Habitat Use and Threats of Eurasian Otter (*Lutra lutra*) in Kabeli Khola of Taplejung District, Eastern Nepal

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A dissertation submitted

In partial fulfilment of the requirements for the award of the degree of Master of Science in Zoology with special paper Ecology and Environment

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Declaration

I hereby declare that the work presented in this dissertation "Habitat use and threats of Eurasian otter (*Lutra lutra*) in Kabeli khola of Taplejung district, eastern Nepal" has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

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Certificate of acceptance

This dissertation work submitted by Mr. Amir Basnet entitled "Habitat use and threats of Eurasian otter (*Lutra lutra*) in Kabeli khola of Taplejung district, eastern Nepal" has been accepted as a partial fulfilment for the requirements of Master's Degree of Science in Zoology with special paper Ecology and Environment.

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Abstract

The presence of otter is one of the indicators for assessing the health of ecosystem. The Eurasian otter (*Lutra lutra*) has been the subject of numerous researches including its distribution and threats in Nepal. However, those studies were either confined to scope and space or were based on inadequate evidence, resulting in an information gap, notably about the Eurasian otter habitat in eastern Nepal. Despite of anecdotal indications of otter existence in the Kanchenjunga Conservation Area, there has been lack of rigorous survey of otter along the Kabeli khola. Therefore, this study investigated the habitat use and threats of the Eurasian otter in Kabeli khola of eastern Nepal. Transect survey was applied along the river creating a plot of 200 m x 10 m at every 500 m interval. In each plot occurrence of otter and habitat variables were measured. The occurrence of otter in the study area was confirmed based on sign detection and camera traps i.e., photographic evidence of Eurasian otters. The effects of variables on the habitat use by the species was assessed through generalized linear mixed model. Boulder percentage and fishing evidence were identified as the significant variables that positively influenced the habitat use by the species. Threats were assessed through the questionnaire survey to the fisherman residing near to river. Poaching and accidental killing were identified as the direct threats while electrofishing, dam construction, prey declination, habitat disturbance and poaching were identified as primary cause for the population declination of otter. Conservation measures such as including otters as local courses in schools, controlling the use of electricity in fishing, monitoring the effects of hydropower and controlling poaching were recommended to address these threats. Future research should focus on population counting, impact of dam construction and direct habitat measurement techniques for effective conservation strategies.

शोध सार

ओतको उपस्थिति जलीय पर्यावरणको स्वास्थ्य मूल्याङ्कन गर्ने एक सूचक हो । नेपालको पहाडी तथा हिमाली क्षेत्रका ताल, नदी तथा स-साना खोला खोल्साहरुमा Eurasian otter को बासस्थान प्रक्षेपण गरीयता पनि यसको अध्ययन भने केही सिमित क्षेत्र र दायरामा मात्र भएको छ । भएका अध्ययनरु पनि कमजोर प्रमाणमा आधारित रहेका छन; साथै अर्कातर्फ, यसको चोरी शिकारी र वासस्थानको विनाश समेत बढिरहेको छ । पूर्वी नेपालको कञ्चनजङ्घा संरक्षण क्षेत्रमा केही दशक पहिले Eurasian otter को बासस्थान रहेको अध्ययनले देखाएता पनि पछिल्लो समयका अध्ययनमा नभेटिनुले उक्त क्षेत्रमा यसको उपस्थितिमाथि अन्योलता बढेको थियो । यहि जानकारीको अभावलाई पूर्ती गर्न पूर्वी नेपालको काबेली खोलामा कालो ओतको बासस्थान र संरक्षण चुनौतीका बारेमा अध्ययन गरिएको छ । खोलालाई transect मानेर काबेली खोलाको एक किनारमा 200 m x 10 m को plot बनाई ती plot मा ओतको उपस्थिति र तिनिहरुको बासस्थानलाई प्रभाव पार्ने बिभिन्न एघार प्रकारका कारकहरुको विवरण सङ्कलन गरिएको थियो । उपस्थितिलाई चिह्न मार्फत निर्क्योल गरिएको थियो, साथै क्यामेरा ट्रापको प्रयोग गरी Eurasian otter रहेको प्रत्यक्ष प्रमाण समेत जुटाइयो । स्थानियले माछा मारिरहने प्रसस्त ठुलो ढुङ्गा भएको ठाँउलाई ओतले बासस्थानको रुपमा धेरै प्रयोग गर्ने गरेको पाइयो । करीब एकतिहाइ अन्तर्वार्तामा सहभागी मछुवारालाई मानिसले ओत मार्ने गरेको जानकारी रहेको र करीब तीन चौँथाइलाई ओतको संख्या घटेको आभाष भएको पाइयो । यसरी ओत मार्नुमा चोरी निकासी र आकस्मिक हत्या साथै संख्या घट्नुमा बिद्युतद्वारा माछा मार्ने, बाँध निर्माण, आहार घट्ने, बासस्थानको विनाश, चोरी शिकारी प्रमुख कारक रहेको उनिहरुको बुझाइ थियो । बिद्यालय शिक्षामा स्थानीय पाठ्यक्रमको रुपमा ओतजस्ता स्थानीय जनावरहरुलाई समावेश गर्ने, माछा मार्नमा बिद्युतको प्रयोगलाई नियन्त्रण गर्ने, हाइड्रोपावरको प्रवाभलाई निगरानी गर्ने, चोरी शिकारी नियन्त्रण गर्ने तथा भविस्यमा प्रत्यक्ष विधिबाट बासस्थानको अध्ययन, बाधनिर्माणको प्रभाव र ओतको संख्याको अध्ययन गरी क्षेत्र बिशेष प्रजाती कार्य योजना बनाई काबेली खोलामा रहेको ओतको संरक्षण गर्न सिफारिश गरिन्छ ।

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List of abbreviations

Abbreviated form	Details of abbreviations
AICc	Akaike Information Criterion with correction for small sample size
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
GLMM	Generalized Linear Mixed Model
GPS	Global Positioning System
IUCN	International Union for Conservation of Nature and Natural Resources
KCA	Kanchenjunga Conservation Area
QGIS	Quantum Geographic Information System
WWF	World Wide Fund for Nature

1. Introduction

1.1 Background

An animal habitat is multifaceted, involving a number of factors and the circumstances that arise from their interactions (Madhusudhan & Johnsingh, 1998). There are many different factors that affect habitat selection, and they vary depending on the species. The utilization of a habitat is determined by its requirements for feeding, resting, reproduction, and foraging, which are distinct and particular to the species (Perrin & Carranza, 2000). Analyzing these factors separately is crucial for developing effective conservation programs, especially for species like otters, which play a significant role in their ecosystem and whose habitats are particularly vulnerable. Freshwater ecosystems, where one-third of vertebrate species reside, are especially noteworthy for their biodiversity (Dudgeon et al., 2006). However, human activities are drastically altering natural river systems, posing a serious threat to aquatic biodiversity and making freshwater habitats among the most endangered ecosystems worldwide (Dudgeon et al., 2006; Vörösmarty et al., 2010). The Eurasian otter (*Lutra lutra*) stands out as an apex predator and keystone species in freshwater ecosystems, serving as an important biological indicator of aquatic health (Kruuk, 2006).

