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Multi-species Survey in River Gandak, Bihar with
focus on Gharial & Ganges river dolphin
(2009 – 10)



Sunil K. Choudhary

VBREC



Suggested Citation: Choudhary, Sunil K. (2010): Multi-species survey of River Gandak, Bihar with focus on Gharial & Ganges river dolphin. T.M.B.U., Bhagalpur.

Keywords: Multi-species survey, River Gandak, Bihar

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PREFACE

The multi-species survey of data deficient and biodiversity rich Indian rivers/river stretches was conceptualized in the 'River Watch' workshop organized at Jiwa Ji University, Gwalior in 2006. Mr. Ravi Singh (Secretary General & CEO, WWF-India), Romulus Whitaker (MCBT), R. J. Rao (Jiwa Ji University), Parikshit Gautam and Sandeep Behera (WWF-India), D. Basu (GCA), Sunil Choudhary (T. M. Bhagalpur University) and Forest officials of Uttar Pradesh, Madhya Pradesh and Rajasthan were present in the workshop, and all agreed on the need and importance of conducting multi-species survey of rivers by joining hands. Rivers Kosi and Gandak in Bihar were identified for conducting such survey. Accordingly, Vikramshila Biodiversity Research & Education Center (VBREC) under T. M. Bhagalpur University did a Recce of Rivers Kosi and Gandak supported by WWF-India, in 2007, and based on the notes of the Recce, the present survey was conducted in the River Gandak in January 2010. VBREC was given the key role of organizing the river survey and the partner agencies joining the survey included, WWF-India, Wildlife Trust of India, Gharial Conservation Alliance and Forest officials of Bihar State.

Prior to this survey, River Gandak in Bihar had never been assessed for gharial population. There were few reports about the presence of

gharial population surviving in the Gandak River in Bihar. In fact, it was S. P. Sahi (former Chief Wildlife Warden of Bihar) who had collected a clutch of gharial eggs from the Gandak in Bihar which had contributed to the initiation of Gharial Conservation Project in India. Somehow, Bihar was not one of the states to be included in the Project Crocodile when it began in 1974-75 in Orissa and Uttar Pradesh to be followed by Tamil Nadu, M.P, W.B, Gujarat, Andhra Pradesh and Kerala in India (personal communication with B C Choudhary of Wildlife Institute of India).

Recent assessments confirm the continued survival of only 5 breeding population of this endemic critically endangered species (*Gavialis gangeticus*) globally (Nepal & India) of which, only one population in the Chambal River, with about 100 breeding females, is comparatively robust in both numbers as well as distribution while all other populations are relict and seriously threatened. In view of the recent decline in both its range and population size, and goals of Species Recovery plan (SRP), the present survey of River Gandak is important as it examined the possible existence and conservation viability of a reported population of gharial in the Gandak River in Bihar. The survey is also important as it documented the status of other major river fauna such as Ganges River Dolphin (*Platinasta gangetica gangetica*), Smooth coated otter (*Lutrogale perspicillata*),

birds, turtles as well as the mugger crocodile (*Crocodylus palustris*), sharing the habitat with gharial. In addition, the assessment for fisheries, river water quality and habitat conditions were also made. Wherever possible, the survey team interacted with local community and educated them about the importance of conserving the river and its unique biodiversity.

I am happy that inspite of severe cold, and threat of violence in the river, the survey was completed successfully, and I hope this report will be helpful in preparing Conservation Action Plan for gharial and other threatened fauna of the Gandak River in Bihar.

Sunil Choudhary

Principal Coordinator

River Gandak Survey 2010

VBREC, T. M. Bhagalpur University

ACKNOWLEDGEMENTS

I offer sincere thanks to Ravi Singh (Secretary General & CEO, Worldwide Fund for Nature – India) Rom Whitaker (Multi Gharial Task Force) and B. A. Khan (Chief Wildlife Warden, Bihar) for assistance and encouragement for multi-species survey of River Gandak in Bihar with focus on Critically Endangered Gharial, and the Endangered Ganges river dolphin.

I gratefully acknowledge financial assistance for the survey from the Worldwide Fund for Nature – India and the Wildlife Trust of India. I sincerely thank Parikshit Gautam of WWF – India and Samir Whitaker of Gharial Conservation Alliance for organizing the funds.

Special appreciation goes to Sushant Dey and Subhasis Dey for preparations made in advance for the survey and also for taking care of the survey team for almost three weeks. I also thank D. Basu (MCBT), Samir Whitaker (MCBT/GCA), Asghar Nawab (WWF-I), Viveksheel Sagar (WWF-I), Samir Sinha (WTI), Braj Nandan Kumar (T. M. Bhagalpur University), B. C. Nayak (CF-Wildlife, Bihar), J. P. Gupta (Director, Valmiki Tiger reserve), S. Chandrasekhar (DFO, VTR), Kumar Sami (DFO, VTR), Karelal Mandal, Chhotelal Sahni, Dinesh Mahaldar and Chhotu Khan who assisted us during the survey.

I offer thanks to Nachiket Kelkar (NCBS, Bangalore) for doing statistical treatment to dolphin data. To D. Basu I owe special thanks for writing Gharial Section and for editing the Recommendation part in this Report.

1. INTRODUCTION

Bihar is located in the eastern part of India between latitude 21°-58'-10" N ~ 27°-31'-15" N and longitude 82°-19'-50" E ~ 88°-17'-40" E. It is an entirely land-locked state. Bihar lies mid-way between the humid West Bengal in the east and the sub-humid Uttar Pradesh in the west which provides it with a transitional position in respect of climate, economy and culture. It is bounded by Nepal in the north and by Jharkhand in the south. Bihar plain is divided into two unequal halves (North Bihar and South Bihar) by the river Ganga which flows through the middle from west to east. Bihar's land has average elevation above sea level is 173 feet.

The Gandak River: The Gandak River, a major tributary on the north bank of the Ganga, is referred by the name Kali Gandaki or Narayani in Nepal, after its confluence with another river the Trisuli. The Gandaki River is mentioned in the ancient Sanskrit epic Mahabharata. The river rises at a height of about 7600 m in Tibet, north of Nepal-Tibetan border in Nepal's Mustang District. The course of this river then proceeds southwards through a steep gorge known as Kali Gandaki Gorge. This is the world's deepest gorge that passes between the Dhaulagiri and Annapurna Massifs at a height between 1300 and 2600 m. Geologically, the Gandak River is much older than the Himalayan Mountains from where it presently descends. It has a total catchment area of 46,300 sq km and the total length of the Gandak River is 630 km out of which 330 km flows in Nepal and Tibet.

Fig. 1: River Gandak

2. OBJECTIVES

The present survey aimed to test the concept of multi-species survey in rivers of India involving researchers/conservationists working for all river fauna, including the critically endangered gharials, highly endangered Gangetic dolphins, and other threatened aquatic wildlife e.g. smooth-coated otters, freshwater turtles and water birds under one umbrella. The main focus of the Gandak River survey was fixed to examine the status of gharial population reported to be surviving in Gandak River in Bihar that had never been assessed to date because of innate logistic and other difficulties associated with this survey.

The aims and objectives of the Gandak River survey included:

1. Survey of Gandak River from Indo-Nepal border at Valmikinagar in West Champaran district to its confluence into River Ganga at

Hazipur/Sonepur near Patna for occurrence of gharial, based on actual sightings and indirect evidences such as basking spoors as well as verifiable reports through interviews with fishing and local communities.

2. Survey for identifying the habitat availability for gharial with regard to stream and riparian parameters.
3. Assessment of anthropogenic activities in gharial habitat i.e. intensity of fishing and nets/gears used for fishing, agro-practices along river banks, sand mining, riverside habitations, navigation (ferry crossings), abstraction of water from the river for irrigation etc.
4. Assessment of river water quality i.e. analysis of important physical and chemical water parameters.
5. Objective assessment of the potential and need for conservation of gharial in the Gandak River, and to develop a strategy and phased plan for gharial conservation in the Gandak.
6. Documentation of other river biodiversity including river dolphins, otters, muggers, turtles, fishes, water and floodplain birds, riparian vegetation and phytoplankton mainly represented by algae, based on direct encounters, indirect evidences and verbal reports of local people.
7. Conduct opportunistic conservation awareness activity by interacting with the local people during night halt of the survey days, and by distributing handbills and pamphlets among them.
8. Preparation of a preliminary report on status, distribution and conservation prospects of Gharial in the River Gandak in Bihar, India for future conservation actions
9. Submission of papers based on the results of the survey in peer-reviewed journals for publication.

3. SURVEY AREA

River Gandak is one of the main north-south flowing tributaries of the Ganga. It originates in the Himalaya in Nepal and descends southward on the Ganges river basin, and has a drainage area of 7620 km² in India. It flows through the states of Bihar and Uttar Pradesh for a distance of 335 km until it joins the Ganga at Patna. At the India-Nepal border, the rivers

Pachnad and Sonha meet the Gandak at the Triveni confluence, where a barrage has been constructed at Valmikinagar, and is a large irrigation and power project. The depth profile of the river stretch within India owing to the flow regulation by the Gandak (Triveni) barrage project, is fairly shallow and ranges between 0.8 to about 7 m, with occasional deep pools about 12 m deep, in the low-flow season. The Gandak River also has a series of flood-control embankments. It is a largely sinuous river (sinuosity index 1.0-1.93), with frequent transitions between braided and meandering channels (Sinha, 1998). It has moved 80 km eastwards over the last 5000 years, and annual movements continue to occur. This river has the highest discharge of the antecedent rivers in the northern plains, and is one of the most flood-prone rivers in the alluvial mega fans of northern Bihar (Jain & Sinha, 2004). Sandstones and alluvial soils make up the dominant substrate types. Industrial activity in this region is low, and flood plain agriculture, despite the high human population densities living along the floodplain, is not excessively high in the upper stretches. Large tracts of alluvial grassland and scrub forest still persist along the banks of the Gandak. Fishing activity is common and widespread across the riverine tracts. The important towns are Valmikinagar, Bagha, Bettiah, Harinagar and Hajipur (Patna). The length of dry-season (low flow period) is about 6 months, from November to May.

