

Study of Investigation of Population, Habitat and Hatching Success of *Gavialis gangeticus* in Narayani River of Chitwan National Park

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**2nd Phase Final Report submitted to
The Rufford Small Grants Foundation, UK**

31 March, 2015



Acknowledgement

We would like to thank to THE RUFFORD FOUNDATION, Small Grants Program, U.K. for the funding of this research. We also express our sincere thanks to the following institutions and individuals for their assistance and support during the field work:

IDEA WILD, U.S.A. for the support of equipment

Department of National Parks and Wildlife Conservation (DNPWC) for providing permission to carry out this research within Chitwan National Park (CNP)

Phanendra Kharel, Deputy Director-General, DNPWC

Prativa Rajbhandari, Jawalakhel

Kunta Adhikari, Bhaktapur

Ram Prit Yadav, Gharial Outreach Program Coordinator/TAL/WWF

Pradeep Khanal, TAL/WWF

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Bed B Khadka, Assistant Warden, Gharial Conservation and Breeding Center (GCBC), CNP

Padam Mahato, Game Scout, Tribeni Post, CNP

Late Juthhe Ram Bote, Gharial Project, Amaltari, CNP

Sante Bote, Gharial Project, Amaltari, CNP

Bir Bahadaur Bote, Amaltari, CNP

Mama Bote, Kaluwa

Acronyms

CITES	Convention on International Trade of Endangered Species
CNP	Chitwan National Park
DNPWC	Department of National Parks and Wildlife Conservation
GCBC	Gharial Conservation and Breeding Center
GCA	Gharial Conservation Alliance
IUCN	International Union for the Conservation of Nature
NTNC	Nepal Trust for Nature Conservation
TAL	Terai Arc Landscape
WWF	Worldwide Fund for Nature

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Summary

This study was carried out in Narayani River of Chitwan National Park from 2014 to 2015. The population census showed a total number of 60 gharials including 1 hatchling, 16 juveniles, 31 sub-adults and 12 adults. The gharial census recorded 10 gharials in Block A (Sikrauli–Amaltari, Nawalparasi branch) followed by 33 gharials in the Block B (Sikrauli-Amaltari, Chitwan branch), 6 gharials in the Block C (Amaltari Ghat-Malebagar) and 10 gharials in the Block D (Malebagar-Tribeni). This study showed that the gharials use sand banks (86%) and rocks (13%). The clutch size ranged from 6 eggs to 50 eggs. A total number of 42 eggs were hatched which accounts to only 16.6 % hatching success in the Narayani River. The existing practice of immediate egg collection from natural nests and their transfer to artificial pits and again to another sand bank near Gohi project after 30 days and lack of recording the nest temperature and humidity have hampered the reproductive success of gharials. The park should adopt scientific measures in the handling and caring of eggs and hatchlings until they are transported to the breeding center in Kasara.

Key words

Gharial crocodile, Narayani River, sand bank, Chitwan National Park, hatching success

1.0 Introduction

The gharial, *Gavialis gangeticus* is a large crocodylian with a long, slender snout. Of the 23 species of crocodylians, which inhabit a range of aquatic ecosystems, the gharial is the only surviving member of the family, Gavialidae. The Gharial is one of the most endangered of all crocodylians and the most endangered large animal in the Indian subcontinent (GCA 2008). It is currently estimated that there are below 200 breeding adult of *G. gangeticus* in the wild. This represents a decline in the population of over 80% since 1940s (a time-span equating to roughly 3 generations), and qualified it for Critically Endangered (CR) listing in the IUCN Red List (Choudhury *et al.* 2007). It is included in the category Appendix I by CITES.

The gharial crocodile (*Gavialis gangeticus*) is also being threatened and included in the protected list of animals by the government of Nepal. The wild population of gharial in Nepal is estimated at 80 in different river systems. The gharials are found in the Narayani, Rapti, Babai and Karnali river systems of Nepal which are under tremendous threats from human disturbances such as overfishing, grazing, dam construction and over-exploitation of natural resources (Rajbhandari & Acharya, 2013).

