Assessing the distribution pattern of otters in four rivers of the Indian Himalayan biodiversity hotspot

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Abstract

1. The Eurasian otter (*Lutra lutra*), Smooth-coated otter (*Lutrogale perspicillata*) and Asian small-clawed otter (*Aonyx cinereus*) have all been previously reported from the Indian state of Uttarakhand. However, little information is available about these species' current distribution in a mountainous region that is subject to increasing human-induced stressors (e.g. hydropower plants, pollution, sand and boulder mining, destructive fishing techniques, poaching).
2. Due to the important role of these otters in structuring riverine food webs (particularly taking account of their roles as top carnivores), it is critical that these animals receive suitable protection in the face of a projected rise in temperature, change in precipitation patterns, and associated river flows in this Himalayan biodiversity hotspot. This study assesses otter distribution in four rivers of Uttarakhand, as a basis for informing future conservation actions.
3. Field surveys were conducted (October 2018 – January 2019) in four Himalayan rivers (reaches of the Kosi, Ramganga, Khoh and Song Rivers), supported by semi-structured interviews (N=379) conducted with members of local communities to ascertain qualitative data on views and perceptions of otter species. In addition,

community-based otter awareness camps were organized for local youths (N=105), adults (N=115) and school children (N=256 covering 10 schools). Habitat suitability maps were created using remote sensing data, survey findings and a Geographic Information System (GIS) to provide information about priority river reaches to be targeted for future conservation efforts.

4. This study provides critical interdisciplinary baseline information to guide decision-makers towards developing a targeted, otter-specific conservation program for this important Himalayan biodiversity hotspot. The otter conservation education programs conducted during this study resulted in a proposal to set up a community-based conservation initiative (CBCI) to monitor and report otter sightings from the area, potentially representing a way forward for achieving simultaneous otter conservation and associated ecosystem benefits for local communities.

Keywords:

climate change, freshwater, human-induced stressors, Lutrinae, Mustelidae, otters, Uttarakhand, wetlands

1. Introduction

Species conservation in the Indian Himalayan region (IHR) has often focused on megafauna. The Bengal tiger (*Panthera tigris tigris*), snow leopard (*Panthera uncia*), Indian elephant (*Elephas maximus indicus*), and the greater one-horned rhinoceros (*Rhinoceros unicornis*) are afforded the highest legislative protection and are often the prime recipients of conservation attention. By contrast, a lesser degree of explicit attention is devoted to otter conservation, despite these animals being regarded as 'ambassadors of wetlands' (Gupta, Johnson, Sivakumar, & Mathur, 2016). A variety of legislation requires decision-makers to pay conservation attention to otters, particularly where they occur within the legislative boundaries of Protected Areas (National Parks, wildlife sanctuaries, and community and conservation reserves) (Gupta, Johnson, Sivakumar, & Mathur, 2016).

A prior review of available information revealed observations of otters in rivers of the IHR in the past decade (Gupta, Johnson, Sivakumar, & Mathur, 2016). Three species of otters have been previously reported from Uttarakhand based on observations in the wild, visual signs, discussion with communities and unconfirmed reports (Hussain, 1999; Hussain, Gupta, & de Silva, 2011; Nawab & Hussain, 2012a; Khan, Dimri, Nawab, Ilyas, & Gautam, 2014). These three species are the Eurasian otter (*Lutra lutra*), Smooth-coated otter (*Lutrogale perspicillata*) and Asian small-clawed otter (*Aonyx cinereus*). However, there is little available information about their current distribution in the face of increasing human-induced stressors (hydropower plants, pollution, sand and boulder mining), and also changing climatic variables including a projected rise in temperature, change in precipitation patterns and river flow in Uttarakhand (INCCA, 2010; Shrestha et al., 2015; Alfthan et al., 2018). It is therefore critical that the distribution of otter species is determined as a key input to otter-specific as well as more general river conservation strategies, as these top carnivores play important roles in structuring riverine food webs (Gupta, Johnson, Sivakumar, & Mathur, 2016).