Table 1. Morphology of River Gandak in Bihar (January, 2010)

	Zone I (0-47 km)	Zone II (48-133 km)	Zone III (134-332 km)
Mean depth (ft)	5.62	8.42	11.43
Depth range (ft)	3.7 - 15	2.9 - 27	2.4 - 48
Mean river width (m)	278	217	339
Width range (m)	130 – 931	50 – 540	92 – 1117
Channel type(s)	%	%	%
Mid- channel island	14.9	24.06	69.28
Narrow meandering	12.8	19.5	2.61
Narrow straight	12.8	15.03	2.61
Wide meandering	25.5	21.8	11.76
Wide straight	34	18.8	11.11
Braided	0	0	1.96
Confluence	0	0.8	0.65

Gandak is a mountain-fed river evolving from Himalaya. It forms very large alluvial fan (mega fan) systems in the plains of North Bihar. Being mountain-fed river, it is high discharge, essentially bed-load river with a braided morphology throughout its course. Gandak brings down a large amount of sediment as bed-load as well as suspended load due to exceptionally high relief and extensive erosion of its Himalayan source

Fig. 2: NASA SAT Imagery of River Gandak: Bihar is bisected by the River Ganga. River Gandak joins River Ganga from the north.

areas, and very high rainfall in some parts of its catchments. The floodplains of Gandak are affected by frequent channel migration through avulsion and cut offs (Mahindra & Parkash, 1994; Sinha & Friend, 1994). A part of this load is deposited in the plains and the rest is carried to the Bay of Bengal via River Ganga due to very high discharge of the river. The major deposition in the plains is through settling of the suspended sediments during overbank flooding, almost every year.

Fig. 3: SAT Imagery of River Gandak. Source: Center of Regional Studies, T.M.Bhagalpur University

Fine-grained sediments consisting of significant percentage of detrital clays and variable carbonate content are present in the plains and are distinctly derived from the Himalaya. Channel margin sequences are represented by frequent sand-mud alterations or a dominantly sandy horizon on otherwise muddy matrix. Overbank sequences are predominantly muddy. The soil of Gangetic alluvium, in general, ranges from clayey to sandy loam in texture with pH ranging from 6.5 – 7.5.

The climate is generally tropical monsoonic with three distinct seasons i.e. summer (March – mid June), monsoon (mid June – mid October) and winter (mid October – February).

The floodplain landscape of river Gandak comprises a mosaic of cultivation, human habitation and natural vegetation that has been heavily used by people. The natural vegetation includes grasslands, secondary scrub, old fields and forests. The forest type is Tropical moist deciduous and Tropical semi-evergreen forests. Grasslands include xeric, mesic and hydric types varying greatly in structure and composition. Grassland communities include mainly the species of the families viz. Poaceae, Asteraceae and Fabaceae. We documented several species of grasses dominating the floodplains, mainly *Saccharum spontaneum*, *Bothriochloa* sp., *Chrysopogon* sp., *Cynodon* sp., *Dichanthium* sp., *Eragrostris* sp., *Paspalum* sp., *Desmostachya* sp. and *Hemarthria* sp. Other grassland communities included the population of *Desmodium trifolium*, *Gomphrena globosa*, *Boerhaavia diffusa*, *Euphorbia hirta*, *Alternanthera* sp., *Cyperus globosus*, *Eclipta prostrata*, *Phyllanthus* sp., *Oldenlandia* sp. *Lippia nodiflora*, *Gnaphalium pulvinatum*, *Centella repens*, *Ipomoea fistulosa* and *Polycarpon* sp. Some of these are palatable herbs (forbs).

4. METHODS

- I. A 10 m wooden rowing boat with a capacity of 17 persons (survey team +crew) was used for the survey. An actual length of 332 km of the Gandak River was surveyed from the barrage point (hydroelectric project) at Valmikinagar near the Indo-Nepal border to its confluence with the Ganga River at Sonapur/Hazipur over a period of 16 days from 6-01-2010 to 23-01-2010. An average of 22.6 km of the river was covered each day with the rowing boat(s). The river stretch was divided into equal-length rectangular sampling units of 1 km each (n=332 km), for recording presence/absence of gharials, muggers, dolphins, otters, turtles and birds. Wherever possible, zigzag line transects (Dawson et al., 2008) were undertaken. A major constraint in carrying out zigzag design based survey throughout the stretch was the highly compromised river flows and shallow depths.
- II. The apparatus and equipments used for the survey included: a fish finder for recording stream depth, GPS (Garmin Etrek) for recording coordinates of all significant survey events, binoculars 7x50; 8x80; 10x30 (image stabilizing), cameras/handy cams for photo/video-documentation, and the Nikon Laser Range finder.
- III. The survey team recorded the following for every kilometer transect of the river: Transect speed, Stream (channel) types: mid-channel island, narrow meandering, narrow straight, wide meandering, wide straight, braided, confluence; Stream depth, Stream width, River bank substrate: boulders/mud/sand, Riparian vegetation, Riparian community activities and Fishing activity.
- IV. **The presence of gharials, muggers, and otters** was visually detected by several observers. The GPS coordinates of sighting locations or locations of indirect evidences of otters, gharials and muggers, wherever encountered, were recorded with a hand held GPS unit.
- V. **Dolphin count:** Three trained observers surveyed each stretch for river dolphin surfacing. Sampling was undertaken in excellent sighting conditions. Observers recorded number of dolphins and estimated distance and angle of each dolphin encounter from the boat's GPS location at the time of survey, with a range finder and compass. Dolphin age-classes (calf, sub-adult, adult) were also estimated and recorded. Care was taken to avoid double counting of dolphins by maintaining close communication among the observers, and also by

recording simultaneous resurfacings of more than one dolphin, and by correcting time interval between resurfacing of a single individual by adjusting the time taken by the boat to cover the distance.

- VI. **Fisheries assessment:** During the survey, fish catches of fishermen were examined at certain locations. Identifications were made using Talwar & Jhingran (1991) and Srivastava (1994), again with modifications to nomenclature according to Fishbase (2005). Fishermen were interviewed at locations of fish sampling to determine what types of gears were used to catch fish species and how many fishermen were involved in fishing. During the interview, the names of fishermen and the boats they operated from were recorded to count the total number of fishermen and boats operating in the area.
- VII. **Listing of Birds & other wildlife:** During the survey, a separate observer searched for water and floodplain birds, and for terrestrial and other aquatic wildlife using the naked eye and binoculars. Birds identifications were made using Ali (1979), Ali & Ripley (1978-1980), Sonobe & Usui (1993) and Grimmet et al. (1999).
- VIII. **Listing of phytoplankton (Algal taxa):** The locations of phytoplankton sampling stations were marked using a Garmin 12-channel GPS. Water samples containing natural population of algae were collected in glass bottles from the surface by using plankton net (45 mm pore size). 125 ml of the samples were preserved with 5 ml of 4% formaldehyde in the field for microscopic examination. The collections were deposited in the Environmental Biology Research Laboratory of T.M. Bhagalpur University, Bhagalpur. Camera Lucida drawings were made under appropriate magnification. Identifications were made following West and West (1907), Desikachary (1959), Randhawa (1959), Philipose (1967), Prescott (1969), Cramer (1984) and Sarode and Kamat (1984).
- IX. **River water variables:** The river water quality parameters analyzed included: Ambient & Water temperature, pH, Conductivity, Turbidity, Total Dissolved Solids, Turbidity, Dissolved Oxygen, Free- Carbon dioxide, Carbonate & Bicarbonate Alkalinity, Chloride, Total Hardness, Phosphate-phosphorus, Nitrate-nitrogen & Chemical Oxygen Demand (Few Sites) following Standard Methods (APHA, 1998).

5. River Water Quality

The ambient and water temperature showed a close proximity relation. Maximum ambient temperature (18°C) was recorded at Sohgi-Barwa Ghat while the minimum (9°C) was recorded at Rewa Ghat. The water temperature fluctuated between 13.2°C – 17.2°C.

The turbidity was measured in NTU (Nepheloturbidity unit). Minimum turbidity (6 NTU) was recorded at Bagha- I while the maximum (43.5 NTU) at Konhara Ghat, Hazipur. The turbidity value was 35.5 NTU at the Confluence point. Gandak River carry high amount of silt and this apparently accounts for the higher turbidity value of the river.

Total dissolved solids ranged from 152.4 – 356 mg/l or ppm. Lower values were recorded at Bagha- I while the higher value was recorded at Susta Ghat. TDS value at the Confluence point was 169 ppm.

Conductivity of water depends upon the concentration of ion and nutritional status of the water body. It ranged from 246.3 – 578.9 ppm. Maximum value was recorded at Susta Ghat and the minimum at Chhitauni Bridge. At the Confluence point, the value was 273.9 ppm.

pH of River water ranged from 7 – 8 i.e. from neutral to slightly alkaline.

Dissolved oxygen content is an indicator of healthy aquatic systems. DO level was minimum at Valmikinagar Ghat (6.5 ppm) and the maximum was recorded at Raj bariya Ghat (10.8 ppm), while at the Confluence point, it was 10.6 ppm.

Free- carbon dioxide concentration was minimum (42 ppm) at Triveni Ghat and maximum (112 ppm) at Valmikinagar Ghat. At the Confluence point, the F-CO₂ value was 50 ppm.

Carbonate alkalinity was found absent at all the investigated sites.

Bicarbonate alkalinity was recorded at all the sites. It ranged from 34 – 106 ppm. All the sites, more or less, showed the same range of bicarbonate alkalinity.

Total hardness values ranged from 134 – 180 ppm. The minimum value was recorded at Valmikinagar and maximum at Kalyanpur Ghat. At the Confluence point, the value was 150 ppm. Its range of variation was not significant from the chemical pollution point of view.

Chloride is one of the important indicators of water pollution. The chloride values were lower ranging from 3.99 – 10.99 ppm.

Phosphate-phosphorus and Nitrate-nitrogen values were very low in concentration. Phosphate-phosphorus values ranged from 0.033 – 0.05 ppm and nitrate-nitrogen values from 0.027 – 0.031 ppm.

