2 ranging from 2,100-2,741m located in the Mahabharat range. The highest altitude of each block was distributed until the border of India and below the lowest altitude of each studied block had human settlement area except Chhip- Chhipe block where the malingos were not present. The topography of study area is mostly rugged in most areas.

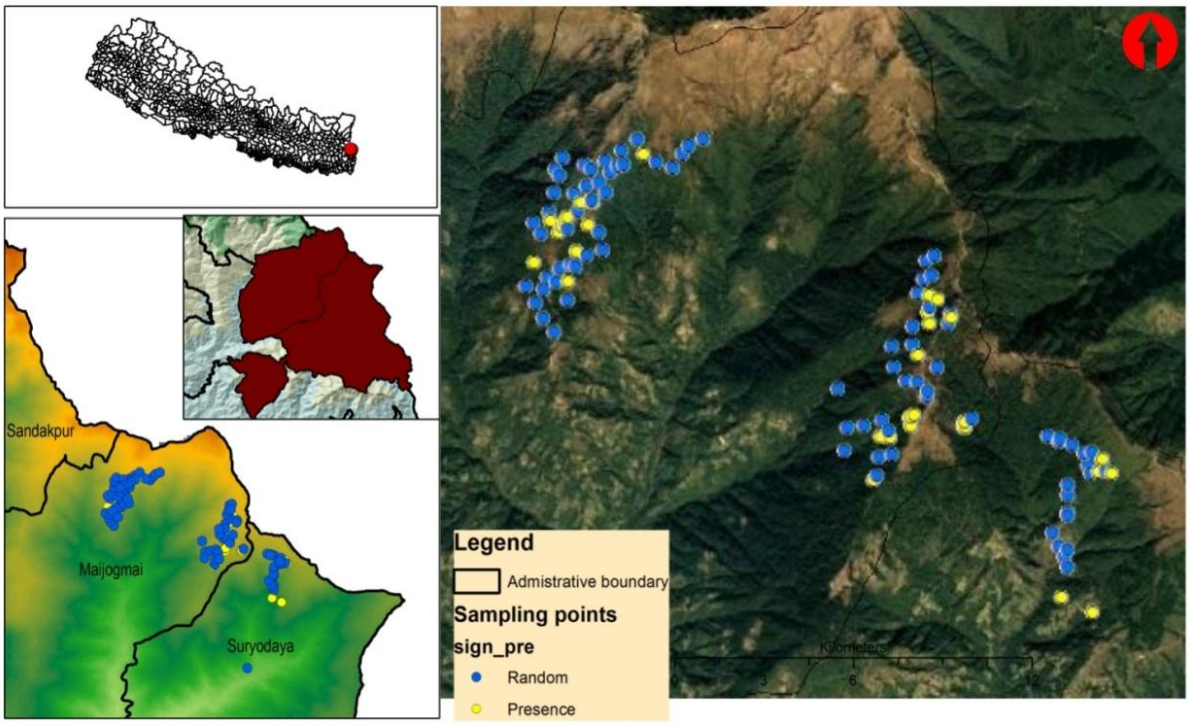

Figure 4: Location of study area in Eastern Nepal

3.1.1 Climate

Ilam district has sub-tropical, lower temperate and upper temperate climate. It harbours lower and upper temperate climate from 1,000 meters up to the altitude of 3,500 meter and covers about 2/3 area of the district.

- **Rainfall**

November and December are the dry months and minimum rainfall occurs in February, November and December (0 mm) however Highest rainfall occurs in August (395.9mm) (Figure 5).

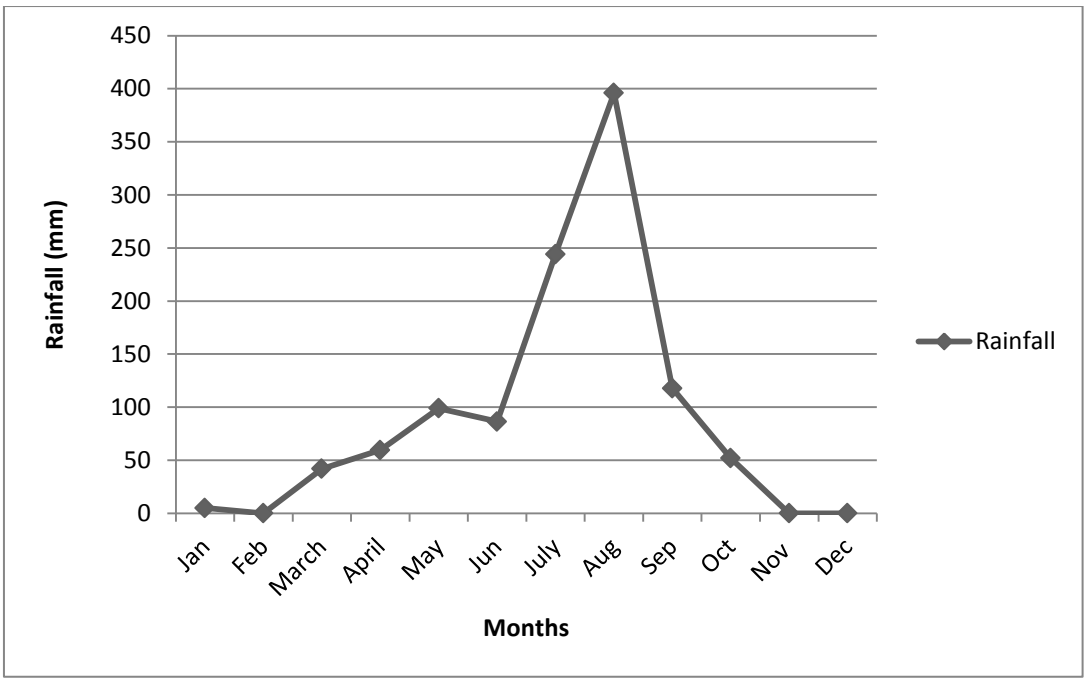

Figure 5: Monthly mean rainfall recorded at the Meteorological station located in Ilam Tea Estate (2017) (Source: DHM Government of Nepal)

- **Temperature**

Hottest months of the year are April, May, June, August and October having maximum temperature (26.8°C) in August where as coldest months are January and February having minimum temperature (6°C) in January (Figure 6).

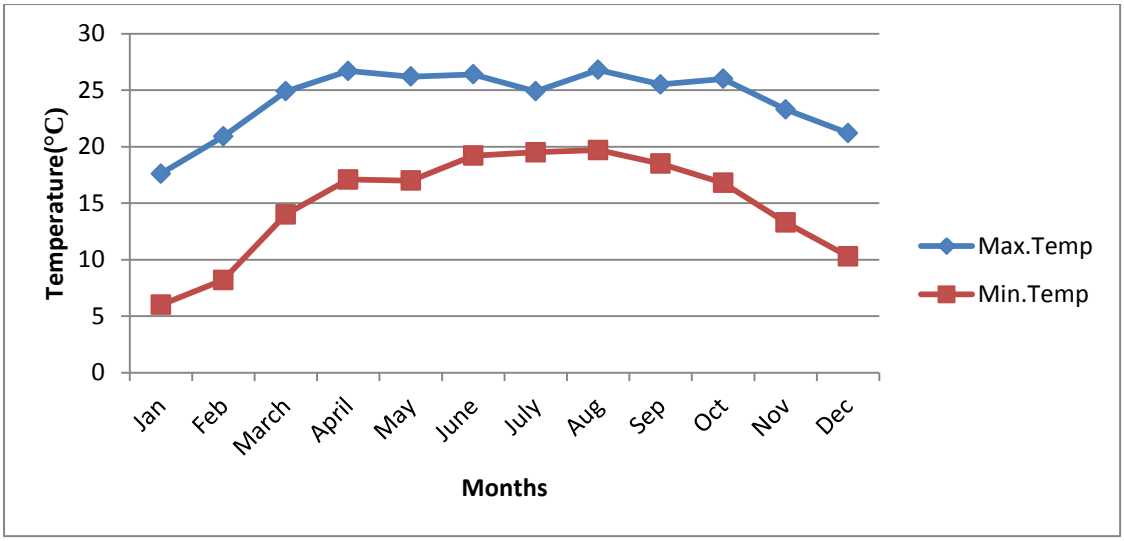

Figure 6: Monthly mean maximum and minimum temperature recorded at the Meteorological station located in Ilam Tea Estate (2016) (Source: DHM Government of Nepal)

- **Relative humidity**

The average monthly maximum relative humidity was 93.1% in July and minimum relative humidity was 57.3% in March (Figure 7).

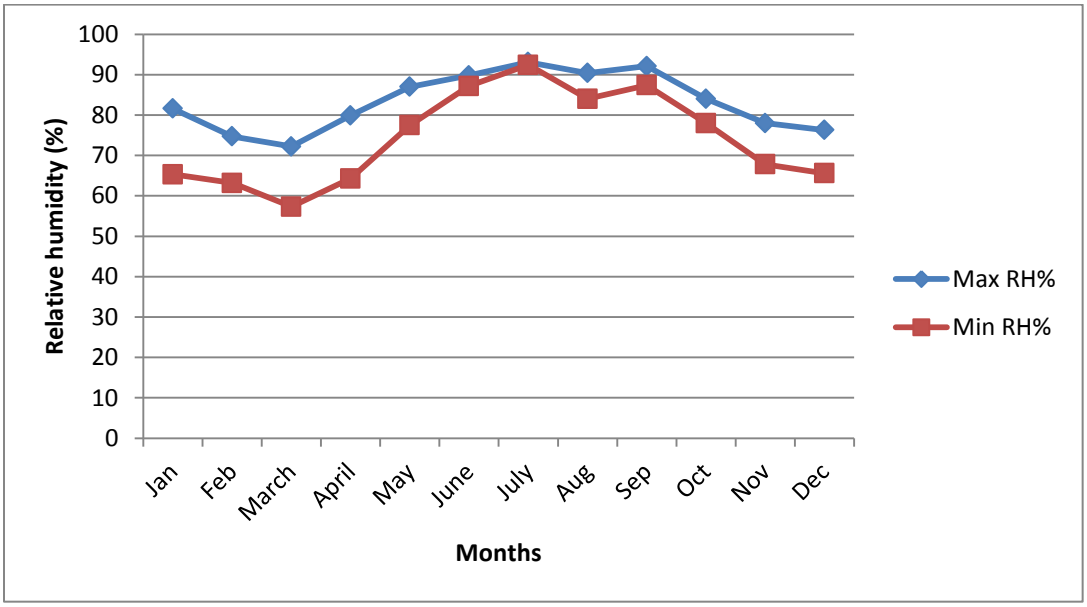

Figure 7: Monthly mean maximum and minimum Humidity recorded at the Meteorological station located in Ilam Tea Estate (2016) (Source: DHM Government of Nepal)

3.1.2 Biodiversity

The forest of the Eastern Himalaya is represented by the eastern Himalayan broadleaf forest. They are dominated by evergreen broadleaf trees (*Quercus, Lauraceae)* in the lower part (2,000-2,500m) and a mixture of evergreen conifers (*Tsuga, Taxus)* and

winter-deciduous broadleaf species (eg *Acer, Betula, Magnolia*) in the upper part (2,500-3,000m). South-facing slope consists of *Rhododendron* species that may co-occur with oak (*Quercus spp*.). These temperate forests support a rich epiphytic community such as dicots, orchids, ferns and mosses. Bamboo (*Arundinaria spp*.) is an important understory vegetation. Subalpine conifer forests begins from about 3,000 m- 4,000m and *Abies* dominates above 3,500m (WWF and ICIMOD, 2001). The study area comprises of lower temperate Broad – Leaved Forest and Upper Temperate Broad- Leaved forest cover (Stainton, 1972).

Lower Temperate Broad-leaved Forest This forest type occurs between 1,700- 2,400m in the east. *Alnus nitida, Castanopsis tribuloides, C. hystrix, Lithocarpus pachyphylla,* and several species of *Quercus* forests thrive in the Mid-hills. *Quercus lamellosa* forests are widespread in central and eastern Nepal. *Lithocarpus pachyphylla* forests occur in eastern Nepal.