The fragmented population of the endangered gharial crocodile is continuously under high risk by human disturbances. In addition, inadequate awareness and skills in conservation of gharials among the fishermen have hampered the conservation of gharials in the Narayani River. The Government of Nepal initiated ex-situ conservation of gharials in Kasara, 1975 to recover and maintain healthy populations of gharials in the river basins of Nepal. The reintroduction of gharials that are reared in captivity is a regular annual program. Since then several batches of bred gharials have been reintroduced into the rivers of Nepal. Despite, these efforts of gharial conservation program, its population has not increased considering the large number of gharials that have been reintroduced in the past. This is mainly due to the high human disturbances in the river and inadequate monitoring.

This study is a continuation of the 1st phase RSG gharial project in Narayani River and the information generated from the study could be baseline information to Chitwan National Park.

1.1 Objectives

The overall objectives of the study is to strengthen the gharial conservation in Nepal through the understanding of critical habitats, population, nesting ecology and in raising the public awareness with active participation of local communities to maintain viable population of gharial. The Objectives of the study are: 1) assess the population of *Gavialis gangeticus* in Narayani River; 2) study the basking activities of gharials in relation to water depth; 3) study the hatching success of gharials; and 4) generate awareness and education towards gharials amongst and between conservationists, local communities, natural resource managers and policy makers.

1.2 Rationale

The gharial is one of the key predators of the Narayani river system which helps in maintaining the health of the river and biotic integrity. The species is protected by Nepal Government under the National Parks and Wildlife Conservation Act 1973. The population of gharial crocodile in the Narayani is estimated at 44 (DNPWC, 2011). This remnant population is under continuous pressure from different human activities. On the other hand, the construction of Gandak barrage along the international border with India has further threatened the population through rapid loss of habitats. Conservation initiatives towards the protection of gharial crocodiles are inadequate though the government of Nepal monitors its population in different river systems of Nepal. Therefore, the isolated population is declining which may lead to its extinction from the river. This research intends to investigate the status, distribution, habitat preferences, nesting behavior and hatching success of this endangered species. On the other hand, the status of conservation issues and the perceptions of the local community will also be studied.

The research outcomes could be extremely beneficial to the park managers to ensure long term conservation of this species in the river basins of Nepal.

1.3 Status of gharial in Nepal

The gharial was previously present in all the gangetic river systems in several countries of South-East Asia – Pakistan, Bhutan, Myanmar (ex-Burma), India, Nepal and Bangladesh. In the 1940's, the gharial population was estimated from 5000 to 10000 individuals. It declined to 150-200

individuals in the 1960's principally due to habitat destruction and uncontrolled exploitation. It's now only present in India and Nepal, about 120 individuals in India and 81 in Nepal.

Gharial conservation began in 1971 in Nepal with the help of the Frankfurt Zoological Society. It consists of population reintroduction by egg collection, gharial breeding and release of reared gharials after 5 years. Until now, nearly 700 individuals were released in 4 different rivers of Nepal (Andrews and Mc Eachern, 1994; DNPWC, 2005).

The gharial crocodile (*Gavialis gangeticus*) is a critically threatened reptilian species of Nepal. The wild population of gharial in the world is estimated at about 200 of which 80 individuals was recorded from Nepal. The gharials are found in the Narayani, Rapti, Babai and Karnali rivers of Nepal which are under tremendous threats from human disturbances such as overfishing, grazing, dam construction and over-exploitation of natural resources.

