Habitat use pattern and conservation status of smooth–coated otters *Lutrogale perspicillata* in the Upper Ganges Basin, India

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Abstract

Habitat use pattern and conservation status of smooth–coated otters Lutrogale perspicillata *in the Upper Ganges Basin, India.*— Smooth–coated otters inhabit several major river systems in southern Asia, and their environmental requirements link them to food and water security issues as the region is so densely populated by humans. The lack of baseline data on their distribution and ecology is another major constraint that the species is facing in India. The present study was stimulated by the rapid decline in the otter's population in the country and focuses on estimating the conservation status, habitat use pattern, and associated threats in the upper Ganges River Basin (N India). Our findings contribute towards a better understanding of the complex ecological interactions and the design of effective conservation measures. Coupled with the habitat preferences, the study also provides new locations in the species distribution. This paper highlights the gap areas in the conservation of the species and suggests areas that should be prioritized for management.

Key words: Otter, Ganges Basin, Conservation status, Habitat use.

Resumen

Modelo de uso del hábitat y estado de conservación de las nutrias lisas Lutrogale perspicillata *en la zona alta de la cuenca del Ganges, India.*— Las nutrias lisas habitan en varios sistemas fluviales importantes del Asia meridional y sus necesidades medioambientales las vinculan con problemas de seguridad alimentaria e hídrica, debido a la elevada densidad de humanos. La falta de datos de referencia sobre su distribución y ecología es otra limitación notable que la especie está afrontando en la India. El presente estudio se vio impulsado por el rápido descenso de la población de nutrias en el país y se centra en estimar el estado de conservación, el modelo de uso del hábitat y las amenazas asociadas en la zona alta de la cuenca del río Ganges (Asia septentrional). Nuestros resultados contribuyen a comprender mejor las complejas interacciones ecológicas y a elaborar medidas de conservación eficaces. Junto con las preferencias de hábitat, en el estudio también se informa sobre nuevas ubicaciones en la distribución de la especie. Asimismo se ponen de relieve las deficiencias existentes en la conservación de la especie y se sugieren las zonas cuya ordenación debería ser prioritaria.

Palabras clave: Nutria, Cuenca del Ganges, Estado de conservación, Uso del hábitat.

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Introduction

Natural floodplains are biologically the most productive and diversified ecosystems on earth (Mitsch & Gosselink, 2000) but due to their very slow recovery they are also the most threatened (Vitouesk et al., 1997; Ravenga et al., 2000). The Ganga River Basin is among the world's largest productive floodplain ecosystems with enormous ecological, cultural and economical value (Ambastha et al., 2007). It has an extraordinary variety in altitude, climate, land use and biodiversity (O'Keeffe et al., 2012) The entire span of the Ganga River Basin in India can be divided into three stretches *i.e.* the upper reach from the origin to Narora, the middle reach from Narora to Ballia, and the lower reach from Ballia to its delta.

The upper Ganga River Basin is a dynamic, bio–spatial complex eco–region. The natural landscape has been severely fragmented by anthropogenic factors and most of the wildlife endowments are restricted either to the Shivalik hills and their adjacent Bhabar–Terai tract or to protected areas (Rodgers & Panwar, 1988). These pockets in the upper Ganga River Basin provide refuge to some threatened populations of endangered aquatic and semi–aquatic mammalian species like the Ganges river dolphin *Platanista gangetica* and the smooth–coated otter *Lutrogale perspicillata*, respectively.

The amphibious life styles of otters allow them to disperse over wide areas of riverine landscape, and as a result, they influence the ecological processes of the river floodplain in a direct and expansive manner. Smooth–coated otters play a vital role in balancing the freshwater ecosystems as a top carnivorous species (Sivasothi, 1995; Acharya & Lamsal, 2010), and they may therefore significantly influence the overall spatio–temporal dynamics of the eco–region over a long period of time (Naiman et al., 2000). There is little information available on the status of otter populations in India, although there seems to have been a rapid decline due to loss of habitat and intensive trapping (Hussain, 1999; Nawab, 2007, 2009; Nawab & Gautam, 2008). Presently, the population is severely fragmented throughout its distribution range and isolated populations are restricted mostly to protected areas (Hussain, 1999; Nawab, 2007, 2009). Although otter occurrence in the upper Ganga River Basin has been previously reported from the National Chambal Wildlife Sanctuary (Hussain, 1993), Corbett Tiger Reserve (Nawab, 2007), Dudhwa Tiger Reserve and Katerniaghat Wildlife Sanctuary (Hussain, 2002), the present study appends new geographical locations in the distribution range of smooth–coated otter, *i.e.* (i) Alaknanda–Ganga Basin in Uttarakhand and (ii) Hastinapur Wildlife Sanctuary in Uttar Pradesh. The present study was triggered by the rapid decline in the otter's population in the country and it focuses mainly on assessing the otter's conservation status, its habitat use pattern, and associated threats in the upper Ganga River Basin (N India). This will improve the understanding of the complex ecological interactions and will help to design effective conservation measures for this species (Stanford et al., 1996). The purpose of this paper is to highlight the gap areas in the conservation of the species and to suggest areas for management in the upper Ganga River Basin.

