Hariyo Ban Program

Blue Sheep Monitoring

in the Upper Kali Gandaki Valley

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Abstract

The iconic snow leopard is an indicator species of the healthy mountain ecosystem. Snow leopard inhabits widely but patchily in the central Asia and along Himalaya including trans-Himalaya region. In Nepal snow leopard is distributed across east-west northern fringe of sub-alpine and alpine region including Mustang. The diet of this wide ranging animal is dominated by blue sheep, Himalayan tahr and domestic stock. Rare, elusive predators offer few sighting, hindering research with small sample sizes and lack of experimentation. While predator like snow leopard may be elusive, their prey such as blue sheep is more readily observed. In the Upper Mustang, blue sheep is the main prey species, however, there lacks data on blue sheep population dynamics for this region and it is important to understand the population structure of blue sheep to better understand the threats to snow leopard so that science-based and practical conservation strategy would be designed.

In order to examine the long-terms population dynamics of blue sheep, we established three permanent monitoring blocks, comprising about 148.5 km², in Samjung-Choser (45.5 km²), Yara-Ghara (61.6 km²) and Marang (41.4 km²). We performed the study in the upper Mustang area from early April to early May 2013. We followed the major rivers, ridgelines and high peaks to maximize accessibility to this region. We trained NTNC-ACAP staff, as well as local people as citizen scientists in monitoring techniques to estimate the population size and structureits of blue sheep. We used a direct count method from appropriate vantage points (also known as a fixed-point count). The total number of individuals in a group was counted, and classified by sex and age whenever possible. In order to classify sex and age classes, we utilized the protocol of the revised version of the Snow Leopard Monitoring Guideline. Observations were made with 8x24 binoculars and 15-60x spotting scope in the morning (06.00-10:00 hrs) and evening (14:00-17.30 hrs), as blue sheep become most active in the morning and evening time and easily detected.

A total of 40 blue sheep groups consisting of 335 individuals were counted in the three study blocks, with an estimated population density of 2.3 blue sheep per km². We calculated a mean group size of 8.4 individuals, with a range from 2 to 22 individuals. The blue sheep inhabits a wide area across this region, and is sparsely distributed with low population density recorded within its range in Nepal. We assessed recruitment rate of 0.6 young per adult female (60 young per 100 females) during spring season (pre-parturition). The young to female ratio indicates a stable population. The ratio of yearlings indicated a poor survival rate, around 0.32 yearlings which is about 47% mortality rate assuming same reproductive rate during the last year. Reason behind this could be predation pressure by multiple predators such as their presence snow leopard, wolf and lynx. On the other hand, there is a slightly female biased sex ratio (female to male: 1:0.83) in the study area. The low male to female ratio in this study could not be explained, but outside the rutting season this low male to female ratio is not surprising. On the other hand, ongoing subsistence hunting, however, this trends reducing gradually after implementation of several conservation and development activities by ACAP, could be another reason for this

This study indicates a low population of blue sheep in upper Mustang that is thinly distributed. We were not able to develop robust reasoning for the low population of blue sheep, but it may be the heavily impact on one and two years age blue sheep by predation of multiple sympatric predators such as snow leopard, wolf, and small predator lynx unlike the Manang and Kangchenjunga regions in Nepal. In addition, it is highly likely that such low densities are associated with climate change, specifically with respect to the availability of water resources, the quality of rangeland, the availability of low nutrient food resources in the arid habitat of the study areas. There are also anthropogenic impacts, such as poaching and unplanned under constructing motor highway, which perhaps could have major factors affecting blue sheep abundance in the area.

To assess the population dynamics of blue sheep in the region, regular follow-up surveys using same methodology and survey blocks have been recommended Till date population status of principal prey species (snow leopard and grey wolf) in the region is

unknown. But, a blue sheep population of 150- 200 with an annual increment of 15% can support one wolf or one snow leopard if the population lacks other mortality causes such as poaching. It will be important to understand the sympatric predator relationship with-their prey, as well as the condition of range land with habitat relationship between wild and domestic ungulates.

Acknowledgements

The study established a monitoring procedure for blue sheep in Upper Mustang, in the Annapurna Conservation Area which forms part of the Chitwan Annapurna Landscape. The report is particularly important to the Hariyo Ban Program because blue sheep is the principal wild prey of snow leopard – a focal species of the Hariyo Ban Program. The study will pave the way to a better understanding of snow leopard and its prey base, thereby helping develop a better conservation strategy for the species.

I would like to thank the staff of the National Trust for Nature Conservation (NTNC) , Annapurna Conservation Area Project. I appreciate the support of Ganga Jung Thapa, Narendra Shrestha, Naresh Subedi and Lal Prasad Gurung for their help during the early phase of project design. Madhu Chhetri and Raj Kumar Gurung with their field team helped in designing the project and sample collection.

Special thanks go to the field technicians and staff involved in this study, namely Niranjna Dhungana, Shree Krishna Neupane, Madan Mohan Acharya, Bhupendra Gurung, Lal Prasad Gautam, Chhombel Lowa and Pema Tcshering Lowa including local people and citizen scientists, for their valuable contributions. Enormous thanks to Gokarna Jung Thapa for GIS maps. Matt Erke kindly edited the report, Pallavi Dhakal managed the production, Judy Oglethorpe, Shant Raj Jnawali, and Eric Wikramanayake, for their critical reviewed and comments.

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Acronyms and Abbreviations

ACA	Annapurna Conservation Area
GIS	Geographical Information System
GPS	Global Positioning System
NTNC- ACAP	National Trust for Nature Conservation - Annapurna Conservation Area Program
USAID	United States Agency for International Development
WWF	World Wildlife Fund

1. Introduction

In the high mountains, wild ungulates and their domesticated relatives and mammalian predators coexist (Fox *et al.* 1994, Miller and Jackson 1994, Schaller 1998). Use of the same habitats by snow leopard, livestock, blue sheep, and Himalayan tahr is probably the best example of co-existence of prey and predators in the semi-arid habitats of the northern part of Nepal. Predator-prey ratios (Schaller 1977, Oli 1994) and retention of age-old pastoral practices (Miller 1987, Fox *et al.* 1994) in the northern parts of Annapurna Conservation Area (ACA) have maintained a relatively stable ecosystem. Rare, elusive predators offer few sighting (Ale and Brown 2010), hindering research with small sample sizes and lack of experimentation. While predator like snow leopard may be elusive, their prey such as blue sheep is more readily observed. Blue sheep (*Pseudois nayaur*) is the principal wild prey of the snow leopard (*Panthera uncia*) in Mustang. However, current status of blue sheep in this region is lacking and it is important to understand the population structure of blue sheep to better understand the threats to snow leopard. Securing data on blue sheep also helps with the assessment of the causes of livestock depredation by snow leopard. The long-term collection of data on blue sheep population dynamics in this valley is crucial to develop effective conservation strategies, and to evaluate current conservation initiatives. This study will provide a baseline on blue sheep population structure and abundance in the region and will be instrumental to understand population dynamics of this important snow leopard prey base. Besides, information generated from this study will contribute in developing regional strategy for predator and prey base conservation.