Upper Temperate Mixed Broad-leaved Forest (2,500-3,500m): This forest type occurs in central and eastern Nepal, mainly on north and west-facing slopes. *Acer* and *Rhododendron* species are prominent throughout this altitude range. However, *Aesculus/ Juglans / Acer* forests are mostly confined to western Nepal. *Tsuga dumosa, Taxus baccata* and *Acer* species are common associated species in this region.

The major fauna present in Ilam are Common Leopard (*Panthera pardus*), Clouded Leopard (*Neofelis nebulosa*), Himalayan Black Bear (*Solenarctos thibetanus*), Leopard Cat (*Prionaulurus benghalensis*), and Red Panda (*Ailurus fulgens*) (Kandel, 2009). Other common wild mammals include Himalayan Serow (*Nemorhaedus sumatraensis*), Wild Boar (*Sus scrofa*), Yellow Throated Martin (*Martes flavigula*), Porcupine (*Hytrix indica*), Assamese Macaque (*Macaca assamensis*), Himalayan Langur (*Semnopithecus entellus*), Barking Deer (*Muntiacus vaginalis*), Black Giant Squirrel (*Ratufa bicolor*), Golden Jackal (*Canis aureu*) and Giant Flying Squirrel (*Petaurista magnificus*). Important bird species found in upper Mai valley region are Yellow Vented Warbler (*Phylloscopus cantator*), Rufous-thorated Wren Babbler (*Spelaeornis caudatus*), Spiny Babbler (*Tordoides nepalensis*), and Hoary-throated Barwing (*Actinodura nipalensis*) and very rare in Nepal: Asian Fairy Bluebird (*Irena puella*). Other bird species recorded are Monal (*Tragopan satyra*), Pale Headed Woodpecker (*Gecinulus grantia*), Darjeeling Woodpecker (*Dendrocopos darjellensis*), Yellow Billed Blue Macpie (*Rocissa flavirostris*), Himalayan Griffon (*Gyps himalayansis*) (Baral and Inskipp, 2005).

3.1.3 Socioeconomic status

Total population of Suryodaya Municipality is 56,691 including a population of Suryodaya Municipality -1 (Gorkhey) is 5,357 and in Mai-Jogmai rural-municipality total population residing is 21,044. Major ethnic communities are Brahmins, Chettri, Sherpa, Tamang, Thami, Rai, Limbu, Magar, Newar, Kami, Damai, etc. The main occupations are agriculture and animal husbandry and other occupations are tourism, business and government job (CBS, 2011). People from Gorkhe and Jogmai depend on the resources in the community forest for grazing, fodder and timber. Tourism industry is also one of the major sources of income for the villagers living near the community forest.

3.2 Materials used

- GPS (Garmin eTrex® 10)
- Topographic map (1:25,000)
- Camera (Canon EOS 1300D)
- Measuring tape
- Quadrates
- Field stationary
- Herbarium press

3.3 Research design

The potential sites were identified by analyzing topographic map, literatures and preliminary survey. Altitudinal line intercept method was used to assess distribution and relative abundance of Red Panda and ten tree plotless methods is for habitat characteristics. Threats to Red Panda were also observed in the same line intercepts and plots. The questionnaire survey was conducted with the local communities on the presence or absence of Red Panda, their habitat and existing conservation threats. The entire study area was divided into 5 blocks. Within each block altitudinal line intercept (1,000m) were laid out on every 100m altitudinal interval. Systematic plots were created on every 200m on the intercepts. Panda sign plots were also laid out when panda signs (direct or indirect) were encountered.

3.4 Methods of data collection

A combination of preliminary surveys, intensive study based on direct and indirect evidences of the animal and interviews were used to assess the distribution, relative abundance, habitat characteristics, use and threats to Red Panda.

3.4.1 Preliminary field survey

Preliminary survey was carried out from 2-7 December, 2017 to establish the presence/absence of the Red Panda. The existing trails were used to survey the Red Panda signs. During the survey, evidence (indirect and direct) of Red Panda, variables such as the altitude, general habitat characteristics, vegetation of the area, and the presence of any other animal were also recorded. The preliminary survey was done with the help of forest guardian.

3.4.2. Distribution and relative abundance

Field work was done from April to May 2018. Distribution and relative abundance of Red Panda were determined by using altitudinal line intercept following the method used by Williams (2004). The survey was conducted from 2,100m – 2,700m asl. Within each selected blocks the horizontal transects of length 1,000m were established in each 100 m elevation intervals. The existing trails within the selected blocks were also used as transects. Altogether twenty-three transects were established, four in Singadevi, three in Chitre- Hile, six in Chhip-Chhipe, five in Kalikhop-Dadheli 1st and Kalikhop- Dadheli 2nd block and Red Panda evidences were searched for. Apart from direct sighting, among

other evidences, fecal matter was also recorded because it is an effective indicator of Red Panda's occurrence (Wei *et al.*, 2000, Pradhan *et al.*, 2001a, Williams, 2004). On the feeding site, panda usually leave a group of faeces with 8-15 number of pellets in single defecation, but they repeatedly use single site**s** (latrins) which consists of 15- 30 pellets or sometime more than 100 (Yonzon, 1989, Reid *et al.*,1991). The faecal pellets of the Red Panda are spindle shaped with soft, moist, light green colour (Yonzon, 1989).
Government of Nepal (GoN) 1:25,000 survey map was used as altitudinal guides. When the signs (direct or indirect) of Red Panda were encountered then the Garmin eTrex® 10 GPS was used to record the latitude and longitude. During the survey number of times, the direct and indirect signs of Red Panda encounter were recorded.

3.4.3 Habitat assessment

Ten tree plotless methods were used to assess habitat characteristics following the method used by Williams (2004). Plots were established from the closest eleven trees encircling a center point. To derive the area of each plot, distance from the center point to the tenth and eleventh tree was measured and radius of circle was calculated by averaging the two distances (Mueller-Dombois and Ellenberg, 1974; Pradhan, 2001, Williams, 2004). In this study, two types of plots were measured; plots where Red Panda sign were found (panda sign plot) and systematic plots (non- sign plot).The transects established were followed and when the panda signs were encountered then the panda sign plots were laid out. Simultaneously systematic plots were established in every 200m as used by Ghose *et al.* (2011). Garmin eTrex® 10 GPS was used to record the latitude and longitude of panda sign and systematic plot. Parameters including altitude, canopy cover, tree diameter at breast height (DBH), species for all eleven trees, Shrubs, herbs were recorded on both types of plots. Water distance was measured using Google earth. Number of pellet groups and substrate used were also recorded in sign plot.

3.4.3.1 Vegetation sampling

Quadrates of size $3x3m^2$ were used to measure density, cover, and frequency of bamboo and density and frequency of shrubs (Woody plant below 3m height) within eachTen- tree plot following the quadrate size as used by Bullock (2006). Similarly $1x1m^2$ quadrates for herb (plants upto1m height) species were used within the same plot to measure density and frequency. Number and type of shrub and herb species, number, height, and cover of bamboo species were recorded. Some plants were identified in the field with the help of field guide and local people. The herbariums were prepared for unidentified plant species and were taken to Central Department of Botany, Tribhuvan University and identified with the help of plant expert using book "Flora of Bhutan".

3.4.4. Threats assessment

Information relating to threats was identified by direct observation in the field and Questionnaire Survey with local respondents.

3.4.4.1 Direct observation

In both systematic and panda sign plots, three types of threats, livestock grazing, human disturbance (firewood and fodder collection) and malingo cutting were measured on percentage. Percentage of plot grazed by livestock was measured for livestock disturbance and for Human disturbance (H.D.), percentage of plot trees cut for firewood and fodder was measured. Similarly Malingo disturbance (M.D.) in the plot was measured by the percentage of malingo stems cut. The transects were observed directly on both sides of it within 5 meter to identify Red Panda occurrence, presence or absences of predator for Red Panda, number of livestock dung, condition of habitat, poaching (if any traps), habitat condition and development activities etc. The number of livestock dung encountered in transect was counted to make an index of livestock pressure in different sites.

3.4.4.2 Questionnaire survey

A set of semi-structured questionnaire was prepared and randomly interviewed with 50 local people (forest staff, guide, farmer, students, others) to know the information on the status, habitat and specially threats of Red Panda including habitat loss, poaching, grazing pressure, predator of Red Pandas and human dependency on forest (Appendix I).

3.5 Data analysis

The collected information were categorized and tabulated based on the objective to determine status, habitat preference and threats associated with Red Panda. Data were manually processed and analyzed in descriptive way as well as by statistical measure.

3.5.1 Distribution

The sign locations of the Red Panda were overlaid as GIS layers to prepare distribution map using Arc GIS (10.4). To determine the distribution pattern of Red Panda fecal group, variance to mean ratio (Odum, 1971) was used. It is based on the fact that in Poisson distribution, the variance is equal to mean.

If $S^2/X < 1$, Distribution is uniform
If $S^2/X = 1$, Distribution is random
If $S^2/X > 1$, Distribution is clumped

Chi-square test for goodness-of-fit (x^2)

Chi-square goodness-of-fit test was used to determine whether the Red Panda were distributed according to the availability of habitat types. The test was performed by setting hypothesis that the Red Panda was uniformly distributed in all habitat type.
The hypothesis was tested at 5% level of significance.
Under H_0, the test statistic is given by:

$$x^2 = \sum \frac{(O-E)^2}{E} \quad \ldots\ldots\ldots\ldots \quad \text{(n-1) d.f.}$$

Where, O = observed frequency
E = Expected frequency

3.5.2. Habitat selection assessment

3.5.2.1 Vegetation Analysis

Sorensen's Index of Similarity

Similarity of plant species between Red Panda plot and systematic plot were calculated using Sorensen's Index of Similarity (Gysel and Lyon, 1980).

$$\text{Sorensen's Index of Similarity} = \frac{2C}{(A + B)} \times 100\ \%$$

Simpson's index of Dominance

$$\text{Index of dominance (D)} = \sum (ni/N)^2$$

Shannon-Wiener Index *(H)*

Relative abundance of the trees recorded in different Red Panda sign plot and systematic plot was measured in terms of Shannon-Wiener Index *(H)* (Gysel and Lyon, 1980).

$$H = \sum_{n=1}^{s} pi \ln pi$$

Student's *t* test was used to test the significance of differences in value of H obtained for Panda sign and systematic plot (Jayaraman, 2000).

$$t = \frac{|\ H1 - H2\ |}{\sqrt{\text{Var}\ (H1) + \text{Var}(H2)}}$$

Which without the absolute sign of numerator, follows Student's t distribution with v degree of freedom where,

$$v = \frac{((\text{Var}\ (H1) + \ \text{Var}\ (H2))^2}{\frac{(\text{Var}\ (H1))^2}{N1} + \frac{(\text{Var}(H2))^2}{N2}}$$

And,

$$\text{Var}\ (H) = \frac{(\sum \text{pi}\ (\ln \text{pi})^2 - \ (\sum \text{pi} \ln \text{pi})^2)}{N} + \frac{S - 1}{2N^2}$$

Where,

Var (H) = Variance in diversity

N1 and N2 = Number of individuals based on which H1 and H2 are calculated

S = Number of species in a sample

Importance Value Index

To calculate the IVI of tree species, relative density, relative frequency and relative abundance were calculated following the formula mentioned by (Kapur and Govil, 2000).

$$\text{Density} = \frac{\text{Total number of individuals of a species}}{\text{Total number of quadrate sampled} \times \text{Area of quadrate}}$$

$$\text{Relative density (\%)} = \frac{\text{Density of individual species}}{\text{Total density of all species}} \times 100$$

$$\text{Frequency (\%)} = \frac{\text{Total number of plots in which species occured}}{\text{Total number of plot sampled}} \times 100$$

$$\text{Relative frequency (\%)} = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100$$

$$\text{Relative dominance (\%)} = \frac{\text{Basal area of a species}}{\text{Total basal area of all species}} \times 100$$

Where, Basal area $= \pi d^2/4$

d = Diameter at Breast Height

Important value index (IVI) = Relative Density + Relative Frequency + Relative Dominance

3.5.2.2 Digital Elevation Model

Digital Elevation Model (DEM) was used for the feature digitization of slope and aspect. Digital data was downloaded from earth explorer SRTM (1ARC Second Global) Feature and was used for finding slope and aspect value of the panda sign and systematic plot using ARC GIS 10.4. Slope was categorized as gentle slope (0°-10°), moderately steep slope (10°-20°) and (20°-30°), steep slope (30°-40°) and very steep slope (>40°). Aspect was categorized into Flat, North, Northeast, East, Southeast, South, Southwest, West and Northwest.