Otters of Uttarakhand

The conservation status of the three species of otters previously reported from Uttarakhand are outlined below.

The Eurasian otter (*Lutra lutra*) is classified as Near Threatened on the IUCN Red List based on declines in the Asian population, attributed to the sensitivity of the species to the recent intensification of human-induced threats (Roos, Loy, de Silva, Hajkova, & Zemanová, 2015). The Eurasian Otter is listed on Appendix I of CITES, Appendix II of the Bern Convention, and Annexes II and IV of the EU Habitats and Species Directives (Roos, Loy, de Silva, Hajkova, & Zemanová, 2015). It is also listed as an endangered species in India and is protected in Schedule II (Part 2) of the Wildlife (Protection) Act, 1972.

The smooth-coated otter (*Lutrogale perspicillata*) is classified as Vulnerable on the IUCN Red, List based on an inferred population decline due to habitat loss and exploitation (de Silva et al., 2015). Since 1977, the smooth-coated otter has been listed in Appendix II of CITES. It is a protected species in almost all of its range countries, which prohibits its killing (de Silva et al., 2015). In India, it is protected in Schedule II (Part 2) of the Wildlife (Protection) Act, 1972.

The Asian small-clawed otter (*Aonyx cinereus*) is also classified as Vulnerable on the IUCN Red List based on an inferred past population decline because of habitat loss and exploitation (Wright, de Silva, Chan, & Reza Lubis, 2015). Threats to Asian small-clawed otter are similar to those facing the smooth-coated and Eurasian otters. Potential threats to the survival of Asian small-clawed otters throughout Asia include destruction or degradation of essential habitat due to changing land-use patterns and other development activities (Wright, de Silva, Chan, & Reza Lubis, 2015). In India, the primary threats are loss of habitats due to tea and coffee plantations along the hills, in the coastal areas where loss of mangroves is driven by aquaculture and increased human settlements, and siltation of smaller hill streams due to deforestation (Wright, de Silva, Chan, & Reza Lubis, 2015). The threat posed by poaching is still very significant in many parts of India, and across South-east Asia, requiring constant monitoring (Wright, de Silva, Chan, & Reza Lubis, 2015). Since 1977, the Asian small-clawed otter has also been listed in CITES Appendix II. In India, the species is protected in Schedule I of the Wildlife (Protection) Act, 1972.

Threats faced by these three otter species are similar at the local level. Poaching is suggested as a principal cause of the decline of otters in South and Southeast Asia, and possibly also in North Asia (Savage & Shrestha, 2018). Despite existing conservation legislation, trade of these animals continues, principally for their pelt (most seizures of big cat products are accompanied by otter skins). In 2005, there were six seizures of otter skins in Uttarakhand and another six seizures of otter skins from the neighbouring Indian state of Uttar Pradesh (Savage & Shrestha, 2018). A major wildlife seizure in Delhi in November 2009 comprising 30 kg of tiger bones, two tiger skins and two leopard skins also included seven otter skins (Times of India, 2009). These seized cargos almost certainly substantially underrepresent the scale of poaching and animal trade (Gomez, Leupen, Theng, Fernandez, & Savage, 2016; Savage & Shrestha, 2018). Uttarakhand, on the border with Nepal, has a central position on the northward route of traded wildlife, and as a likely source of otter skins. In addition, Uttarakhand has a very high human population density and is also sensitive to climate change (Shrestha et al., 2015; Alfthan et al., 2018). All of these human-induced and climate-vectored influences are likely to have an adverse impact on otter populations in the region.

All three of these otter species are top carnivores, playing critical roles in the balance and processes of riverine ecosystems, significantly influencing the overall spatiotemporal dynamics of river systems and thus the beneficial ecosystem services that they provide (Gupta, Johnson, Sivakumar, & Mathur, 2016). Otters should therefore constitute an integral part of any wetland conservation programme in India and beyond.