Objectives

The main objectives of this study were to:

1. Establish baseline data on blue sheep population in the Samjung-Chhoser, Yara-Ghara, and Marang blocks in Upper Mustang area of the Annapurna Conservation Area
2. Map the distribution of blue sheep in Samjung-Chhoser, Yara-Ghara, and Marang blocks
3. Develop local capacity for long term monitoring of blue sheep

2. Methods

Study area

We selected blue sheep monitoring blocks in three sub-watersheds, namely Samjung-Chhoser, Yara-Ghara, and Marang of Upper Mustang along the Nepal- Tibet border (Figure 1). This region is located in the northern part of Mustang District at approximately 83° 45' to 84° E and 29° 04' to 29° 18' N. The area is characterized by cold desert, strong winds and intense solar radiation. The climate is alpine and subalpine, with maximum temperature ranges of 26.8° C in July and -9.8° C in December. Total rainfall is less than 200 mm, and more than half of the total precipitation is snowfall during winter. Upper Mustang is almost tree less region, but have *Kobresia pygmaea, Caragana* spp, *Artemesia* spp, *Lonicera* spp, *Potenilla* spp , *Astragalus* spp, *Lancea tibetica Potentialla* spp and *Ephedra gerardiana*. The region falls under the Dhaulagiri-Annapurna mountain rain-shadow zone, and includes a unique assemblage of rare and endangered wildlife species including Tibetan argali (*Ovis ammon hodgsonii*), the Tibetan gazelle (*Procapra picticaudata*), the wild ass (*Equus kiang*), and blue sheep (*Pseudois nayaur*), as well as predators such as snow leopard (*Panthera uncia*), lynx (*Lynx lynx isabellinus*), grey wolf (*Canis lupus*), brown bear (*Ursus arctos*), and red fox (*Vulpes vulpes*).

Monitoring blocks

We established three monitoring blocks in Samjung-Choser, Yara-Ghara and Marang sub-watersheds of upper Mustang (Figure 1), the key blue-sheep habitats between 3,000 and 5,400 meters (Jackson and Hunter 1996). Monitoring blocks were laid with the help of 1:50,000 topographic maps. The monitoring blocks are representative of all suitable habitats in Upper Mustang. Therefore, this study focused on representative sample areas (or blocks) within potential blue sheep habitat. A relatively large area was used to allow for the likelihood that some of the area was inaccessible due to permanent snow, ice, or dangerously steep ground between 3,000 m and 5,400 m.

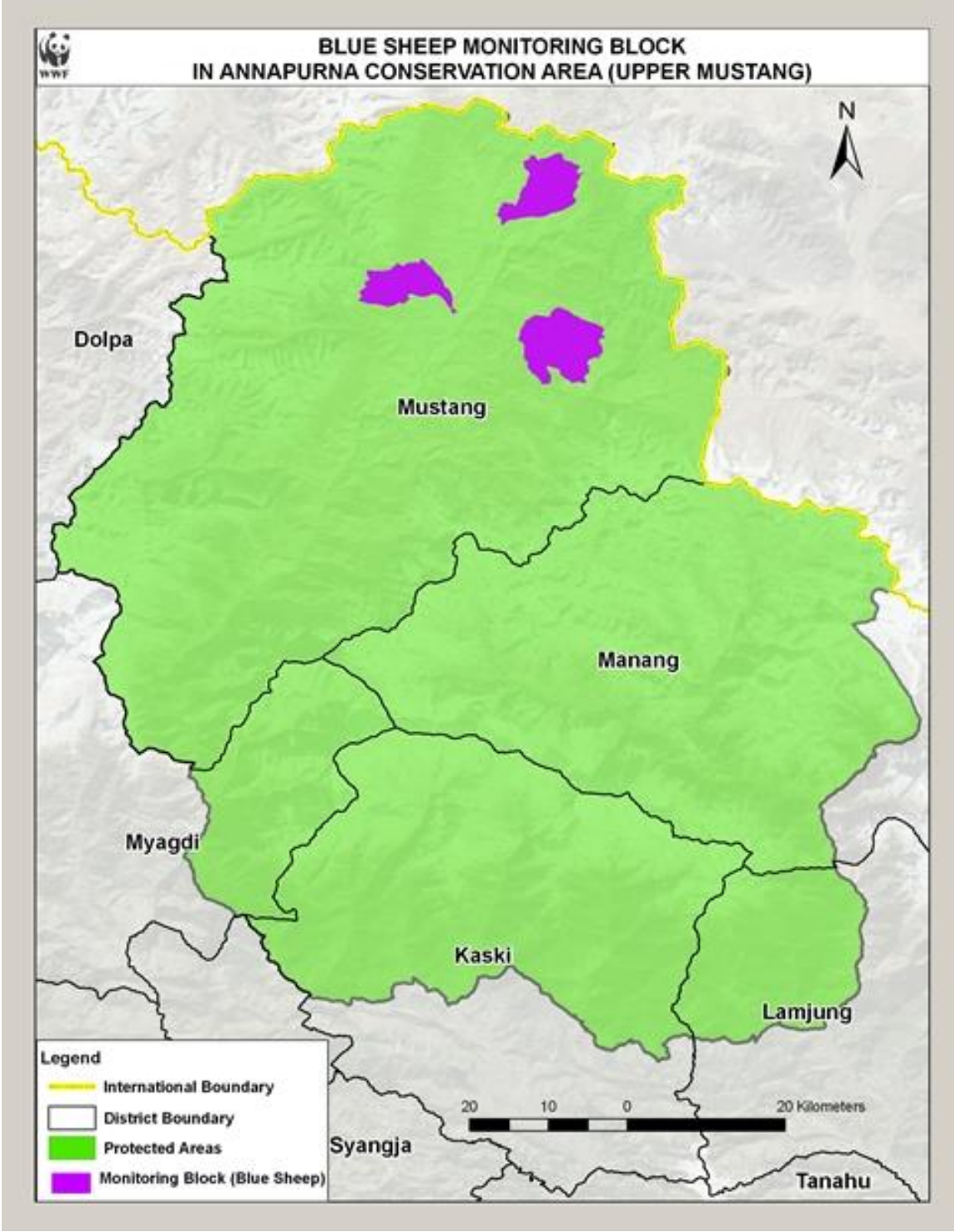

Figure 1: ***Blue sheep monitoring blocks in Samjung-Choser, Yara- Ghara and Marang sub-watersheds in Upper Mustang.***