3.5.2.3 Generalized linear model of habitat analysis

Both the presence data and absence data were collected from the field. Habitat selection was examined by comparing habitat variables at occupied sites by Red Panda with those at unoccupied sites. The random points were taken from the absence point data during the line transect. All the absence points obtained from the line transect were given a specific number and forty one points were randomly selected by lottery method. Firstly accessing the differences in each scale and variables using a generalized linear model (GLM) was performed, assuming the binomial distribution of errors and logistic link function. The response variables were either one (presence point) or zero (absence point).The response variable can be affected by correlation among explanatory variables hence a multivariate model for each scale was developed. Using Akaike Information Criteri (AIC) for the model selection, stepwise approach in multivariate model was performed for the variable

seletion. No any variable was added if the AIC didn’t decreas by two units. All the statistical analysis was performed using R 3.5.1 (Rcore Team 2018).

3.5.3 Threats

Cattle dung found in each transect was used to calculate dung encounter rate using following formula used by Mahato (2004) and Thapa (2010).

$$\text{Cattle dung encounter} = \frac{\text{Total number of cattle dung encountered}}{\text{Total transect length (km)}}$$

Data were arranged in Microsoft Excel 2007 and was statistically analyzed using Microsoft Excel spreadsheet and R 3.5.1. The Microsoft Excel Sheet was used to find Shannon- Wiener Index of diversity, Simpson's index of dominance, similarity index, importance value index of tree species, density and frequency of shrub and herb species and performing Student's'*t* ' test (at 5% significance level) to test any significant difference in diversity indices between panda sign and systematic plots while R was used for doing Generalized Linear Model.

4. RESULTS

4.1 Distribution of Red Panda in Ilam

Presence of the Red Panda was confirmed in Gorkhe and Jogmai, Ilam. A total of 63 pellets groups and a Red Panda were recorded. Total of 15 transects summing 15 km were studied in Lower temperate broad- leaved forest (1,700-2,400m) where 51.56% of signs were recorded including a direct sighting. Similarly eight transects of eight km in Upper-temperate mixed broad- leaved forest (2,500-2,741m) yielded 48.43% pellet groups of panda.Relatively higher frequency (68.25%) of signs were recorded in elevation range from 2,400-2,500m. The Red Panda signs were found to be distributed at altitude range from 2,200- 2,700 m.

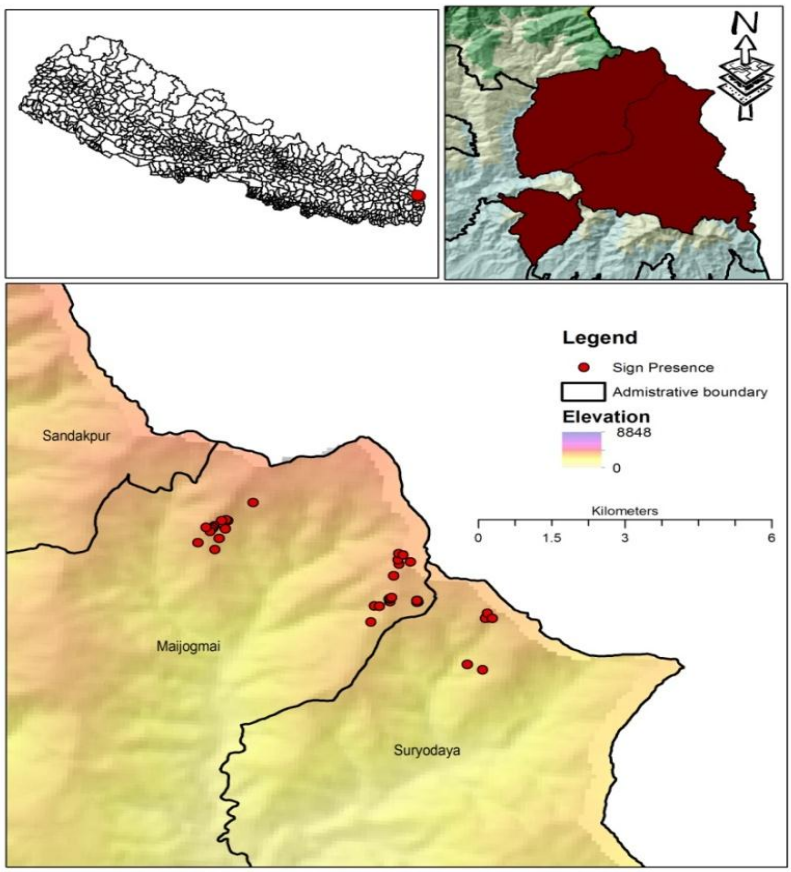

Figure 8: Distribution map of Red Panda in Gorkhe and Jogmai

The variance to mean ratio was found to be greater than 1, so the distribution pattern of Red Panda fecal group was clumped and Red Pandas were evenly distributed in different habitat type available the study area (S^2/ X= 3.91 >1, $x^2 = 0.031 < x^2_{0.05.}$ at 1 d.f).

4.2 Relative sign abundance

Among the total 133 plots laid out, 30.82% contained Red Panda sign. The average sign encounter rate ranged from of 0.4/km in Kalikhop- Dadheli 2nd block to 4/km in in Chitre-Hile and Kalikhop- Dadheli 1st block (Table 1).

Table 1: Encounter rate of Red Panda sign groups/km in the five blocks in different altitudes

Name of blocks	Altitude (m)							Average
	2,100-2,199	2,200-2,299	2,300-2,399	2,400-2,499	2,500-2,599	2,600-2,699	>2700	
Singadevi	0	2	2	5	_	_	_	2.25
Chitre-Hile	_	_	1	2	9	_	_	4.0
Chipp-Chhipe	_	1	3	2	8	3	3	3.33
Kalikhop Dadheli 1st	_	0	2	11	6	1	_	4.0
Kalikhop Dadheli 2nd	_	1	1	0	0	0	_	0.4
Average	0	1.0	1.8	4.0	5.75	1.33	3.0	

No Red Panda sign was recorded in the lowest altitudinal range (2,100- 2,199m) and the highest encounter rate was 5.75/km in 2,500-2,599m altitude.

4.3 Habitat characteristics

Among the 133 plots surveyed, 92 were systematic and 41 were panda sign plots. Maximum (32%) Red Panda sign plots were recorded in Chhip- Chhipe block however minimum (5%) in Kalikhop- Dadheli 2nd block (Appendix II).

4.3.1 Species diversity, dominance and similarity index in panda sign and systematic plots

Shannon-Wiener index of diversity was found higher in systematic plot (2.71) than panda sign plot (2.46). The t- test indicated that there was no significant difference between the diversity indices of panda sign and systematic plots ($t = 1.84 < t_{0.05}$ at d.f. $= \infty$).

Table 2: Variation of Dominance index, Diversity index, Evenness, Species richness, Var (H) and similarity index in systematic and panda sign plots

Plot type	Dominance index	Diversity Index	Evenness (E)	Species richness	Var(H)	Index of Similarity
Red Panda sign plot	0.12	2.46	0.12	20	0.002083	70.58 %
Systematic plot	0.09	2.71	0.08	31	0.01649	

Tree species were more evenly distributed in Red Panda sign plot than systematic plot. Similarly, Index of dominance was found higher in Red Panda sign plot than in systematic plot. Sorensen's similarity index indicates high similarity in terms of vegetation between the systematic and sign plots (Table 2).

4.3.2 Importance Value Index of tree species in Red Panda sign and systematic plots

Species composition of tree differs between Red Panda sign and systematic plots. A total of 32 species of tree species were recorded in the 133 plots, panda sign plots having 20 species and systematic plots having 31 species. Important plant species in the panda sign plots were *Lithocarpus pachyphylla* (45.05), *Symplocos theifolia* (37.19), *Symplocos pyrifolia* (20.99), *Quercus lamellose* (19.25), *Magnolia campbelli* (17.25), *Litsea salicifolia* (16.36), *sorbus cuspidate* (16.17), *Lyonia ovalifolia* (15.80), *Quercus glauca* (15.45), *Hymenodictylon excelsum* (15.13), etc. on the basis of IVI (Appendix: IV).

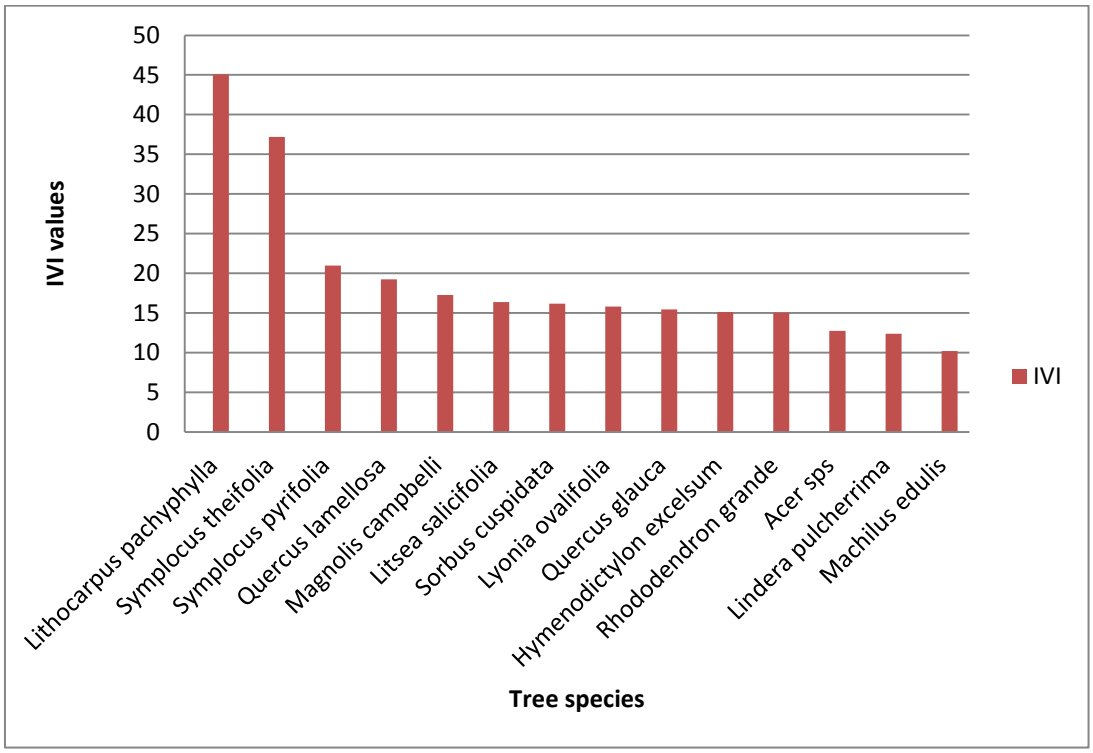

Figure 9: Bar chart showing the IVI values of the major trees (IVI > 10) in panda sign plot.

In the systematic plots, important plants species present were *Lithocarpus pachyphylla* (36.83), *Symplocos theifolia* (31.79), *Quercus lamellose* (23), *Quercus glauca* (17.07), etc. (Appendix: V).

4.3.3 Analysis for shrub species

A total of 15 species of shrubs were recorded in plots along all transects. *Arundinaria maling* was the most common shrub species in all plots. It was found in the study area with frequency of occurrence 92.48% and was present in all panda sign plot with the density 20/m^2. The mean number of culms per plot was 175 in panda sign plot. Other shrub species *Daphne bholua*, *Viburnum erubescens*, *Eupatorium adenophorum*, *Sarcococca coriacea* had highest density and frequency in panda sign plot (Appendix: VI).

Arundinaria maling was present with frequency of 89.13%, density 14.32/m^2 in systematic plot and mean number of culms per plot was 144.17. Shrub species including

Daphne bholua followed by *Viburnum erubescens* had highest density and *Viburnum erubescens*, *Daphne bholua*, *Pteris sp.* had highest frequency in the systematic plots (Appendix: VII).

4.3.4 Analysis for herb species

Total of 20 species of herb were present in the study area. The most common species present in panda sign plot was *Pteridium aquilinum*. The highest density and frequency of herbs including *Pteridium aquilinum, Elastostema sessile, Rubus sp., Viota sp.* were present in panda sign plot (Appendix VIII). Similarly in systematic plot, the most common herb species present was *Pteridium aquilinum*. Herb including *Pteridium aquilinum*, Harkato, *Elastotema sessile, Rubus sp.* had highest density and frequency in the systematic plots (Appendix: IX).