Material and methods

Study sites

The Ganga River Basin is the largest river basin in India, constituting 26% of the country's land mass and supporting about 43% of its population (448.3 million as per the 2001 census) (Ambastha et al., 2007). Rainfall and melt water from snow and glaciers are the main sources of water in the River Ganga (O'Keeffe et al., 2012). The present study was carried out at two selected sites, one in Uttar Pradesh and the other in Uttarakhand, states of India where the species has not been studied previously.

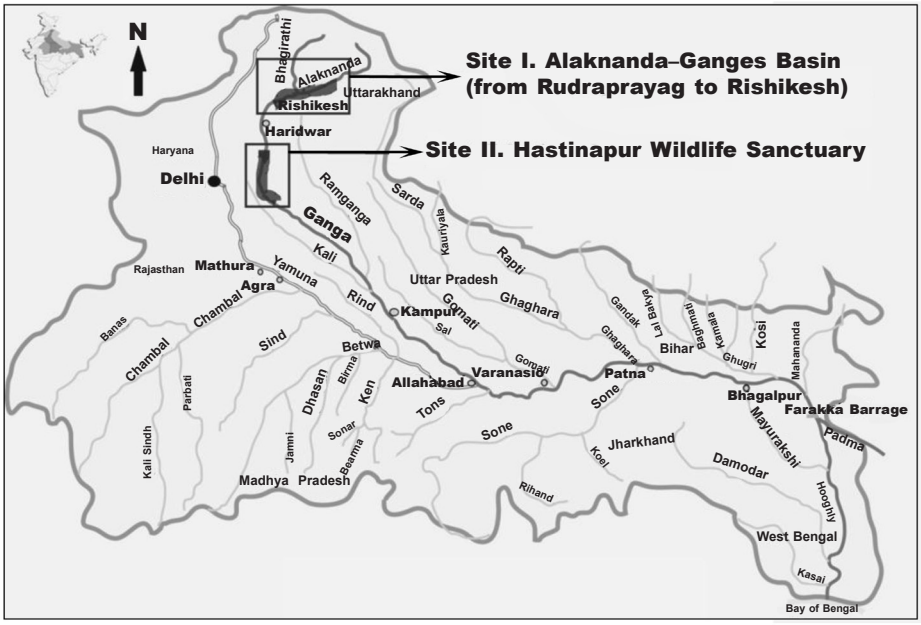
Site I. Alaknanda–Ganga Basin (from Rudraprayag to Rishikesh)

The River Alaknanda originates from the confluence of the Sathopanth and Bhagirathi Kharak Glacier and forms a unified stream of the upper Ganga River by merging with the River Bhagirathi at Devprayag. The Alaknanda–Ganga Basin (fig. 1) is characterized by rugged topography with major landforms comprising moderate to steep precipitous sloping mountainous terrain, narrow and broad valleys and highly dissected ridges with the formation of deep gorges (Anbalagan et al., 2008). Despite its unprotected status, the basin holds a good variety of wildlife, including endangered freshwater fauna like Golden Mahasheer *Tor putitora*. The general vegetation in the area is dominated by *Pinus roxburghii*, *Anogeissus latifolius*, *Acacia catechu, Holoptelea integrifolia, Syzgium cumini* and *Aegle marmelos*. The drainage system of the basin has been extensively regulated for hydroelectric production.

Site II. Hastinapur Wildlife Sanctuary

Hastinapur Wildlife Sanctuary spreads over an area of 2,073 km² along the banks of the River Ganges in western Uttar Pradesh (fig. 1). The Sanctuary was established in 1986 to conserve the fast vanishing, unique Ganga River grassland–wetland complex, locally known as Khadar. It is unique in the sense that it presents a variety of landforms and habitat types that include wetland, marshes, dry sandy beds and gently sloping ravines.