Counting method

The present study performed direct counts from appropriate vantage points (also known as a fixed-point count), which involved counting from opposite sides of blue sheep groups. The total number of individuals in a group was counted and classified by sex and age (see Annex 2). In order to classify the blue sheep by sex and age classes (Annex 3), we utilized a revised version (Table 1) of the Snow Leopard Monitoring Guideline (Thapa 2007) adopted from Wegge (1979), Jackson and Hunter (1996); Schaller (1977).

S.N.	Age & Name	Description	Remarks
1.	Young	Below one year	Male and female
2.	Yearling	From one year to two years	Male and female
3.	Adult female	More than two years (female)	Female
4.	Young male	More than two years to four years	Male
5.	Sub-adult male	More than four years to seven years	Male
6.	Adult male	More than seven years	Trophy age male

Table 1: Blue sheep sex and age are classified into the following categories as described by Thapa 2007 adopted from Schaller 1977; Wegge 1979.

Observations were made with 8-24x binoculars and 15-60x spotting scope early in the morning (06.00-10) and evening (14.00-17.30) when blue sheep are known to be most active.

We trained NTNC-ACAP local staff and a citizen scientist on blue sheep counting technique and later mobilized throughout the count.

3. Analysis

The population data on blue sheep and Global Positioning System (GPS) locations were recorded by the field teams and processed by using Microsoft Excel. We quantified the demographic structure and distribution of blue sheep, and determined the sex and recruitment ratio from the total blue sheep count data. Using GIS ArcView software, we

estimated the density of blue sheep, recruitment rate is expressed per 100 female and mapped the locations and distribution pattern of blue sheep groups.

4. Use of data

The data collected during this study will provide important baseline figures that can be used to assess the long-term trends of blue sheep population. The trained staff and citizen scientist engaged during the present count will be mobilized in regular monitoring of prey base in future. Moving forward, the blue sheep surveys will be performed by NTNC-ACAP on an annual basis in the same season using the same methodologies. Information generated from this study will be useful to develop predator and prey base conservation strategy.

5. Results

Population structure

A total of 40 blue sheep groups with 335 individuals were observed in the three study blocks. The study blocks covered about 148.5 km² (Samjung-Choser - 45.5 km²; Yara-Ghara - 61.6 km²; and Marang - 41.4 km²). The study estimated a population density of 2.3 blue sheep per km² (SD 0.84, N=3). The mean group size was 8.4 individuals (SD 5.5, n=40), ranging from 2 to 22 individuals.

The overall recruitment of 0.6 young per adult female, or 60 young per 100 females (SD 0.16, N=3), was counted in the spring season (April to early May). Similar to the findings of Schaller (1977) and Wegge (1979), we did not find evidence of twinning in the study area (N=3, n=40). This study also found that the young to yearling ratio is about 0.53, indicating a 47% mortality rate if we assumed the recruitment rate was similar in 2011. Moreover, a slightly female biased sex ratio (female to male: 1:0.83; SD 0.43, N=3) indicates the possibility of pressures on males from predation and poaching, or simply that there was an absence of male groups during our counting periods (n=40). The Yara-Ghara block had the highest density (2.8 individuals/km2), followed by Samjung-Choser (2.4 individuals/km2) and then Marang (1.2 individuals/km2). However, the blue sheep population density was not significantly different between the blocks ($P>0.05$). In the Samjung-Choser block, a minimal recruitment rate was observed (44 per 100 adult female) and indicates a decreasing trend in the population. This contrasts with what was observed in Yara-Ghara and Marang (about 70 young per 100 adult female), which show increasing trends. The Samjung-Choser and Marang blocks had female biased sex ratios (Table 2 & 3), which were in contrast to that of Yara-Ghara where males outnumbered females.

Table 2: Blue sheep population structure (N=3, n=40) in Upper Mustang during spring 2013.

					Male						
Block	Group	Female	Young	Yearling	Young	Sub-adult	Adult	Unidentified	Total	Area km²	Density
Samjug Choser	15	54	24	8	8	9	8	0	111	45.5	2.4
Yara Ghara	19	51	37	22	17	33	14	0	174	61.6	2.8
Marang	6	14	10	8	4	4	2	8	50	41.4	1.2
Total	40	119	71	38	29	46	24	8	335	148.5	2.3

Table 3: Sex ratios, recruitment rates, and young to yearling ratios in blue sheep (N=3, n=40) in Upper Mustang.

SN.	Block	Recruitment rate	Female to male ratio	Young to yearling ratio
1	Samjung Choser	0.44	1:0.46	1:0.33
2	Yara Ghara	0.73	1:1.3	1:0.41
3	Marang	0.71	1:0.71	1:0.8
	Overall	0.6	1:0.83	1:0.53

Blue sheep habitat

Blue sheep were recorded during this study from an altitude of 3,577 meters to 5,009 meters above sea level in upper Mustang (mean: 4,387m, , n=40). Blue sheep were observed in areas with a mean slope of 40° (min: 5° to max: 90°). This study found that the south-west facing slopes were highly preferred by blue sheep (almost 48%), followed by south-east, north-east and north-west. During our study, the north facing slopes were avoided by blue sheep (n=40). In addition, we observed almost 40% group of blue sheep in scrubland, followed by 38% in grassland and 22% in barren land.(see Figure 5). Slightly broken terrain and rolling terrain were mostly selected by blue sheep over flat and highly broken terrain. Blue sheep were found at a mean distance of 205 meters from escape cover, or cliffs (min=0; to 2000m). Here blue sheep perhaps minimize risk by selecting 200 meters distance from escape cover, because their presence of multiple predators the snow leopard a solitary but opportunistic predator and grey wolf, group hunter with coursing technique to hunt. Figure 2 below portrays the distribution of blue sheep in Samjung-Choser, Marang and Yara-Ghara.