2.0 Literature Review

Andrews and Whitaker (2004) reports that *Gavialis gangeticus* females attain sexual maturity when they are about 3 m and males 3.5 m and above. The nesting season is during summer occurring between March and May and the maximum number of nests was laid between the 16th to 20th April. Total clutch weight highly correlated with clutch size than with mean egg weight. Significant variation in clutch size and percentage of viable eggs within a nest was evident between nesting seasons in the 13 years of breeding. Age and clutch size were found to be highly correlated and total clutch weight is strongly correlated with mean clutch size. *G. gangeticus* has temperature- dependent sex determination (TSD) and the TSD pattern is female-male-female. Fertile eggs incubated at set constant temperatures from 29-31.5°C produced only females and at 32°C 89% were males. At 33 and 33.5°C, 20% and 15% males were produced, respectively. Incubation period averaged 70 days for eggs incubated at 31°C, which was 1.20 times higher than eggs from 29°C and 1.17 times longer than 33°C (Lang and Andrews 1994).

Aufrey (2010) reported that the gharial population in Nepal is still stable with only 81 gharials present in the country (2008). The gharial release program since more than 25 years have taken place with the release of more than 700 young gharials that have been raised in the two gharial breeding centers, Bardia and Chitwan National Park.

Ballouard and Cadi, (2005) have conducted a census to know the status of gharial in Chitwan and assess the evolution of the population dynamics since 2003. The measures that they have identified will be helpful to protect the gharial population in Chitwan and in the protection of natural resources in the Terai Arc Landscape. They have concluded that the knowledge of animal population status as the main factor to make recommendations to improve the conservation of the species.

Ballouard *et al* (2010) have carried out a survey in 2003 and 2004 of the largest gharial population in the Chitwan National Park with the population size estimates as 34 and 38 respectively. Although the park has been re-introducing regularly young gharials since 1981, their populations have declined over their entire distribution range. The main threats that they have identified are from a dam that causes fish depletion and flushes gharials from the protected area, sand mining and grazing that destroy basking sites, fishing that causes food shortage, drift nets that kill gharial, and water pollution. The conservation measures recommended are strict protection of preferred basking sites and prohibition of fishing in the main settling zones and education/participatory management of the local people.

Bhatta (2009) conducted a study to determine status of gharial with factors affecting to stabilize the population in the Rapti river of Chitwan National Park. The population size of gharial was estimated as 26 with male and female sex ratio at 1:9. A total 3 nests were found in the Rapti River with average clutch size 33. About 50% of eggs produced hatchlings from the wild nests while about 49% of eggs produced hatchlings in case of captive nests. The major threats to gharial in Rapti River have been identified as fishing, human disturbance, sand mining, use of gill net and cleaning and washing activities. The social survey showed that the people have positive attitude for collaborative conservation activities with the park.

Khadka *et al* (2008) have conducted a census that revealed a minimum of 58 wild and released gharials are surviving in Chitwan population with 34 individuals in Narayani and 24 individuals in Rapti Rivers. The Karnali and Babai rivers of Bardia National Park support a very small population of 6 and 10 individuals respectively. The gharial is extinct from the Koshi River. The sex ratio of Chitwan population is only 1 Male: 6 Female and existence of only 27 percent of adult breeding population poses hindrance for its natural multiplication. The factors responsible for the decrease of gharial population are due to flood and dam construction, habitat destruction

and decline in food. Overfishing, use of gill nets and river poisoning has also adversely affected the gharial population. The killing of gharial was only found to take place in case the animal got entrapped in the fishing net. The study also revealed high awareness among local community regarding gharial conservation as it has benefited local communities through the conservation programs associated with the species. The study concluded the declining population of gharial should be addressed through scientific study and preparing a Gharial Conservation Action Plan for regulating conservation activities to conserve gharial in Nepal.

Maskey *et al* (2006) reports that the captive breeding at the Gharial Conservation Project launched since 1981 is successful but survival of the released animals is very low. The recent observation of the gharial in the Narayani and Rapti rivers indicated that the population of the adult gharialis declining but it is compensated by the regular release of the captive reared animals though the survival is very low. As part of reinforcement program, activities such as construction of scientifically improved hatchling pools and regular monitoring of the released gharials in the Narayani River have been launched by the Department of National Parks and Wildlife Conservation.