4.3.5 Substrate use by Red Panda

The overall substrates used by Red Panda for defecation were found mostly on tree branches (78.12%) followed by forest floor (15.62%) and rocks (6.25%) (Table3). Red Panda used tree branches and forest floor for defecation in Singadevi and Kalikhop-Dadheli 1st block. Similarly, they defecated on trees, forest floor and rocks in Chitre- Hile and Chhip- Chhipe block. All the signs were recorded on tree branches in Kalikhop – Dadheli 2nd block.

Table 3: Percentage deposition of Red Panda fecal matter in different categories of substrates

Substrates use (%)			
Name of blocks	Tree branch	Forest floor	Rock
Singadevi	66.66	33.33	0.00
Chitre-Hile	58.33	33.33	8.33
Chhip- Chhipe	80.95	4.47	14.28
Kalikhop- Dadheli 1st	90.00	10.00	0.00
Kalikhop – Dadheli 2nd	100.00	0.00	0.00
Overall	78.12	15.62	6.25

Red Panda used 14 plant species namely *Lithocarpus pachyphylla* (28.3%), *Symplocos pyrifolia* (13.3%), *Rhododendron grande* (13.3%), *Eurya acuminate* (8.3%), *Quercus glauca* (5%), *Hymenodictylon excelsum* (5%), *Magnolia campbelli* (5%), *Evodia fraxinifolia* (3.3%), *lindera pulcherrima* (3.33%), *Quercus lamellosa* (3.33%), *Litsea salicifolia* (3.33%), *Acer spp* (1.6%), *Castanopsis hysterix* (1.6%) and *Lyonia ovalifolia* (1.6%) for defecation.

4.3.6 Deposition of fecal matter (in %) by Red Panda in different slope and aspect categories

Majority (39.02%) of the Red Panda signs were recorded in moderately steep slope (10-20°) followed by 31.70% signs in 20-30° slope and 25% in steep slope (30-40°). Only

2.43% of Red Panda signs were recorded from gentle slope (0-10°) however no signs were present in very steep slope (>40%) (Figure10).

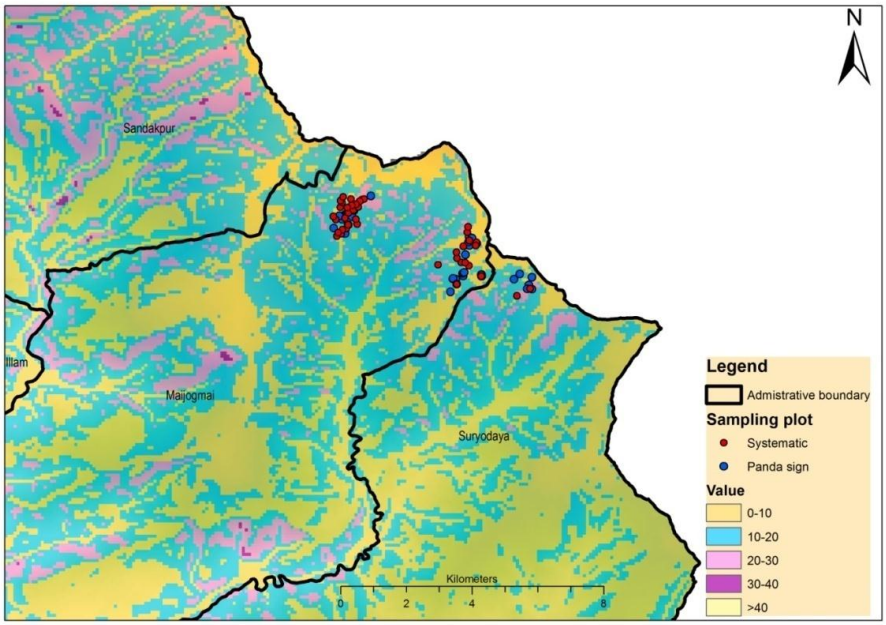

Figure 10: Deposition of fecal matter (in %) by Red Panda in different slope categories

Majority (43.90%) of panda signs were recorded from Southeast facing aspect whereas 26.82% from West facing aspect, 12.19% from South facing aspect, 9.75% from East facing aspect, 7.31 % from Southwest facing aspect and no panda signs were found from flat, North, Northeast and Northwest facing slope (Figure 11).

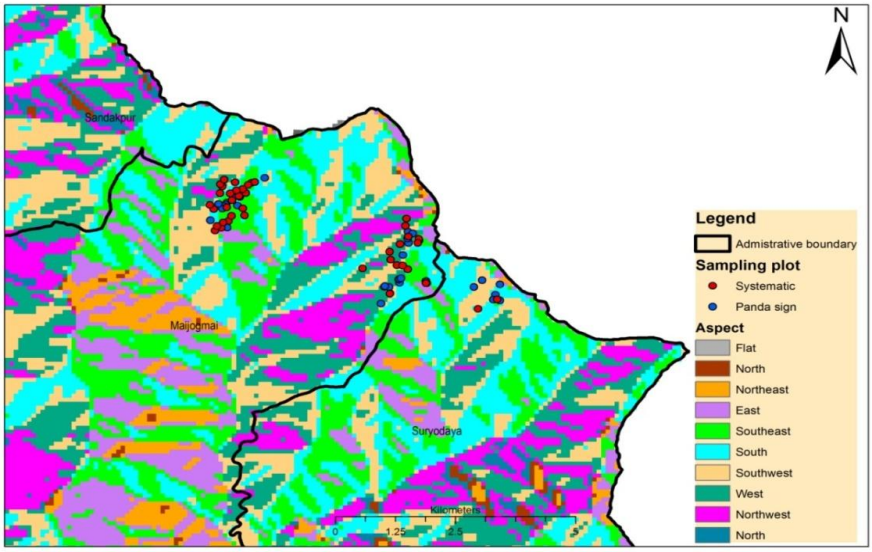

Figure 11: Deposition of fecal matter (in %) by Red Panda in different aspect categories

4.3.7 Habitat preference of Red Panda

Among the 13 variables (Altitude, Canopy Canopy , Bamboo Cover , Bamboo Density , Bamboo Height , Basal Area , Shrub Density ,water distance,slope , aspect, Malingo cutting , Human Disturbance , Livestock Grazing), Univariate GLMs (Table 4) showed only three variables namely bamboo density, bamboo height and distance to water

sources had significant influence for the habitat selection by Red Panda. The most important factor was proximity to water with greatest explanatory power (D^2= 22.5%). Distance to water showed negative response indicating increase in distance causes decreases in the rate of Red Panda presence. Bamboo density (D^2=4.87%) and bamboo height (D^2=7.81%) showed positive response indicating Red Panda presence increases with the increase in bamboo density and bamboo height (Table 5).

Table 4: Univariate GLMs for Significance test of Red Panda presence with different habitat variables

Models/Variables	Estimate	Std. Error	z value	Pr(>|z|)	D^2
Bamboo Density	0.007165	0.003181	2.253	0.0243 *	0.04873
Bamboo Height	0.4149	0.1517	2.736	0.00622 **	0.07814
Water distance	-0.007041	0.002013	-3.498	0.000468 ***	0.22465
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 D^2= explained deviance					

However, Multivariate GLMs showed bamboo density, bamboo cover, water distance, altitude, canopy cover and slope were major ecological factors causing significant impact on habitat selection by Red Panda. The most significant factor was water distance (E=-0.009805, D^2 =34.8%) followed by bamboo density (E=0.022162, D^2= 4.87%), bamboo cover (E=-0.049678, D^2 =12.6%), altitude (E=-0.007647, D^2 = 39%) and canopy cover (E=0.049195, D^2 =43.6%), slope (E=-0.102326, D^2 =46.6). However bamboo height was not associated. The best-fit model for habitat selection by Red Panda was obtained using the variables distance to Bamboo density, Bamboo Height, bamboo cover, water distance, altitude, canopy cover and slope (Table 5).

Table 5: Multivariate GLMs for Significance test of Red Panda presence with different habitat variables.

Models/Variables	Estimate	Std. Error	z value	Pr(>|z|)	AIC	D^2
Bamboo Density	0.022162	0.008604	2.576	0.0100 **	113.7	0.0487
Bamboo Height	0.256086	0.20978	1.221	0.2222	109.7	0.088
Bamboo cover	-0.049678	0.022408	-2.217	0.0266 *	107.3	0.126
water distance	-0.009805	0.002518	-3.894	9.87e-05 ***	84.07	0.348
Altitude	-0.007647	0.003269	-2.339	0.0193 *	81.34	0.39
Canopy cover	0.049195	0.021659	2.271	0.0231 *	78.11	0.436
Slope	-0.102326	0.058709	-1.743	0.0813.	76.1	0.466
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 AIC=Akaike information criterion D^2= explained deviance						

4.4 Threats on Red Panda

Based on ocular observation and questionnaire survey, livestock grazing, human disturbance and malingo cutting were main anthropogenic threats to Red Panda as they were prevalent in all the blocks visited. Red Panda were also threatened due to land encroachment by the construction of permanent Goths (Sheds). Singadevi block had highest (7) cattle sheds followed by Chitre- Hile (4), Chhip- Chhipe and Kalikhop-

Dadheli 1st (2) and lowest (1) in Kalikhop- dadheli 2nd block. Each cattle sheds had 10-30 cattle and people from village rear 3-6 cattle in each house.

Table 6: Cattle dung distribution in the five different blocks

Blocks	Cattle dung encounter rate per km								Panda sign ER
	2,100-2,199m	2,200-2,299m	2,300-2,399m	2,400-2,499m	2,500-2,599m	2,600-2,699m	>2,700m	Average	
Singadevi	90	35	50	10	_	_	_	46.25	2.25
Chitre-Hile	_	_	0	15	50	_	_	22	4
Chhipchhipe	_	40	30	50	85	42	5	42	3.5
Kalikho-dadheli 1st	_	8	14	90	35	4	_	30.2	4
Kalikhop-Dadheli 2nd	_	30	30	50	45	50	_	41	0.4
Average	90	28.25	25	43	54	32	5		2.78
Panda sign ER	0	1	1.8	4	5.75	1.33	4		

Livestock grazing was assessed through cattle dung encounter rate. Average cattle dung encounter rate was highest at 2,100-2,199m (90/km) and lowest (5/km) was at >2700m altitude (Table 6). Taking the individual blocks in consideration, highest encounter rate (46.25/Km) was occurred in Singhadevi block while lowest (22/km) in Chitre- Hile block (Table 6).

Among the respondents, 18% totally depend on firewood as only source of energy and 82 % use both firewood and LPG for cooking purpose, but LPG is used only in emergency. They informed trees species such as *Castonopsis hysterix, Quercus lamellosa, Quercus glauca, Symplocos pyrifolia*, *Symplocos theifolia* are mostly used as firewood and fodder. All the people who live in shed for the purpose of rearing cattle also produce cheese locally so firewood consumption has been increased. All respondents told that they collect malingo for making kitchen, cattle shed, baskets, fencing agricultural land as well as for fodder to cattle.

Among the total plots, the anthropogenic disturbances were observed in 70.67% (n=94) plots. Out of 41 panda sign plots, disturbance was observed in 56.09% of plots and 77.17 % of 92 systematic plots were disturbed.Total of 181 disturbance was counted in study area and the highest was livestock grazing (41%) followed by human disturbance (32%) and malingo cutting (27%) (Figure12).