Eurasian otter is a carnivore mammal of the subfamily Lutrinae under Mustelidae family (Hung & Law, 2016). Physically it possesses typical otter characteristics, such as a broad, round head with whiskers and semi-webbed feet that display visible toes (Kruuk, 2006). Its elongated body concludes with a cone-shaped tail, and its dense, dark brown pelage, lighter on the underside, distinguishes the species (Kruuk, 2006; Hung & Law, 2016). It is sexually dimorphic, males are 50% larger than females, with body masses ranging from 5.45–11.4 kg for males and 3.36–7.6 kg for females (Conroy et al., 2000). The species diet includes fish, amphibians, birds, small mammals, and aquatic invertebrates, and influenced by local prey abundance (Smiroldo et al., 2009; Delibes-Mateos et al., 2014). Females reach sexual maturity at 2 years, remaining in breeding condition until 15 years, producing small litters of 1–2 young (Hauer et al., 2002; Ruiz-olmo et al., 2011). Eurasian otters display intrasexual territorial behaviors, with territories rarely overlapping among individuals of the same sex (Erlinge, 1968).

Eurasian otter is the most widely distributed otter species having its distributional range throughout Europe, all over Asia and some parts of northern Africa with uneven density and constantly declining population (Hung & Law, 2016; Yoxon & Yoxon, 2019). In Nepal, the species is believed to be present in mountain streams, rivers and lakes (Acharya & Rajbhandari, 2011) with estimated population of 1000–4000 (Jnawali et al., 2011). The species long history of infrequent sightings conflicts with past estimates and notions of a large distribution. After 1991, there was uncertainty regarding its presence but new records from the Barekot river in Jajarkot district (camera trap images), the Roshi river in Kavrepalanchok district (a dead Eurasian otter's skull), a pelts and photos from the Tubang river in Rukum East district and dead otter from Chandragiri, Kathmandu, have clarified the situation (Shrestha et al., 2021b; 2022; 2023a). In both IUCN Red List of Threatened Species and Nepal National Red List, the species is listed as Near Threatened (Jnawali et al., 2011; Loy et al., 2022). The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has listed this species in Appendix I (CITES, 2015).

Eurasian otter resides in variety of habitats including lakes, marshes, rivers, estuaries, and the seashore (Mason & Macdonald, 1986; Kruuk, 2006). They are also recorded > 4000 m in Tibet (Mason & Macdonald, 1986). Many of them can be found in Nepal reside under rock piles or under the tree roots near to river (Acharya & Rajbhandari, 2011). The species faces significant threats from pollution and habitat alterations (Mucci et al., 2010). Human activities, such as mining, river canal construction, damming, aquaculture, wetland drainage, and habitat removal are further endangering Eurasian otter populations (Mucci et al., 2010). Additionally, there are risks of accidental entrapment in traps meant for other species and vehicular collisions (Madsen & Prang, 2001). Lack of awareness, accidental killing, poaching, and habitat degradation are the major threats to Eurasian otter in Nepal (Basnet et al., 2020).

Study on habitat and threats identification is helpful in directing conservation and management of a species (Noon et al., 2012). These baseline ideas can give us a way to decide where to concentrate the conservation efforts and allocate our time and resources for their study and conservation.

1.2 Statement of problem

Numerous studies in Nepal have focused on the Eurasian otter (Acharya & Rajbhandari, 2011; Kafle, 2011; Basnet et al., 2020; Shrestha et al., 2021a; 2021b; 2022, 2023a);

however, they are either restricted to particular place or solely based on sign survey and people's perception. This created knowledge gap on Eurasian otter especially from eastern region of Nepal. The former Nepal Otter Action Plan 2020 acknowledges these shortcomings and intends to strengthen surveys with strong evidence (Thapa, 2020). Despite of anecdotal indications of otter existence in the Kanchenjunga Conservation Area (KCA), there has been lack of rigorous survey of otter along the Kabeli khola in Taplejung. Failure to address this information gap could lead to the species' local extinction owing to a lack of understanding and conservation efforts.

1.3 Objectives

1.3.1 General objective

The general objective of this study was to identify the habitat use and threats of Eurasian otter in Kabeli khola of Taplejung district, eastern Nepal.

1.3.2 Specific objectives

The specific objectives of this study are:

- To assess the habitat used by Eurasian otter in Kabeli khola.
- To identify the threats on Eurasian otter along study river.

1.4 Research questions

- What were the effects of habitat variables on occurrence of Eurasian otter in Kabeli khola?
- What were the threats to Eurasian otter along the study river?

1.5 Significance of the study

Otters are top predator and keystone species in aquatic ecosystems, and their extinction could lead to cascade effects throughout the entire ecosystem (Fortin et al., 2005; Raymond et al., 2021). Otters also acts as flagships for freshwater conservation and their presence indicates good aquatic health since they are sensitive to pollution (Mason & Macdonald, 1986; Kruuk, 2006). Knowledge about their habitat and associated threats is crucial for developing a conservation plan. However, there is currently no information available on the habitat use and threats to the Eurasian otter in the Kabeli khola of eastern Nepal. Therefore, the study on habitat and threats is essential for Eurasian otter conservation. The

data generated from this study can also be used for long-term monitoring of the species in this region.

1.6 Limitations of the study

The study has the following limitations:

- Twelve study plots were discarded due to the rugged and inaccessible terrain.
- Fisherman were not in contact that limits the sample size of the questionnaire.