Maskey *et al* (1995) have evaluated habitat of gharials in June, 1987 and January, 1988 between Sikrauli and Tribenighat, surveying channels on each side of large, wooded islands for a total distance of about 180 km. Thus, use of all 1778 sightings would greatly inflate sample size; therefore, for all analyses we scaled our habitat-use observations to include only single sightings of the 50 wild, adult gharials known to live in the study area. Although gharials used all habitats, we did not observe them across the five habitat types in proportion to habitat-type abundance in either sea-season (monsoon: $X^2 = 171.51$; $df = 4$; $P < 0.01$; non-monsoon $X^2 = 85.89$; $df = 4$; $P < 0.01$) (Table 1). During monsoon gharials frequented sand banks ($X^2 = 163.86$; $P < 0.01$; df throughout this paragraph = 1) and avoided grass banks ($X^2 = 44.18$; $P < 0.01$); during non-monsoon season animals selected sand banks again ($X^2 = 53.50$; $P < 0.01$) and avoided rock banks ($X^2 = 54.63$; $P < 0.01$). We could not definitively demonstrate other habitat preferences or avoidances. Even though habitat-type availability changed substantially between summer and winter, proportional habitat-type use remained rather constant. This trans-seasonal consistency in observed habitat use, despite changing proportions of habitat availability, suggested that general site fidelity might be important in defining habitat use. However, long-term site fidelity cannot

be the sole factor at work. Observations (N = 1474) on 43 newly-released, captive-reared gharials (1-2 m total length) showed the same pattern of habitat-type preference and habitat-type avoidance; furthermore, these habitat-use patterns persisted even when the animals moved long distances from original release sites (Maskey, 1989). Habitat selection may be mediated (1) by tactile qualities of substrate, (2) thermoregulatory considerations, and/or (3) by prey availability. Data do not presently exist to test any such hypotheses.

Maskey (1999) conducted a field study of gharial was conducted in the Chitwan National Park and Bardia National Park during 1997 to determine the status of gharial in the Kali, Narayani, Karnali and Babai river systems of Nepal. Systematic survey conducted in December revealed a minimum of 55 wild gharials and 50 released gharials survived in the Narayani, Kali, Karnali and Babai rivers. The sex ratio of wild gharial 1 male to 10 females was at critical stage. The low number of males was attributed to the heavy poaching of males in the past. The population may be sustained by releasing captive-released gharials.

Maskey and Percival (1994) conducted a study in the Royal Chitwan National Park and Royal Bardia National Park during 1993 to determine the status of gharial in the Narayani, Kali, Karnali, and Babai river systems of Nepal. Systematic survey conducted in December and May revealed that a minimum of 58 wild gharials and about 70 released gharials survived in the Narayani, Kali, Babai, and Karnali rivers. The sex ratio of wild gharials was 1 male to 10 females. The low number of males was attributed to the heavy poaching of males in the past. The population may be sustained by releasing captive-reared gharials.

Kumar (1988) observed that basking was common behavior observed both in adults and juveniles. It was found to be related to the ambient temperature. Both adults and juveniles basked during morning and late evening hours. They avoided the high atmospheric temperature of the mid day. Basking was high during January 1988 and low during March 1988. There was a significant difference between a time spent for basking by adults and juveniles. Adults spent more time for basking during the study period. Further, adults were found on land at night but juveniles were found under water at night. It was suggested that gharials generally prefer temperatures between 27°C and their basking pattern mainly depends on the atmospheric temperature as they bask on land during lesser temperature and move into water when the atmospheric temperature becomes warm.

Nair (2010) studied the gharial in a 75 km stretch of Chambal River and concluded that one-fifth of the study area as preferred gharial habitat. The availability of undisturbed basking sites in conjunction with deep water segments emerged as the main variable explaining gharial occurrence. The human activities appeared to negatively influence the use of areas by gharials. The mining of sand and cultivation around the banks negatively impacted the use of such sites for basking. The gharials were seen less often and in fewer numbers in areas where fishing was high. Similar results were seen with movement of people and livestock along the river stretch. This study indicates the importance of inviolate areas that satisfy the bio-physical requirements of the gharial.