Chemical Oxygen Demand (COD) was higher at Rewa Ghat (25 ppm) and at Konhara Ghat (34 ppm) i.e. towards lower reaches of the river (downstream) and close to the confluence point. A higher value of COD indicated the presence of higher amount of algal biomass and organic

matter. The lower reaches of the river support the human settlement on the bank of the river, potential source for disposal of domestic sewage and other wastes into the river and thus accounts for higher COD values possibly.

On the basis of the present investigations of the river water quality variables at 21 sampling stations distributed over 332 km length of the river, the Gandak River can be termed as free from pollution. None of the water parameters analyzed was found beyond the permissible limit as prescribed by Indian Standards. Along the entire river course, the DO is maintained at a level above 6.8 ppm. Even near urban centers downstream (Kalyanpur Ghat and Konhara Ghat), DO value does not drop significantly. COD values analyzed at two sampling stations in the initial part of the river (Valmikinagar and Susta Ghat) were 3 ppm and 5 ppm respectively whereas in the last part before confluence (Rewa Ghat at 284 km downstream and Konhara Ghat at 328 km downstream) were 25 ppm and 34 ppm respectively. At the confluence point further downstream, COD dropped to 15 ppm. That means, the river water quality is somewhat degraded in last 48 km stretch of the river compared to upland stretch. pH values indicated the river water as neutral to moderately alkaline. The variations in conductivity, total dissolved solids, total hardness, chloride, phosphate and nitrate were not significant in the

Table 2. Physico-chemical characteristics of water variables at 21 locations of River Gandak in Bihar (January, 2010)

S.N.	Location	Coordinates	Distance (km)	Ambient temp. (°C)	Water temp.(°C)	Turbidity (NTU)	TDS (ppm)	Conduvtivity (ppm)	pH	DO (pp m)	FCO2 (ppm)	CO3 ⁻ (ppm)	HCO3 ⁻ (ppm)	TH (ppm)	Cl ⁻ (ppm)	PO4 - P (ppm)	NO3 (ppm)	COD (ppm)
1	Triveni	27 26 362 83 55 263	Upstream	15	14.5	10.9	158.7	258.2	7.5	8.4	42	Absent	34	166	6.99	0.036	0.031	-
2	Valmikinagar Ghat	27 26 193 83 54 428	0	15	16	12.2	154.8	249.2	7.5	6.8	112	Absent	36	134	6.99	0.038	0.031	3
3	Susta Ghat	27 21 310 83 51 332	13	15	17	12.8	356.9	578.9	7.5	9.2	120	Absent	106	170	3.99	0.036	0.03	5
4	Sohagi Barwa Ghat	27 15 434 83 50 834	27	18	16	12.8	155.4	250.6	7.0	10.4	90	Absent	46	156	5.99	0.034	0.027	-
5	Chitaoni Bridge	27 11 024 83 58 079	46	10.5	15.5	10.2	152.5	246.3	7.5	9.6	60	Absent	40	150	6.99	0.035	0.025	-
6	Bagha 1	27 05 363 84 05 512	67	13.5	16	6	152.4	246.5	7.5	7.6	50	Absent	46	170	6.99	0.035	0.027	-
7	Raatwaol Ghat	26 58 738 84 10 721	90	13	14.5	9.1	154.9	250.7	7.5	9.6	120	Absent	40	168	6.99	0.035	0.027	-
8	Laydiarwa Ghat	26 53 693 84 12 523	95	13	14.5	9.3	153.9	249.4	7.5	8.8	90	Absent	40	160	6.99	0.033	0.027	-
9	Srinagar Ghat	26 50 430 84 20 009	124	12	14	7.2	161.3	259.5	7.5	10	100	Absent	44	140	6.99	0.035	0.025	-
10	Singhi-Pipra	26 44 510 84 23 603	140	14	14.5	8.4	162.4	262.4	7.0	10	70	Absent	44	146	6.99	0.034	0.027	-
11	Raajbariya Ghat	26 33 523 84 27 014	165	11.5	13.5	7.2	165.4	268.1	8.0	10.8	90	Absent	42	150	6.99	0.04	0.027	-
12	Baterde Ghat	26 25 604 84 36 427	192	13.8	14.7	8	164.7	268.5	7.5	10.4	92	Absent	44	146	5.99	0.041	0.026	-
13	Dumaria Ghat	26 24 532 84 44 285	213	12	14	8.7	164.4	271.4	8.0	10	150	Absent	48	160	8.99	0.045	0.027	-
14	Sattar Ghat	26 08 648 84 49 433	231	10	14	8.6	172.4	278.7	7.0	9.6	70	Absent	48	150	8.99	0.038	0.028	-
15	Hosepur	26 10 478 84 53 822	255	14	13.5	9.7	169.5	273.6	7.5	9.2	90	Absent	54	160	8.99	0.041	0.025	-
16	Singhgahi	26 06 980 84 56 444	264	10.6	14.5	8.1	176.9	284.4	7.0	9.2	60	Absent	44	146	5.99	0.036	0.028	-
17	Dhaala	25 59 435 85 02 309	284	9	13.5	6.9	163.7	284	7.0	8.8	66	Absent	48	152	6.99	0.038	0.03	25
18	Rewa Ghat	25 50 583 85 09 601	308	10	13.2	7.5	171.6	277	7.5	10.6	70	Absent	46	156	10.99	0.05	0.027	-
19	Jahanabad Ghat	25 43 924 85 10 845	321	17.5	14.2	32.3	169.3	274	7.5	8.8	60	Absent	46	180	8.99	0.039	0.027	-
20	Kalyanpur Ghat	25 40 839 85 11 746	328	15.5	17.2	43.5	171.9	278.3	7.5	8.8	60	Absent	46	170	9.99	0.04	0.029	34
21	Gandak & Ganga confluence	25 39 935 85 10 643	332	11	12.5	35.5	169	273.9	7.0	10.6	50	Absent	48	150	11.99	0.037	0.027	15

river stretch investigated. More or less similar trend of hardness and alkalinity at all the 21 sampling stations show that the river water is saturated in carbonate content. Hardness values suggest the river water as moderately hard. The clarity of the river is seen to be higher in the major part of the river stretch (308 km river segment downstream from Barrage point), the turbidity values ranging from 6 – 12.8 NTU only. The turbidity values increased appreciably in 23 km river segment near confluence point (35.5 – 43.5 NTU) i.e. the clarity of the river is affected adversely. The clarity in major stretches of the river shows that the river has high aesthetic appearance and greater photosynthetic activity (Bhargava, 1985).

From the consideration of the water quality parameters investigated, the Gandak water can be considered as suitable for aquatic wildlife, and also for all beneficial uses.

6.1 Survey for Gharial

Gharial (*Gavialis gangeticus*), the only surviving member of its crocodylian family, is an endemic, critically endangered species of South Asian rivers. Recent assessments confirm the continued survival of only 5 breeding population of this species globally of which, only one population in the Chambal River, with about 100 breeding females is comparatively robust in both numbers as well as distribution while all other populations are relict and seriously threatened on one or both the above counts.

The Gandak River in Bihar in north India was the only river within the Gharial's range that had never been assessed to date because of innate logistic and other difficulties associated with this survey. The Species Recovery Plan (SRP) for gharial, presently being formulated, envisages integrated conservation of a network of river ecosystems and their faunal assemblage with gharial as the apex predator. The survey of the Gandak River was conducted to examine the possible existence, status and conservation viability of a reported population of gharial in the Gandak River in Bihar, to supplement other known populations of the species, in keeping with the goals of the SRP and to fill a major gap in the requirements of the SRP.

This survey also aimed for capacity building of wildlife managers and conservationists in Bihar, a major range state of gharials, for conservation of the critically endangered species, through collaboration in the survey.

A total of 5 gharials were observed at 4 locations and indirect evidence (recent spoor), confirming the occurrence of 4-5 individuals, was observed at one more location. The details of direct sightings of gharial and recent spoor of gharial are given in the Table 2.

Gharials were also reported from several additional locations by members of fishermen or riparian communities. Almost everywhere along the river, especially in the segment flowing upstream of the southern limits of the East and West Champaran Districts, people consistently reported observing gharial especially during the months (August-October), when the river remains in spate due to the monsoons. The interview with local people/fishermen at Ratwal Ghat (90 km downstream from Barrage point) revealed that a female gharial had laid 50 eggs approx. last year i.e. 2009 on the left bank of the river with no successful hatching as the local people consumed the eggs. The occurrence of gharial was also reported from the Harha tributary along with muggers. The occurrence of the latter in this stream could be confirmed by their spoors but the occurrence of gharials requires substantiation, as the habitat available in the stream was not typical for this species and it seems more probable that migratory gharial are seen as well in the stream during the monsoon period.

Table 3. Sightings of Gharial in River Gandak in Bihar (January, 2010)

S.No.	Date/ time	Location of sighting/ indirect evidence	GPS coordinates	Description of animals seen/estimated to occur			Comments
				Sex	Size/ maturity	Number	
1	07.01.2010; 1112 hr	Valmiki TR/ Sohgi Barwa WLS	27 19' 11.4" N 83 50' 29.2"E	F	Adult- 3m+	1	19 km downstream from Barrage point
2	07.01.2010 1326 hr	Sohgi Barwa WLS	27 19.310' N 83 50.581'E	F	Adult- 3m+	1	25 km downstream from Barrage point on edge of mid-channel island
				M	Adult- 5m+	1	
3	08.01.2010 1648 hr	Bagha I	27 06 25.7" N 84 04 54.3"E	F	Adult- 3m+	1	63 km downstream from Barrage point, was observed swimming/drifted downstream with current and adjudged to be non-resident at this location
4	14.01.2010 1440 hr	Between Rajwahi and Sakma Ghats	26 31 31.0"N 84 29 24.9"E	F	Adult- 3m+	1	172 km downstream from Barrage point
5	18.01.2010	Dumariya to Sattar Ghat	26 20 20.7"N 84 46 31.4"E	–	Adults as well as sub-adults	4-5	Between 213 – 230 km downstream from Barrage point, only basking spoors were recorded and

							photographed; total number of discrete spoors observed were greater than 20 which were adjudged to belong to at least 4-5 individuals
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F = Female; M= Male

A supplementary survey (supported by the GCA/MCBT) for gharials was conducted between March 16 to April 1, 2010 in a 19 km river segment, 3km upstream and 16 km downstream of Dumariyaganj Road Bridge, the location where we had recorded a number of spoors in the January, 2010 survey.