2. Literature review

2.1 Habitat

The Eurasian otter is the most widely dispersed otter species, with a distribution range that includes entire Eurasia and some areas of northern Africa (Yoxon & Yoxon, 2019; Loy et al., 2022). In Nepal Eurasian otter is believed to be present in mountain streams, rivers and lakes (Acharya & Rajbhandari, 2011). Presence of the species is suggested from 21 districts including Saptari, Sunsari, Ilam, Panchther, Taplejung, Chitwan, Bardia, Kapilvastu, Bara, Kailali, Kanchanpur, Kaski, Bajhang, Bajura, Gorkha, Lamjung, Myagdi, Mugu, Solukhumbu, Manang, and Sankhuwasabha and six protected areas like Annapurna Conservation Area, Koshi Tappu Wildlife Reserve, Makalu Barun National Park, Bardia National Park, Rara National Park, Ghodaghodi Lake Area (Jnawali et al., 2011; Kafle, 2011). Kafle (2011) suggested the presence of the species in Pyaudikhola and Kapringkhola of Gorkha. In Sanibheri River and its upstream tributaries, the Pelma and Utterganga rivers; presence of otters is suggested based on scats without species identification (Shrestha et al., 2021a; Shrestha et al., 2022). But most of these researches were based on sign and people perception so there is no any direct evidence since early 1990s except the photograph of Eurasian otter by Paras Mani Acharya from Lakes in Pokhara Valley (Basnet et al., 2020) and Shrestha et al. (2021b; 2022; 2023a) found the photographic images and pelt from Tubang River in East Rukum, camera trap images from the Barekot River in Jajarkot, skull of a dead otter from Roshi river of Kavrepalanchok and dead otter from Chandragiri, Kathmandu. Eurasian otter presence in the Kanchenjunga Conservation Area was also suggested by Biodiversity Project Profile (BPP, 1995) and Yonzon (1996) but a preliminary assessment by WWF in 2019 found no species of otters from this region (Basnet et al., 2020).

A variety of habitats, including lakes, marshes, rivers, estuaries, and the seashore, are home to Eurasian otters (Mason & Macdonald, 1986; Kruuk, 2006). Additionally, they are recorded from the sea level to elevations greater than 4000 m in Tibet (Mason & Macdonald, 1986). According to Acharya & Rajbhandari (2011) the Eurasian otter found in Nepal used open spaces with lots of food, as well as flora along the banks that gives them peaceful locations to build their holts and reed-covered wetlands for resting and raising young. Shrestha et al. (2021a) examined the habitat variables including river width, plant cover, bankside substrata and habitat disturbance, and discovered that otter scats were

positively correlated with large flat rocks and boulders. Shrestha et al. (2022) have also constructed a predictive model for Eurasian otter distribution in Nepal, with elevation and small stones as a significant-predictors.

2.2 Threats

Eurasian otters continue to face a number of challenges to their existence. The main causes of these include pollution, road deaths, disputes with fishermen, habitat fragmentation, poaching and hydrological changes brought on by dam construction (Yoxon & Yoxon, 2019). The removal of shoreline vegetation, low people awareness, overfishing, poisoning of prey species, human intrusion into river banks for settlement, livestock grazing, dam construction and accidental killings entanglement on fishing nets are all factors contributing to the decline of otter species in Nepal (Acharya & Rajbhandari, 2011; Basnet et al., 2020). In addition, illegal trade of fur is a major threat in Nepal. Savage & Shretha (2018) mentioned that 755 otter furs were captured in Nepal between 1989 and 2017. Because of this, the status of Eurasian otters in Nepal is unclear and there is inadequate data of their habitat.

3. Materials and methods

3.1 Study area

The study was conducted in two periods; pre-monsoon (25 March 2023 to 9 April 2023) and post-monsoon (1 November 2023 to 7 November 2023) in Kabeli khola of Taplejung district located in eastern Nepal. Kabeli khola originates from the eastern part of Kanchenjunga Conservation Area and flows towards south-west direction until it confluence with Tamor river. There are three major tributaries: Tawa khola, Iwa khola, and Phawa khola that feeds their water to the Kabeli khola. At the confluence of the Iwa khola and Kabeli khola, Kabeli H1 hydropower dam was located. The survey was begun from 1.75 km upstream to Kabeli H1 hydropower dam lies nearby Sinam village and continue up to Yamphudin covering a total of 25 km. Both Sinam and Yamphudin village lies within Sirijangha rural municipality.

The major vegetation of the region are Chilaune (*Schima wallichii*), Utis (*Alnus nepalensis*), Katus (*Castanopsis tribuloides*), Guras (*Rhododendron arboreum*), Malato (*Macaranga pustulata*) and Salla (*Pinus roxburghii*) (HHEPL 2021; SRPL 2021). Major mammal species include red giant flying squirrel (*Petaurista petaurista*), leopard cat (*Prionailusus bengalensis*), rhesus macaque (*Macaca mulatta*) and red panda (*Ailurus fulgens*); major herpetofauna include Asian common toad (*Bufo melanostictus*), Himalayan pit viper (*Gloydius himalayanus*), skittering frog (*Euphlyctis cyanophlyctis*) and Himalayan toad (*Bufo himalayanus*) and 31 fish species including katle (*Neolissochilus hexagonolepis*), titey (*Psilorhynchoides pseudecheneis*), chuche asala (*Schizothorax labiatus*) are found in the Kabeli khola (NESS, 2012; SRPL, 2021) which are the potential prey species of otter (Kruuk, 2006; Kafle, 2011).