River Ganga and its old bed, locally called Boodhi Ganga, forms the drainage system of the Sanctuary. River Ganga enters the Sanctuary area at Bijnor and leaves it at Garmukteshwer after flowing for 125 km. During summers, Boodhi Ganga becomes fragmented into a series of small swampy patches with nil or very insignificant water current. Because of this discontinuous belt of highly marshy land, there is profuse growth of vegetation like *Phragmites* species*, Arundinella* species and *Typha* species.



Source: The original map is downloaded from www.sandrp.in on 20 January 2014

Fig. 1. Location of study sites in the Ganges River Basin.

Fig. 1. Ubicación de las localidades de estudio en la cuenca del río Ganges.

Data collection

During the summer in 2010 we surveyed 35 kilometers of the River Alaknanda–Ganges (sampling sections, *n* = 7) and 145 km stretch of River Ganga (main stream) and its old bed Boodhi Ganga (sampling sections, *n* = 29). The selected river stretches were divided into 5 km sections using a Survey of India's 1:50,000 topographic maps (Macdonald & Mason, 1983; Kruuk et al., 1994; Hussain & Choudhury, 1997; Nawab, 2007). Data on the habitat parameters and indirect evidences of otter occurrence such as tracks, spraints, den sites or scent marks were recorded from each section. Searches were made in 15 m wide strips along the edge of the river with the help of two trained researchers, by walking along both banks. In each study section, any location where spraints, tracks, den sites and other signs of otter presence were found was defined as a 'used plot' with dimensions 100 × 15 m; additionally, for each used plot, two available plots, one each at 500 m downstream as well as upstream, were considered. In case of spraint sites, a new site was registered only when spraints were separated by more than 5 m (Melquist & Hornocker, 1983; Newman & Griffin, 1994; Medina, 1996; Nawab, 2007).

At each section habitat parameters and human activities which are considered potentially threatening to otters were also recorded (Prenda & Granado–Lorencio, 1996; Prenda et al., 2001; Anoop & Hussain, 2004) (table 1). Species habitat selection was analyzed at plot scale.

Data analysis

The present study was based on the premise that otters live at low densities and are shy and often nocturnal or crepuscular, and hence difficult to track and to make direct estimates of population size and density. The distribution and frequency of occurrence of spraints and tracks were considered as the index of habitat use by the otters. The preference of habitat covariates was established following Bonferroni confidence intervals in combination with Chi–square goodness of fit test (Neu et al., 1974; Byers et al., 1984).

Bonferroni confidence interval equation:

$$\bar{P}_i - Z_{\alpha/2k}\sqrt{\bar{P}_i(1-\bar{P}_i)/n} \leqslant P_i \leqslant \bar{P}_i + Z_{\alpha/2k}\sqrt{\bar{P}_i(1-\bar{P}_i)/n}$$

where P_i is the proportion of indirect evidences in the i^{th} habitat category, n is the sample size, k is the number of categories of habitat studied, α is confidence interval while Z is the tabular value of standard curve.

Chi–Square equation:

$$\chi^2 = \frac{\sum (O_i - E_i)^2}{E_i}$$

where O_i is the observed number of indirect evidence in the i^{th} habitat category and E_i is expected number of indirect evidence in the i^{th} habitat category.

An independent sample *t*–test was performed to know the significance of difference between the used and available habitat covariates following Neu et al. (1974), Byers

Table 1. Ecological parameters and human activities affecting the occurrence of smooth–coated otter, recorded during the study.

Tabla 1. Parámetros ecológicos y actividades humanas registrados durante el estudio que afectan a la presencia de la nutria lisa.

Variable	Data type	Description and measurement details
Width of river (m)	Continuous	Distance between shorelines visually estimated
Average depth of river (m)	Continuous	The depth of the river was measured at both banks and middle of the river and mean depth was calculated
Shoreline substrate type (%)	Categorical	Approximate percentage of total area (100 m × 15 m) of the plot covered by rock/boulder, sand, mud, clay or alluvial deposit was visually estimated
Water current (m/s)	Continuous	The surface water velocity was calculated via floating ball method.
River bank slope (degree)	Continuous	Measured via Clinometers
Shoreline vegetation cover (%)	Categorical	Approximate percentage of total area (100 m × 15 m) of the plot covered by tree, shrub, herb or grass was visually estimated
Escape distance (m)	Continuous	Nearest distance from water's edge to shoreline vegetation which provides cover for otter measured by measuring tape
Disturbance (present/absent)	Binary	Presence of disturbing activities/evidences was recorded at every plot

et al. (1984) and Zar (1984). Statistical package SPSS 7.3 (Norusis, 1994) was used for computing purposes.