Table 4. Sightings of Gharial in River Gandak in a Supplementary Survey (March 16 – April 1, 2010)

S.No	Location	Description of animals
1	Pakaha Fadlepur (ca. 16 km downstream of Dumariyaganj Road Bridge)	1 adult
2	Majhariya Karan (ca. 10 km downstream of Dumariyaganj Road Bridge)	2 large sub adults (2.5 – 3.0 m); 2 adults (3.0 – 3.5 m)
3	Maharani-Gogra (ca. 3 km upstream of Road Bridge)	1 adult (A considerable number of spoors had been recorded at this site during the January survey on 18-01-2010).

This makes 07, the total number of sites where gharials were detected in the Gandak during this survey and the number of animals located less than <15.

DISCUSSION ON STATUS, DISTRIBUTION AND CONSERVATION PROSPECTS OF GHARIAL IN THE GANDAK RIVER

The Gandak is a snow fed northern tributary of the Ganges System similar in physiography but much smaller in length and width and with far fewer sub-tributaries of its own than another northern tributary, the Ghaghra. As in the Ghaghra River, there are resident breeding populations of gharial in the upper reaches of the Gandak, which is separated from the major downstream segment of the river by a barrage. An unspecified

population of gharials, including adults, still resides in this segment of the river, which is rather remarkable for habitats not protected under the Wildlife (Protection) Act 1972. It is difficult to say without further study if the surviving animals belong to a relict population or one which has been formed through the congregation of isolated dispersing individuals subsequently becoming residents of a particular area. Although one population, comprising an adult male and a seemingly compatible adult female, was originally assessed as a functional breeding group and another was reliably reported to have bred in the breeding season of March – June, 2009. On final reconsideration, the assessment of their breeding status remains inconclusive. Although these populations seem to have managed to escape extirpation, the exact factors enabling their survival outside a protected area are not exactly clear. Possibly, the past acute law and order problem of these comparatively remote areas prevented intensive fishing with gear inimical to gharial.

Status

Distribution: The gharials (isolated individuals; non-breeding pairs/groups; the remote likelihood of breeding pairs/groups) surviving in the Gandak are restricted to the West Champaran and the border of East Champaran and Gopalganj districts.

Abundance/density: The gharials of Gandak River (in India) are rare and highly threatened with almost no possibility of the survival of even a single functional breeding population. The population in the Gandak therefore, is one that seems to be undergoing extirpation and consists of only a few surviving individuals of this long lived species.

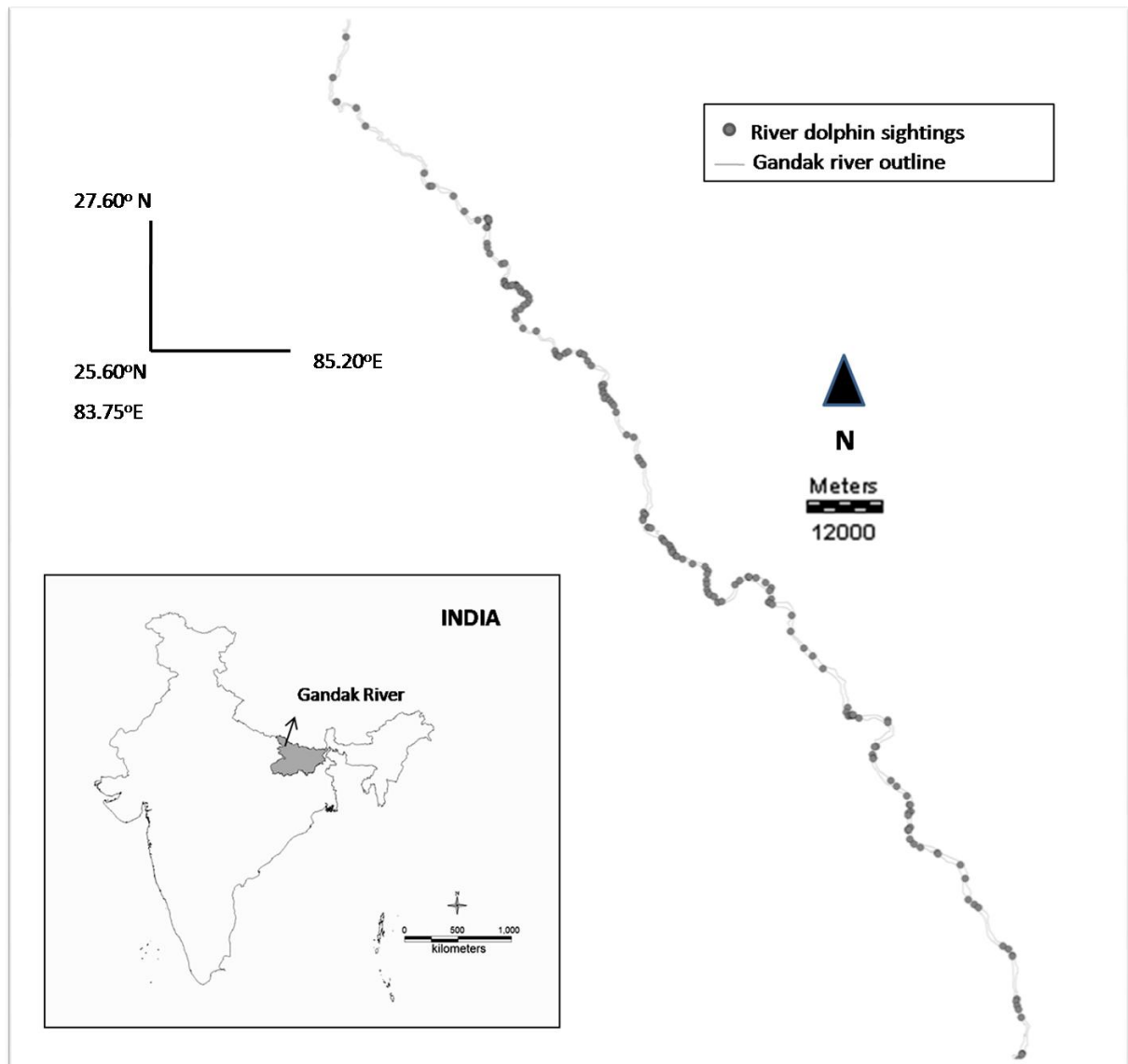
Conservation prospects: The survival of relict gharial populations in the Gandak River in Bihar, suggests a remote possibility that habitat factors may be more favorable for assisted *in-situ* recovery of the species here than in many other unprotected river segments of the gharial's historic distribution and range. The main factor favoring their survival in the Gandak seems to be the substantial stretches of rivers without human habitation on the river banks that are dominated by extensive tracts of natural grasslands. However, the dynamics and intensity of threats operating on gharial and its habitat need further study to be conclusively determined. The Gandak in Bihar also serves as a sink for the efflux of dispersing animals from gharial conservation areas in the Narayani/Rapti Rivers in the Chitwan National Park in Nepal, considerably enhancing the advantages of the gharial conservation scenario.

6.2 Survey for Gangetic Dolphin

Dolphin presence was recorded at 39.7 % of the total number of segments (n=332). A total best count of 257 (range 250-267) and individual encounter-rate was 0.75 (SD 0.89) per km. Non-zero encounter rate for

dolphins was 1.42 (SD 0.77) per km. Dolphin counts per segment were positively influenced by river channel depth. Presence of meanders and gillnet fishing was significantly related to dolphin habitat use. Presence of mid-channel islands, always associated with reduced river flows and channel depth, negatively influenced dolphin abundance. Dolphin encounter-rates increased with distance from barrage from 52 (0-100 km), to 113 (100-200 km) and 92 (200-332 km).