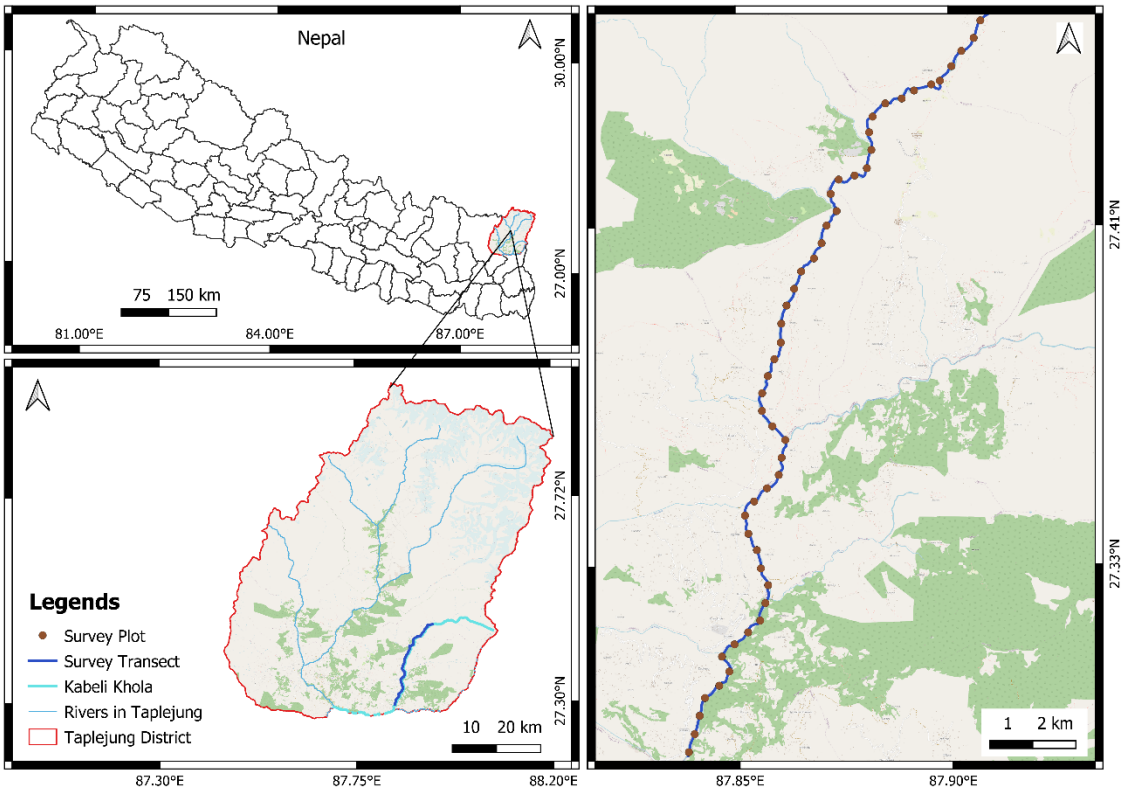

Figure 1. Study area with transect and plot along the Kabeli khola of Taplejung district, eastern Nepal.

3.2 Methods

The occurrence of Eurasian otter in the study area was confirmed based on camera traps photography and sign detection. In this study, 25 km of river was used as a transect. Fifty plots of 200 m (along the river bank) x 10 m (away from the river's edge) were established along one side of river bank at every 500 m.

Eleven habitat variables including elevation, slope, aspect, river flow, river width, river depth, bank width, river bank substrate, distance to nearest human settlement and road/foot trail, and habitat disturbance were measured in each plot as these variables determine the otter presence (Kruuk 2006; Shrestha et al. 2022). Elevation was recorded using GPS device (Garmin eTrex 10) and slope and aspect using clinometer (Silva type 15TD-CL). River width and river bank width was measured using rangefinder (Aspresys). River depth was measured using bamboo stick scaled with measuring tape. All these variables were measured near to the center of the plot. River flow was measured by floating ball method. For this plastic ball was released into the river at 50 m upstream from the center of plot and time to reach 50 m downstream from the center of that plot was recorded, and flow was

calculated by dividing the distance travelled by ball (100 m) to the recorded time (in sec). Riverbank substrate was measured as percentage of boulder. Boulder was defined as the substrate having diameter < 1 m and was measured as percentage from the five subplots (10 m x 10 m) established at every 50 m interval in each plot by visual estimation and was averaged for the analysis. The distance to nearest human settlement and road/foot trail were measured from the center of plot using QGIS 3.26.2. For this vector layer for roads/trails and human settlements were extracted from OpenStreetMap (OpenStreetMap Contributors, 2023), and the website of the Humanitarian Data Exchange (HDX, 2023) respectively. After that distances were measured by overlaying these layers with layer of center of plots using NNjoin tool of QGIS. In addition, habitat disturbance was assessed based on evidence of fishing and excavation. Fishing evidence was identified as if fisherman were fishing in the plot while excavation was recorded if there was access of road and riverbank substrate was extracted.

In addition, signs like footprints, spraints and latrines of Eurasian otter were recorded from each plot. Footprints were distinct with faintly webbed five clawed toes (Olsen, 2014) and their sizes (6 to 8.3 cm) (Kistner et al., 2022). Distinct dietary remnants (fish bones or scales, frog bones and crustacean exoskeletons), fishy smell and conspicuous locations (stones and logs) helped to identify the spraints (Macdonald, 1990; Kruuk, 2006). Latrine site was defined as the area having more than five spraints within 5m. As, these signs only cannot guarantee the species identification, camera traps (Bushnell) were installed near fresh spraints presence area for 100 trap days (10 camera x 10 days). Captured photograph were identified as Eurasian otter since its cone-shaped tail, and dense, dark brown coarse pelage, lighter on the underside, distinguishes the species (Kruuk, 2006; Hung & Law, 2016).

Threats of Eurasian otter were assessed through questionnaire survey. For this semi-structured questionnaire was prepared and fisherman residing near the study river were selected by snowball sampling and interviewed. Both demographic and socio-economic data of fisherman were also recorded during the questionnaire survey.

3.3 Data analysis

Initially, the continuous variables were standardized, followed by a check for normality using the Shapiro-Wilk test. Subsequently, a correlation test was conducted to identify highly correlated independent variables ($|r| > 0.7$). Additionally, variation inflation factors

(VIFs) were computed to detect any variables that might inflate the variation in estimates (VIF > 10). To assess the association among categorical variables, a chi-square test was performed. Neither multicollinearity for any pair of variables nor variation inflation for any variable was found so all the variables were retained for the analysis.

A Generalized Linear Mixed Model (GLMM) with a binomial family was employed to evaluate the effects of selected habitat variables (as fixed effects) on otter detection and non-detection (as the response variable), while treating survey periods as a random effect. GLMM offers a flexible approach for analyzing non-normal data and accounts for random effects associated with nested design (Bolker et al., 2009). Global model (i.e. saturated model with all explanatory variables) was developed using glmer function of the lme4 package in R Studio (Bates et al., 2015). In addition, models with all possible combinations of explanatory variables were generated using dredge function of MuMIn package (Barton, 2023). Given the absence of a dominant model (with distinct Akaike weight), model selection uncertainty was addressed by employing model averaging based on their ΔAICc (Burnham & Anderson, 2002). The top sets of N models with $\Delta AICc \leq 2$ were selected, and their Akaike weights (ωi) were calculated. The ωi of each model represents the relative likelihood of that model being the best within a set of N models. To determine the importance of each variable relative to all others, the ωi of all models within the top set containing the variable of interest was calculated, and the variables were ranked by their ωi values (McAlpine et al., 2006); higher values of ωi (ranging from 0 to 1) indicate greater importance of the variable. Multi model inference and model averaging were employed to ascertain the effect size (parameter estimates) of each variable across the top set of models (Burnham & Anderson, 2002). Variables with equal ωi values were ranked based on the magnitude of their model-averaged regression coefficients.