As their elusive nature mean that they are rarely encountered during day-time surveys, there has been a growing concern among ecologists and conservationists in Uttarakhand regarding presence or possible absence of the three otter species, and particularly outside the boundaries of Protected Areas (i.e. Corbett and Rajaji Tiger Reserves). Insufficient attention has been given to understanding how increasing human-induced stressors and projected climate change in Uttarakhand has affected the distribution of these top predators. This study assesses otter distribution in four rivers in Uttarakhand, then develops habitat suitability maps for use in future conservation actions and in particularly outside Protected Areas. An additional objective was to evaluate possible species-specific targeted actions for immediate protection and long-term otter conservation.

2. Study area

The study is focused on four rivers in the Indian state of Uttarakhand (30.0668° N, 79.0193° E), located in the western region of the Indian Himalayas. Uttarakhand is endowed with a rich biodiversity with numerous rivers, reservoirs, freshwater lakes and wetlands (Gupta, Sivakumar, Mathur, & Chadwick, 2015). The Kosi River originates from Budha Peenath village in the Kausani area of Almora District of Uttarakhand, and has a total length of approximately 240 km with a catchment area of 3,420 km^2. The Western Ramganga River is an important tributary of the Ganges River, originating from the Shivalik Himalayas at Dudhatoli in Chamoli District of Uttarakhand. The Khoh River is a tributary of the Western Ramganga, originating from Langur in Dwarikhal spanning a catchment of over 250 km^2. The Song River is a tributary of the Suswa River, which is in turn a tributary of the Ganges, and originates as a spring-fed stream in the southern slopes of the Mussoorie ridge of the Himalayan range (Gupta, Sivakumar, Mathur, & Chadwick, 2015) (Figure 1).

3. Methods

Field surveys were conducted on foot along the banks of the rivers (Kosi, Ramganga, Khoh and Song) to collect evidence of otters. These rivers are recognised as some of the last bastions of otter populations in Uttarakhand.

Otters defecate on prominent structures (e.g. rocks, tree trunks, islands and river banks) and these droppings, called spraints, can be easily observed in the field. Otter tracks are also clearly visible on the sandy banks and in muddy sites along rivers. Otter latrines (discrete sites where otters regularly deposit spraints, urine and anal secretions) are also prominent, and their dens, while rarely seen, are also important signs of otter presence. Fieldwork was conducted pre- and post-monsoon, and in the winter months of 2018 and 2019. Conditions during the monsoon season can wash away indirect signs od otters, such as spraints, tracks, dens and latrines, and can also make access to survey site challenging. The post-monsoon sampling season is favourable as declining water levels expose muddy banks enabling more frequent recording of otter tracks. Otter surveys were conducted between 08:00 – 17:00 in order to avoid negative interactions with wildlife in the study sites, following learning from an initial scoping study in 2018.

3.1 Otter survey

The otter survey methodology followed Anoop & Hussain (2004) and Nawab & Hussain (2012a). An entire river was divided using a geographical information system (GIS) into minimum otter home ranges common to all three species (following Hussain & Choudhury, 1997). Data on otter signs (spraints, tracks, dens and grooming sites) were recorded every 400 m. A team of four researchers conducted the survey by walking along both river banks, searching for otter signs. In each survey section, environmental parameters and disturbance were also recorded where considered potentially important for otters (Anoop & Hussain, 2004), and any opportunistic observations of otters during the course of the survey were also recorded and their position noted.

Important habitat variables – bankside condition, water current and depth, bank slope, escape cover distance, basking and grooming sites, vegetation, dead logs, sandy islands, and braided channels –were recorded where present. The GPS locations of tracks, spraints and other indirect and direct signs were recorded. Surveying of indirect signs of otters was very important as these species are elusive and either nocturnal or crepuscular (Hussain, 1999; Hussain, Gupta, & de Silva, 2011; Nawab & Hussain, 2012b; Khan, Dimri, Nawab, Ilyas, & Gautam, 2014).