Figure 2: Distribution of blue sheep in Samjung-Choser

Figure 3: Distribution of blue sheep in Marang

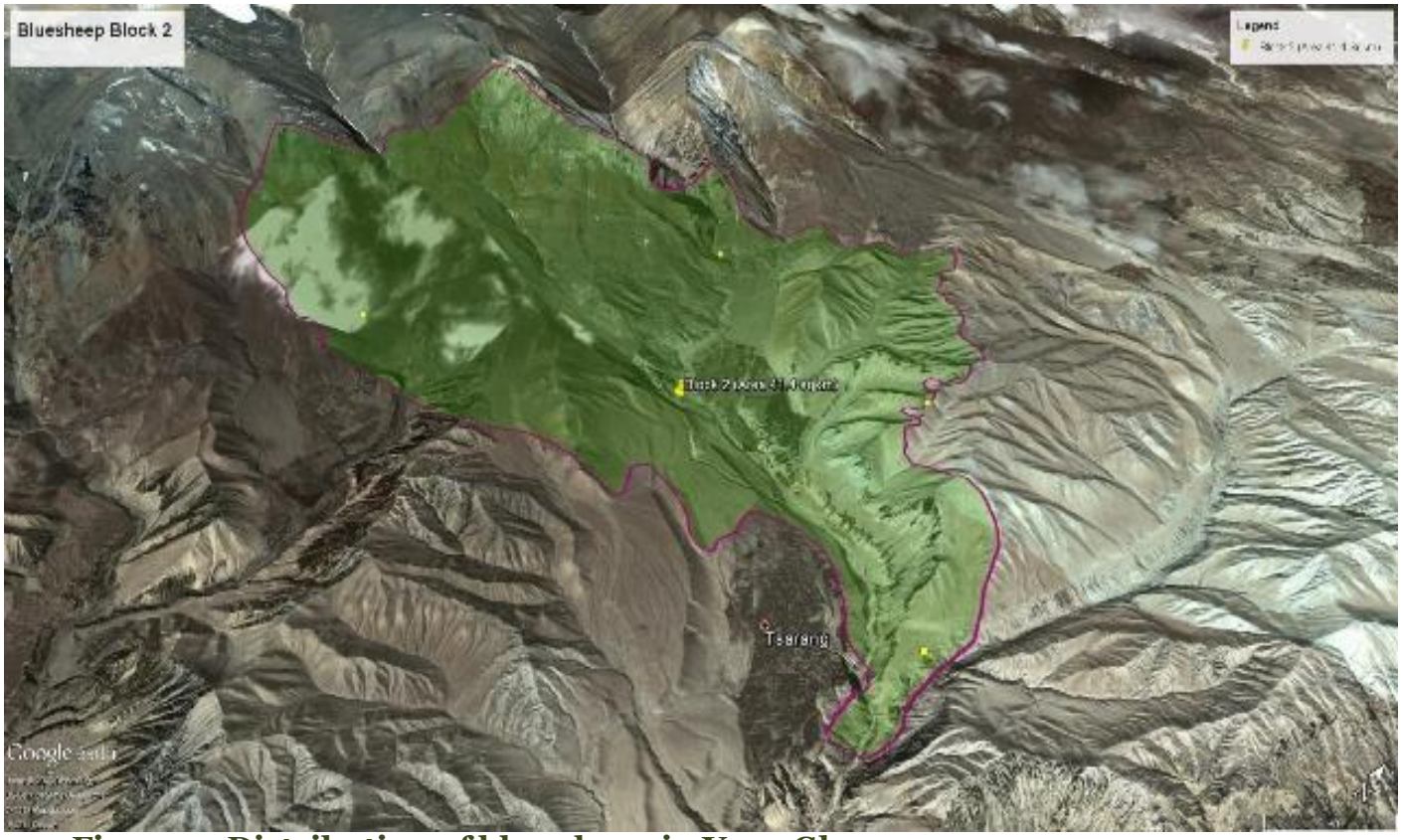

Figure 4: Distribution of blue sheep in Yara-Ghara

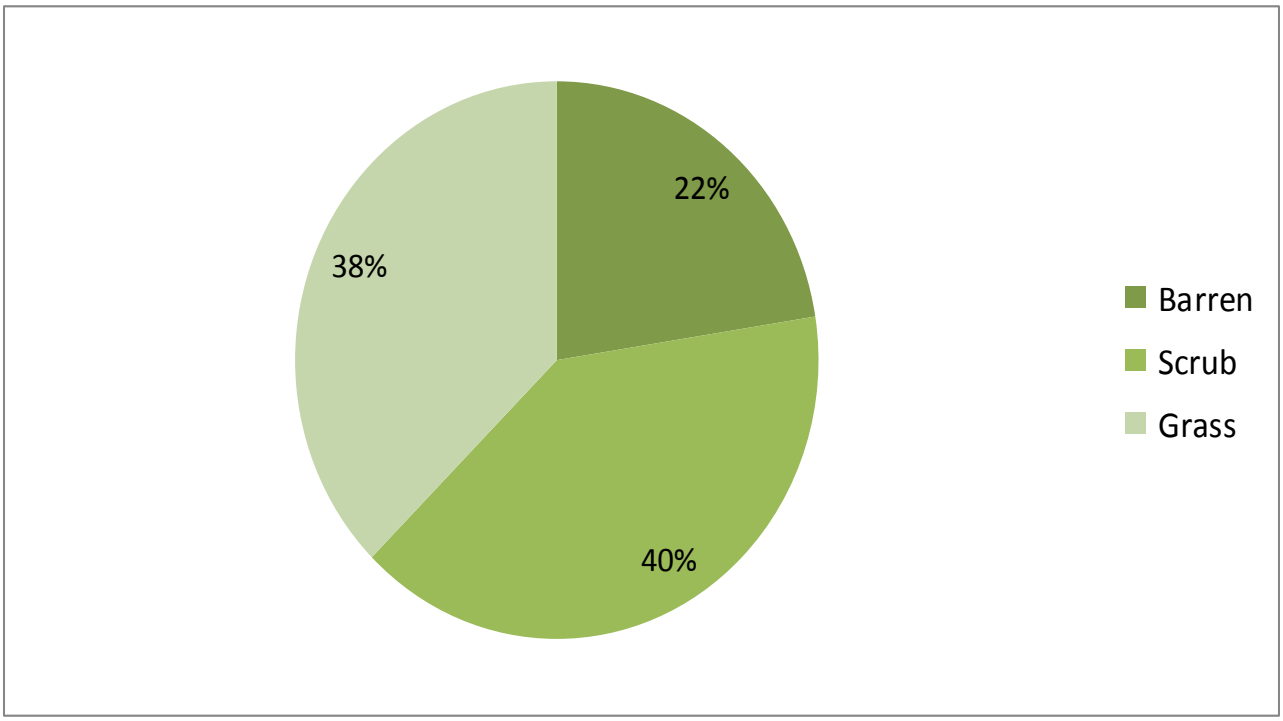

Figure 5: Chart showing percentage of habitat type used by blue sheep

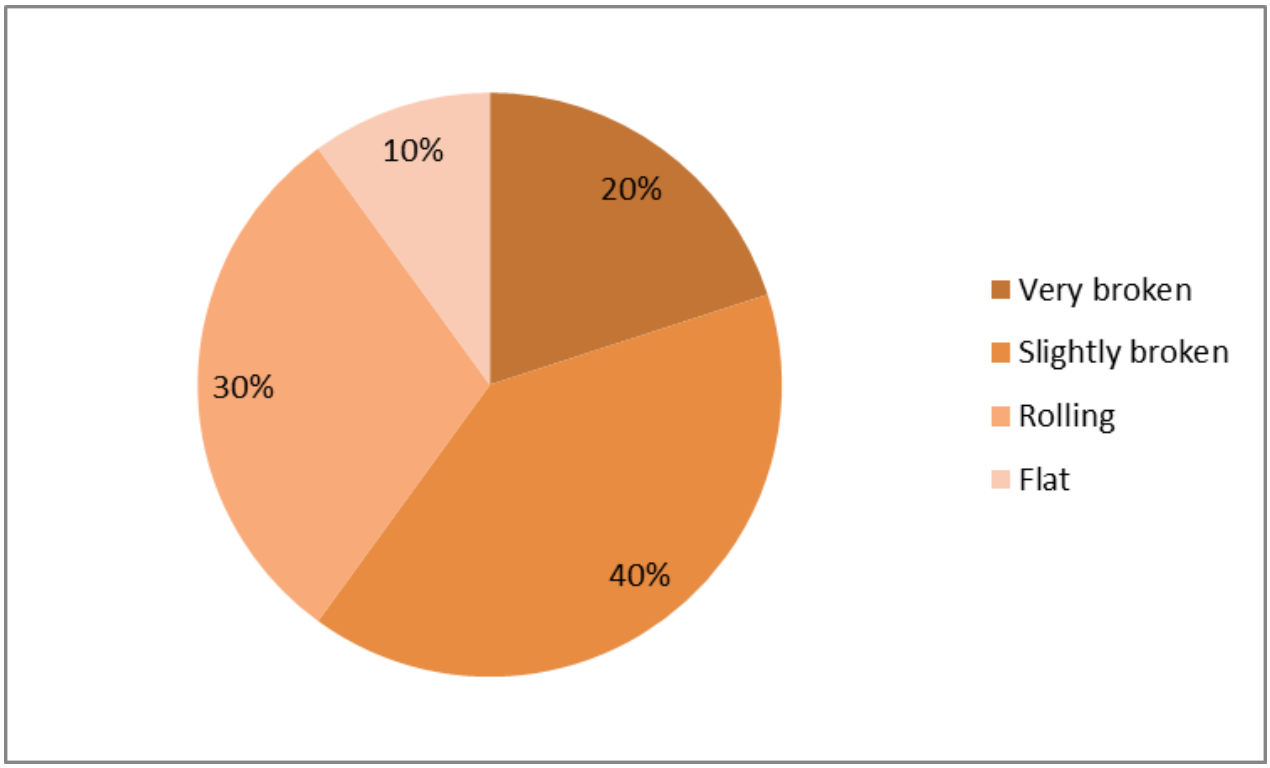

Figure 6: Chart showing landform ruggedness used by blue sheep

6. Discussion

The blue sheep densities differed greatly from area to area. Blue sheep in the present study area occupy large areas and are sparsely distributed in comparison with adjoining districts of Manang, Dolpa and Dhorpatan of the Nepal Himalaya (Shrestha and Wegee 2008; Thapa 2006; Ale and Thapa 2000; Oli 1994; Wilson 1981; Schaller 1977) (Table 4). Blue sheep densities reported by other studies in this region also vary. For example, Aryal *et al.* (in press) observed a blue sheep density of 0.86 individuals per km² in upper Mustang, which is lower than the density observed in the present study. Chetri and Pokharel (2005) estimated slightly higher (5.6 animals/km2) densities of blue sheep in Damodar Kunda that adjoins the present study area.

Table 4: Minimum crude densities and population compositions of blue sheep in Several areas of Nepal

Location	Season	Surveyed area	No. of blue sheep	Density per km²	Male per 100 female	Recruitment per 100 female	% of Survival	Source
DHR	Year (1977)	960	700-740	0.7-0.8	102	83	96	Wilson 1981
Lapche	Spring	35	50	1.4	116	88	93	Schaller 1977
Shey	Winter	550	500-700	0.9-1.3	134	40	73	Schaller 1977
Manang	Spring	105	697-1071	6.6-10.2	93	51	65	Oli 1994
Phu	Spring	192	1209	6.3	67	50	97	Thapa 2005
Shey	Spring	360	721	2.1	70	50	67	Thapa 2006
KCA	Autumn	400	1404	3.5	73	44	55	Thapa 2012