Results

Site I. Alaknanda–Ganga Basin (from Rudraprayag to Rishikesh)

The thirty–five kilometer stretch of the River Alaknanda–Ganga was divided into seven sampling sections of five kilometers. Otter occurrence was recorded only from two of these sections (*i.e.* 28.57% occupancy), at village Malysu and Papdasu (district Rudraprayag). Informal interviews with locals suggested occurrence of otters in the study area was common in the 1990s, but due to human disturbance, the habitat quality had declined and consequently the numbers of otters in the area had decreased.

Sandy substrate was preferred over other available substrates by the species in the area (table 2). Of the 16 habitat parameters, the means of shoreline vegetation cover ($P < 0.05$), percentage of clay substrate ($P < 0.001$) and bank slope ($P < 0.001$) were used significantly different from their availability (table 3).

Site II. Hastinapur Wildlife Sanctuary

The total 145 km stretch of River Ganga (main stream) and its old bed Boodhi Ganga was surveyed. The findings of the survey append the new locality record in the distribution range of smooth coated otter in north India. From a total of 29 sampling sections, only 6.89% ($n = 2$) were found occupied by otters. Interviews with locals revealed that the occurrence of otters in the sanctuary was common a decade before. However, excessive changes in land–use pattern and human disturbance led to a vast decline in habitat quality and hence the otter population also decreased.

The result of Bonferroni confidence intervals indicates that smooth–coated otter prefer the most remote muddy parts of the river and avoid alluvial, sand and areas with clay as dominant substrate (table 2) as they are found adjacent to cultivated fields and easily accessible. Of the 15 parameters, the respective means of used and available plots of ten parameters were found significantly different at $P < 0.001$ level, while the differences between the mean of used and available plots for % sand was found significant at $P < 0.05$ level (table 3).

Table 2. Preference of shelter sites by the smooth–coated otter along site I and II: S. Substrate type; Pio. Proportion of total sampling plots; O_i. Number of used plots; E_i. Expected number of used plots; Pi. Proportion of indirect evidences at each sampling plot; χ^2. Chi–square distribution; Bonferroni. Bonferroni confidence interval proportions; C. Conclusion (+ Used more than available; – Used less than available)

Tabla 2. Preferencia de la nutria lisa por los lugares de cobijo en las localidades I y II: S. Tipo de sustrato; Pio. Proporción en el total de parcelas de muestreo; Oi. Número de parcelas utilizadas; E_i. Número esperado de parcelas utilizadas; Pi. Proporción de pruebas indirectas en cada parcela de muestreo; χ^2. Distribución de la χ^2; Bonferroni. Intervalo de confianza de Bonferroni para las proporciones; C. Conclusión (+ Más utilizado de lo esperado; – Menos utilizado de lo esperado)

S	Pio	O_i	E_i	Pi	χ^2	Bonferroni	C
Site I							
Sand	0.29 (N = 14)	4	2.00	0.57	2.00	0.395 ≤ Pi ≤ 0.748	+
Clay	0.02 (N = 1)	0	0.14	0.00	0.14	0.000 ≤ Pi ≤ 0.000	–
Boulder	0.65 (N = 32)	3	4.57	0.43	0.54	0.252 ≤ Pi ≤ 0.605	–
Alluvial	0.04 (N = 2)	0	0.29	0.00	0.29	0.000 ≤ Pi ≤ 0.000	–
Site II							
Sand	0.16 (N = 71)	0	4.02	0.00	4.02	0.000 ≤ Pi ≤ 0.000	–
Mud	0.49 (N = 218)	18	12.33	0.72	2.16	0.667 ≤ Pi ≤ 0.773	+
Clay	0.29 (N = 126)	7	7.13	0.28	0.00	0.227 ≤ Pi ≤ 0.333	–
Alluvial	0.06 (N = 27)	0	1.53	0.00	1.53	0.000 ≤ Pi ≤ 0.000	–