To analyze the threats, descriptive statistics were used. Data obtained from questionnaire survey were entered and curated in Ms-Excel 2019 and presented in table and bar graphs. All analysis work was done using R studio (R Core Team, 2023).

4. Results

The camera traps installed in Kabeli Khola in Srijanga Rural Municipality, ward - 2, Ambegudin, Taplejung, Nepal, captured photographic evidence of Eurasian otter in pre-monsoon period (Figure 2).

Figure 2. Camera trapped image of Eurasian otter in Kabeli khola, Sirijangha Rural Municipality ward - 2, Ambegudin, Taplejung, eastern Nepal.

4.1 Habitat

In total 67 plots (pre-monsoon period: 35 plots; post-monsoon period: 32 plots) were surveyed during this study. Among them, 29 plots were common to both periods, ensuring consistent survey locations. In the pre-monsoon period otter sign had recorded in 13 plots (spraints = 10; spraint and latrines = 2; spraint and track = 1). Similarly, during the post-monsoon period, otter signs had recorded in 16 plots (spraints = 10; tracks = 4; latrines = 2). The average river width was 17.59 ± 7.45 m across the study periods, whereas the average river depth was 1.12 ± 0.54 m, the average bank width was 13.40 ± 6.44 m, the average river flow was 1.31 ± 0.37 m/sec and the average boulder was 40.86 ± 16.60 %. In addition, the average elevation was 1172.71 ± 308.90 m, the average slope was 33.47 ± 10.20° and the average aspect was 181.21 ± 105.24°. Furthermore, the average distance to nearest settlement and distance to nearest foot trail/road was 191.28 ± 96.28 m and 156.25

± 111.68 m, respectively. Interestingly, no significant variation was observed in otter occurrence between the two survey periods ($\chi 2$, p = 0.289).

Table 1. Models (ΔAICc $\leq$ 2) averaged parameters and their lower confidence interval (LCI) and upper confidence interval (UCI) describing factors affecting the habitat use by Eurasian otter. Eurasian otter occurrence (presence/absence) was response variable while fishing evidence (presence/absence), boulder (%), distance to nearest settlement (m), river flow (m/sec), bank width (m) and river width (m) were predictive variables. Significant effects are in bold.

Parameters	**Estimate**	**Std. Error**	**LCI**	**UCI**	**Z**	**P**
Intercept	-1.818	0.775	-3.366	-0.270	2.301	**0.021**
Fishing evidence	2.122	0.972	0.183	4.061	2.145	**0.032**
Boulder	2.001	0.566	0.870	3.131	3.469	**0.001**
Distance to nearest settlement	-0.726	0.409	-1.544	0.091	1.741	0.082
River flow	-0.787	0.422	-1.630	0.056	1.830	0.067
Bank width	0.491	0.366	-0.241	1.224	1.314	0.189
River width	-0.377	0.420	-1.216	0.462	0.880	0.379

Eurasian otter habitat was influenced by boulder and fishing evidence (Table 1). Predicted otter occurrences demonstrated an upward trend having higher boulder percentage and were notably higher in areas where fishing evidence was recorded (Figure 3). Although not statistically significant, the occurrences of Eurasian otters had a positive association with bank width and a negative correlation with river width, river flow, and distance to nearest settlement (Table 1).

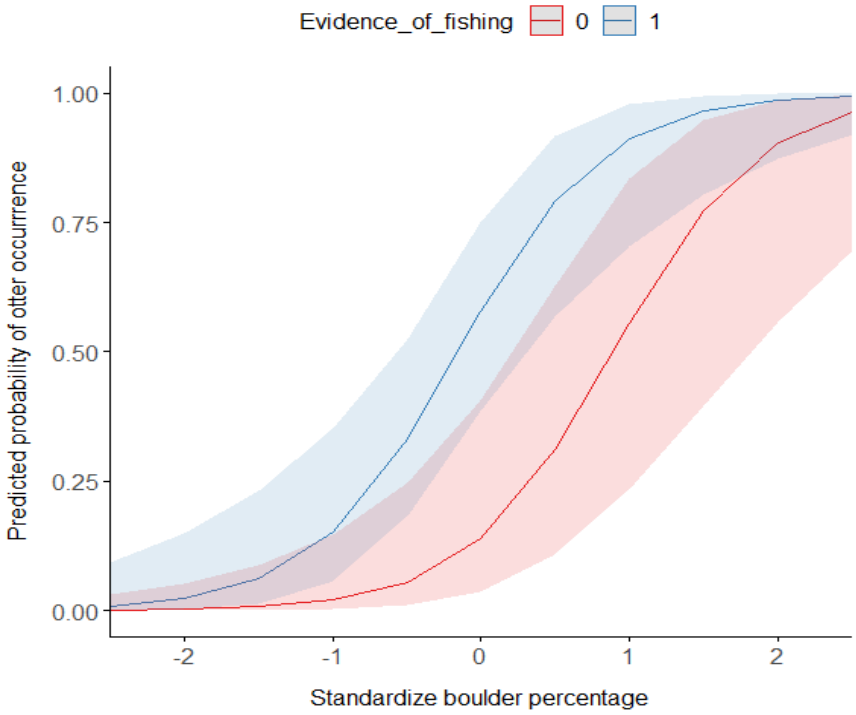

Figure 3. Predicted probability of Eurasian otter occurrence relative to the boulder (%) and fishing evidence (presence/absence) in Kabeli khola, eastern Nepal based the top model (i.e. model with the lowest AICc value).