3.2 Social science surveys

Social science surveys were conducted using a semi-structured interview approach (Gupta, Sivakumar, Mathur, & Chadwick, 2014). The aim of these social surveys was to document local community knowledge, attitudes and perceptions regarding otters, including questions such as: (i) have otters been present in the past in your area; (ii) are otters present in your area now; (iii) have otter numbers here been increasing, decreasing, stable, or not known; and (iv) are any factor(s) perceived as threatening the otter population. The respondents were from the communities located along the rivers. As many households as possible were approached for the survey, seeking responses from both men and women, to ensure that a significant number of individual responses were obtained for the analysis.

Community selection was based on the voluntary willingness and the availability of members in the study area during the field survey. Consent was requested and obtained from all the participants to make notes of the conversations. All responses were kept anonymous so that respondents felt free to express their views (following Everard et al., 2019).

3.3 Otter conservation education programs

A number of otter conservation education programs were also conducted to promote awareness about the importance of otters as top carnivores in river ecology. These were delivered through informal talks with local people, forest managers and nature guides; presentations and education programmes at community groups and at schools; and by putting up posters and distributing leaflets. This was conducted after the questionnaire surveys to avoid influencing respondents' answers.

3.4 Habitat suitability mapping for otters

Habitat suitability mapping was achieved by integration of remotely sensed data. Satellite datasets used in this study were: Sentinel 1 (Synthetic Aperture RADAR) VV Polarization band; Sentinel 2 (Multispectral) bands B1 to B8, B8A, B9, B11 and B12; and Topographic data from Shuttle Radar Topography Mission (SRTM) (see supplementary material).

The habitat suitability mapping methodology was divided into two parts:

1. Derivation of a land use land cover (LULC) map. The datasets from different sensors (Sentinel 1 SAR, Sentinel 2 Optical, SRTM- Topography) have unique characteristics. These datasets were co-registered to produce a layer stack (Schmitt, Hughes, & Zhu, 2018). 'Random forest', a machine learning technique, was utilized for classification, from which the land use land cover (LULC) map was produced (Gislason, Benediktsson, & Sveinsson, 2006). In total, 70% ground control points (GCP) were used for training the classifier, and the remaining 30% GCP were utilized for validation. The classified map was subjected to accuracy assessment using statistical methods such as Overall, Users, Producers accuracy.

2. Habitat suitability mapping. A weighted linear modeling approach (Malczewski, 2011) was utilized for mapping suitable areas for otters in ArcGIS 10.1 (ESRI, 2012); a weighted linear combination is the most prevalent procedure for multi-criteria evaluation. Factors (e.g. variables) are combined together by applying a weight to each one, followed by the sum of the weights applied to each factor. The presence of otters has been strongly related to various features of land cover and protected reaches of river, and negatively correlated with elevation (Jo, Won, Fritts, Wallace, & Baccus, 2017; Barbosa, Real, Olivero, & Vargas, 2003; Robitaille & Laurence, 2002; Romanowski, Brzeziński, & Żmihorski, 2013) (see supplementary material). Four selected primitive attributes were selected as a basis for development of habitat suitability mapping: land cover, elevation range, slope, and distance from the river. Equal weighting of these factors was applied in the model

as all were equally important for suitability mapping. The output of this combined approach was an otter habitat suitability map; the final product was a Habitat Suitability Index (HSI) quantitatively representing the capacity of an area to fulfill the requirements of study the species.

The linear model depicted in equation 1 was used to derive the habitat suitability map, identifying four classes: high suitability (s=1); moderate suitability (s=0.75); low suitability (s=0.50); and unsuitable (s=0.25).