Discussion

Mainly due to habitat loss and over–exploitation, the population of smooth–coated otters is declining throughout their range of distribution and the trend of population decline is expected to continue (Hussain et al., 2008). A deficiency of baseline data on the ecology of the species is another constraint for its conservation. Information on habitat selection by otters is further sketchier as compared to other aspects of their ecology (Hussain, 1996). In Europe and North America, many studies on *Lutra lutra* and *Lutra canadensis* have led to an increasing understanding of otter habitat preferences in temperate regions (Melisch et al., 1996), whereas in the case of the smooth–coated otter, availability of food, freshwater and shelter for resting, grooming and breeding are the important factors known to govern the process of habitat selection by otters (Mason & Macdonald, 1986; Kruuk, 1995; Anoop & Hussain, 2004; Nawab, 2009).

In site I (Alaknanda–Ganga Basin), otters showed preference for sandy stretches in all the seasons, as these stretches provide sites for dens and grooming (Hussain, 1993); while in site II (Hastinapur Wildlife Sanctuary), the species preferred to use the muddy stretches of Boodhi Ganga which is almost inaccessible to humans and thus less disturbed. This ability of the species to adapt to diverse aquatic habitats accounts for its broad geographic distribution (Pocock, 1941).

Otter occurrence was associated with shallow and calmer regions (with low water velocity) along the Ganga River Basin in site I, as these conditions increase the rate of prey capture per efforts. Ease in capturing prey was interpreted to be the most important factor in selecting the habitat by the species, as also suggested by other studies (Kruuk, 1995; Anoop, 2001; Nawab, 2007; Acharya & Lamsal, 2010).

Hastinapur Wildlife Sanctuary is one of the most populated and disturbed protected areas in Uttar Pradesh. As most of its land is cultivated, the area is highly accessible to humans, imposing an adverse effect on the inhabiting wildlife. Therefore, despite being a protected area, only 6.89% (n = 2) of otter occupancy was recorded in the area, far below the 28.57% (n = 2) recorded for otter occupancy at site I. Moreover, most of the animals like otters restricted themselves to the remaining inaccessible parts of the sanctuary, such as the swampy patches of the Boodhi Ganga River. Habitat features of Boodhi Ganga, such as deep waters forming pools, prey availability, presence of shoreline vegetation and gentle bank slopes, endorse the occurrence of otters. Other authors have also found a positive correlation between otter signs and the percentage of vegetation cover (Macdonald & Mason,1983; Melisch et al., 1996; Anoop & Hussain, 2004; Nawab, 2007). Gentle bank slopes are favored by otters as they reduce energy expenditure while foraging or grooming (Kruuk, 1995).

Otters are facing extreme threats by human–induced habitat destruction. The expansion of agriculture has led to the destruction of huge areas of natural habitats, including forests, grasslands and wetlands, in nearly all regions of the world (Ottino & Giller, 2004).

Table 3. Habitat variables influencing otter distribution along site I and II. (SE. Standard error)

Talba 3. Variables del hábitat que influyen en la distribución de la nutria en las localidades I y II.

	Available plots		Used plots			
Variables	Mean	SE	Mean	SE	*t*	Sig.
Site I						
River bank characteristics						
% Alluvial	10.12	1.69	7.14	1.84	-0.70	0.486
% Boulder	55.86	4.22	55.71	13.60	-0.01	0.990
% Clay	5.29	1.53	0.00	0.00	-3.45	**0.001**
% Grass cover	19.88	2.52	22.14	2.86	0.36	0.723
% Herb cover	17.98	2.15	22.14	3.91	0.75	0.454
% Mud	1.55	0.65	1.43	1.43	-0.07	0.944
% Sand	27.19	4.20	35.71	13.07	0.74	0.463
% Shrub cover	30.95	4.03	46.43	8.29	1.48	0.146
% Total veg. cover	28.33	3.02	47.14	6.44	2.39	**0.021**
% Tree cover	9.76	1.69	9.29	2.02	-0.18	0.859
Escape distance	7.07	0.82	5.29	2.01	-0.83	0.412
Slope	50.76	3.91	14.29	2.02	-8.29	**< 0.001**
River characteristics						
Average depth	4.91	0.44	3.06	0.74	-1.64	0.108
Average width	28.58	2.96	26.14	6.24	-0.32	0.753
Water current	1.28	0.08	0.93	0.23	-1.68	0.101
pH	7.81	0.02	7.83	0.02	0.75	0.461
Site II						
River bank characteristics						
% Alluvial	9.70	1.09	0.00	0.00	8.89	**< 0.001**
% Clay	32.81	1.96	25.80	7.34	0.86	0.393
% Grass cover	86.47	1.20	94.00	1.35	-4.16	**< 0.001**
% Herb cover	6.16	0.46	4.40	0.97	1.64	0.109
% Mud	41.49	2.05	74.20	7.34	-4.30	**< 0.001**
% Sand	16.01	1.59	0.00	0.00	2.46	**0.014**
% Shrub cover	0.94	0.14	1.40	0.68	-0.77	0.444
% Total veg. cover	31.74	0.61	65.60	2.13	-13.28	**< 0.001**
% Tree cover	0.35	0.09	0.60	0.33	-0.69	0.491
Escape distance	48.68	8.67	2.78	0.49	5.29	**< 0.001**
Slope	14.17	0.	9.00	0.82	5.74	**< 0.001**
River characteristics						
Average depth	0.86	0.04	0.48	0.03	8.02	**< 0.001**
Average width	145.61	7.94	19.72	4.96	3.88	**< 0.001**
Water current	0.65	0.04	0.02	0.00	14.33	**< 0.001**
pH	8.55	0.02	7.88	0.07	9.92	**< 0.001**