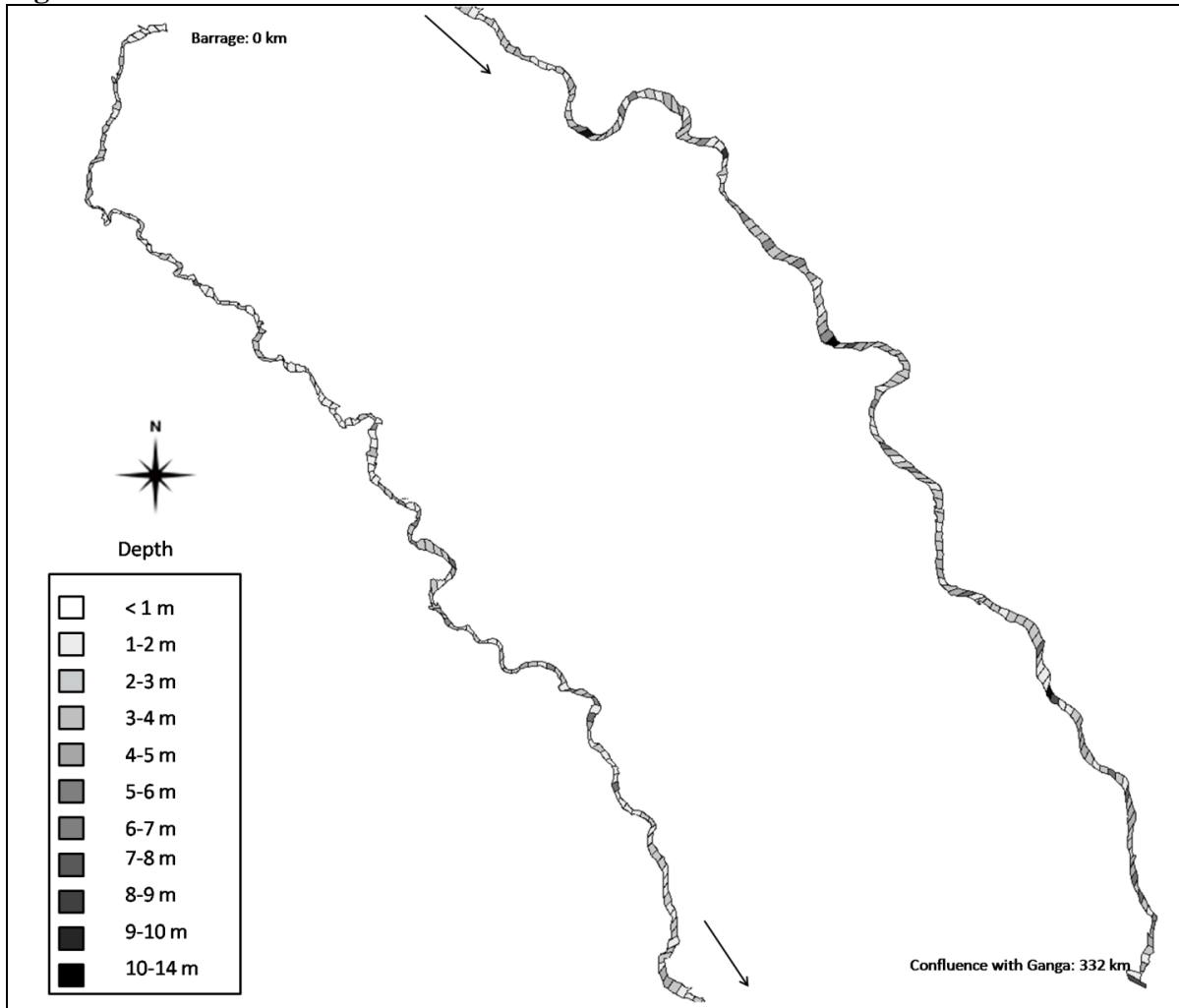
Fig. 4



The first dolphin sighting (an adult) was after 10 km from the barrage. Adult-calf pairs were observed after 57 km from the barrage. Adult dolphins seemed to avoid areas with depth below 5.245 m. Many dolphins (about 60%) occurred in depths between 1.4 to 2.5 m, particularly when meanders were present. However, a minimum threshold depth of 3.77 m

was estimated for sub-adult presence in a segment, and sub-adults also preferred depths of over 5 m. Adult-calf pairs were found mainly in shallow

Fig. 5



areas with depth range at 2.18 – 2.38 m, often close to mid-channel islands. Adult – calf pairs were less frequent (~20%) in deeper segments (>4m) without mid-channel islands. Dolphins preferred narrow and deep channels (scoured sections) over shallow, wide areas (Choudhary et al., 2006; Kelkar et al., 2010). Overall land-use reflected considerably lower extent of agriculture and hard large tracts of alluvial scrub forest and grassland, but bank land-use did not influence dolphin abundance.

Table 5. Summary of dolphin sightings in River Gandak, Bihar (January, 2010)

River dolphin distribution in the Gandak showed patchiness of distribution

	Zone 1	Zone 2	Zone 3	Total
Total survey distance (km)	47	133	152	332
Dolphins	17	131	119	267
Adult	12	47	51	110
Sub-adult	2	59	50	111
Calf	0	20	8	28
Unclassified	2	5	10	17
Range	1-2	1-5	1-5	
Mean group size	1.14	1.31	1.38	
Encounter rate/km	0.34	0.98	0.77	
SD	0.34	0.4	0.5	
CV	29.82 %	30.53 %	35.71%	

at small spatial scales and positive relationships with water depth and pool habitats, with low water velocity. The survey result forms an important baseline for future monitoring in this region, and provides updated estimates of minimum abundance (previously < 150) (WWF Nepal, 2006). Surveys of river dolphins from the biophysically similar, flow-regulated Kosi River (Sinha & Sharma, 2003), and the highly regulated Indus River (Braulik, 2006) also reported highest dolphin abundance in the middle to lower reaches, and overall abundance increased with distance from barrage, possibly due to downstream migration (Braulik, 2006).

6.3 Survey for Other Wildlife

6.3.1 Smooth-coated Otter: We did not have any first-hand sighting record of Smooth-coated otter (*Lutrogale perspicillata*) during this survey, But we located single active den of otter (26° 31' 721"N 84° 29' 284"E) at the right bank of the river, 172 km downstream from the barrage and 6 km downstream from Rajwahi Ghat. The river channel was wide meandering at this location. Local people also informed us that they have often seen these animals active during monsoon period.

6.3.2 Mugger: Mugger/Mugger spoors were observed at 5 locations whose details are given in the Table - 6. One of these locations was a disjointed wetland habitat within Valmiki Tiger Reserve with no connection to the Gandak River while a second was a tributary of the Gandak River. The mugger/mugger spoors were sighted only

towards right bank of Gandak (Sohgi-Barwa Wildlife Sanctuary side), and that also up to 70 km downstream from the barrage point.

Table 6. Sighting of Mugger/Mugger spoors during survey of River Gandak in Bihar (January, 2010)

S. N.	Date/Time	GPS Coordinates	Description of the animal	Remarks
1	05.01.2010 1400 hr	NR	Mugger spoors	3 km from Madanpur Forest Rest House, in between Belahuwa & Amhat villages, there is a perennial wetland habitat and the water supply to the wetland is from the adjacent Gandak canal. The wetland appears to be the ideal habitat for muggers. Locals reported that a large number of muggers are seen in this wetland during monsoon period. We could detect only some fresh spoors.
2	06.01.2010 1105 hr	27° 19' 965" 85° 50' 503"	Adult Mugger-1	basking on the lower edge of the right bank (erosional side) of the river, 17.9 km downstream from barrage, lines of forest trees on the right bank.
3	06.01.2010 1323 hr	27° 17' 128" 83° 49' 670"	Adult Mugger-1	basking on right bank of the river, 24 km downstream from barrage.
4	06.01.2010 1344 hr	27° 16' 514" 83° 49' 645"	Active mugger dens-2/3	Mugger dens found on the right bank of the river, 26.5 km downstream from barrage, Fish finder indicated lots of fish at this spot.

5	09.01.2010 1430 hr	27° 08' 453" 84° 05' 124"	Mugger spoons	fresh mugger spoors on the north bank of River Harha – a tributary of Gandak, originating from foothills upstream and meeting into Gandak at Rajbatia. Perennial, we found deep pool downstream to Gainti village; locals reported that muggers are seen at this point regularly, we found water almost blackish and stagnant at this point.
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NR = Not Recorded

6.3.3 Turtle: Turtles were conspicuous by their absence and were observed only on a few occasions. Similarly spoors of basking turtles were rarely observed. The details of a few instances when turtles were encountered are given in the Table -7.

Table 7. Sighting of Turtles and spoors of basking Turtles during the survey of River Gandak in Bihar (January, 2010)

S. No.	Date/Time	GPS coordinates	Description of animals	Sighting location/ Remarks
1	07.01.2010 1107 hr	27° 19' 767"N 83° 50' 520"E	Hard shelled Turtle - 3	17 km downstream from barrage & 3 km downstream from Susta Ghat, basking on mid-channel island
2	11.01.2010 1347hr	26° 54' 103"N 84° 11' 878"E	Fresh claw marks	105 km downstream from barrage & 14 km downstream from Ratwal Ghat, on mid-channel island
3	12.01.2010 1241 hr	26° 49' 127"N 84° 22' 141"E	Fresh claw marks	124 km downstream from barrage & 5 km downstream from Baisia Bazaar Ghat, on mid-channel island
4	12.01.2010 1317 hr	26° 47' 939"N 84° 22' 108"E	Fresh claw marks	132 km downstream from barrage & 8 km downstream from Baisia Bazaar Ghat, on mid-channel island

5	12.01.2010 1510 hr	26° 43' 120"N 84° 24' 174"E	Hard shelled Turtle	143 km downstream from barrage & 19 km downstream from Baisia Bazaar Ghat, basking on mid-channel island
6	14.01.2010 1419 hr	26° 31' 721"N 84° 29' 284"E	Fresh claw marks	172 km downstream from barrage & 6 km downstream from Rajwahi Ghat, on mid- channel island
7	16.01.2010 1122 hr	26° 27' 956"N 84° 34' 488"E	Carcass of dead soft shell Turtle	185 km downstream from barrage & 5 km downstream from Sakmahi Tola Ghat, on mid-channel island
8	17.01.2010 1452 hr	26° 20' 770"N 84° 45' 099"E	Very large claw mark	222 km downstream from barrage & 9 km downstream from Dumaria Ghat, on mid- channel island
9	17.01.2010 1510 hr	26° 20' 349"N 84° 46' 529"E	Very large claw mark	223 km downstream from barrage & 10 km downstream from Dumaria Ghat, on mid- channel island

6.3.4 Floodplain Terrestrial Wildlife: The river survey was conducted everyday from 10 A.M. to 4 P.M. Hence, there was ample time (after the completion of the primary survey) to interact with villagers and for surveying the surrounding grasslands for wildlife. The information regarding the presence of different species of wildlife present in the grasslands was gathered opportunistically from local villagers encountered on the riverside, and from the direct and indirect sightings (of pellets, pugmarks, hoof prints) by the survey team members. Local villagers were asked open-ended questions regarding different species without suggesting the profile of the animals. They were later shown field guides and species identification pamphlets and were asked to identify animals they had recently encountered or seen in the vicinity. The field guide was in English

and villagers (mostly illiterate) could not read them so their information was based on their experience, hence, unbiased. GPS coordinates of the animals, detected by direct as well as indirect sightings, were recorded and marked in the Occupancy Survey datasheet.

On the morning of the 20 January, 2010 at around 8 A.M, a pair of **Indian wolf** (*Canis lupus pallipes*) was seen running in the middle of a patch of wheat cultivation about 15 meters from the camp site (26° 06' 945'' N; 84° 56' 469'' E) at a place called Singhgahi Dhaala, 264 km downstream from the starting point of the survey. This area was semi-isolated and was characterized by patch wheat farming within grassland tract. The nearest human settlement was approximately 2 km and metal road about 3.5 km away from the camp site. One large male was seen leading followed by a smaller female about 10 m behind. They ran across the camp site in a relaxed banter, where 10 members of the survey crew and an equal number of villagers were talking, without arousing much curiosity from the villagers or from the wolves. They ran into the grassland thicket and emerged about 100 m north of the camp site, the male scent-marked on the trunk of a Jamun tree and again went inside the grassland thicket. The pair of wolf was circling a herd of **Nilgai** (*Boselaphus tragocamelus*) cows with calves. The survey team had pitched their tents on the elevated river bank at the edge of the River. The wolves were about 30 m approx. from the river waterline. About 30 Nilgai, comprising bulls, cows and calves were seen grazing in the wheat fields, scattered in a radius of 150 m from the camp site and totally impervious to our presence. Two **Indian Hares or Rufous tailed hares** (*Lepus nigricollis ruficaudatus*) were also seen running across a tractor track in between the grasslands. Previous night, a group of 5 **jackals** (*Canis aureus*) had sneaked into the camp site in search of morsels and started howling and making a ruckus and had to be shooed away. About 50 m from the camp site at the waterline of the river, hoof prints of a small herd of **Wild Boar**

(*Sus Scrofa*) were also seen. Other than Ratwal (91 km downstream, 26° 58' 603'' N; 84° 10' 611'' E) and Sakmahi Tola (180 km downstream, 26° 29' 424'' N; 84° 32' 845'' E) along the Gandak river, Singhgahi Dhaala was the third place where villagers were able to describe the **Hog Deer** (*Axis porcinus*) and confirm its presence in the grassland of the area.