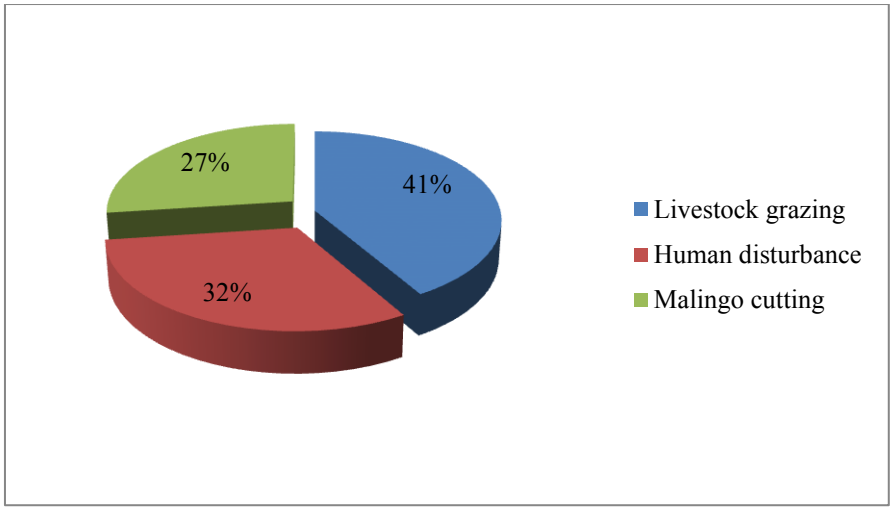

Figure 12: Percentage of anthropogenic disturbance in Red Panda habitat

5. DISCUSSION

5.1 Distribution of Red Panda

The distribution pattern of Red Panda sign in this study area follow a clumped pattern (S^2/ X= 3.91 >1), which is almost the rule and common in nature (Odum, 1971). Clumped pattern of distribution was also recorded in Buffer Zone of Sagarmatha National Park by Mahato (2004), Kandel (2008) in DHR and Kandel (2009) in Hangetham and Choyatar CF of Eastern Ilam. The even distribution ($x^2 = 0.031 < x^2_{0.05.}$ at1 d.f) of Red Panda in different type of habitat in the study area may be due to uniform distribution of habitat resources (food, water resources and cover).

The Red Panda ranged between 2,200 m to 2,700 m with relatively high abundance in elevation between 2,400m – 2,500m. In general Red Panda occurred in the temperate forests of Himalayas at an altitudinal range between 2,200m – 4,800m (Yonzon and Hunter, 1989). Various studies in different habitats revealed that the Red Panda are restricted within narrow range of elevation (Yonzon, 1997; Pradhan *et al.*, 2001b; Mahato, 2003; Williams, 2004; Kandel, 2009; Panthi, 2011; Ghose *et al.*, 2011; Sharma, 2012; Bhatta *et al.*, 2014) indicating resources availability, local microenvironmental conditions and anthropogenic factors play important role in the distribution of Red Panda. The lowest altitude where Red Panda was reported in Singalila National Park was at 2,400m asl (Pradhan *et al.*, 2001a) and 2,442m asl in eastern Ilam (Williams, 2004). Similarly, Chalise (2009) and Kandel (2009) recorded Red Panda at 2,280 m asl in Hangetham and Choyatar community forests of Ilam. In this study also a Red Panda was encountered during transect walk in Singadevi block at an altitude of 2,425m elevation on the branch of *Lithocarpus pachyphylla*. Sighting of single Red Panda indicate its solitary nature (Yonzon and Hunter, 1991b).

5.2 Relative sign abundance

No records of Red Panda signs in lower elevation might be related to unsuitable habitats as well as collection of malingo, firewood and fodder by local people and livestock grazing. Somewhere, there was very steep rocky area with very less vegetation cover in the upper range causing unsuitability for them. Abundant distribution of Red Panda signs in the middle elevtion (2,400-2,500 m) in Gorkhe and Jogmai area could be correlated with least human disturbance and good high vegetation coverage especially Malingo cover. Present finding was different with the conclusion of Williams (2004). The most preferred altitudinal range was 2,800-3,000m in Jamuna and Mabu village Ilam (Williams, 2004) and Kandel (2009) reported maximum sign abundance in between altitudinal range of 2,700-2,900m asl in Hangetham and Choyatar CF. All these reports clearly indicate that Red Pandas are found in diverse altitudinal range and distribution might be correlated with the local ecology, disturbances and resource availability.

5.3 Habitat preference

In this study the occurance of fecal group was used to assess the micro habitat use by Red Panda. Red Pandas probably rely on mature trees especially mature fir in conifer forest for resting, denning and escape from predators (Yonzon and Hunter, 1991; Glatston, 1994).

Plants species in Red Panda sign and systematic plots were almost similar (S= 70.58%). The t- test revealed no significant difference in the Shannon – Weiner index of diversity between panda sign and systematic plots ($t = 1.84 < t_{0.05}$ at d. f. $= \infty$) could be due to that sign plot had 20 and systematic plot had 31 tree species having nearly similar evenness (evenness for panda sign plot = 0.1232 and systematic plot= 0.0876). Higher proportion (78.12%) of the pellet group detection on trees than forest floor (15.62%) and rocks (6.25%) can be related with its arboreal nature of the Red Panda which spends most of its time on trees for foraging and resting as well as escaping themselves from ground dwelling predators. But, fecal pellet was reported occasionally on ground which may be due to their need for water and bamboo shoots. Pradhan *et al.* (2001a) reported deposition of fecal matter on trees (81.25%) indicating most preferred defecation site during pre-monsoon (March- May). Tree as the most preferred site for defecation was also recorded in other studies (Williams, 2004; Kandel, 2009; Bista *et al.*, 2017). In this study 14 plant species including *Lithocarpus pachyphylla* (28.3%), *Symplocos pyrifolia* (13.3%), *Rhododendron grande* (13.3%) etc were found to be mostly used for defecation. That might be due to higher DBH and large trunk of the trees provide the facilities for resting, nesting, and escaping from predators (Yonzon and Hunter 1991b; Williams, 2004). Similar types of tree species used for defecation were also recorded in the study of Pandhan *et al.* (2001b), Williams (2004) and Kandel (2009).

The high bamboo density and dense canopy cover were positively associated with the distribution of Red Panda in Ilam while dense bamboo cover, increasing water distance, increasing elevation and very steep slope were negatively associated. Positive response of high bamboo density might be due to its feeding behaviour because bamboo leaves and shoots together constitute 83% of the Red Panda diet (Yonzon and Hunter, 1991b) as they die without bamboos (Williams, 2004). Red Pandas occupy dense bamboo forests (Yonzon and Hunter 1991; Pradhan *et al.*, 2001b). Similarly, bamboo was recorded in nearly 89% of the sign plots in CHAL, with density ranging from 0.21 to 31.81 bamboos culm/m^2 and an average value of 6.01±5.59 culm/m^2 (Bista *et al*., 2017). Dense canopy cover was preferred by Red Panda in the study area. It is one of the important habitat components in the Red Panda habitat and mostly prefers forest with greater canopy cover (Pradhan *et al.*, 2001b, Williams, 2004). Panthi (2011) also recorded Red Panda from the areas having the dominant trees with large DBH, greater height and broader canopy cover as they used crown cover for resting, hiding and thermoregulation. That might be due to a good quality canopy provides better shelter and safety from predators and easy movement from the branches of trees (Pradhan *et al*., 2001b; Reid *et al.*, 1991). In open canopy cover, mainly grassland is occurred such area is highly disturbed by livestock and human so Red Panda avoid such disturbed area. This result was further supported by study of Pradhan *et al.* (2001b), Williams (2004), Han *et al*. (2004), Panthi *et al.* (2012), Zhou *et al.* (2013) and Bhatta *et al*. (2014).

Negative response of bamboo cover, water distance, altitude and slope suggested that the presence of Red Panda decreases with increase in bamboo cover, water distance, altitude and slope in Ilam. In the study area very dense canopy cover caused less growth of bamboo that's why medium bamboo cover had occurred in Red Panda habitat. Similarly, Kandel (2009) found more fecal groups (46.43%) on 26-50% bamboo coverage followed by 27.39% on 51- 75% coverage and only 9.52% in the highest bamboo cover (76-100%). Proximity to water may be the important habitat requirement for Red Panda (Yonzon and Hunter, 1991a). They rest most (51-55%) of the day time taking bamboo and other supplemental food full of digestive tract (Reid *et al*., 1991). For such process they need to drink water frequently for easy digestion. Proximity to a water source is probably important to supplement the low water content associated with bamboo leaves (Reid *et al.*, 1991; Yonzon and Hunter, 1991; Pradhan *et al.*, 2001b). These all support that Red Panda prefer the area near from water resources. The result was further supported by study of Yonzon and Hunter (1991a), Kandel (2009), Dorji *et al.* (2011), Zhou *et al*. (2013), Bhatta *et al.* (2014), Bista *et al*. (2017).

Red Panda was present within elevation range of 2,200-2,700m with most preferable range 2,400-2,500m in the study area. This might be due to lower part was highly disturbed area and Upper range was least preferred because somewhere there was very steep rocky slope with very less vegetation cover which causes unsuitability to them therefore the middle range was preferred due to least disturbed area, absence of steep rocky area and resources availability. Slope was also found to have the significant impact on the Red Panda presence as they highly preferred the area with moderately steep slope which may be for their safety than in gentle slope. Also in moderately steep slope trees and shrub branches intersect with leaf layer of bamboo and easily achieve by them. However there is high competition between Red Panda and livestock in gentle slopes as lowest range was mostly used by livestock for grazing in the study area therefore gentle slope was least preferred by Red Panda. Avoidance of very steep slope can be related with elevation range. The result was similar with the finding of Panthi (2011) in DHR, Bhatta *et al*. (2014) in Jumla and Ghose *et al*. (2011) in Sikkim as they also found moderate slope as important habitat features ideally suited to the Red Pandas.

5.4 Potential threats

The Red Panda is threatened by habitat loss, fragmentation, poaching and inbreeding depression (Wei *et al*., 1999). MoFSC (2016) estimated that nearly 70% of Red Panda habitat remained outside the protected areas and has higher risk due to human pressure. Red Pandas are disturbed by overlapping habitat with other livestock (Mahato, 2004; Karki, 2009; Thapa, 2010).

Present study has identified that habitat loss was serious threats of Red Panda. Agriculture and animal husbandry were the main occupation of villagers. Cattle dung encounter rate was highest at 2,100-2,199m where no Red Panda signs were found. This shows that livestock spend most of time in lower elevation. Singadevi block had maximum livestock pressure because there was highest number (seven) of sheds in comparison to other blocks and more proximity from human settlement area. The area having overgrazed consists of higher cattle dung encounter rate and unsuitable for Red Panda. Least

livestock grazing in the highest altitudinal range might be due to steepy slope and occurrence of rocky area. Presence of human being and livestock may cause serious problem to its existence due to it's shy nature and may run away from their habitat. It also might create disturbances in the mating activities of Red Panda. Chitre- Hile block was least disturbed in comparison to other blocks because there was very high bamboo density and livestock grazing was almost impossible. Due to which sign encounter rate was also highest (4/km) in Chitre- Hile block. Villagers totally depend on the forest for timber and non timber forest products causing serious threats on Red Panda habitat and major feeding species *Arundinaria* is consumed by people for various purposes. Similarly presence of Yak, their herders and dogs, cattle grazing and firewood collection were also the major threats to Red Pandas in Langtang National Park (Yonzon and Hunter, 1991a; Yonzon *et al*., 1991). Two cheese factories inside the park had caused over comsumption of firewood. People's dependency on forest for firewood, timber and ringle bamboo collection, livestock grazing, illegal felling of green trees, hunting, poaching, tourism, predation, natural dying of ringal bamboo species, lack of awareness are main threats of Red Panda in Nepal (Mahato, 2004; Mahato and Karki, 2005; Kandel, 2008; Panthi, 2011; Sharma, 2012). However hunting and poaching were not recorded in my study area. Similar threats have been recorded in India, China, Bhutan and Myanmar (IUCN, 2015). Choudhury (2001) found both the legal and illegal felling of old- growth trees throughout the Red Panda occurrence area in India. Some of the important tree species for Red Panda habitat such as *Lithocarpus pachyphylla, Symplocos theifolia*, *Symplocos pyrifolia*, *Quercus lamellose, Rhododendron spp* are felled to meet their local demands especially for timber and firewood, which causes disturbance in Red Panda habitat.