The recruitment rate of 60 young per 100 adult females in spring season displayed a satisfactory reproductive rate (or birth rate). However, it was the early breeding season (pre-parturition) during the surveys, thus it can be assumed that more offspring would have been born but was not reflected in the data. Weather, range condition and level of nutrition could have marked effect on reproductive success and survival rate in any one year as many ungulate studies have shown. Reproductive success in blue sheep varied greatly from area to area. In Nepal, the ratio ranged from 40:100 in Shey (Schaller 1977) to 83: 100 in Dhorpatan (Wilson 1981) (Table 4). It is important to note that Aryal *et al.* (in press) and Chetri and Pokharel (2005) found 30 and 45 young per 100 females, respectively, in the autumn season after lambing in the Upper Mustang area. The corresponding reproductive rates of several blue sheep populations in the Tibetan

plateau range from 0.26 to 0.4 (Schaller 1998). The recruitment rate of the blue sheep in upper Mustang indicates relatively stable population but higher mortality rate between one and two years of age. Young, which needs to invest much energy in body growth, there is no doubt that enters the stressful winter with low fat reserves, making them susceptible to malnutrition, disease, and predation (Schaller 1977; Lovari et. al. 2009). In present study, another reason for this could be the presence of multiple sympatric predators, such as snow leopard, wolf and lynx suppressing on those ages of blue sheep. Another reason could be rangeland quality and its nutritional condition and presence of herbivore species such as blue sheep may compete with domestic stock, Marmot, Woolly hare, Tibetan Argali and Tibetan Gazelle, unlike Manang and Kangchenjunga. But, Shrestha and Wegge (2008) studied livestock- blue sheep relationships in the Phu valley of Manang and concluded that two species groups overlap in both habitat and food, competition is not acute due to resource partitioning.

This study shows the high mortality rate of 47% between one year and two years age. This could be due to acute predation pressure on yearling by multiple predators. In Dhorpatan's fine alpine meadows, about 50% of the blue sheep died between birth and two years of age, most during winter (Wegge 1979). The decline between young and yearling in Manang was 44.3% (Ale and Thapa 2000). Such evidence was also reported by Lovari *et al.* (2009), young to female ratio was high in summer (0.8-0.9) and the decrease by up to 0.1 to 0.2 in autumn implying summer predation concentration on young Himalayan tahr.

We observed a slightly female biased sex ratio, probably due to poor reflection of male groups during our survey. Such evidence was supported by Aryal *et al.* (in press) and Chetri and Pokharel (2005), who counted 79 and 56 males per 100 females in Upper Mustang, respectively. In other studies, the blue sheep populations in the Tibetan Plateau also had an extremely low male to female ratio (25:100; Schaller 1977) due to sexual segregation of those populations. However, Wegge (1979) and Wilson (1981) in Dhorpatan in west Nepal found no evidence of sexual segregation in the fine alpine meadows. The Manang populations showed a higher male-to-female ratio (93:100; Oli *et al.* 1993). Evidently, adult females outnumbered males (Ale *et al.* 2007), in contrast to most ungulate species which demonstrate a 1:1 ratio(Schaller 1977) a typical situation in the wild sheep and goats with low predation pressure and un-hunted pressure . The low male to female ratio in this study could not be explained, but perhaps adult male groups could not be located during the study period. Outside the rutting season, because of sexual segregation, such a low male to female ratio is not surprising. In addition, subsistence hunters may prefer males because these provide more meat, but this was unlikely to be the main reason for the disparate ratios (Schaller 1977).

7. Recommendations

1) Blue sheep monitoring should be continued in future in the same blocks using same methodology and season to assess the population dynamics. It will also be important for continued engagement of local experts and trained citizen scientists for long-term monitoring and conservation of blue sheep.
2) The present study was not able to explain the reasons for the low survival rate of young of one to two yeas age. It is, therefore, essential that future studies assess the predator (mainly snow leopard and wolf) and blue sheep relationship, rangeland condition and its relationship between wild and domestic ungulates.

3) The present study area falls under climate sensitive zone, specifically with respect to the availability of water resources. Impact of climate change in the local human communities in upper Mustang is already evident. For example in two settlements namely Dhey (14 households) and Samjung (18 households) greatly suffer water scarcity and planning to move into water rich areas nearby. This trend is likely to increase in future (pers. com with Shree Krishna Neupane, ACAP staff during survey period). Impact of climate on local wildlife populations and their habitat is not studied yet. Therefore, a long term study on potential impact of climate change on overall biodiversity of the region is strongly recommended.

4) Blue sheep population could also be affected by a range of anthropogenic pressures, mainly hunting and habitat degradation due to livestock grazing. An integrated climate smart and participatory conservation and development programs are recommended to avoid the risk of anthropogenic pressure to blue sheep, predators and their habitats..