The sighting of Indian Wolf in the wet-grassland habitat of River Gandak floodplains might have two explanations:

1. This new sight record of Indian wolf in the River Gandak floodplains might be the extension of the known eastern distribution range of Indian Wolf from the Chhotanagpur plateau in Jharkhand to include the region north of the River Ganges. The presence of a variety of ungulates, cover, and access to large source of water represents an ideal habitat suitable for the survival of the Indian Wolf (Jhala, 2003). To this, aids the fact that people here seem not to have forgotten the art of coexistence with predators as in other parts of India (Jhala & Sharma, 1997).
2. The Indian wolf *Canis lupus pallipes* and the Tibetan wolf *Canis lupus chanco* are considered sub-species of the gray wolf *Canis lupus*. Recent DNA studies have shown that there is another wolf that is very genetically different from these two sub-species, so much so that researchers are calling it a new species *Canis himalayensis* with population less than 350 and assessed as critically endangered. It reportedly ranges from north-west Jammu through Himachal to eastern Nepal. Our sighting north of the Ganga, south of Nepal could be that of the Himalayan wolf. There is no way to substantiate it. At the best, we can only say that the wolf sighted by us in the River Gandak floodplains might be either *Canis lupus pallipes* or *Canis pallipes himalayensis*.

7. Survey for Fisheries Assessment

During the 15 days survey, fishing was observed through out the stretch of the river beginning right near the barrage up to the confluence of Gandak with Ganga near Patna. Throughout the stretch, 6 types of fishing practices were observed: Gill net fishing, Cast net fishing, Barricade fishing, Hook and line fishing, Scoop net fishing, Basket net fishing and Mosquito net fishing. Out of these six, the most popular fishing technique was the Gill net fishing and the least observed technique, apart from the basket net fishing which is primarily a gear used during the monsoon period, was the Scoop net fishing which was seen being used only at one place. Fishing techniques considered destructive and unsustainable to fisheries such as the mosquito net and barricade fishing were recorded from three and four places respectively.

Fisheries in the Gandak seemed to be dominated by fishermen from the villages and small towns adjacent to the river banks. They all belonged to the districts through which the river flows but some fishermen were from the district of Bhagalpur and they were the only fishermen fishing in the river, far away from their home district.

Maximum fishing was observed between Rajwahi Ghat ($26^{\circ}33' 747''N$ & $84^{\circ} 26' 929''E$) and Dumaria Ghat ($26^{\circ}24'524''N$ & $84^{\circ}44'285''E$) covering a distance of 48 km and between Singhgahi Dhala ($26^{\circ}06'945''N$ & $84^{\circ}56'469''E$) and Sonapur town ($25^{\circ}40'425''N$ & $85^{\circ}11'300''E$) covering a distance of 67 km. The downstream distance of Rajwahi Ghat from the barrage is 166 km and of Singhgahi Dhala 264 km.

During the survey, fishermen were interviewed opportunistically and at random to record their fishing gears and fish catch. They were only interviewed whenever the team had time in hand, as they had to cover fixed distances each day and when the fishing boat/s were within reach of the team, as the shallow nature of the river during the month of January did not allow the survey boat to maneuver within the channel at

will. So in this way, we were able to interview only 15 fishermen, out of which only 6 had their fish catch with them and which was recorded. 5 types of gears were recorded from the fishermen interviewed. 11 fishermen had only monofilament gill nets, 2 had gill nets along with a cast net and the other had a multiple hook and line gear (Hazaria bansi). One fishermen had a hand held scoop net and one had a Basket net. The smallest mesh size recorded for a gill net was 10 mm and the largest was 17 mm size. The maximum number of nets recorded with a fisherman among the 15 was from two fishermen, one from the district of Gopalganj and the other from the district of Vaishali, both had four nets each. From the 6 fishermen who had their catch with them, 33 species of fish belonging to 6 orders and 14 families were identified, out of which 11 species belonged to the Order Cypriniformes, 12 to the Order Siluriformes, 1 from the Order Beloniformes, 6 from the Order Perciformes and one each from Mugiliformes and Synbranchiformes.



Fig. 6 : Fish catch recovered from fisherman at Shastri Nagar Ghat 50 KM downstream from Barrage

Table 8. Listing of Fish species in River Gandak in Bihar (January, 2010)

S.No.	Order	Family	Species
1.	Cypriniformes	Cyprinidae	<i>Labeo Kalbasu</i>
			<i>Labeo bata</i>
			<i>Labeo dero</i>
			<i>Puntius Saphore</i>
			<i>Puntius conchonius</i>
			<i>Barbodes sarana</i>
			<i>Salmostoma bacaila</i>
			<i>Aspidoparia morar</i>
			<i>Chela atpar</i>
		Cobitidae	<i>Botia lohachata</i>
			<i>Lapidocephalus guntea</i>
2.	Siluriformes	Bagridae	<i>Sperata aor</i>
			<i>Sperata seenghala</i>
			<i>Mystus cavasius</i>
			<i>Mystus vittatus</i>
		Siluridae	<i>Ompok pabda</i>
			<i>Wallago attu</i>
		Schilbeidae	<i>Ailia coila</i>
			<i>Clupisoma garua</i>
			<i>Pseudeutropius atherinoides</i>
			<i>Eutropiichthys vacha</i>
		Sisoridae	<i>Gangra viridescens</i>
			<i>Gagata cenia</i>
3.	Beloniformes	Belonidae	<i>Xenentodon cancila</i>
4.	Perciformes	Chandidae	<i>Prambasis ranga</i>
			<i>Chanda nama</i>
		Gobiidae	<i>Glossogobius giuris</i>
			<i>Colisa fasciatus</i>
		Nandidae	<i>Nandus nandus</i>
		Channidae	<i>Channa punctata</i>
5.	Mugiliformes	Mugilidae	<i>Sicamugil cascasia</i>
6.	Synbranchiformes	Mastacembelidae	<i>Macragnathus pancalus</i>
			<i>Mastacembelus armatus</i>

Table 9. List of fishermen with their residential location, area of fishing, and fishing gears used by them, encountered in the survey of River Gandak in Bihar (January, 2010)

S.N.	Fisherman	Village	District	GPS Coordinates	Fishing Location	Nets/Gears used	Mesh size (mm)	L (m)	W (m)	No. of nets/gears	Local name of nets/gears
1.	Hardeo Malla	Narsahi	Paschim Champaran	27° 24' 399"N 83° 51' 698"E	Narsahi – Susta Ghat	Gill nets	-	-	-	2	Sataon, Chauna
2.	Dinesh Rajbhar	Ramnagar	Paschim Champaran	27° 22' 781"N 83° 51' 371"E		Gill nets	-	-	-	2	Chiaun, Angutha
3.	Santhal Sahni	Shastrinagar	Paschim Champaran	27° 09' 739"N 84 00' 948"E	Kanti tola	Hand held lift net	10	-	-	1	Bomaila
4.	Dhrub Sah	Rajbatia	Paschim Champaran	27° 02' 335"N 84° 08' 019"E	Rajbatia - Birta	Cast net	10	-	-	2	Phekawa jal
						Gill net	20	-	-		Currenti jal
5.	Deepak Kr. Sahni	Kagjitola	Bhagalpur	26° 30' 425"N 84° 30' 400"E	Rajwahi – Sakma Ghat	Gill net	100	40	1.5	1	
6.	Chandan Sahni	Kagjitola	Bhagalpur	26° 30' 425"N 84° 30' 400"E	Rajwahi – Sakma Ghat	Gill net	40	200	5	2	Dohni
						Multiple hook liner					Hazaria bansi
7.	Suresh Sahni	Kharatwa	Gopalganj	26° 32' 145"N 84° 29' 005"E	Bhagwanpur – Simrahi Ghat	Gill net	30	125	3	1	Angutha
8.	Pujo Sahni	Kagjitola	Bhagalpur	26° 29' 424"N 84° 32' 845"E	Sakma Ghat	Gill net	55	100	3	2	Araiya
							25	150	4		Chaoubis

9.	Basant Sahni	Dumaria	Gopalganj	26° 22' 900"N 84° 43' 773"E	Salepur - Maharani	Gill nets	170	50	0.5	4	Tiari
							25	50	1.5		Tiari
							15	50	0.5		Tiari
							45	50	0.5		Tiari
10.	Malik Sahni	Chitupaghar	Chhapra	26° 00' 647"N 84° 59' 917"E	Bariarpur	Gill nets	160	25	0.5	2	Sisa jal
							110	25	0.5		Sisa jal
11.	Vijay Sahni	Chitupaghar	Chhapra	26° 00' 647"N 84° 59' 917"E	Bariarpur	Gill nets	160	25	0.5	3	Sisa jal
							150	25	0.5		Sisa jal
							140	15	0.5		Sisa jal
12.	Bhagheo Sahni	Bariarpur	Chhapra	26° 00' 321"N 85° 00' 666"E	Bariarpur	Gill net	45	75	4	1	Dohni
13.	Viswanath Sahni	Baligaon	Chhapra	25° 55' 355"N 85° 04' 915"E	Baligaon	Gill net	12	100	1.5	1	Chaati
14.	Birbal Sahni	Jahanabad	Vaishali	25° 50' 338"N 85° 09' 727"E	Jahanabad	Basket trap nets	2	1	-	2	Ghana
15.	Mohan Sahni	Jahanabad	Vaishali	25° 50' 338"N 85° 09' 727"E	Balha – Khanjha chowk	Gill nets	67	30	1.5	4	Tehni
							130	50	1		Satauna
							22	25	1		22mm
							37	75	3		Dedhi