6. CONCLUSION AND RECOMMENDATIONS

The study conducted on April-May 2018 confirmed the presence of Red Panda in Singadevi and Chitre- Hile CF of Suryodaya Municipality- 6 Gorkhe and Chhip- Chhipe and Kalikhop- Dadheli CF of Mai- Jogmai Rural Municipality Ilam. The evidences (direct and indirect) of Red Panda were found to be distributed from 2,274- 2,715m. The most preferred range of Red Panda habitat was 2,400-2,500m where the sign abundance rate was 4.9 groups/km. Bamboo densities, bamboo cover, water distance, altitude, canopy cover and slope were found to have significant impact on the habitat selection. Bamboo density and canopy cover showed positive response however bamboo cover, water distance, altitude and slope showed negative response. Altitudinal range of 2,400 - 2,500 m (moderately steep slope) close to water resources having high bamboo density and canopy cover with less bamboo cover was preferred by them. Red Panda mostly used tree as substrate for defecation. Tree species such as *Lithocarpus pachyphylla*, *Symplocos theifolia*, *Symplocos pyrifolia*, *Quercus lamellose*; shrub species of *Arundinaria maling*, *Daphne bholua*, *Viburnum erubescens, Eupatorium adenophorum* and herb species of *Pteris sp., Elastostema sessile, Rubus sp., Viota sp.* are mostly preferred by them. Continuous habitat loss was the major threat associated with Red Panda in the study area. Anthropogenic disturbance including livestock grazing, human disturbances and Malingo cutting were serious threates for their existence. Red Panda in the study area can be conserved by launching livelihood development program of villagers, conservation awareness program and strict implementation of rules and regulations.

The following are some of the recommendations arisen from the study which will help to conserve Red Panda as well as other flora and fauna of the forests.

1. Though some forests of Ilam are good habitat of Red Panda, very less research activities on it have been conducted. So further research is necessary to explore new potential sites in Ilam and a comprehensive ecological study of Red Panda in identified habitat should be done to determine the specific habitat requisite of the species.
2. Illegal and unmanaged collection of fodder and consumption of malingo is rampant in the area. So the forests authorities should be more attentive in protecting the forest.
3. Training should be conducted on improved cooking stove as alternative energy source in order to reduce the existing pressure on forests.

7. REFERENCES

Acharya, K.P., Shrestha, S., Poudel, P.K., Sherpa, A. P., Jnawali, S.R. and Acharya, S. *et al.* 2018. Pervasive human disturbance on habitats of endangered Red Panda *Ailurus fulgens* in the central Himalaya, **15**.

Anton, M., Salesa, M.J., Pastor, F.F., Peigne, S. and Morales, J. 2006. Implications of the functional anatomy of hand and foream of *Ailurus fulgens* (carnivora, Ailuridae) for the evolution of the ' false – thumb'in pandas. Journal of anatomy, **209**: 757-764.

Baral, B. 2014. Baseline study of Red Panda (*Ailurus fulgens fulgens* CUVIER, 1825) in Jajarkot district, Mid western Nepal. M.Sc. Thesis Central Department of Environmental Science, Tribhuvan University, Kirtipur, Nepal.

Baral, H.S. and Inskippe, C. 2005. Important Bird areas of Nepal: Keys sites for conservation. Bird Conservation Nepal, Kathmandu and Birdlife International, Cambridge, UK.

Bhatta, M., Shah, K.B., Devkota, B., Paudel, R. and Panthi. 2014. Distribution and Habitat Preference of Red Panda (*Ailurus fulgens fulgens)* in Jumla District. Journal of Ecology, **4**: 989-1001.

Bircher, P. 1989. Brief history of Red Pandas at Marwell Zoo. In Glatson, A.: Red Panda Biology. p 123-128. The Hague: SPD Academic Publishing.

Bista, D. and poudel, R. 2013. An overview of the status and Conservation Initiation of Red Panda *Ailurus fulgen* (Cuvier, 1825) in Nepal. SUFFREC, **5**: 171-181.

Bista, D., Shrestha, S., Kunwar, A.J., Acharya, S., Jnawali, S.R. and Acharya, K.P. 2017. Status of gastrointestinal parasites in Red Panda of Nepal. PeerJ 5:e3767; DOI 10.7717/peerj.3767.

Bista, D., Shrestha, S., Sherpa, P., Thapa, G.J., Kokh, M. and Lama, S.T. *et al.* 2017. Distribution and habitat use of Red Panda in the Chitwan-Annapurna Landscape of Nepal. PLoS ONE, **12**(10): e0178797.

BPP. 1995. Biodiversity profiles of high mountains and high himal physiographic zones. Biodiversity Profiles Project Publications No. 14. Department of National Park and Wildlife Conservation, Ministry of Forest and Soil Conservation, His Majesty's Government of Nepal, Kathmandu.

Central Bureau of Statistics. 2011. National Population and Housing, Census, Vol.6, Ilam Nepal.

Chakravarty, R., Nahmo, L., Dutta, P., Srivastava, T., Mazamdar, K. and Dorji, D. 2015. Status, Abundance and habitat association of Red Panda (*Ailurus fulgen*) in pangchen valley, Arunanchal Pradesh , India. Mammalia, **79**(1): 25–32.

Chalise, M. K. 2008. Nepalka Samrakshit Banyajantu, (Nepal's Protected Wildlife) in Nepali. Shajha Prakashan, (A Corporate publishing house) Lalitpur Kathmandu Nepal, page 116+12.

Chalise, M.K. 2009. Panda observed in Ilam. Himal Fortnightly, **18**: 21 (235).

Chalise, M. K. 2013. The presence of Red Panda (*Ailurus fulgens*, Cuvier 1825) in Polangpati area, Langtang National Park, Nepal.18th Wildlife week, 2070 BS. DNPWC/ Govt. of Nepal.pp. 11-22.

Choudhury, A. U. 1997. Red Panda *Ailurus fulgen* (F. Cuvier) in the northeast with an important record from the Garo hills. Journal of Bombay Natural History Society, **94**: 145-147.

Choudhury, A.U. 2001. An overview of the status and conservation of the Red Panda in India, with reference to its global status. Oryx, **35**: 250-259.

District Forest Office. 2012. Annual improvement report, Vol. 1, District Forest Office Ilam. Dittoe, G. 1944. Lesser pandas. Zoonooz, **17**: 4-5.

Dorje, K. 2009. Final Critical Ecosystem Partnership Fund Report: Conservation and Management of the Red Panda *Ailurus fulgens* in Sakteng Wildlife Sanctuary, Bhutan. Unpublished Report to WWF Bhutan, Thimphu, Bhutan.

Dorji, S. 2009. Final critical ecosystem partnership fund report: Distribution and Conservation Status of the Red Panda *Ailurus fulgens* in Bhutan with Reference to Jigme Dorji and Thrumshingla National Parks. Unpublished Report to WWF Bhutan, Thimphu, Bhutan.

Dorji, S., Rajaratnam, R. and Vernes, K. 2012. The Vulnerable Red Panda *Ailurus fulgens* in Bhutan: distribution, conservation status and management recommendations. Oryx, 46, pp 536-543.

Dorji, S., Vernes, K. and Rajaratnam, R. 2011. Habitat correlates of the Red Panda in the temperate forests of Bhutan. PLoS ONE, **6**(10).

Ghose, D. and Dutta, P.K. 2011.Status and distribution of Red Panda, *Ailurus fulgens fulgens*, in India. Red Panda, biology and conservation of the first panda, pp. 357 - 374.

Ghose P.S., Sharma B.K., Chakraborty R. and Legshey K. 2011. Status of Red Panda in Sikkim: A case study in east Sikkim.

Glatston , A. R. 1994. Status and Conservation Action Plan for Procyonids and Ailurids: The Red Panda, Olingos, Coatis, Raccoons and their Relatives. Gland, Switzerland: IUCN.

Glatson, A R. and Leus, K. 2005. Global Captive breeding masterplan for the red or lesser panda *Ailurus fulgens fulgens* and *Ailurus fulgen styani*. Rotterdam, The Netherland: The Royal Rotterdam Zoological and Botanical Gardens.

Grierson, A.J.C. and Long, D.G. 1983-2000. Flora of Bhutan. Royal Botanic Garden, Edingburgh, UK and Royal Government of Bhutan, Thimpu, Bhutan.

Han, Z. X., Wei, F. W., Zhang, Z. J., Li, M., Zhang, W. and Hu, J. C. 2004. Habitat selection by Red Pandas in Fengtongzhai Natural Reserve. Acta Theriol Sin., **24**(3), 185-192.

Hilton-Taylor, C. (Compiler). 2000. IUCN Red List of Threatened species.IUCN, Gland, Switzerland & Cambridge, UK. xvii + 61pp.

Hodgson, B.H. 1847. On the cat-toed subplantigrades of the sub-Himalayas. Journal of the Asiatic Society, **16**: 1113-1129.

IUCN 2011. IUCN Red List of Threatened Species. Version 2011.2. <www.iucnredlist.org>.Downloaded on 20 April 2018.

IUCN 2015. Red List of Threatened Species. Version 2015.2. <www.iucnredlist.org>.Downloaded on 20 April 2018.

Jackson, R. 1990. Threatened wildlife, crop damage and wildlife depredation and grazing in the Makalu Barun National Park and Conservation Area. The Makalu Barun Conservation Project Working Paper Series, Department of National Park and Wildlife conservation, Kathmandu, Nepal and Woodland Mountain Institute, West Virginia, USA.

Jnawali, S.R., Baral, H.S., Lee, S., Acharya, K.P., Upadhyay, G.P. and Pandey, M. *et al.* (compilers). 2011. The Status of Nepal Mammals: The National Red List Series, Department of National Parks and Wildlife Conservation Kathmandu, Nepal.

Jnawali, S., Leus K., Molur, S., Glatston, A. and Walker, S. (Editors) 2012. Red Panda (*Ailurus fulgens*), Population and Habitat Viability Assessment (PHVA) and Species Conservation Strategy (SCS) Workshop Report. National Trust for Nature Conservation, Kathmandu, Nepal, Conservation Breeding Specialist Group and Zoo Outreach Organization, Coimbatore, India.

Johnson, D.H.1980. The comparison of usage and availability measurement for evaluating resource preference. Ecology, **61**: 65-71.

Johnson, K.G., Shaller, G.B. and Hu, J. 1988. Comparative behavior of Red and Giant Pandas in the Wolong Reserve, China. Journal of Mammology**, 69**(3): 552- 564.

Kandel, R. N. 2008. Distribution and conservation status of Red Panda (*Ailurus fulgen*) in Dhorpatan Hunting Reserve, Nepal. M.Sc. Thesis Central Department of Zoology, Tribhuvan University, Kirtipur, Nepal.

Kandel, K. 2009. Distibution and habitat use of Red Panda (*Ailurus fulgen*) in eastern Nepal. M. Sc. Thesis Central Department of Zoology, Tribhuvan University, Kathmandu, Nepal.

Karki, J. B. 1999. Study of Red Panda habitat at Cholangpati area of Langtang National Park. A report submitted to Department of National Park and Wildlife Conservation, Kathmandu, Nepal.

Karki, J. B. and Jendrzejewski, J. 2000. Biodiversity Conservation in Langtang National Park. Department of National park and wildlife conservation, Kathmandu, Nepal and U. S. peace Crops, Lazimpat, Kathmandu, Nepal.

Karki, K. 2009. Habitat and feeding behaviour of Red Panda (*Aliurus fulgens*)in Choloangpati-Dokachet Area Langtang National Park, Nepal, M.Sc.Thesis, Central Department of Zoology, Tribhuvan University, Kathmandu, Nepal.

Kapu, P. and Govil, S.R. 2000. Experimental plant Ecology, CBS publisher and Distributor, New Delhi, India.

Lama, S.T., Lama, R.P., Regmi, G.R. and Ghimire, T.R. 2015. Prevalence of intestinal parasitic infections in free-ranging Red Panda *Ailurus fulgens* Cuvier, 1825 (Mammalia: Carnivora: Ailuridae) in Nepal. Journal of Threatened Taxa**, 7**(8): 7460–7464.

Mahato, N.K. 2003. Status of Red Panda *Ailurus fulgens* (Cuvier, 1825) in the Kanchanjungha Conservation Area. B.Sc. project paper submitted to Institute of Forestry, Tribhuvan University, Pokhara. Pages 40

Mahato, N.K. 2004. Baseline Survey of Red Panda *Ailurus fulgens* Status in the Buffer Zone of Sagarmatha National Park. A report submitted to WWF Nepal programme, Kathmandu, Nepal.

Mahato, N.K. 2010. Distribution of the Red Panda (*Ailurus fulgens*, Cuvier, 1825), in Nepal based on a predictive model. Masters thesis for Texas State University, USA.

