Habitat Use and People's Perception towards Smooth-Coated Otter (*Lutrogale perspicillata*) in Shuklaphanta National Park, Nepal

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Declaration

I hereby declare that the work presented in this dissertation "Habitat use and people's perception towards Smooth-coated otter (*Lutrogale perspicillata*) in Shuklaphanta National Park, 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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This is to recommend that the dissertation entitled "Habitat use and people's perception towards Smooth-coated otter (*Lutrogale perspicillata*) in Shuklaphanta National Park, Nepal" has been carried out by Shree Krishna Devkota for the partial fulfilment of Master's Degree of Science in Zoology with special paper Ecology and Environment. This is his original work and has been carried out under my supervision. To the best of my knowledge, this dissertation work has not been submitted for any other degree in any institutions.

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Letter of approval

On the recommendation of supervisor "Bishnu Prasad Bhattarai, PhD" this dissertation submitted by Shree Krishna Devkota entitled "Habitat use and people's perception towards Smooth-coated otter (*Lutrogale perspicillata*) in Shuklaphanta National Park, Nepal" is approved for the examination in partial fulfilment of the requirements for Master's Degree of Science in Zoology with special paper Ecology and Environment.

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Certificate of acceptance

This dissertation work submitted by Shree Krishna Devkota entitled "Habitat use and people's perception towards Smooth-coated otter (*Lutrogale perspicillata*) in Shuklaphanta National Park, 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

Smooth-coated otters (SCO) are generally found in lowland areas near the flowing water, where they depend upon fish species for feeding. This study was conducted to assess the major factors that act upon the habitat use by SCO in Shuklaphanta National Park (ShNP) along with the perception of local people of that area. Transect survey inside ShNP and semi-structured questionnaire survey in the periphery of the park were conducted for data collection. Landsat-8 images were used for RS to extract the Modified Bare Soil Index (MBI), Enhanced Vegetation Index (EVI), Modified Normalized Difference, Water Index (MNDWI) through R studio. Landcover proportion, Surface Temperature, Slope were calculated using GIS. Generalized Linear model (GLM) was used to analyze the relationship between presence or absence of SCO in relation to surface temperature, MBI, MNDWI, EVI, Slope, water proportion, forest proportion and rangeland. In addition, Fischer's Exact test was done for testing the association between occupation and categories of people's perception about SCO. The EVI and proportion of water are positively associated whereas, MNDWI is negatively associated with the presence or absence of SCO signs in the buffered areas. The perception of local people is not highly influenced by their occupation however; the activity of fishing is associated with the occupation. Priority should be given to the conservation of riverine vegetation that are especially adjacent to sandy banks with significant proportion of water and connectivity should be maintained between the wetlands. Sustainable fishing practices should be promoted as most of the local people around the park are engaged in fishing activities which may potentially impact the prey for SCO.

शोध सारांश

खैरो ओंत (SCO) सामान्यतया बहने पानी नजिकको तराई क्षेत्रमा पाइन्छन् । उनीहरू आहाराका लागी माछा प्रजातिहरूमा निर्भर हुन्छन् । यो अध्ययन शुक्लाफाँटा राष्ट्रिय निकुञ्ज (ShNP) मा खैरो ओंत द्वारा बासस्थानको प्रयोगमा प्रभाव पार्ने प्रमुख कारकहरूको मूल्याङ्कन गर्नका साथै उक्त क्षेत्रका स्थानीय बासिन्दाहरूको धारणा बुझ्नका लागि गरिएको थियो । तथ्याङ्क सङ्कलनका लागि निकुञ्ज भित्र transect सर्वेक्षण का साथमा निकुञ्ज वरपरका स्थानीय मानिसहरू संग semi-structured प्रश्नावली सर्वेक्षण गरिएको थियो । R studio मार्फत Modified Bare Soil Index (MBI), Enhanced Vegetation Index (EVI), Modified Normalized Difference Water Index (MNDWI), landcover अनुपात, सतहको तापक्रम र slope को मापन गर्नका लागि Landsat-8 तस्वीर हरूको प्रयोग गरिएको थियो । सतहको तापक्रम, MBI, MNDWI, EVI, slope, पानीको अनुपात, वन अनुपात rangeland सम्बन्धमा खैरो ओंत को उपस्थिति वा अनुपस्थिति बीचको सम्बन्धको विश्लेषण गर्न Generalized Linear model (GLM) प्रयोग गरिएको थियो । यसको अतिरिक्त, खैरो ओंत को बारेमा स्थानीय मानिसहरूको पेशा र उनीहरूका धारणाको वर्गहरू बीचको सम्बन्ध परीक्षण गर्न Fischer's Exact test गरिएको थियो । EVI र पानीको अनुपात खैरो ओंतको उपस्थितिको संकेतहरू सँग सकारात्मक रूपमा सम्बन्धित देखिन्छन् भने, MNDWI नकारात्मक रूपमा सम्बन्धित देखिन्छन् । स्थानीय बासिन्दाहरूको धारणा उनीहरूको पेसाबाट धेरै प्रभावित नभए पनि, माछा मार्ने गतिविधि भने उनिहरुको पेसासँग सम्बन्धित देखिन्छ । पानीको अनुपात उच्च भएका र बालुवा किनारहरूसँग जोडिएका नदीजन्य वनस्पतिहरूको संरक्षणलाई प्राथमिकता दिनुपर्छ र सिमसार क्षेत्रहरू बीच भौतिक सम्पर्क कायम राख्नुपर्छ । निकुञ्ज वरपरका अधिकांश स्थानीय मानिसहरू माछा मार्ने कार्यमा संलग्न भएकाले यो गतिविधिले SCO का आहारमा पर्ने प्रजातिहरूमा प्रभाव पार्न सक्छ, त्यसैले माछा मार्ने अभ्यासलाई SCO को आहारमा नकारात्मक प्रभाव नपर्ने गरी प्रवर्द्धन गर्नु उपयुक्त हुन सक्छ ।

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List of abbreviations

Abbreviated form	Details of abbreviations
BNP	Bardia National Park
CNP	Chitwan National Park
CSV	Comma Separated Values
DEM	Digital Elevation Model
ESRI	Environmental Systems Research Institute
EVI	Enhanced Vegetation Index
GLM	Generalized Linear Model
GPS	Global Positioning System
KTWR	Koshi Tappu Wildlife Reserve
LULC	Land Use Land Cover
MBI	Modified Bare Soil Index
MNDWI	Modified Normalized Difference Water Index
MS-excel	Microsoft Excel
NIR	Near Infrared
RS	Remote Sensing
SCO	Smooth Coated Otter
ShNP	Shuklaphanta National Park
SRTM	Shuttle Radar Topography Mission
SWIR	Shortwave Infrared
USGS	United States Geological Survey
UTM	Universe Transverse Mercator

1. Introduction

1.1 Background

Otters belong to family *Mustelidae* under the order *Carnivora*, acts as apex predator in freshwater ecosystems and are highly dependent upon wetlands (Acharya & Rajbhandari, 2011). Globally, 13 otter species known (Duplaix & Savage, 2018), of which only three have been recorded in Nepal: the Eurasian otter (*Lutra lutra*), the Asian small-clawed otter (*Aonyx cinereus*), and the smooth-coated otter (*Lutrogale perspicillata*) (Basnet et al., 2020).

Wetlands supports the life of diverse species including SCO but are constantly shrinking due to human interference on various dimensions, that attributes to loss of 21% of their preferred habitats (Fluet et al., 2023). In context of Asia, the area of wetlands is being gradually converted into urban areas, agricultural lands and other infrastructure development which causes habitat shrinkage or fragmentation for SCO (Hu et al., 2017).

SCO is common species among otters found across Asian countries such as India, Pakistan, Bangladesh, Malaysia, etc. (De Silva, 2011). They are listed as Vulnerable species in IUCN Red list of threatened species (Khoo et al., 2021). SCO are generally found in lowland areas near the flowing water where they can depend upon fish species for feeding (Acharya & Lamsal, 2010).In Nepal, they are mostly reported in river basins of major rivers such as; Narayani, Karnali and Mahakali along with wetlands of Chitwan National Park (CNP), Bardia National Park (BNP) and Shuklaphanta National Park (ShNP) (Awasthi & Yoxon, 2019). In addition, photographic evidences of SCO has also been recorded in Koshi Tappu Wildlife Reserve (KTWR) (Mishra et al., 2022).