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Annex 1

Figure 7: Figure shows permanent blue sheep monitoring in Samjung-Choser

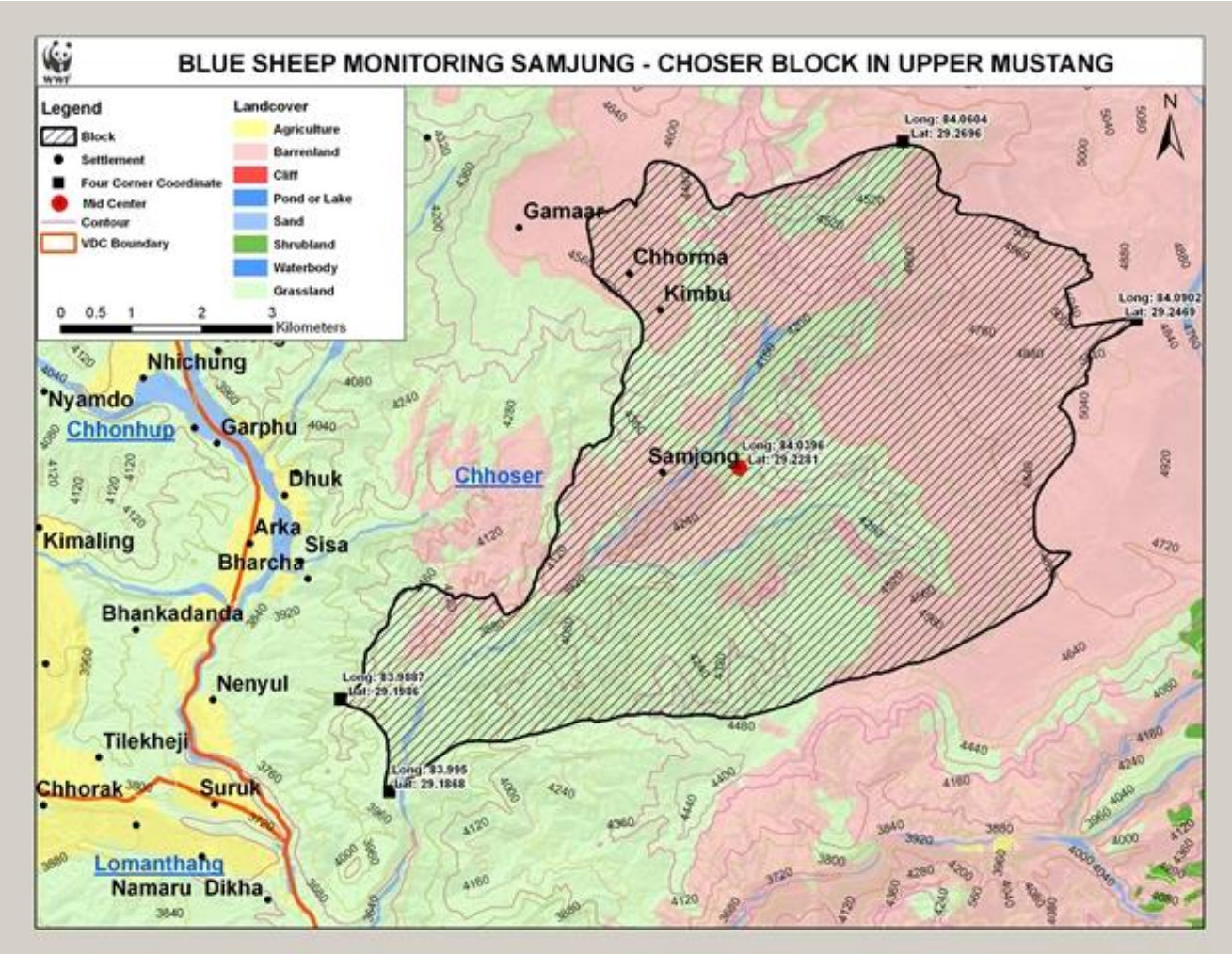


Table 5: Center and four corners of GPS locations of Samjung- Choser block

Block	Location	Longtude	Latitude	Area km²
Samjung- Choser	Center	84. 0396	29. 2281	45.5
	East	84. 0902	29. 2469	
	West	83. 9887	29. 1986	
	North	84. 0604	29. 2696	
	South	83. 995	29. 1868	

Figure 8: Figure shows Marang permanent blue sheep monitoring block

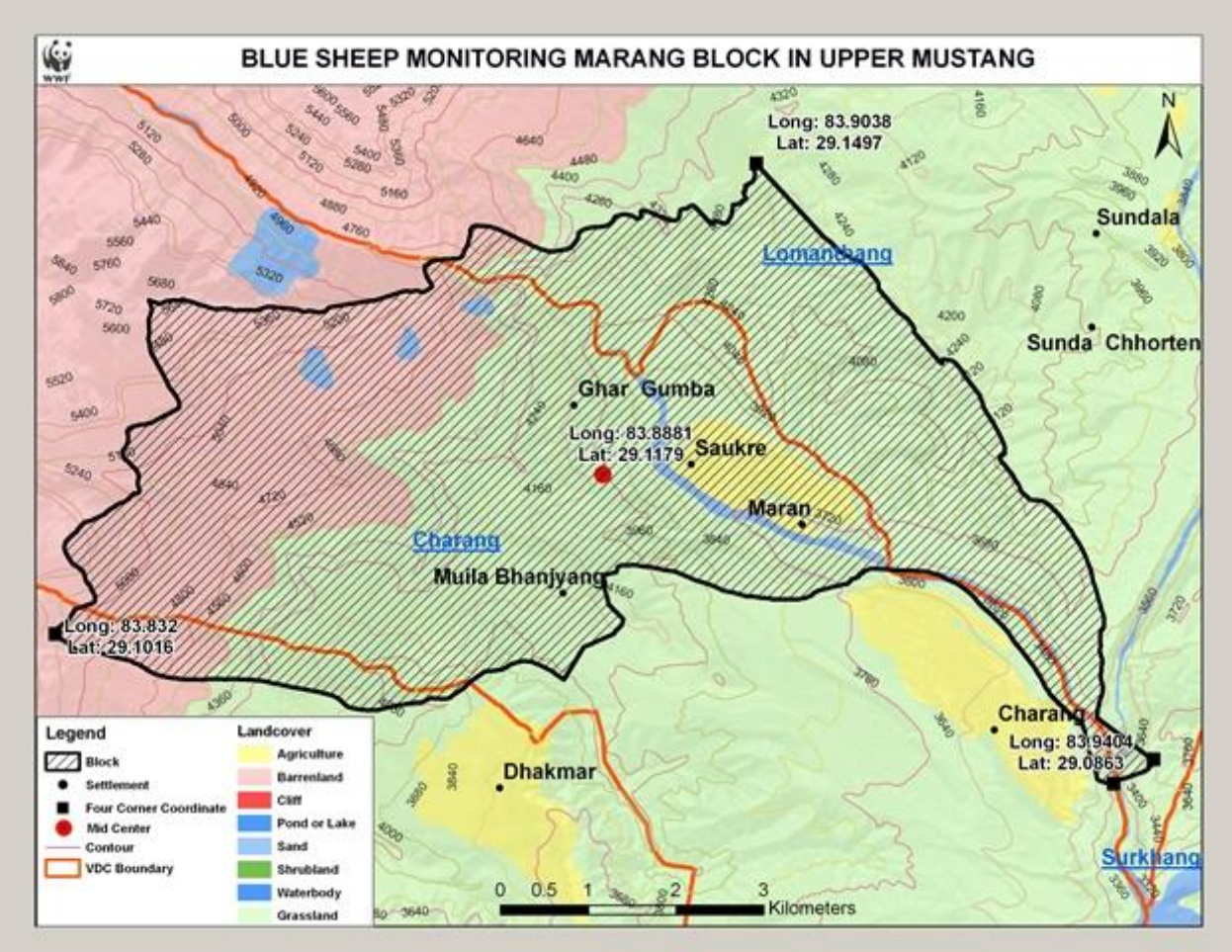


Table 6: Center and four corners of GPS locations of Marang block

Block	Location	Longitude	Latitude	Area km²
Samjung- Choser	Center	83. 8881	29. 1179	41.5
	East	83. 9404	29. 0863	
	West	83. 832	29. 1016	
	North	83. 9038	29. 1497	
	South	-	-	