Mahato, N.K. and Karki, J.B. 2005. Distribution and habitat assessment of Red Panda (*Ailurus fulgens*) in Kanchenjunga Conseravation Area with reference to Riya Samba and Lama Khanak forests. Nepal Journal of Forestry, **12**: 32–40.

Mahato, N.K., Kandel, K. and Shakya, S. 2011. A Long-Term Community-Based Monitoring and Conservation Program for Red Panda in Unprotected Forests of Eastern Nepal. Tiger Paper, **38**, 1-10.

MoFSC. 2016. National survey of Red Panda to assess its status, habitat and distribution in Nepal. Report submitted to Ministry of Forest and Soil Conservation. Himali Conservation Forum, Taplejung and Red Panda Network, Kathmandu.

Odum, E.P. 1971. Fundamentals of Ecology. W.B. Saunders Company, USA. Pp. 574.

Panthi, S. 2009. Status of *Ailurs fulgens* (Red Panda) in Dhorpatan Hunting Reserve. DHR office, Baglung, Nepal.

Panthi, S. 2011. Feeding Ecology, Habitat Preference and Distribution of the Red Panda (*Ailurus fulgens fulgens*) in Dhorpatan Hunting Reserve, Nepal. A Project Paper Submitted in the Partial Fulfillment of the Requirement for the Degree of Bachelor of Science in Forestry, Tribhuvan University, Institute of Forestry, Pokhara Campus, Nepal.

Panthi, S., Aryal, A., Raubenheimer, D., Lord, J. and Adhikari, B. 2012. Summer diet and distribution of the Red Panda (*Ailurus fulgens fulgens*) in Dhorpatan Hunting Reserve, Nepal. Zoological studies, **51**: 701- 709.

Pradhan, S. 1999. Observation of Red Panda, *Ailurus fulgens* in the Singhalila National Park, Darjeeling, India. Small Carnivore Conservation, **21**: 6-8.

Pradhan S., Khan, J.A. and Saha, G.K. 2001a. Feeding habits of the Red Panda in the Singhalila National Park, Darjeeling. J. Bomb. Nat. Hist. Soc. **98**: 224–230.

Pradhan, S., Saha, G.K. and Khan, J.A. 2000. Food habits of the Red Panda, *Ailurus fulgens* in the Singhalila National Park, Darjeeling, India. Journal of the Bombay Natural History Society, **98**: 224–230.

Pradhan S., Saha, G.K. and Khan, J.A. 2001b. Ecology of the Red Panda *Ailurus fulgens* in the Singhalila National Park, Darjeeling, India. Biological Conservation, **98**: 11–18.

Prater, S. H. 1980. The book of Indian animals. Bombay Natural History Society, Bombay.

R Core Team. 2017. R: A Language and Environment for Statistical Computing. Vienna: R Foundation for Statistical Computing.

Rabinowitz, A. and Khaing, S.T. 1998. Status of selected mammals in north Myanmar. Oryx, **32** (3): 201-208.

Reid, D.G., Jinchu, H. and Hunang, Y. 1991. Ecology of the Red Panda (*Ailurus fulgens*) in the Woolong Reserve, China. Journal of Zoology, **225**:345-364.

Reid, D. G., Jinchu, H., Sai, D., Wei, W. and Yan, H. 1989. Giant Panda *Ailuropoda melanoleuca* behaviour and carrying capacity following a bamboo die-off. Biological Conservation, **49**: 85-104.

Roberts, M. 1983. The Red Panda: its history and fragile hold on the future. Cincinnati Zoo News, 1-5.

Roberts, M. S. and Gittleman, J.L. 1984. *Ailurus fulgens*. Mammalian species, **222**: 1-8.

Roberts, M. and Kessler, D. 1979. Reproduction in Red Pandas, *Ailurus fulgens* (Carnivora: Ailuropodidae). Journal of Zoology, **222**: 1-8.

RPN. 2010. Baseline Survey of Red Panda distribution, abundance, and population status in the Eastern Himalaya of Nepal. A report submitted to Ocean Park Conservation Foundation- Hong Kong (Unpublished).

Sharma, H.P. 2008. Distribution and conservation status of Red Panda (*Ailurus fulgens*) in Rara National Park, Nepal. Final report submitted to PTES, London.

Sharma, H.P. 2012. Exploration and diet analysis of Red Panda (*Ailurus fulgens*) for its conservation in Rara National Park, Nepal, A report Submitted to The Rufford Small Grants Foundation, UK.

Sharma, H.P. and Belant, J.L. 2009. Distribution and observations of Red Panda *Ailurus fulgens fulgen* in Dhorpatan Hunting Reserve in Nepal. Small carnivore conservation, **40**.

Sharma, H.P. and Kandel, R.N. 2007. Red Panda *Ailurus fulgens* in the Dhorpatan Hunting Reserve of Nepal: An Assessment of Their Conservation Status. A report submitted to People's Trust for Endangered Species, UK.

Shrestha, M.K. 1988. Vegetation study of Red Panda habitat in Langtang National Park, Central Nepal. M. Sc. Thesis, Tribhuvan University, Nepal.

Shrestha, R. and Ale, S.B. (Eds) 2001. Species diversity of Modi khola Watershed. King Mahendra Trust for Nature Conservation, Annapurna Conservation Area Project ,Pokhara , Nepal. PP. 47.

Smith, R.L. 1974. Ecology and Field Biology (New York) Harper and Row publishers. Southwood, T.R.E.1977. Habitat, the templet for ecological strategies? Journal of Animal Ecology, **46**: 337-365.

Sowerby, A. de C. 1932. The pandas or cat-bears. China Journal, **17**: 296-299.

Stainton, J.D.A.1972. Forest of Nepal. John Murray, London.

Subedi and Thapa, 2011. Habitat Status and Distribution of Red Panda (*Ailurus fulgens*) in Dhorpatan Hunting Reserve, Nepal.

Tews, J., Brose, U., Grimm, V., Tielborger, k., Wichmann, M.C. and Schwager, M. *et al.* 2004. Animal Species Diversity Driven By Habitat Heterogeneity/ Diversity: The Importance of Keystone Structure. Journal of Biogeography, **31**: 79-92.

Than Z., Saw, H., Saw, H.T. P., Myint, M., Lynam, A.J. and Kyaw, T. L. *et al.* 2008. Status and distribution of small carnivores in Myanmar. Small Carnivore Conservation, **38**: 2–28.

Thapa, A. 2010. An analysis of food habits and conservation of Red Panda (*Ailurus fulgens* Cuvier, 1825) in Langtang National Park, Nepal. M.Sc. Thesis Central Department of Zoology, Tribhuvan University, Kirtipur, Nepal.

Thapa, A. and Basnet, K. 2015. Seasonal diet of wild Red Panda (*Ailurus fulgen*) in Langtang National Park. Nepal Himalaya, **6** (2): 261-270.

Thapa, A. Thapa, S and Poudel, S. 2013. Gaurishankar Conservation Area - A Prime Habitat for Red Panda (*Ailurus fulgens*) in Central Nepal. Nepal journal online, **5**: 43-49.

Thomas, D.L. and Taylor, E.J. 1990. Study designs and tests for comparing resource use and availability. The journal of wildlife Mangement, **54**(2): 322 -330.

Wei, F., Feng, Z., Wang, Z. and Hu, J. 1998. Assessment on the current status of the Red Panda in China. Small Carnivore Conservation, 18: 1-4.

Wei, F., Feng, Z., Wang, Z. and Hu, J.1999. Current Distribution, Status and Conservation of Wild Red Pandas (*Ailurus fulgen*) in China. Biological Conservation, **89**(3): 285-291.

Wei, F., Feng, Z., Wang, Z. and Hu, J. 2000. Habitat Use and Separation between the Giant panda and the Red Panda. Journal of Mammology, **81**(2): 448-455.

Wei, F., Zhang, Z. and Liu, Z. 2011. Conservation initiatives in China. In: A.R. Glatston (ed.), Red Panda, biology and conservation of the first panda, pp. 409–418. Academic Press, London, UK.

Williams, B. H. 2004. The status of Red Panda in Jamuna and Mabu village of Eastern Nepal. Unpublished thesis M.Sc. The faculty of the Department of Environmental Studies. San Jose State University.

Williams, B.H. 2006. Red Panda in Eastern Nepal: How do they fit into Ecoregional Conservation of the Eastern Himalaya. Society for Conservation Biology and Resources Himalaya Kathmandu, Nepal, Pp. 236-251.

Williams B, Dahal, B.R. and Subedi, T. 2011. Project Punde Kundo: Community-based monitoring of a Red Panda population in Eastern Nepal. Red Panda: Biology and Conservation of the Original Panda. Elsevier, San Diego, CA. 2010:393±408.

Yonzon, P. B. 1989. Ecology and Conservation of Red Panda in the Nepal Himalayas. Ph.D. Dissertation (Unpublished). University of Marine**.** USA**.**

Yonzon, P. B. 1991. Conservation of the Red Panda (*Ailurus fulgens*). Biological Conservation, **57**(1): 1-11.

Yonzon, P. and Hunter, M .L. 1991a. Conservation of the Red Panda (*Ailurus fulgens*). Biological Conservation, **57**(1991) 1-11.

Yonzon, P.B. and Hunter, M.L. 1991b. Cheese, tourists, and Red Pandas in the Nepal Himalayas. Conservation Biology, **5**(2):196±202.

Yonzon, P.B, Jones, R. and Fox, J. 1991. Geographic information system for assessing habitat and estimating population of Red Panda in Langtang National Park, Nepal. Ambio, **20** (7): 285-288.

Yonzon, P.B., Yonzon, P., Choudhury, C. and Vaidya, V. 1997. Status of the Red Panda in the Himalaya. A Resources Nepal, Kathmandu and Metropolitan Toronto Zoo Project, Toronto, Canada. pp.21.

Zhang, Z. J., Wei, F. W., Li, M. and Hu, J. C.2006. Winter microhabitat separation between giant and Red Pandas in Bashania faberi bamboo forest in Fengtongzhai Nature Reserve. Journal of Wildlife Management, **70**: 231-235.

Zhou, X., Jiao, H., Dou, Y., Aryal, A., Hu, J. and Mang, X. 2013. The winter habitat selection of Red Panda (*Ailurus fulgens*) in the Meigu Dafengding National Nature Reserve, China. Current Science**, 105**: 1424–1429.

8. APPENDICES

Appendix I: Questionnaire Survey Data Sheet

Part 1: Basic information about the interviewee

Survey number:-… Name of Respondent:-...……...…. Date:- ….……

Age:-….. Sex:-….. Occupation:-…….. Address:-……..……

Part 2: Red Panda questionnaire

1) Do you know about Red Panda? If yes, then describe its physical feature

……..……

2) How often do you see Red Panda here?

- Often
- Sometimes
- Never
- Usually

3) Indicate what kind of evidences of Red Panda were found

- fecal matter
- foot marks
- Sighting
- other

4) In which/what time did you see Red Panda?

- Morning
- Afternoon
- Evening
- Night

5) Are Red Pandas being poached here? If yes, who are the persons responsible for poaching?

- Villagers
- Visitors
- Others

6) For what reasons that Red Panda are being poached?

7) How often do you see the dead Red Panda?

- Sometime
- Usually
- Never

8) How often the forest is fired?

- Sometime
- Usually
- Never

9) Do you see the traps set for animals in the jungle?

10) What techniques are used for cooking purpose in this village?

- Firewood

- LPG Gas
- Bio-gas
- Other

11) Are the domestic cattle left for grazing in jungle?

- Yes
- No

12) What type of animal are seen grazing in jungle?

- Cow
- Ox
- Horse
- Other

13) Any program has been launched for conservation of Red Panda? If yes who are the program launcher?

- Person
- Organization
- NGOs/ INGOs

14) What type of program has been launched?

- Seminar
- Training
- Group discussion
- Other

15) What do you think is the Red Panda valuable? If yes what are its importance?

16) What actions are ongoing now for conservation?