Table 10. Composition of the fish catch recovered from fishermen with fishing nets/gears used by them during survey of River Gandak in Bihar (January, 2010)

S.N.	Fisherman	Nets / gears	Mesh size (mm)	Distance from barrage (km)	Distance from confluence (km)	Lat / Long	Fish composition
1.	Santhlal Sahni	Hand held lift net	10	50	281	27° 09' 739"N 84° 00' 948"E	<i>Labeo Kalbasu, Labeo dero, Puntius Sophore, Puntius conchonioides, Barbodes sarana, Botia lohachata, Mystus cavasius, Mystus vittatus, Ompok pabda, Lapedocephalus guntea, Pseudeutropius atherinoides, Prambasis ranga, Colisa fasciatus, Channa punctata, Nandus nandus, Macrognathus pancalus, Mastacembelus armatus</i>
2.	Dhrub Sah	Cast net	10	80	251	27° 02' 335"N 84° 08' 019"E	<i>Salmostoma bacaila</i>
		Gill net	20	80	251	27° 02' 335"N 84° 08' 019"E	<i>Aspidoparia morar, Chanda nama, Glossogobius giuris, Chela atpar, Labeo dero</i>
3.	Suresh Sahni	Gill net	30	171	160	26° 32' 145"N 84° 29' 005"E	<i>Clupisoma garua, Eutropiichthys vacha</i>
4.	Pujo Sahni	Gill net	25, 55	180	151	26° 29' 424"N 84° 32' 845"E	<i>Clupisoma garua</i>
5.	Malik Sahni	Gill net	110, 160	279	52	26° 00' 647"N 84° 59' 917"E	<i>Spereta aor</i>
6.	Mohan Sahni	Gill net	22	308	23	25° 50' 338"N 85° 09' 727"E	<i>Labeo Kalbasu</i>
		Gill net	67				<i>Labeo bata</i>
		Gill net	130				<i>Labeo dero, Aspidoparia morar, Puntius conchonioides, Spereta aor, Spereta seenghala, Mystus cavasius, Wallago attu, Ailia coila, Clupisoma garua, Eutropiichthys vacha, Gangra viridescens, Gagata cenia, Xenentodon cancila</i>

* Out of the fifteen fishermen interviewed, only the above six had their catch with them at the time of interview.

8. Survey for Birds

The survey team recorded 83 species of birds from the river stretch (within-river habitats), and the precinct areas of the floodplain stretching on the Gandak's banks. An annotated checklist of birds observed during the survey is given in the Table- 11.

Table 11. Listing of Bird species during the survey of River Gandak in Bihar (January, 2010)

S.No	Species	Scientific name	Status
1.	Lesser Pied Kingfisher	<i>Ceryle rudis</i>	R
2	Little Blue Kingfisher	<i>Alcedo attis</i>	R
3	Large Egret	<i>Egretta alba</i>	R
4	Pariah Kite	<i>Milvus migrans</i>	R
5	Intermediate Egret	<i>Egretta intermedia</i>	R
6	Woolly -necked Stork	<i>Ciconia episcopus</i>	R
7	White-rumped Vulture	<i>Gyps bengalensis</i>	R
8	Indian Peafowl	<i>Pavo cristatus</i>	R
9	Paddy-field Pipit	<i>Anthus rufulus</i>	R
10	Indian Darter	<i>Anhinga melanogaster</i>	R
11	Indian Pond Heron	<i>Ardeola grayii</i>	R
12	Indian Cormorant	<i>Phalacrocorax fuscicollis</i>	R
13	Pied Wagtail	<i>Motacilla maderaspatensis</i>	R
14	Brahminy Kite	<i>Haliastur Indus</i>	R
15	Grey Heron	<i>Ardea cinerea</i>	R
16	Oriental Skylark	<i>Alauda gulgula</i>	R
17	Common Kestrel	<i>Falco tinnunculus</i>	R
18	Black -winged Kite	<i>Elanus caeruleus</i>	R
19	Jungle Crow	<i>Corvus macrorhynchos</i>	R
20	Grey Hornbill	<i>Ocyrceros birostris</i>	R
21	House Crow	<i>Corvus splendens</i>	R
22	Little Ringed Plover	<i>Charadrius dubius</i>	R
23	Egyptian Vulture	<i>Neophron percnopterus</i>	R
24	Crested Serpent Eagle	<i>Spilornis cheela</i>	R
25	Pied Myna	<i>Sturnus contra</i>	R
26	Lesser Whistling Teal	<i>Dendrocygna javanica</i>	R
27	Coucal	<i>Centropus sinensis</i>	R
28	Peregrine Falcon	<i>Falco peregrinus</i>	R
29	Red-headed Marlin	<i>Falco chicquera</i>	R
30	Bluethroat	<i>Luscinia svecica</i>	R
31	House Sparrow	<i>Passer domesticus</i>	R
32	Ring Dove	<i>Streptopelia decaocto</i>	R
33	Drongo	<i>Dicrurus macrocercus</i>	R
34	Hoopoo	<i>Upupa epops</i>	R
35	Shikra	<i>Accipiter badius</i>	R
36	Cattle Egret	<i>Bubulcus coromandus</i>	R
37	Spot-billed Duck	<i>Anas poecilorhyncha</i>	R

38	Large Indian Kite	<i>M.m.lineatus</i>	R
39	Common Myna	<i>Acridotheres tristis</i>	R
40	White Breasted Kingfisher	<i>Halcyon smyrnensis</i>	R
41	Black Bittern	<i>Dupetor flavicollis</i>	R
42	Rose-ringed Parakeet	<i>Psittacula krameri</i>	R
43	Crag Martin	<i>Ptyonoprogne concolor</i>	RM
44	Sand Martin	<i>Riparia riparia</i>	RM
45	Little Pratincole	<i>Glareola pratincola</i>	RM
46	Common Stonechat	<i>Saxicola torquata</i>	RM
47	Tawny Eagle	<i>Aquila rapax</i>	RM
48	Ruddy Shelduck	<i>Tadorna ferruginea</i>	M
49	Shoveler	<i>Anas clypeata</i>	M
50	Barn Swallow	<i>Hirundo rustica</i>	M
51	Large Cormorant	<i>Phalacrocorax carbo</i>	M
52	Common Greenshank	<i>Tringa nebularia</i>	M
53	Great Crested Grebe	<i>Podiceps cristatus</i>	M
54	Eurasian Sparrow Hawk	<i>Accipiter nisus</i>	M
55	Gadwall	<i>Anas strepera</i>	M
56	Pallas's Gull	<i>Larus ichthyaetus</i>	M
57	Common Sandpiper	<i>Actitis hypoleucos</i>	M
58	Pallas's Gull	<i>Larus ichthyaetus</i>	M
59	Pallid Harrier	<i>Circus macrourus</i>	M
60	Brown-headed Gull	<i>Larus brunnicephalus</i>	M
61	Common Merganser	<i>Mergus merganser</i>	M
62	Black Stork	<i>Ciconia nigra</i>	M
63	Grey Wagtail	<i>Motacilla cinerea</i>	M
64	Bar-headed Goose	<i>Anser indicus</i>	M
65	Osprey	<i>Pandion haliaetus</i>	M
66	Common Pochard	<i>Aythya ferina</i>	M
67	Long-legged Buzzard	<i>Buteo rufinus</i>	M
68	Marsh Sandpiper	<i>Tringa stagnatilis</i>	M
69	Demoiselle Crane	<i>Anthropoides virgo</i>	M
70	Little Stint	<i>Calidris minuta</i>	M
71	Common Shelduck	<i>Tadorna tadorna</i>	M
72	Common Teal	<i>Anas crecca</i>	M
73	Kentish Plover	<i>Charadrius alexandrinus</i>	M
74	Common Ringed Plover	<i>Charadrius hiaticula</i>	M
75	Dusky Warbler	<i>Phylloscopus fuscatus</i>	M
76	Hodgson's Bushchat	<i>Saxicola insignis</i>	M
77	White-tailed Stonechat	<i>Saxicola leucura</i>	M
78	Common Crane	<i>Grus grus</i>	M
79	Northern Pintail	<i>Anas acuta</i>	M
80	Grey Bushchat	<i>Saxicola ferrea</i>	M
81	Pied Harrier	<i>Circus melanoleucos</i>	M
82	Marsh Harrier	<i>Circus aeruginosus</i>	M
83	White-eyed Pochard	<i>Aythya nyroca</i>	M

Key: R = Resident: 42 species, RM = Resident migratory: 5 species M =; Migratory : 36 species.

The socio-economic condition of the local stakeholders, particularly fishermen, living in the floodplain area is very poor. Bihar is amongst the most economically impoverished state in India and the fishing community is socio-economically very deprived (Choudhary et al., 2006). Various anthropogenic activities leading to habitat degradation, poaching and hunting, and persecution have adversely affected bird species. The existing human disturbance and movement, particularly on banks and on mid-channel islands severely disturbs breeding birds like pratincoles and terns. Bird hunting has always been common, and is now perhaps accentuated by fishery resource declines. Birds are hunted mainly for food, and this constitutes mainly migratory waterfowl. Sustained awareness campaigns, community meetings and interactions should be organized to check poaching incidents and snaring.

9. Survey for Algal taxa

We have documented, for the first time, the micro-algal flora from 21 locations of the River Gandak from Valmikinagar (the barrage point i.e. where Gandak enters into Indian territory) to Hazipur (confluence point, where Gandak meets into River Ganga).

The algal community at all stations (21) was composed of four major groups: Diatoms, Chlorophytes, Cyanophytes and Euglenophytes. In total, there were 37 diatom, 24 Chlorophytes, 13 Cyanophytes and single Euglenophyte species (Table-13). Diatoms were dominant. 50 species were recorded at sampling station-1 i.e. 1 km upstream of Gandak Barrage at Valmikinagar. In general, the upper reaches of the river had more number of algal species because of more favourable conditions for algae to grow in this region i.e. wave action and mixing providing more nutrients, high temperature and reduced silt level allowing light to penetrate to greater depth. Species composition in the lower reaches of the river including confluence point was different (3-12 species) from those at sampling stations in the upper reaches (2-50). Some species were recorded from collection of almost all the sampling stations i.e. *Spirogyra parvula*, *Spirogyra condensata*, *Spirogyra rhizoides* and *Synedra ulna*.