SCO prefer sandy banks near riverine vegetations adjacent to lakes or rivers with moderate stream and shallow water (Acharya et al., 2022). Study suggests the signs of SCO were mainly found in the areas of sand cover, shrubs, rocks, fallen trees and junction of slow flowing streams (Kathariya et al., 2023). Generally SCO have two types of movements; extensive and small-scale, varying according to the needs of foraging, den building and seasonal movements where most of the movements were found to be limited within 250 to 1,500 meters (Hussain, 2013). Availability of fresh water, presence of silty substrate favors their presence whereas, crossing the high traffic roads and regular interaction with humans remains as challenge for them (Utthamapandian et al., 2025). Freshwater ecosystems with vegetation are declining continuously as a result of loss in wetlands attributed to the

development of massive hydroelectric projects, agriculture practices spreading of human settlements and use of poison for fishing (Joshi, 2009). In addition, overfishing, poisoning of water with pesticides, industrial waste, extraction of sand and boulders, building huge dams also aids to the decline in population of SCO (Acharya & Rajbhandari, 2011).

Satellite imagery based Remote Sensing (RS) is an important tool for monitoring and tracking the conditions of biodiversity and land cover changes of targeted areas. It can be useful in tracking the vegetation status as the satellite covers the larger areas providing the real-time multi-spectral bands (Buma & Lee, 2019). RS combined with field observations is an important tool for evaluation of vegetation, animal movement pattern and their habitat conditions which also makes it a promising technique of wildlife research (Duporge et al., 2021). Satellite imagery comes with multi-spectral data that consists of eight bands; shortwave infrared (SWIR), near-infrared (NIR) and visible regions of the electromagnetic spectrum with moderate 30 m resolution (Madonsela et al., 2017). The characteristics of earth surface and forest could be better explained by various bands of Landsat images as it collects all the essential information in the electromagnetic spectrum (Nagendra et al., 2010).

Understanding the factors that mostly act upon the habitat use by SCO is necessary for developing the effective conservation plans and policies for the targeted species. Various studies have been carried out regarding the most preferred kind of vegetation and habitat features of SCO in various parts of Nepal including ShNP. However, the fine-scale study of habitat use by those species is still lacking in Nepal. This study will help to assess the major factors that acts upon the habitat use by SCO in ShNP along with the assessment of local people's perception and knowledge about SCO in that area.

1.2 Statement of the problem

Despite being essential species in maintaining the ecosystem of Nepal's river basins otters are largely threatened due to inadequacy of conservation methods and essential habitat monitoring (Acharya & Rajbhandari, 2011). SCO being apex predators of aquatic ecosystem plays a crucial role to maintain healthy ecosystem but their natural habitat is shrinking gradually (Trevedi et al., 2024). Field-based studies about habitat use by SCO are spatially limited and time consuming. RS and GIS efficiently provides tools to assess the fine-scale habitat features in the study area.

It is necessary to understand the key environmental factors that affects the habitat use by SCO to develop strategies for targeted conservation program. Surveys and studies regarding their population and habitats preference using traditional methods and field-based variables have already been carried out in ShNP (Awasthi et al., 2024; Thapa set al., 2020). However, study about habitat use by SCO in ShNP is still lacking which could be carried out thoroughly using remote sensing and GIS.

1.3 Objectives

1.3.1 General objective

The general objective of this study was to assess factors affecting habitat use along with local people's perception towards Vulnerable smooth-coated otter (*Lutrogale perspicillata*) in Shuklaphanta National Park (ShNP), Nepal using remote sensing technology.

1.3.2 Specific objectives

The specific objectives of this study were as follows:

i. To assess the factors affecting habitat use by smooth-coated otter in Shuklaphanta National Park (ShNP), Nepal.

ii. To understand the local people's perception and knowledge about smooth-coated otter in Shuklaphanta National Park (ShNP), Nepal.

1.3.3 Research questions

i. What habitat parameters influence the habitat used by SCO in ShNP?

ii. What influences the local people's knowledge about SCO in ShNP?

1.3.4 Significance of the study

The habitat of SCO in ShNP is mostly recorded in the periphery of wetlands so that water quality, quantity and vegetation health should be regularly monitored in the habitats of SCO for their conservation (Awasthi, Balram, et al., 2024). Detailed study needs to be carried out in ShNP to understand the distribution and ecology of SCO in relation to their habitat (Joshi et al., 2021). This study will fulfill the gap of detailed factors associated with core habitat used by SCO using the RS technology. The results and conclusion will provide direction towards protection of this vulnerable mammals.

1.3.5 Limitations of the study

i. The findings on perception of local community only reflect the perception of those people who knew about the existence of SCO.

ii. Due to the lack of spatial knowledge about the study area the spots for sign survey were mostly reliant on nature guide.

2. Literature review

2.1 Habitat use by Smooth-coated otter

Hwang & Larivière, (2005) concluded that the vigilance activity and duration of SCO is associated with change in climatic conditions and temperature which influences the habitat use by the species. The study about factors determining habitat choice of SCO in South Indian river system revealed that preferred habitats were generally loosely packed sand and rocks rather than hard surfaces and gravel along with less anthropogenic disturbance levels (Shenoy et al., 2006). The survey conducted in the Narayani River bank in Chitwan National Park (CNP) found out that SCO mostly use sandy riverbanks on the side of narrow streams with shallow water due to probability of more prey species and grooming spots (Acharya & Lamsal, 2010).

The habitat evaluation of SCO in Indus plains of Pakistan revealed that the species being semi-aquatic preferred connectivity between water bodies and terrestrial territory for their habitat (Ali et al., 2010). Another study conducted by Nawab & Hussain (2012), to understand the factors influencing the occurrence of SCO in Upper Gangetic Plains in India concluded the most preferred habitat features to be sandy river banks with gentle slopes that may consist of rocks, slow moving water, fallen trees and junction of multiple streams. Pugmarks and various signs found during camera trap survey done by (Awasthi et al., 2019) brought to light that the most preferred habitat by SCO was periphery of wetlands with dense vegetation and low anthropogenic disturbances.

During transect survey conducted in ShNP, the most of the presence signs of SCO were found near riverine forest that consists of sandy banks and fallen trees rather than in Sal forest (Thapa et al., 2020). SCO signs were mostly recorded on sandy, silty, clay and rocky river banks that shows most used habitat type of SCO is near water resources in river banks (Gupta et al., 2020).

The study to access the distribution of SCO in ShNP disclosed the signs were mostly found in the Sbanks of Bahuni and Chaudhar rivers and other lakes (Joshi et al., 2021). The analysis between SCO occurrence and habitat features in Goa, India concluded that salinity, occasional fishing and cover of mangrove plants were positively associated (Dias et al., 2022).The study about effects of habitat parameters in Karnali River also revealed that dense vegetation with short escape distance and low human disturbances were preferred habitat for SCO (Kathariya et al., 2023).

Study to determine the habitat status of SCO in Geruwa-Khaurahi river revealed the most preferred habitats were riverine forest connected to sandy riverbanks or tall Saccharum with narrow escape distance and shallow water (Gwachha et al., 2023). The foot survey conducted by Utthamapandian et al. (2023) in Tamil Nadu, India revealed that the habitat features including hard surfaces in addition to prevalence of sufficient prey species and number is most preferred habitat of SCO. Study to analyze the relation between SCO occurrence and various biological water quality parameters in Far Western Nepal using indicated that presence of riverine forests and water quality hugely affects the capacity of wetlands to support their population (Awasthi, Balram, et al., 2024). Study conducted to access the distribution of SCO in Southern Peninsular, Malaysia recorded about 90% of sightings near rivers along with occasional sightings near ponds indicating the adaptive capacity of SCO to different habitats (Abdullah-fauzi et al., 2025).

A case study done to access the habitat preferred to be used by SCO revealed the species used closed canopy dense forest for resting and foraging along with sites with dense vegetation, riverine forest and fallen logs (Jha, 2018). A study concluded that river buffer was mostly used by SCO for foraging and sprainting at landscape level (Moun et al., 2024). The habitat use and distribution of SCO was mostly influenced by sandy and silty substrates for sprainting and grooming along with shallow depth, gentle slopes and escape distance (Utthamapandian et al., 2025).