F suitable = 0.25 (LULC Map) + 0.25 (Slope) + 0.25 (Elevation) + 0.25 (distance from river) – eq (1)

The linear model used binary values, with primitive attributes converted to binary image (0 and 1). 1 represented the areas where conditions depicted were satisfied for each primitive, and 0 represented the area where the conditions were not satisfied in each of the primitives. The model was then applied to derive suitable maps.

4. Results

4.1 Current distribution of otters in the four rivers of Uttarakhand

Otter tracks and dens were recorded from the banks of the Ramganga River, and otter tracks and a latrine were recorded from the banks of the Kosi and Khoh Rivers (Figure 2). These were identified as smooth-coated otter signs (Nicole Duplaix, pers. comm.). Direct sightings of smooth-coated otters were also made on the Ramganga (bordering the Corbett Tiger Reserve) and Khoh Rivers (bordering the forest boundary) (Figure 3). The study revealed that the distribution of smooth-coated otters along three of the four examined rivers is patchy and largely restricted to a small subset of reaches (Table 1).

Otter signs were found at 26.6% of sites from all four rivers during surveys. Most of the positive sites (45%) were found on rocky banks, followed by sandy banks (40%), clay banks (9%), and banks with shoreline vegetation and marsh (6%), indicating greater preference for rocky banks. This may be due to the higher availability of den sites in rocky terrains (Hussain & Choudhury, 1997), though rocky banks may have more marking locations available compared to sandy or clay banks. During the survey, seven otters were sighted in two different groups, each consisting of 3-4 animals. No evidence of pups was recorded. No signs of otters were recorded within at least 2 km of such areas, indicating avoidance of disturbed sites (Hussain & Choudhury, 1997). No direct (visual) or indirect sightings of the Eurasian or small-clawed otters were recorded from any of the study sites. No direct or indirect signs of smooth-coated otters were recorded from the Song River.

It is important to note here that the survey during this study had its limitations, as the study sites were dynamic systems, with species occurrence and detection constrained by season and time of the day due to variation in activity levels and behaviour among species. Otter species could also have been under-recorded as they are highly sensitive to disturbance, including the presence of surveyors. Therefore, the sightings and signs were pooled for each river separately during each complete survey, aggregating up reported encounter rates of species for entire river stretches.

4.2 Social science surveys

A total of 279 semi-structured interviews were conducted during the survey period among villages present along surveyed rivers. Interviewed participant included 204 male and 75 female local community members aged between 18 and 70 years old. Respondents were shown photographs of otters, and 20% reported not having seen otters in the preceding 5 years during their day-to-day work along the rivers. Sixty percent of the respondents mentioned that, although they had not directly seen otters, they knew someone from the area who had, or else that they had seen indirect signs of otters. They highlighted that this could either be because the animals are shy in nature, or they are not present in as large a number as they had been over a decade ago. The remaining 20% of the respondents had seen otters in the wild, either in the rivers during dusk or along the banks during dawn.

Interestingly, 40% of respondents mentioned that, although not aware of any cultural or religious associations with otters, they believed that killing any living species will bring bad luck. Fifty-five percent of the respondents mentioned that it was likely that otters have some importance, but were not aware of their exact function. Ninety percent of the respondents mentioned that there had been a sharp increase in human-induced stressors in the area, which could impact otter species, the remaining ten percent of respondents preferring not to answer this question. Remarkably, 15% of respondents mentioned that changes in the weather, reporting less rainfall and hence less water in the rivers and their tributaries especially in the drier months, which could have impacted otter populations. These observations are supported by published literature (see Alfthan et al., 2018).

4.3 Otter conservation education programs

The otter conservation education programs (Figure 4) assisted in securing the involvement of local community members in setting up a community-based conservation initiative (CBCI) to monitor and report otter sightings from the area. This was extremely helpful, as it showed immediate results as photographs of observed otter footprints and latrines are being sent by CBCI members to the research team. Additional strategies to enhance the sustainability of the initiative will be a key focus area during a planned second phase of the field research.