Figure 9: Figure shows Yara- Ghara permanent blue sheep monitoring block

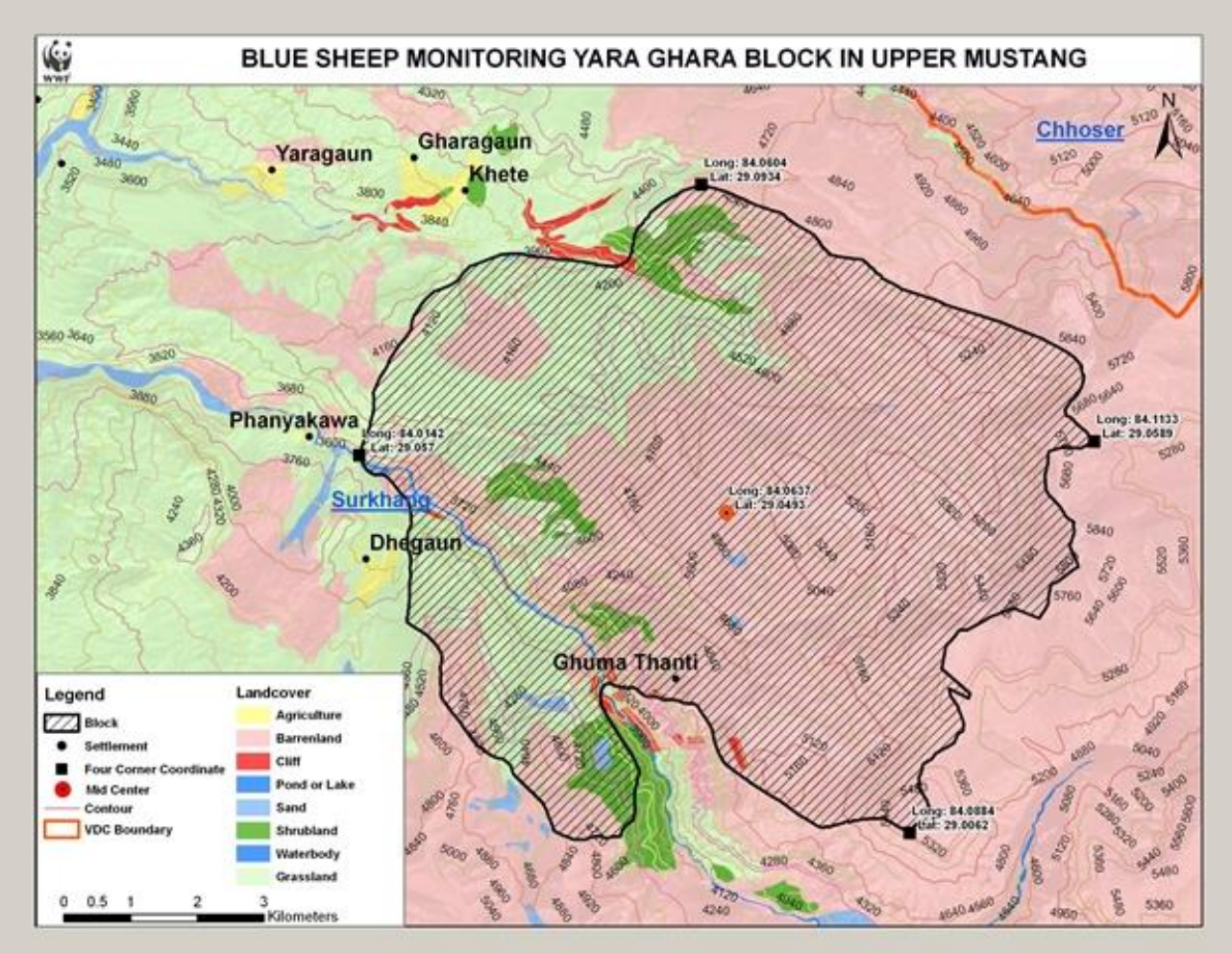


Table 7: Center and four corners of GPS locations of Yara- Ghara block

Block	Location	Longitude	Latitude	Area km²
Yara- Ghara	Center	84. 0637	29. 0493	61.6
	East	84. 1133	29. 0589	
	West	84. 0142	29. 057	
	North	84. 0604	29. 0934	
	South	84. 0884	29. 0062	

Annex 2

Blue Sheep Second Order Form

Observer_____ Block_____ Location_____
Date _____ Start time_____ End time_____

Block	Group no.	Population Structure							
		AF	Y1	Y	YM	SAM	AM	UI	Total

Codes:
AF = Adult female, Y1 = Young, Y = Yearling, YM = Young Male, SAM = Sub-adult Male, AM = Adult Male, UI = Un identified

Habitat and GPS location

Group no.	Habitat	Dominant Topography	Ruggedness	Elevation	Aspect	Slope	Dist to Cliff	Lat	Long	Alt.

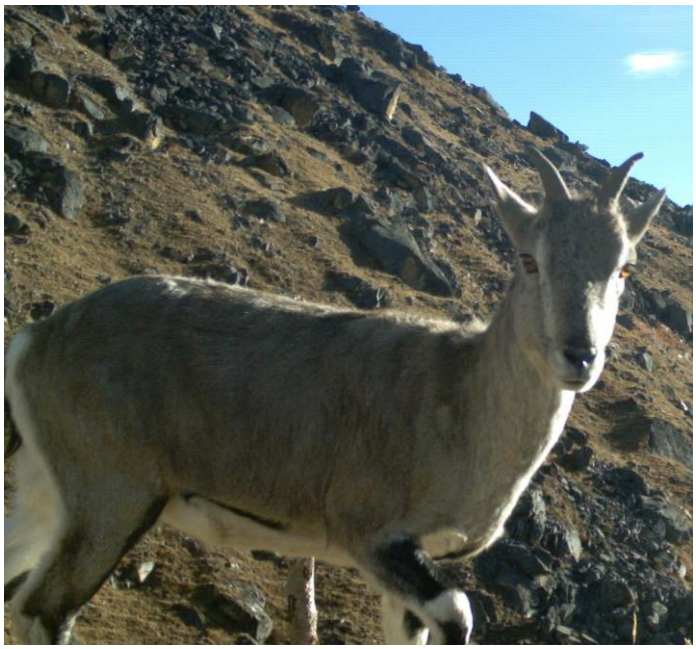
Note: Dist to cliff: Distance from nearest cliff

Remarks:

Annex 3.

Photographs of Blue sheep with sex and age

Young (less than 1 year)



Adult female (more than 2 year)

Yearling (more than 1 year to less than 2 year)

Young male (more than 2 year to less than 4 year)

Sub-adult male (more than 4 year to less than 7 year)

Adult male (more than 7 year)