2.2 People's perception towards Smooth-coated otter

Interview and interaction with people around South Indian river system revealed that the main reason of poaching was to use its fat and skin for various medicinal purposes however the population of SCO was still stable (Shenoy et al., 2006). Dey et al., (2018) recommended on through and precise interaction with local people in order to truly understand the cultural and social contexts that helps to develop and implement the conservation strategies of SCO in Bihar, India. During the survey it was revealed that only 86% of respondents has seen SCO in recent times meanwhile, remaining had never seen them and decreasing trend of otter population was concluded due to scarcity of food and shrinkage of preferred habitats (Jha, 2018).

Key informants and local people in ShNP believed that mostly poaching of otters are done for its fur, medicinal purposes and its meat however, majority of participants were positive about conservation of the species (Thapa et al., 2020). During a social survey majority of

respondents believed that SCO had some kind of religious beliefs and highlighted that there was a sharp increase in anthropogenic disturbance that could potentially affect the population of the species (Gupta et al., 2020). Interviews with local as well as fishermen communities around ShNP highlighted that most of them were interested in conservation of SCO as the population status of SCO was decreasing however, most of the fishermen were reluctant for conservation due to their vested interest in fishing (G. K. Joshi et al., 2021).

Mixed attitude in terms of economic loss and mild level of conflict between them as retaliatory behavior from fishermen was present in low degree in Western India (Dias, 2021). First community based awareness program was conducted through rapport building, awareness campaigns in schools, sensitization in governmental departments, wall paintings, local community workshops and fishing net compensation in Odisha, India (Samal et al., 2022). Semi-structured interview was conducted to access either the attitude and perception of people towards SCO has been changed or not after the first community based awareness program which uncovered the fact that local people were more conscious and aware about the conservation of the species (Pandey et al., 2022).

In the past times local people were not much concerned about foraging behavior of otters in Tamil Nadu, India but as the fish population is being decreased the otters are regarded as their competitor as both of them are dependent on same area for survival (Utthamapandian et al., 2023). SCO returned back to highly urbanized Singapore after nearly 3 decades due to the combination of sremaining suitable habitats, greening efforts, wildlife protection acts and reduced negative human-otter interaction after development of positive perception of public people towards them (Khoo & Lee, 2020).

The study about interactions between fishermen of Surat district, India and SCO revealed the negative interaction between them as the fishermen community was dependent upon the fishing but SCO were causing serious economic loss by damaging nets and preying on them which was later resolved by compensating the economic loss (Trivedi & Variya, 2023). Hughes et al., (2024) raised the challenges that have been increasing due to the conflicts and negative interactions between local people and SCO in the periphery of highly urbanized areas of Singapore.

Survey to understand the local people's perception towards SCO in the urban Visakhapatnam, India suggests the local fishermen community had very less knowledge

about otter behavior and human-otter conflict was going on due to financial loss and damaged fishing equipment during predation of commercially farmed fish species by SCO (Tamarapalli & Kolipaka, 2022). Study carried out to analyze the community knowledge and perception towards SCO in ShNP revealed 95% of respondents were positive about otter conservation despite having the inadequate knowledge about their ecological role in maintaining the healthy water ecosystem (Awasthi et al., 2024).

Questionnaire survey conducted among 49 respondents in Southern Peninsular, Malaysia concluded the local communities faced considerable financial loss due to predation of otters upon fish and damage to the fishing equipment (Abdullah-fauzi et al., 2025). The primary cause of human-SCO conflict was concluded to be damage in fishing gears lack of fish population that causes conflict between human and SCO for prey (Utthamapandian et al., 2025).

Smooth-coated otters are most often found in areas with sandy riverbanks, shallow waters, and dense vegetation, especially in areas with little human disturbances like riverine forests and wetlands across South Asia. Their choice of habitat depends on factors such as temperature, availability of food, water quality, and vegetation cover. People's perception on otters are often mixed; while many support their protection, especially in conservation areas, mainly fishermen see them as a threat due to the damage they cause to fishing activities. However, efforts like community awareness programs and habitat restoration have helped change public attitudes, leading to better coexistence and support for otter conservation in places like India and Singapore.

3. Materials and methods

3.1 Study area

The study area was Shuklaphanta National Park (ShNP), Far-west lowland of Nepal. The total area of this park is 305 km^2 and the elevation ranges from 175 to 1,300 meters. The location of ShNP lies between 28° 42' 29" N to 29° 03' 27" N latitude and 80° 03' 08" E to 80° 25' 53" E longitude and was established in 2031 B.S. The average temperature ranges from minimum 7° C to 37° C. It is surrounded by Syali River in the east, Mahakali River in the west, Chure hills in the north and Indian border in the south.

The land cover of ShNP consists of 60% forest area, 27% grassland, 3% shrubs and bushes along with 10% of wetlands (ShNP, 2078/79). Total 665 species of 118 families of flora along with more than 56 mammal species are found in this area. Chaudhar River is the biggest lotic water source followed by Bahuni River (Figure 1) in ShNP along with about 127 natural and artificial wetlands including Kalikich, Rani, Baba and Salgaudi Taal (ShNP, 2078/79).

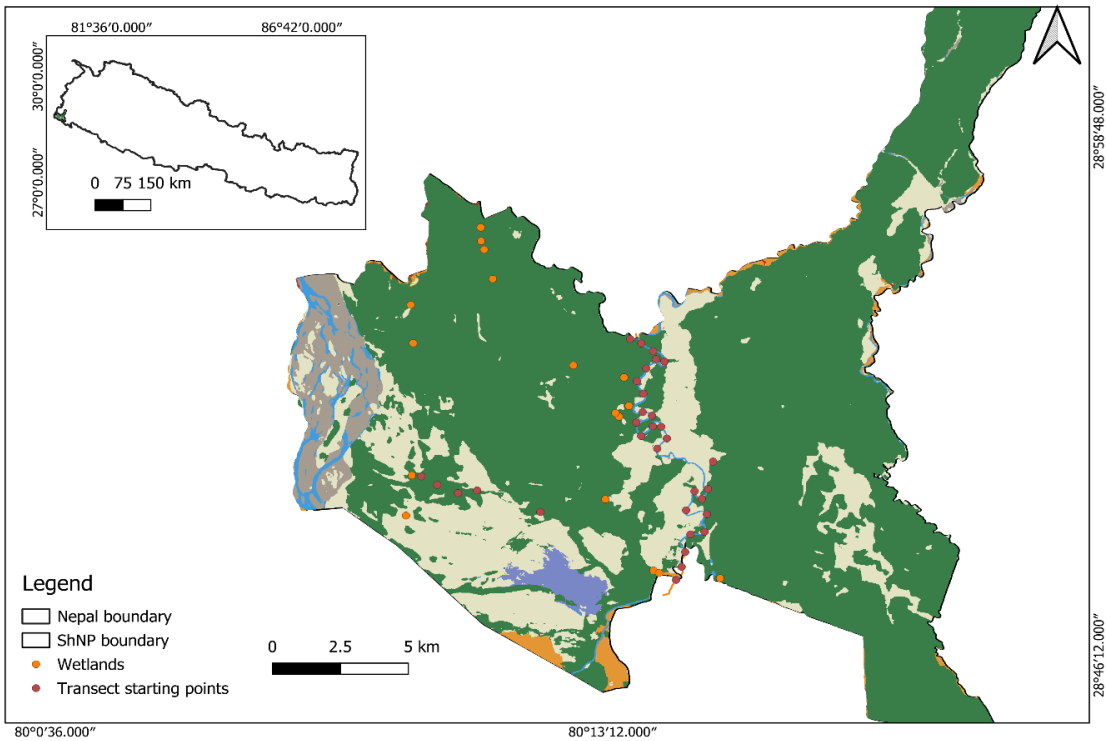

Figure 1. Study area including wetlands and transect starting points

3.2 Methods

3.2.1 Transect survey

Line transect sign survey was conducted in Chaudhar and Bahuni River and other wetlands as suggested during the informal interaction with game scouts, NP staffs and nature guides to record the presence signs of SCO. The length of each transect were 450 m with gap of 250 m (Thapa et al., 2020) and total 32 transects were surveyed during the field visit. Whereas, 17 natural or artificial wetlands were visited in which smaller ponds were surveyed to cover its whole circumference and about 450 m walking was done in larger ponds (Figure 2). During the survey live spotting along with distinctive signs such as pugmarks, spraints (droppings) and spraint sites were recorded using Global Positioning System (GPS) (Garmin eTrex® 10). Presence of fish bones and scales with fishy odor to identify spraint and distinctive impression of five toes with faint claws were recorded as pugmarks (Jamwal et al., 2016).