4.4 Habitat suitability mapping for otters

Figure 5 shows the classified LULC map of the rivers. The map is classified into six major land use classes. Accuracy assessment was also performed by ground truthing to evaluate the quality of the LULC map. Quality control assessments of the LULC maps based on field observations indicated 90% accuracy (see supplementary material).

The LULC data revealed that Ramganga (64%) and Khoh (45%) rivers had the highest percentage of forest cover. This is not surprising since these rivers are located between Protected Areas in Uttarakhand. Agricultural areas were highest along the Song (29%) and Khoh (19%) Rivers. This could be contributory to the non-detection of otters in the Song river, as settlements were also recorded to be highest here (6.5%) in comparison to the other three rivers. Grassland/shrubs were highest in the Kosi River (43.6%) followed by the Khoh River (28%) (Figure 6).

Habitat suitability maps (or indices?) for the studied rivers are presented in Figure 7. These maps were validated with field observations (ground control points and field photographs) of otter sightings. The Kosi River had the highest percentage of high suitability area (20.34%), followed by the Khoh with 11.73%. The Song River had the lowest percentage of high suitability area (3.82%). In terms of suitable area, the Khoh had the greatest value with 46.79%, whereas the Song River had the highest percentage of moderate suitability area at 61.66%. The low area was along the Kosi River (1.26%) (Figure 8). Where positive field observations of otters were recorded, these coincided with river reaches within the high suitability category in all rivers surveyed.

5. Discussion

The otter species directly identified in the study areas was the smooth-coated otter. Eurasian and small-clawed otters were not observed during this study. Absence of otter signs in a particular place does not necessarily mean the absence of otters in that area (see Hussain & Choudhury, 1997). Furthermore, some indirect signs are not specific to any of the three otter species. To address greater specificity of otter species identification, the authors plan to place camera traps at otter latrines to detect their presence in a follow-on study. Placement of camera traps at otter latrines will serve as an additional approach for monitoring the proportion of each species of otter in riparian areas. One option being explored for regular data retrieval and protection of camera trap equipment is replication of the 'goatwala for tigerwala' model developed for monitoring of tigers and other wildlife by the NGO Tiger Watch, engaging local volunteers (many of them local grazers or 'goatwala') to collect and transmit data and subsequently serving as community activists promoting wildlife conservation ('tigerwalas') (Everard, Khandal, & Sahu, 2017).

Although not entirely reliable, the semi-structured questionnaire provided a time-saving, cost-effective and systematic way to gather information from a target population (Gupta, Sivakumar, Mathur, & Chadwick, 2014). Semi-structured interviews revealed that, although local communities were aware of these otter species, very few had actually seen them in the wild. There was the need, as expressed by one respondent, to "…*see with our own eyes what you want us to protect*".

The habitat suitability areas for otters in the four river reaches outside Protected Areas is an important finding. There is a possibility of using a combination of suitable areas in the four river reaches – Kosi (66.84%), Ramganga (52.20%), Song (37.60%) and Khoh (58.525) rivers – as opportunities for formulating a targeted, species-specific conservation plan for the region (Gupta, Johnson, Sivakumar, & Mathur, 2016).

The weighted linear modeling approach integrated diverse variables influencing habitat suitability for otters, taking account of factors such as species-specific factors, temporal, spatial and budgetary limitations of field surveys, and available expert and local knowledge. The four most important primitive variables identified for otter species and used in development of habitat suitability maps were land cover; elevation; slope; and distance from the river, weighted equally to develop a Habitat Suitability Index (HSI). However, it is recognised that supplementary variables such as the important factor of prey availability (e.g. Sales-Luís, Pedroso, & Santos-Reisa, 2007) and consideration of the diet and feeding behaviours of otters (see Lanszki, Lehoczky, Kotze, & Somers, 2016) as well as pollution and climatic indicators could be taken into account in future refinement of suitability maps better to support conservation initiatives.