- Habitat management
- Other

Appendix II: Microhabitat Plots in different blocks

Name of blocks		Plot type		Total
		Red Panda sign plot	systematic plot	
Singadevi	Count	9	17	26
	%	21.96	18.48	19.54%
Chitre- Hile	Count	6	11	17
	%	14.63	11.96	12.78%
Chhipchhipe	Count	13	21	34
	%	31.70	22.10	25.56%
Kalikhop Dadheli 1st	Count	11	18	29
	%	26.82	19.57	21.80%
Kalikhop Dadheli 2nd	Count	2	25	27
	%	4.88	27.18	20.30%
Total	Count	41	92	133
	%	30.82	69.17	100%

Appendix III: Floristic community parameters in different altitudes

Study Site	Parameters	Altitudes						
		2100	2200	2300	2400	2500	2600	2700
Singadevi CF	Diversity index	1.4557	1.8919	1.9488	1.6785	*	*	*
	Dominance index	0.3539	0.1733	0.2321	0.2809	*	*	*
	Evenness	0.1119	0.1455	0.1499	0.1291	*	*	*
Chitre- Hile CF	Diversity index	*	*	1.6382	2.2294	2.0788	*	*
	Dominance index	*	*	0.2561	0.1415	0.1527	*	*
	Evenness	*	*	0.0963	0.1311	0.1222	*	*
Chhipchhipe CF	Diversity index	*	1.7153	1.5341	1.9209	2.2376	1.7793	1.7206
	Dominance index	*	0.2952	0.2924	0.1983	0.1362	0.2077	0.2409
	Evenness	*	0.0857	0.0767	0.0960	0.1118	0.0889	0.0860
Kalikhop - Dadheli CF (1^{st} block)	Diversity index	*	2.5491	1.6679	1.6120	1.9180	1.7291	*
	Dominance index	*	0.0979	0.3012	0.2557	0.1891	0.2152	*
	Evenness	*	0.1062	0.0695	0.0671	0.0799	0.0720	*
Kalikhop- Dadheli CF (2^{nd} block)	Diversity index	*	2.0155	1.9306	0.6479	2.1538	1.7340	*
	Dominance index	*	0.1682	0.2092	0.6787	0.1604	0.2377	*
	Evenness	*	0.0876	0.0839	0.0281	0.0936	0.0753	*

Appendix IV: IVI of tree species in Red Panda sign plot

Common name	Scientific name	Relativev Density	Relative Frequency	Relative dominance	IVI
Bante	*Lithocarpus pachyphylla*	16.83204	16.8473	11.37764	45.0575
Kharane	*Symplocos theifolia*	23.11266	13.0438	1.039925	37.1966
Kholme	*Symplocos pyrifolia*	9.295308	9.23913	2.461361	20.9958
Bajrath	*Quercus lamellosa*	2.009796	3.26086	13.98121	19.25188
Gogaichap	*Magnolia campbelli*	2.76347	3.804348	10.68299	17.25081
Pahele	*Litsea salicifolia*	7.034285	7.065217	2.26052	16.36002
Tega	*Sorbus cuspidata*	0.251225	0.543478	15.3835	16.17821
Angeru	*Lyonia ovalifolia*	9.797757	5.434782	0.575001	15.80754
Falat	*Quercus glauca*	2.76347	5.434782	7.253493	15.45175
Seti kath	*Hymenodictylon excelsum*	4.522042	7.065217	3.544359	15.13162
Chimal	*Rhododendron grande*	6.531838	4.891304	3.643497	15.06664
Kabasi	*Acer sps*	6.433037	2.512245	3.804348	12.74963
Sisi	*Lindera pulcherrima*	2.76347	5.978261	3.643497	12.38523
Kaulo	*Machilus edulis*	3.014694	5.434782	1.771366	10.22084
Khanakpa	*Evodia fraxinifolia*	3.014694	3.260869	3.208144	9.483708
Loth salla	*Taxus baccata*	0.251225	0.543478	3.845876	4.640579
Lisse	*Ilex dipyrena*	1.256123	1.086956	2.030793	4.373873
Jhigani	*Eurya acuminate*	1.758572	1.086956	1.415453	4.260982
Chulethro	*Berberis Sp.*	0.502449	1.086956	2.670747	4.260153
Akhane	*Populus ciliate*	0.251225	0.543478	1.234953	2.029657

Appendix V: IVI of tree species in Systematic plots

Common name	Scientific name	Relative Density	Relative Frequency	Relative dominance	IVI
Bante	*Lithocarpus pachyphylla*	15.91187	13.28125	7.639734	36.83285
Kharane	*Symplocos theifolia*	19.23523	11.71875	0.840945	31.79493
Bajrath	*Quercus lamellosa*	6.042481	7.03125	9.931854	23.00559
Falat	*Quercus glauca*	5.941773	5.729167	5.405	17.07594
Katush	*Castanopsis hysterix*	2.01416	2.604167	10.26016	14.87849
Chimal	*Rhododendron grande*	5.136109	7.03125	2.206208	14.37357
Seti kath	*Hymenodictylon excelsum*	4.229737	6.25	2.442426	12.92216
Sisi	*Lindera pulcherrima*	2.819825	5.989584	3.507411	12.31682
Kholme	*Symplocos pyrifolia*	5.538941	4.427084	2.130137	12.09616
Kaulo	*Machilus edulis*	5.136109	4.6875	2.168006	11.99161
Angeru	*Lyonia ovalifolia*	6.848145	3.645834	0.504633	10.99861
Pahele	*Litsea salicifolia*	3.927613	4.6875	1.602149	10.21726
Gogai chap	*Magnolia campbelli*	2.114868	3.385417	3.753472	9.253757
Laligurash	*Rhododendron arboreum*	5.740357	2.864584	0.600556	9.205496
Lisse	*Ilex dipyrena*	1.309204	2.604167	3.703593	7.616964
Salla	*Pinus roxburghii*	0.100708	0.260417	6.672839	7.033964
Jhigani	*Eurya acuminate*	2.416992	2.864584	1.291862	6.573438
Saur*	*UN1*	0.201416	0.260417	5.709448	6.171281
Kabasi	*Acer campbelli*	1.309204	2.604167	2.130137	6.043508
Khanakpa	*Evodia fraxinifolia*	1.309204	2.864584	1.411973	5.585761
Pipli	*Exbucklandia populnae*	0.201416	0.260417	4.270617	4.73245
Timur	*Zanthoxylum armatum*	0.402832	0.520833	3.753472	4.677138
Rani chap	*Michelia doltsopa*	0.100708	0.260417	3.753472	4.114597
Dapdape	*Symplocos ramosissima*	0.100708	0.260417	3.316568	3.677693
Bhalu chinde	*Schefflera impressa*	0.100708	0.260417	3.269691	3.630816
Chap*	*UN2*	0.100708	0.260417	2.819275	3.180399
Akhane	*Populus ciliate*	0.704956	1.5625	0.308452	2.575908
Aarupate	*Prunus sp.*	0.402832	0.78125	0.817423	2.001505
Bhadrase*	*UN3*	0.201416	0.520833	1.505559	2.227809
Loth salla	*Taxus baccata*	0.302124	0.260417	1.205282	1.767822
Dudhilo	*Ficus nemoralis*	0.100708	0.260417	1.067654	1.428779

Appendix VI: Density and frequency of shrub in panda sign plots

Common name	Scientific name	Density	Frequency
Malingo	*Arundinaria maling*	20	100
Lokti	*Daphne bholua*	6.08	46.34
Asare	*Viburnum erubescens*	5.71	36.58
Kalijhar	*Eupatorium adenophorum*	4.83	17.07
Titeri	*Sarcococca coriacea*	2.18	14.63
Kesari	*Berberis nepalensis*	1.76	17.07
Chuthro	*Berberis aristata*	0.66	7.31
Bhogate	*Measa macrophylla*	0.87	2.43
Timur	*Zanthoxylum armatum*	0.22	2.43

Appendix VII: Density and frequency of shrub in systematic plots

Common name	Scientific name	Density	Frequency
Malingo	*Arundinaria maling*	14.32	89.13
Asare	*Viburnum erubescens*	12.29	85.36
Lokti	*Daphne bholua*	16.24	78.05
Fren	*Pteris sp.*	6.59	31.07
Kalijhar	*Eupatorium adenophorum*	6.59	29.27
Titeri	*Sarcococca coriacea*	2.41	17.07
Chuthro	*Berberis aristata*	1.76	17.07
Kesari	*Berberis nepalensis*	1.76	7.32
Thotne	*Aconogonum molle*	0.66	2.44
Argeli	*Edgeworthia gardneri*	0.44	2.44
Timur	*Zanthoxylum armatum*	0.22	2.44
Falame*	*UN1*	0.44	2.44
Jamane mandhro	*Mohania nepaulensis*	0.44	2.44
Aiselu	*Fragaria nubicola*	0.43	2.43

Appendix VIII: Density and frequency of herb in panda sign plot

Common name	Scientific name	Density	Frequency
Uneu	*Pteridium aquilinum*	48.73	80.48
Gaglato	*Elastostema sessile*	27.21	41.46
Banso*	*UN 1*	8.78	19.51
Bhue aiselu	*Rubus sp.*	19.31	19.31
Harkato*	*UN 2*	4.39	14.63
Botuke jhar	*Viota sp.*	13.6	13.6
Kharete	*Pilea sp.*	6.14	12.19
Panilahara	*Tetrastigma sp.*	7.46	7.46
Bukiful	*Anaphalis sp.*	6.14	7.31
Ratnoulo	*Bistorta Amplexicaulis*	2.19	7.31
Chiraito	*Swertia chirayita*	2.19	7.31
Kibu*	*UN 3*	4.82	7.31
Mirre*	*UN 4*	3.07	4.87
Thotne	*Aconogonum molle*	1.31	4.87
Kumkum pati	*Didymocarpus sp.*	0.43	0.43
Dungdunge jhar*	*UN 5*	0.87	2.43

Appendix IX: Density and frequency of herbs in systematic plot

Common name	Scientific name	Density	Frequency
Fern	*Pteridium aquilinum*	60.06	56.52
Harkato*	*UN 2*	35	38.04
Gaglato	*Elastotema sessile*	18.97	33.69
Bhue aiselu	*Rubus sp.*	17.21	26.08
Banso*	*UN 1*	12.91	21.73
Panilahara	*Tetrastigma sp.*	8.21	15.21
Botuke jhar	*Viota sp.*	12.91	14.13
Thotne	*Aconogonum molle*	7.04	13.04
Bukiful	*Anaphalis sp.*	11.64	10.86
Ratnaulo	*Bistorta amplexicaulis*	3.52	10.86
Dubo	*Cynodon dactylon*	14.67	9.78
Kharete	*Pilea sp.*	4.89	6.52
Kibu*	*UN 3*	4.5	5.43
Majhito	*Rubia sp.*	1.36	3.26
Chiraito	*Swertia chirayita*	0.58	1.08
Banmula	*Potentilla sp.*	0.58	1.08
Kumkumpati	*Didymocarpus sp.*	0.39	1.08
Budo- okhati	*Astilbe rivularis*	0.19	1.08

9. PHOTOGRAPHS

Photo 1: Red Panda habitat in Ilam

Photo 2: Red Panda in Singadevi block

Photo 3: Fecal pellets of Red Panda in forest floor

Photo 4: Measuring DBH of tree

Photo 5: Data collection

Photo 6: Measuring the distance between trees

Photo 7: Quadrate for shrub

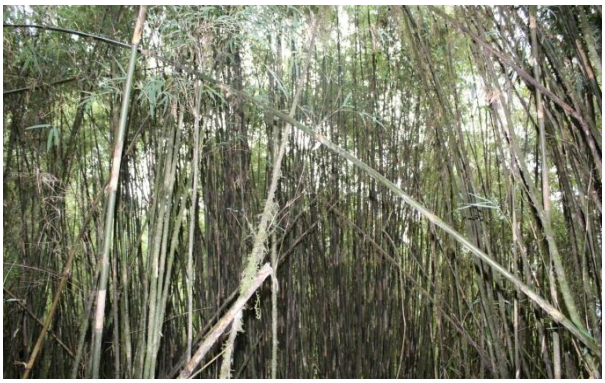

Photo 8: Malingos in study area

Photo 9: Livestock grazing

Photo 10: Cattle dung

Photo 11: Illegal felling of tree in study area

Photo 12: Questionnaire survey with villager

Photo 13: Shed made up of Malingoes

Photo14: Welcome board in Gorkhe

Photo15: Tourist in the forest

Photo 16: Road in India and Nepal border

Photo 17: Lamidhura (India and Nepal border)

Photo 18: Welcome in homestay

Photo 19: Homestay in Gorkhe