Altogether, 10 camera traps were deployed mostly at sprainting sites or junction of the flowing water where the probability of recording SCO was higher. Camera traps were strapped to trees or stakes approximately 40 cm above the ground (Palei et al., 2020). All cameras were operational 24 hours per day for 15 days. However, limited data unsuitable for further analysis was obtained so it was not used for further analysis. The transects where single or multiple signs were recorded only the first point was considered as 1 presence point whereas, the starting point of transect was considered as absence point in those transects where no any presence signs were found.

3.2.2 Questionnaire survey

A semi-structured questionnaire survey (Appendix 3) was conducted with local people selected purposively (Joshi et al., 2021). Interviews were done with people engaged in various occupations including fishermen and farmers to gather desired information around ShNP in Majhgaun, Jhilmila and Daiji areas. Altogether, 30 people were interviewed, up to the point at which no new relevant information was emerging. Interview was performed only after confirming the participants have seen or knew about SCO. For this, a picture of SCO was shown to local people before selecting them. Before the questionnaire the purpose was explained and verbal consent was taken with the participants. At first the questionnaire was done in Nepali language and a data sheet was prepared according to the requirement. Questions regarding ethnicity, education, occupation, fishing activity, time period of SCO

spotting, perceived population status, threats and whether the species are poached for medicinal purpose were asked with the respondents.

3.2.3 Data analysis

Habitat uses by Smooth-coated otter

The entry of presence and absence points along with people's perception collected from field survey was done in MS-excel and a data sheet with only necessary data for result production was created in Comma Separated Values (CSV) format. Analysis were done in R studio (R Core Team, 2023).

Landsat-8 images were used to extract variables through Remote Sensing (RS). At first, raster images with all bands were downloaded in bulk from the United States Geological Survey (USGS) portal (https://earthexplorer.usgs.gov/). Digital Elevation Model (DEM) from Shuttle Radar Topography Mission (SRTM) in USGS Earth Explorer was also acquired in addition and converted into real value by multiplying the scale factor and subtracting additive offset (band= band*0.0000275-0.2) (USGS, 2024) in R studio for each band.

To assess the factors associated with habitat use in fine level, presence and absence points were uploaded in QGIS and each of them were buffered for radius of 250 m as the minimum daily movement of SCO is 250 meter (Hussain, 2013). The mean values of Surface temperature, Modified Normalized Difference Water Index (MNDWI), Modified Bare Soil Index (MBI), Enhanced Vegetation Index (EVI) for each buffered points were calculated from raster images in QGIS using Zonal statistics. Slope for each buffered points were calculated from DEM (30 arc sec resolution) through the same process. Land Use Land Cover (LULC) proportion for each buffered points were calculated from raster image Universe Transverse Mercator (UTM) zone 44 North downloaded from the official website of Environmental Systems Research Institute (ESRI) (https://livingatlas.arcgis.com/landcover/). LULC Raster file was uploaded on QGIS and mean value of each buffered area was calculated using Zonal histogram. However, only dominant land cover types; water cover, forest cover and rangeland were selected for analysis.

Presence (1) or absence (0) of SCO signs were taken as binary response variable with surface temperature, MBI, MNDWI, EVI, slope, water proportion, forest proportion and rangeland as the predictor variable were for the analysis of habitat preference.

Multicollinearity test among the 8 variables was performed using correlation function and only those variables with correlation value less than 0.75 were retained. Due to high value of correlation (0.79) between rangeland and MBI, only MBI was selected for the further analysis.

Table 1. Factors used for analysis of habitat use

S.N.	Variable	Description	Reference
1.	Surface Temperature	Converted into Celcius from Kelvin	(USGS, 2024)
2.	Modified Normalized Difference Water Index (MNDWI)	$MNDWI=\frac{(GREEN-SWIR)}{(GREEN+SWIR)}$ Range = -1 to 1	(Pandey et al., 2023)
3.	Enhanced Vegetation Index (EVI)	$\frac{2.5 \times (NIR - Red)}{(NIR + 6 \times Red - 7.5 \times Blue + 1)}$ Range = 0 to 1	(Jarihani et al., 2014)
4.	Slope	Range = 0 to 90	(Mohanty & Skaggs, 2001)
5.	Landcover proportion	Forest proportion, Rangeland proportion and Water proportion	(https://livingatlas.arcgis.com/landcoverexplorer/)
6.	Modified Bare Soil Index (MBI)	$MBI = \frac{SWIR1 - SWIR2 - NIR}{SWIR1 + SWIR2 + NIR} + f$ Where, f = additional factor (0.5) Range = -0.5 to +1.5	(Nguyen et al., 2021)

Band 2 is blue light, Band 3 is green light, Band 4 is red light, Band 5 is Near Infrared (NIR), Band 6 is Shortwave Infrared 1 (SWIR1) and Band 7 is Shortwave Infrared 2 (SWIR 2)(USGS, 2024). The retained variables were used as predictor variables to run Generalized Linear Model (GLM) to model the habitat use by SCO, taking presence or absence points of signs as the response variable. The "dredge" function under the "MuMin" package was used for selection of best candidate models (Appendix 1). The relative importance of each candidate models was evaluated on the basis of p-value using the "model.avg" function under "MuMin" package. Only those models with p-value less than 0.05 were considered as significant models (Burnham & Anderson, 2004). Plots were created using "ggplot2" package to visualize and interpret the results effectively.

People's perception

As most of the respondents during questionnaire survey were dependent on agriculture and animal husbandry as their main occupation they may often visit near to forests near rivers and wetlands near the boundary of study area. At first, the table showing the demographic characteristics of the respondents was constructed. Perceptions of local people about conservation of SCO, change in fish population, use of poison or dynamite for fishing, perceived threats and methods of conservation of targeted species were classified according to the proportion of the respondents.

Fischer's Exact test was done for testing the association between occupation and categories of people's perception about SCO. Columns for occupation, fishing activity, time period of SCO spotting, perceived population status, threats and whether the species are poached for medicinal purpose were converted into binary categories.

The respondents were classified into illiterate (up to class 10) and literate (above class 10). Occupations such as teacher, foreign employment, business, were considered as non-agriculture and other were considered as agriculture. Those people who went to fishing regularly or sometimes were specified as "Yes" and those who do not go for fishing at all were specified as "No" for fishing activity. Time period of spotting was divided into "within in 5 years" or "before 5 years". Whether the species were used for medicinal purposes and under threats were also specified as "Yes" and "No".

4. Results

4.1 Habitat use by Smooth-coated otter

Among 32 transects in the rivers, presence signs were recorded in 19 of them and in case of ponds signs were recorded in 7 of them (Figure 2). Altogether 49 points (26 present and 23 absent) were recorded.