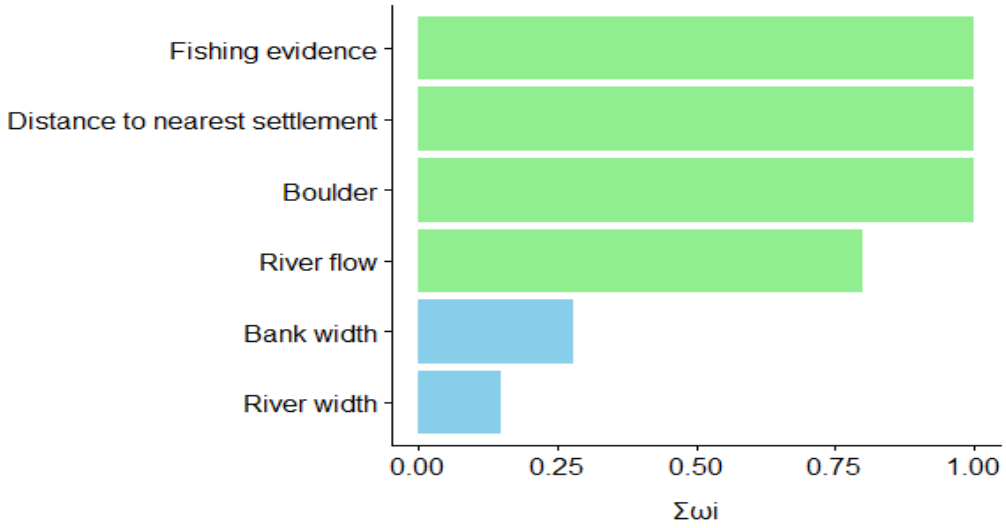

Figure 4. Relative importance of explanatory variables in explaining habitat use by Eurasian otter. Variables are ranked in order of the sum of their Akaike weights ($\Sigma\omega_i$) within the top set of models i.e. models with $\Delta AICc \leq 2$. Green bars indicate those variables that were retained in the top model (i.e. model with the lowest AICc value) and blue bars indicate variables included in all other models within the top set.

4.2 Threats

A total of 44 fishermen were surveyed across seven wards: Sinam, Ambegudin, Tellok, Pedang, Mamankhe, Khebang and Yamphudin in Sirijangha Rural Municipality, Koshi Province, Nepal. Among these fishermen, the majority (57%) were Hindu, and followed Kirat (36%), and the remaining 7% were Buddhist (Appendix Table 2). Regarding ethnicity, half of the fishermen belonged to the Limbu ethnic group, and remaining half comprises from Chhetri, Brahmin, Gurung, Rai, and Sarki. Notably, all surveyed individuals were male. For fishermen's education, 7% had no formal education, 39% had completed primary education, 41% had attained a secondary education, 11% had achieved a higher secondary education, and 2% had obtained a bachelor's degree or higher (Appendix Table 2). Agriculture was major occupation among the fishermen (84%), and followed by individuals involved in business and other students.

All 44 interviewed fishermen confirmed their awareness on the local name for otters and correctly identified the animal, although not the species. Within the Limbu ethnic community of Sirijangha Rural Municipality ward - 6, Mamankhe, otters are referred to as "Haanba" in their native language. Approximately, 86% of the surveyed fishermen (n = 38) had encounters with otters, while 30% of fishermen (n = 13) reported either witnessing or hearing about otters being killed. Among those, approximately 69% believed poaching (n = 9) was the primary cause of killing, while 31% thought accidental killing (n = 4), was the reason (Figure 5). Notably, two fishermen admitted to poaching otters, with one incident occurring during the study period, while another mentioned an accidental entanglement of otter in his fishing net approximately seven years ago.

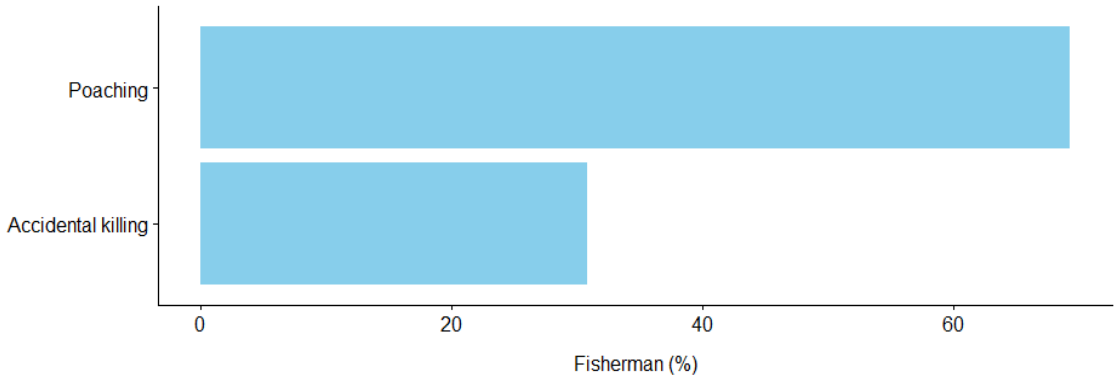

Figure 5. Fisherman's perception of the killing reason of the Eurasian otter in Sirijangha Rural Municipality, Koshi Province, Nepal.

Approximately, 73% (n = 32) of the fishermen expressed concerns regarding the declining population of the Eurasian otter. Among them, 38% (n = 12) mentioned the decline was due to electrofishing, followed by a combination of electrofishing and dam construction (25%, n = 8), prey depletion (13%, n = 4), dam construction alone (9%, n = 4), habitat disturbance (6%, n = 2), and poaching (3%, n = 1) (Figure 6). However, 20% (n = 9) of fishermen believed that the otter population was increasing due to the maintenance of undisturbed and suitable habitat conditions. Additionally, 7% (n = 3) of the fishermen refrained from expressing an opinion on the matter.