**Table 12. Location of algal taxa collection stations in River Gandak, Bihar
(January, 2010)**

S. No.	Location	GPS Position	Distance Upstream/Downstream (km)
1	Triveni	27° 26' 362" N, 83° 55' 263" E	Upstream(1 km) of Gandak Barrage at Valmikinagar
2	Valmikinagar Ghat	27° 26' 193" N, 83° 54' 428" E	0 Just after Gandak Barrage at Valmikinagar
3	Susta Ghat	27° 21' 310" N, 83° 51' 332" E	13
4	Sohgi Barwa Ghat	27° 15' 434" N, 83° 50' 834" E	27
5	Chhitauni Bridge	27° 11' 024" N, 83° 58' 079" E	46
6	Bagha-1	27° 05' 363" N, 84° 05' 512" E	67
7	Ratwal Ghat	26° 58' 738" N, 84° 10' 721" E	90
8	Ledarwa Ghat	26° 53' 693" N, 84° 12' 523" E	95
9	Srinagar Ghat	26° 50' 430" N, 84° 20' 009" E	124
10	Singhi-Pipra	26° 44' 510" N, 84° 23' 603" E	140
11	Raajbariya Ghat	26° 33' 523" N, 84° 27' 014" E	165
12	Baterde Ghat	26° 25' 604" N, 84° 36' 427" E	192
13	Dumaria Ghat	26° 24' 532" N, 84° 44' 285" E	213
14	Sattar Ghat	26° 08' 648" N, 84° 49' 433" E	231
15	Hosepur	26° 10' 478" N, 84° 53' 822" E	255
16	Singhahi Dhaala	26° 06' 980" N, 84° 56' 444" E	264
17	Rewa Ghat	25° 59' 435" N, 85° 02' 309" E	284
18	Jahanabad Ghat	25° 50' 583" N, 85° 09' 601" E	308
19	Kalyanpur Ghat	25° 43' 924" N, 85° 10' 845" E	321
20	Konhara Ghat	25° 40' 839" N, 85° 11' 746" E	328
21	Confluence	25° 39' 935" N, 85° 10' 643" E	331

Table 13. Listing of Algal species from different Sampling Sites in River Gandak, Bihar (January, 2010)

S. No.	Organism	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	Chlorophytes																					
1.	<i>Closterium acerosum</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
2.	<i>Closterium ehrenbergii</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3.	<i>Cosmarium pseudo-broomei</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4.	<i>Cosmarium ctenoidum</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5.	<i>Cosmarium sexangulare</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6.	<i>Hyalotheca indica</i>	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-
7.	<i>Hyalotheca dissiliens</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8.	<i>Cladophora holsatica</i>	+	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-
9.	<i>Chaetophora pisciformis</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

10.	<i>Oedogonium varians</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11.	<i>Spirogyra parvula</i>	+	+	-	+	-	+	+	-	-	-	+	-	+	+	+	+	+	+	+	+	+
12.	<i>Spirogyra decimina</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
13.	<i>Spirogyra submaxima</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14.	<i>Spirogyra condensata</i>	+	-	+	+	-	+	+	-	+	-	+	-	+	+	+	+	+	+	+	+	+
15.	<i>Spirogyra hassallii</i>	-	+	-	-	-	-	+	-	-	-	+	-	-	+	+	-	-	-	-	-	-
16.	<i>Spirogyra rhizoides</i>	-	+	-	-	-	-	+	-	+	-	+	+	+	+	+	+	+	-	-	-	-
17.	<i>Spirogyra hyalina</i>	-	+	-	-	-	-	+	-	-	-	+	-	+	+	+	-	-	-	-	-	-
18.	<i>Spirogyra punctulata</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-
19.	<i>Spirogyra daedalea</i>	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	+	-	-	-	-
20.	<i>Mougeotia sphaerocarpa</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
21.	<i>Oocystis kumaonensis</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
22.	<i>Arthrodesmus subulatus</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
23.	<i>Scenedesmus dimorphus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
24.	<i>Actinastrum hantzschii</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Bacillariophytes																						
25.	<i>Cymbella affinis</i>	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
26.	<i>Cymbella tumida</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-
27.	<i>Cymbella turgidula</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
28.	<i>Cymbella bengalensis</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
29.	<i>Navicula tusculoides</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
30.	<i>Navicula schonfeldii</i>	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
31.	<i>Navicula terrestris</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
32.	<i>Navicula minima</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
33.	<i>Navicula disjuncta</i>	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
34.	<i>Navicula subhamulata</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35.	<i>Nitzschia capitellata</i>	+	-	-	-	-	-	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-
36.	<i>Nitzschia sublinearis</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
37.	<i>Nitzschia commutata</i>	+	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-
38.	<i>Nitzschia microcephala</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

39.	<i>Nitzschia acicularis</i>	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40.	<i>Nitzschia frustulum</i>	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41.	<i>Fragilaria construens</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42.	<i>Fragilaria vaucheriae</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43.	<i>Fragilaria brevistriata</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44.	<i>Rhopalodia gibba</i>	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
45.	<i>Pinnularia acrosphaeria</i>	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
46.	<i>Pinnularia borealis</i> v. <i>lonavlensis</i>	-	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
47.	<i>Gyrosigma scalproides</i>	+	-	-	-	+	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-	-
48.	<i>Gomphonema intricatum</i>	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
49.	<i>Gomphonema constrictum</i> v. <i>indica</i>	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
50.	<i>Gomphonema aequatoriale</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51.	<i>Gomphonema subventricosum</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-

52.	<i>Surirella subsalsa</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
53.	<i>Opephora martyi</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
54.	<i>Cymatopleura solea</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55.	<i>Caloneis bacillum</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56.	<i>Tabellaria fenestrata</i>	+	+	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-
57.	<i>Penium minutum</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58.	<i>Synedra ulna v. biceps</i>	+	+	+	+	+	-	+	+	+	+	-	+	-	-	-	+	+	+	+	+	+
59.	<i>Synedra ulna</i>	+	+	+	+	-	-	-	-	+	+	-	+	-	-	-	+	-	+	-	-	-
60.	<i>Synedra acus v. acula</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
61.	<i>Eunotia pseudoparallela</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanophytes																						
62.	<i>Phormidium ambiguum</i>	+	-	+	-	-	-	-	+	-	-	-	-	+	+	-	-	-	-	+	-	-
63.	<i>Oscillatoria curviceps</i>	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	+	-	-	-
64.	<i>Oscillatoria subbrevis</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+	-	-	+	-	-
65.	<i>Merismopedia minima</i>	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

66.	<i>Merismopedia tenuissima</i>	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-
67.	<i>Aphanothece clathrata</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68.	<i>Aphanocapsa pulchra</i>	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69.	<i>Anabaena variabilis</i>	-	-	+	-	-	-	-	-	-	-	+	+	-	-	-	+	+	-	-	+	-
70.	<i>Anabaena iyengarii</i>	-	-	+	-	-	-	-	-	-	-	+	+	+	-	+	-	-	-	-	+	-
71.	<i>Lyngbya kuetzingii</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	-
72.	<i>Nostoc commune</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-
73.	<i>Nostoc carneum</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74.	<i>Spirulina meneghiniana</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
Euglenophytes																						
75.	<i>Euglena gracilis</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

+ = present; - = absent

10. RECOMMENDATIONS

RECOMMENDED STRATEGY FOR CONSERVATION OF GHARIAL AND RIVER BIODIVERSITY OF GANDAK RIVER:

This will essentially involve an assisted recovery plan for gharial in the Gandak, as the current population does not by any means seem adequate for recouping to sustainable levels on its own. The various actions comprising an overall strategy for conservation of gharial in the Gandak are elaborated below:

1. Continuation of detailed surveys: Weather conditions were extremely adverse during the current survey, with very low daytime temperatures and overcast conditions totally unsuitable for basking by gharial. As such the population assessment made is likely to be biased with respect to actual numbers occurring in the River. In any case, factors like human disturbance, especially in unprotected areas like the Gandak, render individuals more than normally dispersive and nomadic, so only research through sustained repetition of surveys can provide a reliable assessment of the population strength and distribution.
2. Supplementation of natural populations with gharial produced through captive breeding and rearing in ex situ facilities such as the Sanjay Gandhi Zoological Park at Patna. The supplementation programme may be strengthened through innovative strategy such as incentives for rescue of supplemented animals and state of art methodology like satellite telemetry.
3. Implementation of a monitoring and protection mechanism for priority river segments with resident surviving and restocked gharial: The Area covered during the 2nd day of survey from Susta to Chhitauni Bridge (19-45 km), with a resident population of gharial, albeit small, is particularly important in this respect. Because of the unjustifiably exorbitant cost of maintaining an extensive permanent and devoted manpower for monitoring and protection, capacity may be enhanced through motivated involvement and training of personnel of Social Forestry outposts whose jurisdictions encompass gharial habitats and systematic development of a network of

informers and watchers from the riparian and fisherman communities.

4. Implementation of a participatory conservation programme involving fishermen and other communities critically impacting gharials and their habitats, which bring economic benefits to stakeholders through conservation friendly alternative livelihoods.
5. A programme of economic compensation for communities and individuals, which make concessions for and assist in the survival and conservation of gharials as well as other river biodiversity. A specific method of achieving this is by implementing a scheme for insurance of fishing gear lost in rescue of gharial by catches and compensation for relinquishment of fishing grounds and livelihood loss to release habitat for gharial. This can be linked to implementation of the above mentioned alternative livelihoods (3) or informer and watchers network programme (2).
6. Closer trans-boundary collaboration with Nepalese gharial conservation and management authorities facilitating the protection of animals restocked in the Narayani in Nepal that disperse into India by information sharing etc.
7. A sustained and vigorous awareness campaign among the fishermen and river dependent communities through various media, including print and electronic, about the significance of conservation of gharial and river biodiversity.

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