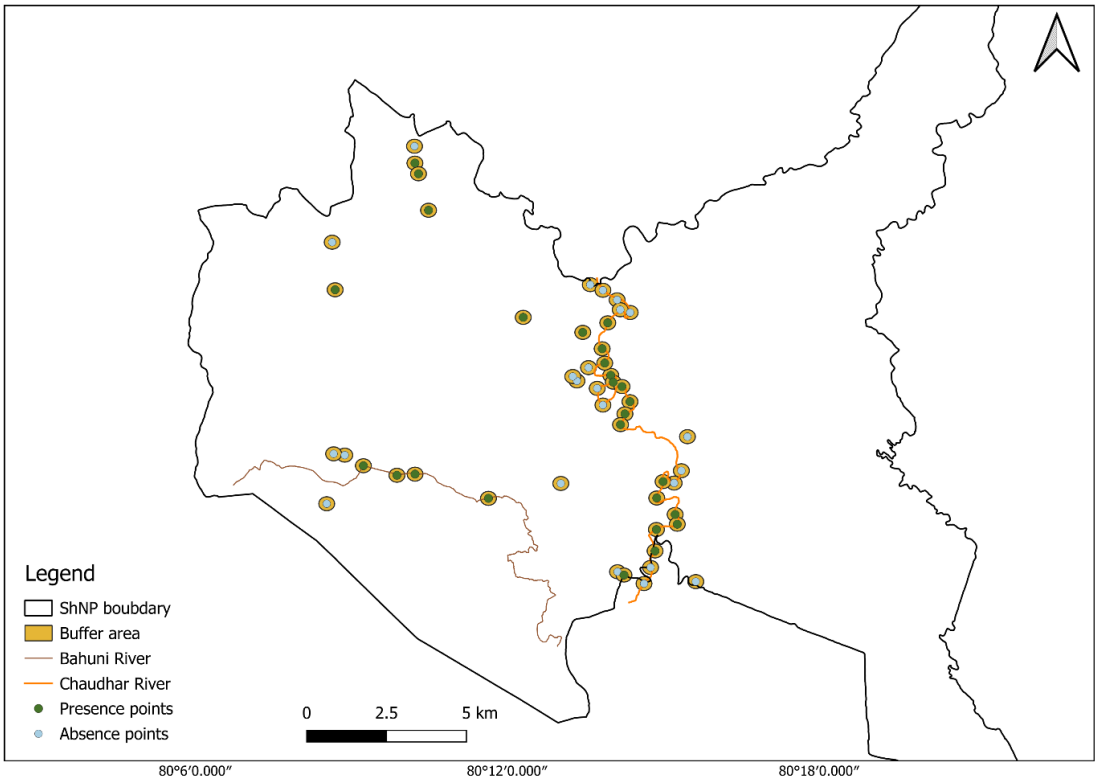

Figure 2. Presence and absence points with buffer areas in study area

The model shows three out of the seven variables are significantly associated ($p < 0.05$) with the habitat use by SCO; MNDWI, proportion of water and EVI (Table 2). The proportion of water also shows positive significance for habitat use. MNDWI shows negative association with habitat use however, there was no correlation between these two variables.

Table 2. Generalized Linear Model showing factors affecting habitat use of Smooth-coated otter

	Estimate	Std. Error	Adjusted SE	z value	Pr(>|z|)
(Intercept)	-44.8858	19.6536	20.0949	2.234	0.02550 *
EVI	31.6993	15.0166	15.4038	2.058	0.03960 *
MNDWI	-61.7788	22.1434	22.7584	2.715	0.00664 **
Proportion of water	18.9840	7.8285	8.0348	2.363	0.01814 *
Surface temperature	0.9425	0.8981	0.9235	1.021	0.30749

No significant positive relation is found between habitat used by SCO and surface temperature of buffered area. Results created by model suggests MBI, slope, landcover proportion and forest proportion are also not significantly associated with habitat use of SCO (Figure 3).

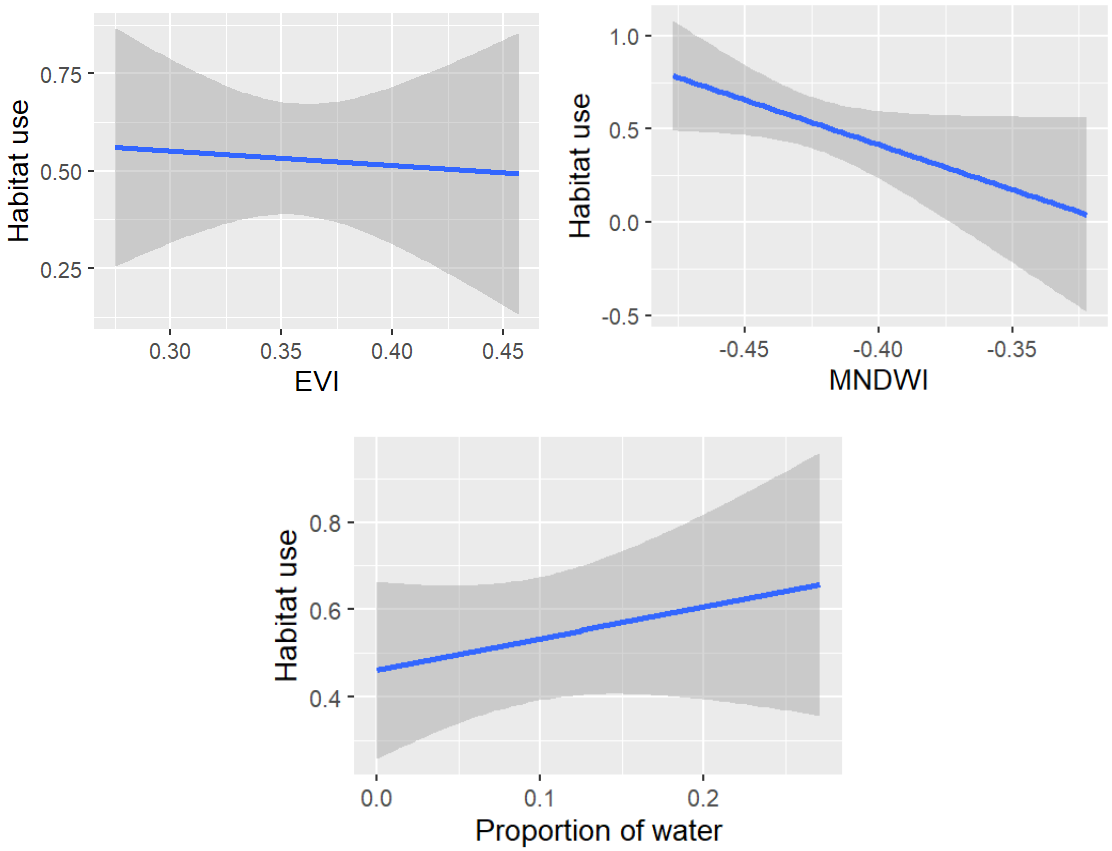

Figure 3. Relationship of Enhanced Vegetation Index, Modified Normalized Difference Water Index and proportion of water with habitat used by *S*mooth-coated otter.

4.2 People's perception

4.2.1 Demographic characteristics of respondents

The characteristics of respondents classified according to gender, occupation, level of education, ethnicity and fishing activities. Majority of the respondents were male and uneducated. Most of them belonged to ethnic Rana Tharu communities and were engaged in fishing activities (Table 3).

Table 3. Characteristics of respondents participated in the questionnaire survey

Respondent characteristics	**Percentage**					
Gender	Male			Female		
	76			24		
Education	Literate			Illiterate		
	33			67		
Occupation	Agriculture	Business	Driving	Household	Teaching	Foreign employment
	60	10	3	10	7	10
Ethnicity	Indigenous			Non-indigenous		
	86			14		
Engaged in fishing	Yes			No		
	67			33		

4.2.2 Perceived change in fish population

More than half of the respondents thought that the population of fish is being decreased. Meanwhile, one third of local people thought the population of fish in the study area is increasing and remaining of them had no idea about the subject (Figure 4).

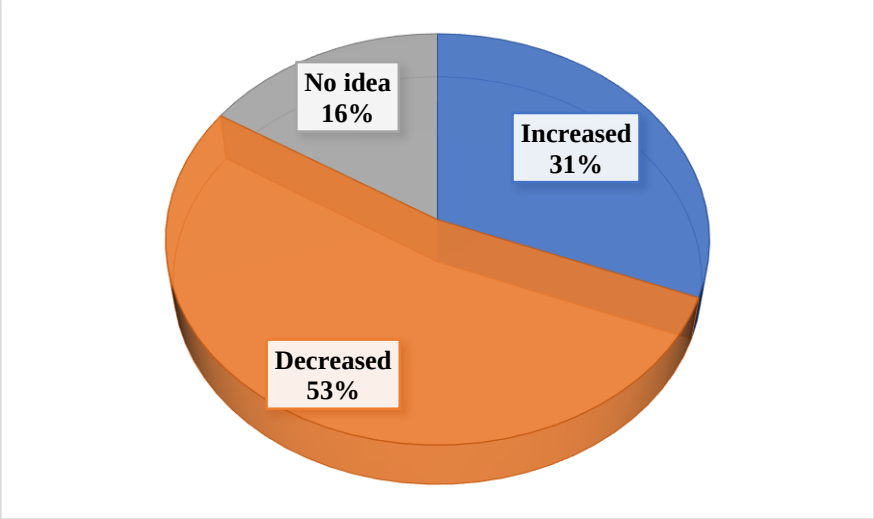

Figure 4. Perceived change in fish population

4.2.3 Measures to conserve the Smooth-coated otter

Majority of the local people believed that strict rules and regulations may help in effective conservation of the mammals followed by proper management of the preferred habitats. However, some of them believed that awareness among local population and adequate prey population may help to conserve them. However, few of them believed that the targeted species are only found inside the protected areas and already conserved due to strict laws of the national park (Figure 5).