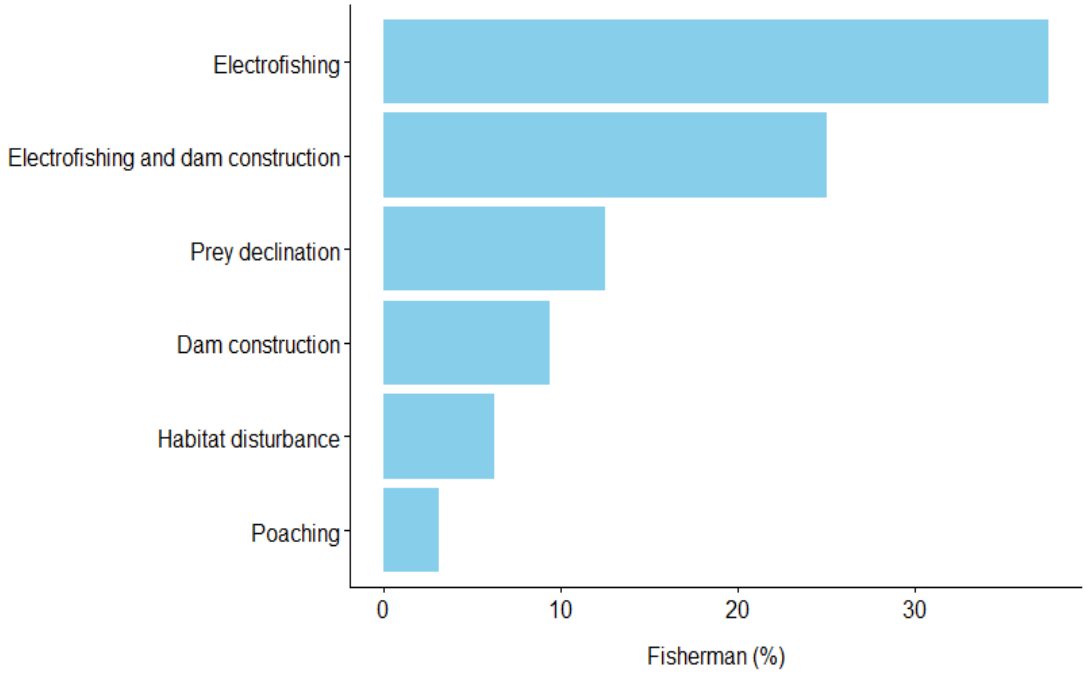

Figure 6. Fisherman's perception of the population declination of the Eurasian otter in Sirijangha Rural Municipality, Koshi Province, Nepal.

When addressing the conservation status, it was found that approximately 16% (n = 7) of the fishermen demonstrated awareness regarding the national protection status since the species is protected in Nepal under Aquatic Life Protection Act, 1961, while the vast majority, comprising 84% (n = 37), lacked knowledge about this matter. A significant proportion of fishermen, constituting 61% (n = 27), expressed the belief that the Eurasian otter should be subject to conservation efforts. Furthermore, around 18% (n = 8) of fishermen expressed their willingness to take personal responsibility for otter conservation by raising awareness among the community. Suggestions put forth by fishermen for the

conservation of the Eurasian otter included enhancing public awareness, monitoring hydroelectric activities, and regulating illegal fishing practices such as overfishing using electricity and explosives, as well as addressing issues related to poaching.

5. Discussion

This study confirms the presence of Eurasian otter in Kabeli khola of eastern Nepal near to the Kanchenjunga Conservation Area. The habitat having boulder and fishing evidence influence occurrence of Eurasian otter. The positive influence of boulder and presence of fishing in the habitat favors on the occurrence of Eurasian otter.

5.1 Habitat

The boulder and fishing evidence both positively influenced the habitat used by Eurasian otter. The positive influence of boulder on the occurrence of Eurasian otter highlights the importance of boulder in shaping otter habitat preferences. This might be due to the spraining behavior of otters as they spraints on conspicuous vantage point like boulders to claim an area for foraging (Erlinge, 1968) and this was even prominent since spraint was the common sign used for otter confirmation in this study. In addition, boulders provide resting site and foraging ground for otters (Kruuk, 2006; Hung & Law, 2016) as it requires covered area to rest and it consumes its prey by taking them outside of the water on large and flat rocks nearby fishing ground (Jamwal et al., 2016). Boulders also provide natural crevices where otter can form denning sites for breeding. Otters prefer river site riffles with boulder substrates for fishing (Durbin, 1996). Not only in this study, Chettri & Savage (2014) and Shrestha et al. (2021a, 2022) also reported the significance of otter presence and the boulder. This emphasizes the necessity of conservation and management efforts focused on preserving and restoring river bank substrate structure and composition to ensure the continued well-being of otter populations.

The odd of otter occurrence was found in favor of fishing evidence in this study, which is different than previous studies (Nawab & Hussain, 2012; Chhettri & Savage, 2014; Jha, 2018). The reason might be lied on the optimal foraging theory which states that animal forage in such a way that minimizes their cost and benefit ratio. Fishing traps laid by fisherman provides the easy meal for otter to optimize their net benefits. This leads a competition between fisherman and otter, escalating human otter conflict and sometime results even killing of otters. This conflict was also validated by the response of fisherman, where all fisherman responded that otters consume their trapped fishes (confirmed from fish remnants) and damage their nets. Despite of the presence of fresh spraints near to fishing trap and even an evidence of trap dragging, the fishing and otter sign was not had

positive relation in Bhutan Chhettri & Savage (2014), it might be due to the unregulated fishing diminishes otter (such as smooth coated otter) availability (Nawab & Hussain, 2012; Jha, 2018). This highlights that positive relationship might not remain for the long term and ultimately conflicts will arise which displaces the otter to confined habitat leading to declination of otter population, emphasizing the need for sustainable riverine resources utilization and conservation and management strategies to balance the coexistence of otter and humans.

5.2 Threats

The study highlights the significant anthropogenic threats faced by Eurasian otter in Kabeli khola, eastern Nepal, resulting decline in their populations. Majority of the fisherman either heard or recognizes the otter photograph (not the species) and had the basic knowledge about where they live and what they eat. Fisherman frequently face the conflict with otter, so they were quite familiar with the species. A study conducted in Mugu district of western Nepal also reported that majority of fisherman were well aware of fish-eating animals, including the otter (Shrestha et al., 2023b). Thapa et al. (2020) also reported that all respondents including fisherman were quite aware about otter and also know otter's signs in Shuklaphanta National Park.

However, Eurasian otter population in the study area faces critical threats. Fishermen believed poaching was one of the major reasons to otter fatalities in Kabeli khola. In addition, it was also persecuted for being a nuisance to fishermen, eating trapped fish and damaging their fishing net which resulted in profit loses for them. Between 1989 to 2017, 755 otter skins were seized in Nepal (Savage & Shethra, 2018) indicating Nepal as the poaching route for largest otter pelt Tibet market (IOSF, 2014). Furthermore, accidental killing of otter entangled in fishing net was also found since nylon loops were used for fishing which was similar to the findings of Shrestha et al. (2022), where they found the pelt of otter dead by entangled with nylon loops set for fishing trap.