The expansion and development of urbanization and riverfront infrastructural developments, such as the construction of dams, has broken the continuum of natural habitats into small fragments (Nawab, 2007) and these patches of suitable habitat may be too small to support a breeding pair or a functional social group. It is of note that area sensitive species (Lambeck, 1997) like otter, that have a low dispersal capacity, are unable to re–colonize such patches following extinction (Collinge, 1996).

Recommendations

Site I. Alaknanda–Ganga Basin (from Rudraprayag to Rishikesh)

Maximum evidence of otter occurrence was concentrated around the villages Malysu and Papdasu in the Rudraprayag district. These areas therefore merit special attention in terms of habitat management and protection. As evident from this study, otters are confined to small areas and the population seems to be vulnerable to anthropogenic and other stochastic disturbances. Detailed research on the population ecology of the species is necessary to implement better management practices to conserve the species in the region. Education and awareness programmes should be launched, focusing special emphasis on fishing and immigrant communities known to be involved in otter killings for meat and skin.

Although otters are often in direct conflict with fishermen who view them as competitors for fish and kill them (Foster–Turley, 1992), in the Alaknanda–Ganga Basin, a tolerable association of otters and human presence was observed. From local sources we heard that otters damage nets and steal fish from the fishermen's catch, but the conflict remains negligible; locals also appreciate the aesthetic and ecological importance of otters, accepting it within their environment and making co–existence possible.

Site II. Hastinapur Wildlife Sanctuary

Until the mid–twentieth century, extensive tracts of grassland–wetland complex (locally known as Khadar) harbored rich biodiversity all along the River Ganga. After India gained independence in 1947, Khadar received a large influx of Pakistani emigrants and in the following decades (*i.e.* 1980s) Punjabi emigrants also settled in the area, converting the Khadar into agricultural farms (Agarwal, 2009).

Presently, the Hastinapur Wildlife Sanctuary is subjected to human disturbance, mainly due to large scale commercial exploitation of grasses (*Phragmites*), livestock grazing and illegal cultivation (Khan et al., 2003). Many swamps have been drained and converted into crop fields, or are in the process of such activity, like Boodhi Ganga. Modernised farming, *i.e.* unabated use of chemical fertilizers and pesticides in these agriculture fields, is deteriorating water quality (Agarwal, 2009). Indiscriminate fishing by use of gillnet, hooks and poison poses a major threat to aquatic fauna (Khan, 2010).

There is a need for locals, especially fishermen and farmers, to become aware of the importance of aquatic ecosystems both for the conservation of wildlife and for their own sustenance. Local communities should be helped to obtain better educational opportunities.

Otters are confined to small swampy patches of Boodhi Ganga and the population is vulnerable to anthropogenic and other stochastic disturbances in the sanctuary. The solution for their long–term survival in the sanctuary lies not only in taking stringent protection measures but also in developing and implementing long–term monitoring programs for otters along Boodhi Ganga in and around the Sanctuary. The illegal encroachment and clearing of Boodhi Ganga that is currently in progress and encouraged by some migrant farmers severely affects the survival of the area´s wild inhabitants. The government needs to apply strict measures and stringently implement the law to prevent such illegal activities.

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