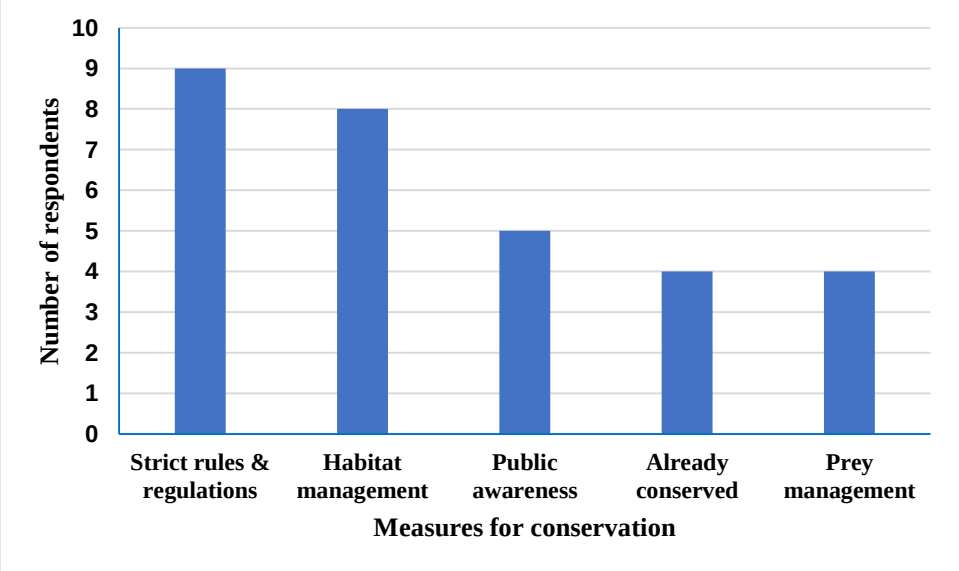

Figure 5. Perceived measures for conservation of Smooth-coated otter

4.2.4 Knowledge about the Smooth-coated otter among local people

Fischer's Exact test reveals statistically significant association between occupation and fishing activity ($p < 0.05$). However, significant association was not found between occupation and other factors. It indicates occupation does not strongly influence sightings, perceived population trend, use for medicinal purposes and perceived threats (Table 4).

Table 4. Contingency table and p-values from Fischer's test for people's perception towards Smooth-coated otter

Occupation vs. Fishing			
	No	Yes	p-value
Agriculture	4	16	0.05
Non-agriculture	6	4	
Occupation vs. Seen SCO			
	Before 5 years	Within 5 years	p-value
Agriculture	7	13	0.2553
Non-agriculture	6	4	
Occupation vs Population of SCO			
	Decreased	Increased	p-value
Agriculture	9	11	0.699
Non-agriculture	6	4	
Occupation vs. Medicinal purposes			
	No	Yes	p-value
Agriculture	16	4	0.64
Non-agriculture	9	1	
Occupation vs. Perceived threats			
	No	yes	p-value
Agriculture	12	8	1
Non-agriculture	6	4	

5. Discussion

5.1 Habitat use by Smooth-coated otter

Prior to conducting the sign survey, informal interviews were held with national park staffs, game scouts, nature guides and safari vehicle drivers to identify the potential sighting locations of the SCO. Most of the respondents suggested Captainghat junction and Gohikunda section of Bahuni River and Chaudhar River in flowing water system. In case of stagnant water, Baba Taal, Salgaudi Taal, Hattikunda, Swami Taal, Batania Taal, Rani Taal, and Kalikich Taal were the most probable habitats of SCO based on informal discussions and review of published literature.

Among the 17 ponds surveyed, the presence signs were recorded in only seven. In those ponds where no any presence signs were found, the periphery were densely covered by tall grasses although anthropogenic disturbances were not found. In case of river transects, present signs were recorded in only 19 transects out of 32 transects. However, pugmarks and scats of deer species, tiger, rhinoceros and elephant were dense. The relatively older signs of SCO might be degraded due to movement of other animals as the transect area is source of drinking water for a wide range of wildlife.

No significant positive relation was found between habitat used by SCO and surface temperature of buffered area, indicating the surface temperature may not influence their habitat as there may not be much variation in temperature near wetlands and rivers. Rather, water availability along with connected habitats may strongly influence their habitat preference. However, Hwang & Larivière (2005) concluded change in temperature and change in climatic conditions may trigger the alteration in vigilance behavior although link between vigilance behavior and body conditions of the species was not confirmed.

Positive association between habitat use and EVI could be due to the behavior of SCO relying on vegetation near to sandy banks of water resources. Riparian vegetation is also preferred by SCO for resting or building dens. Slow flowing water in sandy river along with adjacent vegetation serving as escape cover is the governing factor for habitat selection of SCO (Nawab & Hussain, 2012). Sustaining the health of riverine vegetation aids to maintain the higher EVI around the SCO habitats. MNDWI shows negative relation with habitat use which means they prefer vegetations with better water availability.

Riverbank vegetation along with water quality impacts the supporting capacity of wetlands to support SCO population (Awasthi, Balram, et al., 2024). SCO being semi-aquatic

predator, they must rely on aquatic fish species for their feeding due to which they may prefer to reside near aquatic ecosystems. Vegetation cover, salinity and presence of freshwater influences the occurrence of SCO positively (Jonah Dias et al., 2022). Thus, maintaining the water quality and quantity may help in sustaining of these species as the occurrence of SCO is positively associated with quantity of water (Scorpio et al., 2016).

Connectivity among rivers and wetlands provides better facilitation for survival of these mammals. They prefer riverine forests with tall or short grasslands rather than dense forests which can be estimated through non-significance of habitat used with forest proportion of buffered area. They primarily depend on wetlands rather than structure of land due to which slope and landcover may not seem significant. Selecting the sites with sparse vegetation with high percentage of sand bank is necessary for grooming (Shenoy et al., 2006) which could explain the proportion of forest and MBI not being significant in result.

5.2 People's perception

As this study was conducted within a protected area, local communities are restricted to enter the premises. Most of the local people were unaware of existence of the targeted species. Interviews were conducted with only those people who have heard about or seen otters in any point of their life. As a result, the final number of respondents were only 30.

Almost none of the local people had any conflict or issues with the presence of the targeted species. Though the majority of local people engage in agriculture as their main occupation and have limited access to advanced education (Awasthi et al., 2024), it does not have higher influence on their perception. Our findings suggest that both agricultural and non-agricultural workers shared similar levels of awareness regarding population trends, the timing of otter sightings, perceived threats, and knowledge of potential medicinal uses. The only area where a noticeable difference in interaction was observed was among individuals involved in fishing activities.

Awasthi et al., (2024) concluded that the local people of ShNP do not use body parts of SCO and had no idea about their population status however, majority of them were aware about the otter habitats which also matches with the result obtained during Fischer's Exact test. During our interview, those who knew about SCO mostly had idea about their preferred habitat although they had very less idea about medicinal use and population status.

Majority of respondents around ShNP believed the population of SCO is decreasing meanwhile those remaining people had no idea about the population status however, they

were positive about the conservation of the mammal species (Thapa et al., 2020). Although, most of the respondents believed the population of SCO is being decreased no any statistically significant evidence was found in this study. The population of SCO in ShNP have been declined due to poaching and loss of their natural habitats (Joshi et al., 2021). However, interviews conducted during this study revealed no recent instances or local knowledge of poaching activities.

6. Conclusions and recommendations

6.1 Conclusions

The presence signs of smooth-coated otter were concentrated in the banks of water bodies. It could be concluded that they prefer to use areas with combination of water bodies along with adjacent vegetation. Areas with higher proportion of water is mostly used by SCO which ensures the suitable habitat with adequate availability of prey.

Almost all of the local people have positive attitude about SCO and are ready to take part in their conservation. The prey population of SCO have been decreasing gradually due to decrease in population of fish. SCO in ShNP is not in high degree of threat although there is need of public awareness, habitat management and more strict laws for more effective conservation of those species. The knowledge about SCO among local people is not highly influenced by their occupation however, fishing is associated with their occupation. There is no significant association between occupation and when they spotted SCO, if those species are used for medicinal purposes and their population status.