In addition, around three quarter of the fisherman believed the otter population decline due to electrofishing, dam construction, prey declination, habitat disturbance and poaching. Electrofishing not only kills adult fishes but it also kills fry and fingerlings that leads to collapse of prey population. In addition, dam construction fragments otter habitat and prevents the migration of fishes since three hydropower are in construction phase and one is already operating in Kabeli khola. Eurasian otter populations were declined in Nepal due

habitat degradation and poaching (Acharya, 1997; 2006; 2016; 2017; Acharya & Lamsal, 2010; Acharya & Rajbhandari, 2011). Habitat degradation encompasses a range of threats such as sand and stone extraction from riverbanks, overfishing, poisoning of prey species, utilization of explosives for fishing, removal of shoreline vegetation, deforestation for fuel and fodder, livestock grazing, construction of irrigation structures, sedimentation, dam construction, human encroachment, and industrial and agricultural pollution (Acharya & Lamsal, 2010; Acharya, 2017).

In Nepal, a notable deficit in conservation knowledge persists, particularly concerning otters (Shrestha et al., 2023b). As a result, a majority of the local people remain unaware about the protected status of Eurasian otter since the species was protected under 2002 amendment on Aquatic Life Protection Act, 1961 (Nepal Gazette, 2002). Furthermore, shortcomings within the education system exacerbate this issue by failing to adequately educate students and communities about the importance of native wildlife species, their conservation status, the threats they confront, and the penalties associated with poaching. Nevertheless, local fishermen consistently express their support for the conservation of the Eurasian otter and emphasize the necessity of a collaborative approach involving local communities, as well as local and national governmental bodies, for the protection of this species.

6. Conclusions and recommendations

6.1 Conclusions

The study confirmed the presence of Eurasian otter in the Kabeli khola of Taplejung district, eastern Nepal. The positive impact of boulders underscores the importance of conserving river bank substrate and implementing sustainable management strategies to maintain otter populations, as conflicts arising from fishing may disrupt otter habitats, highlighting the necessity of balancing human activities with conservation efforts. Poaching, accidental killing, electrofishing, dam construction, prey decline and habitat disturbance threaten otter populations. These findings have crucial implications for guiding conservation strategies to ensure the long-term survival of the Eurasian otter in Kabeli khola. Conservation efforts should prioritize the awareness of people, monitoring of hydroelectric activity, and controlling of electrofishing and poaching.

6.2 Recommendations

Conservation recommendations:

- District forest office, Kanchenjunga Conservation Area, local communities, and the local government work together to educate the public about otter ecology and conservation. This includes integrating otter conservation into local school curricula and with local fishermen.
- Develop and implement the site and species specific action plan as the long term effects like poaching, habitat degradation and human otter conflicts may increase in the future.

Future research recommendations:

- Conduct a comprehensive study on the current population status and monitor the changes in otter populations over time, considering anthropogenic pressures.
- Investigate the impact of dam construction on otter habitats and populations. Assess mitigation strategies to minimize adverse effects on otters due to hydrological modifications.
- Explore and implement direct detection methods for accurate measurement of otter habitats.

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Appendices

Appendix Table 1. Generalized mixed models (Δ AICc ≤ 2) describing the habitat use by Eurasian otter, ranked according to the Akaike information criteria corrected for small size (AICc). Otter occurrence is the response variable whereas fishing evidence, boulder, distance to nearest settlement, river flow, bank width and river width are the predictive variables. The number of parameters is df, Δ AICc, is the difference between the AICc value of the best-supported model and successive model, and ω_i is the Akaike model weight.

Models	**Predictive variables**	**df**	**AICc**	**ΔAICc**	**ω_i**
1	Fishing evidence + Boulder + Distance to nearest settlement + River flow	6	75.72	0	0.37
2	Fishing evidence + Boulder + Distance to nearest settlement + River flow + Bank width	7	76.3	0.58	0.28
3	Fishing evidence + Boulder + Distance to nearest settlement	5	76.97	1.25	0.2
4	Fishing evidence + Boulder + Distance to nearest settlement + River flow + River width	7	77.55	1.83	0.15

Appendix Table 2. Socio-demographic characteristics of the respondents in seven wards (except ward number three, Sikaicha) of Sirijangha Rural Municipality, Koshi Province, Nepal.

Sociodemographic status	Categories	Total	Percentage
Religion	Hindu	25	56.82
	Kirat	16	36.36
	Budhist	3	6.82
Ethnicity	Limbu	22	50.00
	Chhetri	12	27.27
	Brahmin	3	6.82
	Gurung	3	6.82
	Rai	3	6.82
	Sarki	1	2.27
Education	Illiterate	3	6.82
	Primary	17	38.64
	Secondary	18	40.91
	Higher secondary	5	11.36
	Bachelor and above	1	2.27
Occupation	Agriculture	37	84.09
	Business	3	6.82
	Student	3	6.82

Appendix 3. Questionnaire for threats to Eurasian otter.

Questionnaire for threats to Eurasian otter

Name: _____ Age: _____ Sex: _____ Date: _____
Occupation: _____ Ethnicity:_____ Religion: _____
Education: _____ No. of family members:___ Annual income _
R. Municipality_____ Ward No.____

Q1. Do you recognize this animal (By showing picture from Pamphlet)? Yes / No
If yes. i) What is it? .....
ii) What do you call it in your native language? .....
iii) In your view where does it live? .....
What does it eat? …….
Q2. Have you ever seen or encounter with otter? Yes / No
Q3. Have you ever seen/know that the otter being killed? Yes / No
If yes. i) when? ……..
iii) Why? a. Meat b. Poaching c. Retaliation over fishing
d. Accidental e. Other …….
Q4. Are any otters being trapped/ killed while you fishing? Yes / No
If yes. i) When……years ago
ii) What did you do? a. consumed its meat b. throw in river
c. other……..
Q5. Do you believe otters are declining? Yes/ No
If yes. Why is it happening?
…….....
Q6. Do you have knowledge on its government protected status? Yes / No, If yes
…….

Q7. Do you think we should conserve the otter? Yes / No
Why……..

Q8. Do you want to conserve it from yourself? Yes / No

If yes, what should be your role?

.....

Q9. Any suggestions for better conservation of otter?

……

Appendix Photograph 1. Photographs showing footprints, latrine of Eurasian otter, study river and questionnaire survey in the Kabeli khola of Taplejung district, eastern Nepal.

Footprints of Eurasian otter in Kabeli khola, Sirijangha Rural Municipality-4, Tellok, Taplejung, eastern Nepal.

Latrine of Eurasian otter in Kabeli khola, Sirijangha Rural Municipality-2, Ambegudin, Taplejung, eastern Nepal.

Study river in Sirijangha Rural Municipality-6, Mamankhe, Taplejung, eastern Nepal.

Questionnaire survey in Sirijangha Rural Municipality-2, Ambegudin, Taplejung, eastern Nepal.