The study area has varying topography. In flat terrain (less topographic variation), topographic variables such as slope are less important than land cover and distance from the river, so an equally weighted linear modeling approach may not optimally represent true ecology of the otters hence it is not appropriate for developing suitability maps. This may also need to be taken into account in future refinements of the method.

Furthermore, by 2050, mean temperature across the IHR is projected to increase by 1-2°C relative to a 1960s baseline; the monsoon is expected to become longer and less predictable; precipitation is projected to vary by 5% on average; and the intensity of extreme rainfall events is likely to increase (Shreshtha et al., 2015; Alfthan et al., 2018). In addition, glacial mass-balance modelling based on climate projections to 2030, 2050 and 2100 indicate substantial losses in glacial mass and area in coming decades for most parts of the IHR (INCCA, 2010), which will affect river discharge and other properties (Alfthan et al., 2018). The selected rivers are also the prime habitat for many other small mammals such as the fishing cat (*Prionailurus viverrinus*), mugger crocodile (*Crocodylus palustris*), gharial (*Gavialis gangeticus*) and a diversity of resident and migratory birds (NG, unpublished data). Conservation measures for otters, as ‘flagship’ species (Verissimo, MacMillan, & Smith, 2010), are also therefore likely to yield conservation benefits for these other taxa and the overall integrity, functioning and ecosystem service provision of these rivers.

A critical finding from the region has been the detection of smooth-coated otters from river reaches outside Protected Areas. Given the important role being played by the Corbett and Rajaji Tiger Reserves in safeguarding threatened species within their boundaries (see Gupta, Sivakumar, Mathur, & Chadwick, 2015), it is vital for conservation strategies to also target these 'unprotected areas' (Gupta, Sivakumar, Mathur, & Chadwick, 2015) to maintain linear connectivity between otter habitats. Given existing and intensifying land use in the region, and the diminishing habitat available for otters and other riverine species, it is further critical to protect these areas through targeted and sustainable measures in the study area.

There is a further need to ensure regular monitoring of existing otter habitats by strengthening the capacities of local community members to help generate a database of the population status of otters. Engagement of local people in identification with their local wildlife and its conservation is significant as the biodiversity and ecosystem services of 'cultural landscapes' are shaped by human management (Antrop, 2004; Schaich, Bieling, & Plieninger, 2010). The otter conservation education programs conducted during this study resulted in a proposal to set up a community-based conservation initiative (CBCI) to monitor and report otter sightings from the area, potentially representing a way forward for achieving simultaneous community-based otter conservation and associated ecosystem benefits for local communities (Gupta, 2013; Everard, Khandal, & Sahu, 2017). Providing this critical information to decision-makers in influential bodies, at national and international levels, could promote development of an otter conservation program for Uttarakhand and other similar regions.

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Table 1: Number and % of positive sites of otter activity along sampled reaches of the four rivers

River	km length of river sampled	Sites surveyed	Positive sites	%
Kosi	35	88	03	03.4
Ramganga	25	63	10	15.9
Khoh	22	55	04	07.3
Song	21	53	00	00.0

Figure legends

Figure 1: A map showing the study areas of the Kosi, Ramganga, Khoh and Song Rivers in Uttarakhand, India.

Figure 2: otter tracks

Figure 3: Smooth-coated otters recorded from the study sites (Photo: Ritesh Suri)

Figure 4: Banner and flyers utilized for enhancing community awareness among local stakeholders for otters and its associated benefits in the region

Figure 5: Land cover classification of the: (a) Kosi, (b) Song, (c) Khoh and (d) Ramganga Rivers.

Figure 6: Land use land cover (in %) for the Kosi, Ramganga, Song and Khoh Rivers.

Figure 7: Habitat suitability maps for otters in the study sites: (a) Kosi, (b) Song, (c) Khoh and (d) Ramganga Rivers.

Figure 8: Habitat suitability areas for otters in the study sites: (a) Kosi, (b) Ramganga, (c) Song and (d) Khoh Rivers.