6.2 Recommendations

i. For the better conservation of SCO habitats, priority should be given to the conservation of riverine vegetation that are especially adjacent to sandy banks with significant proportion of water.

ii. Connectivity should be maintained between the wetlands which could better facilitate for the movement of SCO. Continuous population monitoring along the mostly used habitats should be carried out.

iii. Conservation efforts with the involvement of local communities should be carried out.

iv. Awareness programs about the existence, habitat use and feeding behavior of SCO should be conducted since majority of people do not know about the existence of this species.

v. Controlled fishing practices should be promoted as most of the people are engaged in fishing activities which may potentially impact the prey for SCO.

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Appendices

Appendix 1. Generalized Linear Model describing the habitat use by Smooth-coated otter ranked according to Akaike Information Criterion (AICc).

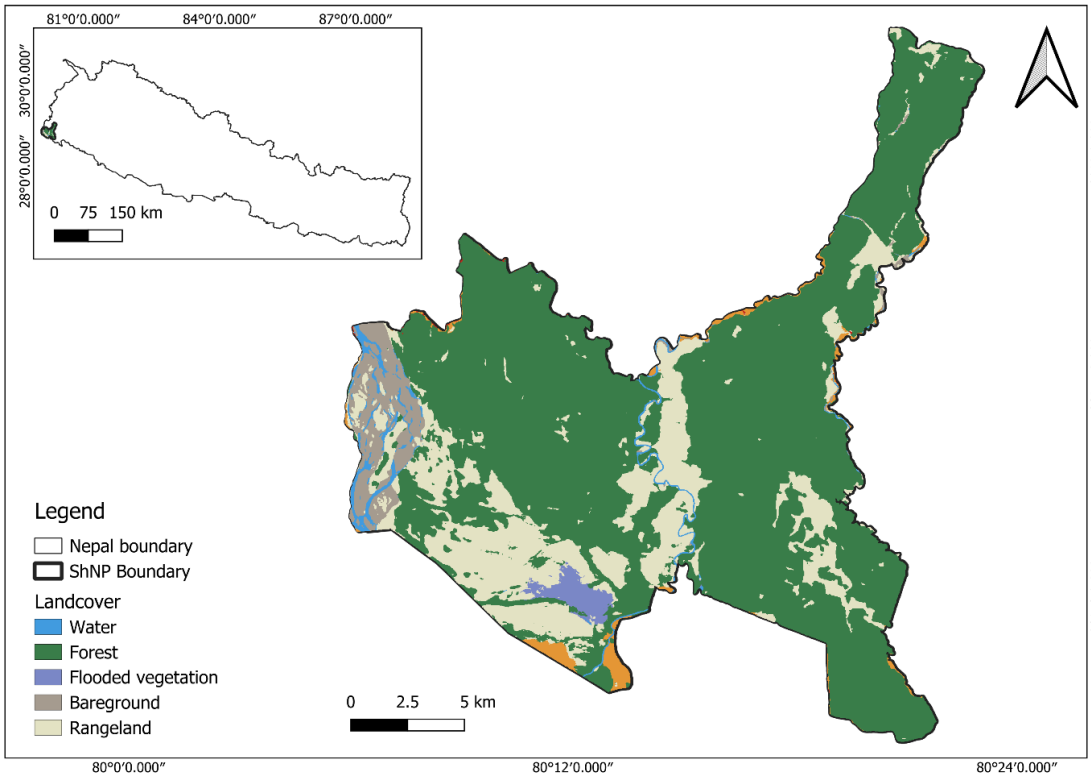
S.N.	Covariates	df	AICc	ΔAIC	Weight
1.	Enhanced Vegetation Index + Modified Normalized Difference Water Index + Proportion of water	4	63.199	0	0.1726
2.	Enhanced Vegetation Index + Modified Normalized Difference Water Index + Surface temperature + Proportion of water	5	64.561	1.3610	0.0874

Appendix 2. Photographs taken during the sign survey

Photograph 1. Pugmark and spraint of Smooth-coated otter recorded during transect survey

Photograph 2. Smooth-coated otter recorded during camera trap survey

Appendix 3. Land Use Land Cover map of study area



Appendix 4. Questionnaires for understanding people's perception towards Smooth-coated otter

Demographic information:

Name:

Gender:

Age:

Occupation:

Education:

Ethnicity:

1. Do you or any of your family members go to the river for fishing?
2. Have you observed any changes in fish population in the river over the past 10 years?

   a) Decline b) No change c) Increase
3. Have you ever seen or heard about otters? a) Yes b) No

   If yes, when and where?
4. Population of otters in last 10 years?

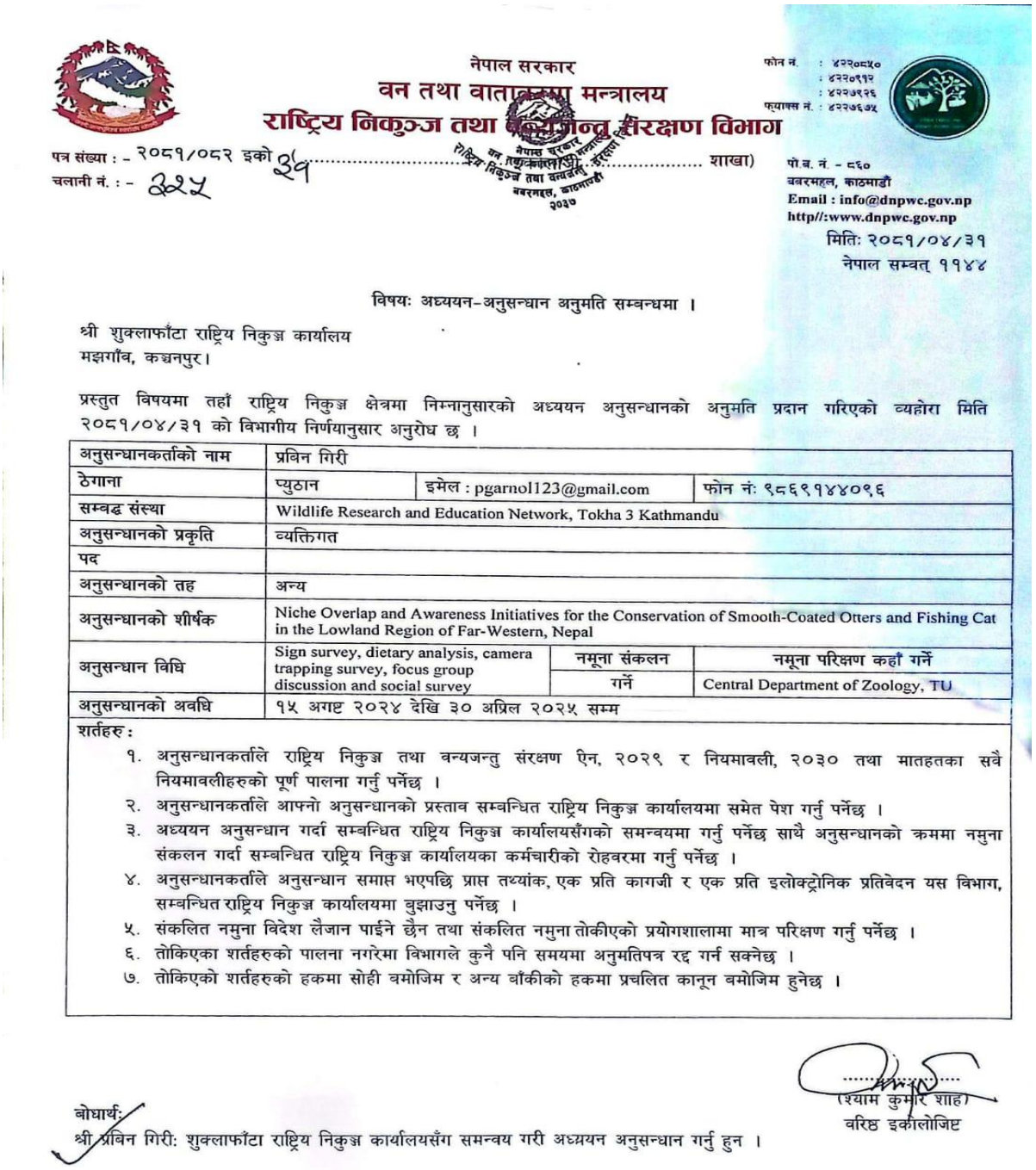
   a) Increased b) Decreased c) Same d) No idea
5. Do people use any of their body parts for medicinal or any other purpose?

   a) Yes b) No

   If yes, which parts do you use for what purpose?
6. Do you agree to conserve this animal (otters)? a) Yes b) No
7. How has the habitat of these species degraded in the last 10 years?

   a) Slightly b) Markedly c) Same d) Improved
8. How can we conserve the otters?
9. Is dynamite fishing or poison killing of fish prevalent in your area? a) Yes b) No

Appendix 4. Research permission from Department of National Parks and Wildlife Conservation. Permission granted to principal investigator (Pravin Giri) of the project.



नेपाल सरकार
वन तथा वातावरण मन्त्रालय
राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभाग

फोन नं. : ४२२०८५०
: ४२२०९१२
फ्याक्स नं. : ४२२७६२६
: ४२२७६७५

पो.ब. नं. - ८६०
बबरमहल, काठमाडौं
Email : info@dnpwc.gov.np
http//:www.dnpwc.gov.np

पत्र संख्या : - २०८१/०८२ इको ३५ ..... शाखा)
चलानी नं. : - ३२५

मितिः २०८१/०४/३१
नेपाल सम्वत् ११४४

विषयः अध्ययन-अनुसन्धान अनुमति सम्बन्धमा ।

श्री शुक्लाफाँटा राष्ट्रिय निकुञ्ज कार्यालय
मझगाँव, कञ्चनपुर।

प्रस्तुत विषयमा तहाँ राष्ट्रिय निकुञ्ज क्षेत्रमा निम्नानुसारको अध्ययन अनुसन्धानको अनुमति प्रदान गरिएको व्यहोरा मिति २०८१/०४/३१ को विभागीय निर्णयानुसार अनुरोध छ ।

अनुसन्धानकर्ताको नाम	प्रविन गिरी		
ठेगाना	प्युठान	इमेल : pgarnol123@gmail.com	फोन नं: ९८६९१४४०९६
सम्बद्ध संस्था	Wildlife Research and Education Network, Tokha 3 Kathmandu		
अनुसन्धानको प्रकृति	व्यक्तिगत		
पद			
अनुसन्धानको तह	अन्य		
अनुसन्धानको शीर्षक	Niche Overlap and Awareness Initiatives for the Conservation of Smooth-Coated Otters and Fishing Cat in the Lowland Region of Far-Western, Nepal		
अनुसन्धान विधि	Sign survey, dietary analysis, camera trapping survey, focus group discussion and social survey	नमूना संकलन गर्ने	नमूना परिक्षण कहाँ गर्ने Central Department of Zoology, TU
अनुसन्धानको अवधि	१५ अगष्ट २०२४ देखि ३० अप्रिल २०२५ सम्म		

शर्तहरु :

१. अनुसन्धानकर्ताले राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९ र नियमावली, २०३० तथा मातहतका सबै नियमावलीहरुको पूर्ण पालना गर्नु पर्नेछ ।
२. अनुसन्धानकर्ताले आफ्नो अनुसन्धानको प्रस्ताव सम्बन्धित राष्ट्रिय निकुञ्ज कार्यालयमा समेत पेश गर्नु पर्नेछ ।
३. अध्ययन अनुसन्धान गर्दा सम्बन्धित राष्ट्रिय निकुञ्ज कार्यालयसँगको समन्वयमा गर्नु पर्नेछ साथै अनुसन्धानको क्रममा नमुना संकलन गर्दा सम्बन्धित राष्ट्रिय निकुञ्ज कार्यालयका कर्मचारीको रोहवरमा गर्नु पर्नेछ ।
४. अनुसन्धानकर्ताले अनुसन्धान समाप्त भएपछि प्राप्त तथ्यांक, एक प्रति कागजी र एक प्रति इलोक्ट्रोनिक प्रतिवेदन यस विभाग, सम्बन्धित राष्ट्रिय निकुञ्ज कार्यालयमा बुझाउनु पर्नेछ ।
५. संकलित नमुना विदेश लैजान पाईने छैन तथा संकलित नमुना तोकीएको प्रयोगशालामा मात्र परिक्षण गर्नु पर्नेछ ।
६. तोकिएका शर्तहरुको पालना नगरेमा विभागले कुनै पनि समयमा अनुमतिपत्र रद्द गर्न सक्नेछ ।
७. तोकिएको शर्तहरुको हकमा सोही बमोजिम र अन्य बाँकीको हकमा प्रचलित कानून बमोजिम हुनेछ ।

(श्याम कुमार शाह)
वरिष्ठ इकोलोजिष्ट

बोधार्थः
श्री प्रविन गिरीः शुक्लाफाँटा राष्ट्रिय निकुञ्ज कार्यालयसँग समन्वय गरी अध्ययन अनुसन्धान गर्नु हुन ।

Appendix 5. Research permission from Shuklaphanta National Park

नेपाल सरकार
वन तथा वातावरण मन्त्रालय
राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभाग
शुक्लाफाँटा राष्ट्रिय निकुञ्ज कार्यालय
मूझगाउँ, कञ्चनपुर

पत्र संख्या: ०८१/८२(योजना फाँट)
चलानी नं.: ८४६०

फोन नं. ०९९-४१४३०९

मिति :२०८१/९/५
नेपाल सम्वत्:-११४४

विषय : अध्ययन अनुसन्धान अनुमति सम्बन्धमा ।

श्री प्रविन गिरि
प्युठान ।

प्रस्तुत विषयमा राष्ट्रिय निकुन्ज तथा वन्यजन्तु संरक्षण विभागको च.न.३२५ मिति २०८१/४/३१ गतेको पत्रानुसार "Niche Overlap and awareness Initiatives for the Conservation of Smooth –Coated Otters and Fishing Cat in the Lowland Region of Far Western ,Nepal " अध्ययन अनुसन्धान कार्य गर्नका लागि अनुमति प्रदान दिईएको भन्ने पत्र प्राप्त भएकोमा उक्त अध्ययन अनुसन्धान कार्य यस निकुन्जमा अध्ययन गर्न मिति २०८१/९/६ देखि २०८१/१०/९ गते सम्मका लागि तपसिलको सर्तमा रही अध्यन अनुसन्धान गर्न अनुमति दिईएको छ । उक्त कार्य गर्दा रा.नि. तथा व.ज.स. ऐन २०२९ को परिधिभित्र रही स्वयम आफ्नो जिम्मेवारीमा गर्न गराउनुहुन अनुरोध छ ।

तपसिल :

शर्तहरु :

१) अनुसन्धानकर्ताले राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन २०२९ र नियमावली, २०३० तथा मातहतका सबै नियमावलीहरुको पूर्ण रुपमा पालना गर्नुपर्नेछ ।

२) अनुसन्धानकर्ताले राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभाग र यस निकुञ्ज कार्यालयसंग समन्वय गरि कार्य गर्नु पर्नेछ ।

३) अनुसन्धानकर्ताले अनुसन्धान समाप्त भएपछि एकप्रति कागजी प्रतिवेदन र एक प्रति विद्युतिय प्रतिवेदन राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभाग र यस निकुञ्ज कार्यालयमा अनिवार्य रुपमा बुझाउनु पर्नेछ ।

४) अनुसन्धानकर्ताले नतिजा प्रकाशित गर्दा अनुसन्धानमा संलग्न यस विभाग र कार्यालय कर्मचारीको योगदानको आधारमा सह लेखकको रुपमा समावेश गराउनु पर्नेछ ।

५) नमुना संकलन (Camera Trapping ,Singh Survey ,daietary analysais, focus group) मात्र गर्न पाउने ।

६.) तोकिएको शर्तहरुको पालना नगरेमा विभाग र कार्यालयले कुनै पनि समयमा अनुमति पत्र रद्द गर्नेछ ।

७.) बाँकीको हकमा प्रचलित ऐन कानुन बमोजिम हुनेछ ।

(मनोज कुमार साह)
वरिष्ठ संरक्षण अधिकृत
वरिष्ठ संरक्षण अधिकृत

बोधार्थ :

श्री राष्ट्रिय निकुन्ज तथा वन्यजन्तु संरक्षण विभाग, बबरमहल, काठमान्डौ : जानकारीको लागि अनुरोध छ ।

श्री रुद्रध्वज गण : शुक्लाफाँटा राष्ट्रिय निकुन्ज : सम्बन्धित गुल्म तथा पोस्टमा जानकारी गरिदिनु हुनअनुरोध छ ।

श्री पूर्वी सेक्टर अर्जुनी/ पश्चिम सेक्टर , :जानकारीको लागि अनुरोद छ ।