Nair *et al* (2012) surveyed 75 km section of the river Chambal and photographed individual gharials for capture–recapture analysis. The total sampling effort yielded 400 captures. Used within the framework of capture–recapture analysis, photo identification provided a reliable and noninvasive method of estimating population size and structure in crocodylians. They also opined that without determining the current status of gharials, highly intensive strategies, such as the egg-collection and rear-and-release programs that are being implemented currently, initiated on the basis of underestimates of population sizes, are unwarranted and divert valuable conservation resources away from field-based protection measures, which are essential in the face of threats like hydrologic diversions, sand mining, fishing and bank side cultivation.

Hussain (1999) studied the reproductive success and hatchling survival of gharial populations in Chambal Sanctuary by monitoring 124 nests between 1987 and 1989. The population increase in the Chambal River of the Sanctuary was also determined between 1988 and 1992. The study showed that between egg laying and hatchling, a large number of eggs were lost due to eggs being damaged during nest searches, predation, desiccation and other reasons although the overall fertility was 91.8%. The study indicated that 92.3% hatchling mortality occurred within the first year. The density of gharial increased during 1992 and the total number of nests also increased in 1989.

A population survey by Thapaliya *et al* (2009) carried out in the river systems of Nepal indicated the presence of 70 gharials. The study showed decreasing trend of gharial population due to high

human disturbances. The study identified a need to carry out scientific study based conservation measures such as restocking and habitat improvement.

Hussain (2009) studied the basking site and water depth selection by gharials in National Chambal Sanctuary between 1992 and 2007 showed the greater habitat preferences to sandy parts of the river banks and sand bars for basking. The juvenile gharials preferred the water depth from 1-4 m while the adult and sub-adult prefer the deeper water greater than 4 m. Sand excavation and water abstraction are the major threats to gharials in Chambal Sanctuary.

Khadka & Thapaliya (2010) surveyed by the use of radio-telemetry in Narayani and Rapti rivers to assess the habitat preference on the basis of degree of human disturbance showed that the gharials preferred less disturbed area. The study also estimated the population of 56 wild and released gharials in Chitwan National Park which includes 36 individuals in Narayani and 20 individuals in Rapti Rivers.

Katdare *et al* (2011) conducted three surveys during 2009 in the Chambal River of National Chambal Sanctuary, India and found that there was the presence of only 15% of the total gharial population in the upstream as a result of highest density of disturbances due to agriculture and fishing activities. The downstream supported 85% of the gharial population due to better habitat quality and lower human disturbances. The study found a positive relationship between gharial numbers and sand habitat features with less human activities.

Maskey (1989) conducted a field survey of gharial in Chitwan National Park from 1986-1987 to determine its status and ecology in Narayani River. The survey during the months of December and May indicated a minimum of 103 (0.93 gharials/km) wild and released gharials, the sex ratio being 1 male:9 females. The habitat surveys of June 1987 and January 1988 showed that rocky banks were the most available habitat in the Narayani River, followed by sand banks, grass banks, sand grass banks and river channel. The larger gharials used sand banks more than on rocky banks. On the other hand, the small gharials used rocky banks more than the larger animals. A mean clutch size of 35.2 ± 1.1 SD resulted from 73 nests collected in the years 1977 and 1987. The mean incubation period and the hatching rates of eggs from the Kali and Narayani rivers were 78 ± 9 SD days and 60.9 %, and 81 ± 11.5 SD days and 67.7 % respectively. 25% to

80% of the hatchlings died within the first year of their life. The prime criteria for release of captive gharial are deep, fast-flowing clear water, high banks, deep pools and undisturbed sand banks at the river edge. The success of gharial reintroduction program in Nepal depends upon three factors: the release of gharials >1.2 m in length; the selection of release sites that provide primary habitats within the dispersion range of the released gharials, and release of gharials in late winter to facilitate the establishment of site-fidelity bonds by individuals prior to the monsoon season.

Whitaker (1987) has reported that the main problems are habitat conservation and sustaining the management effort in the face of adversity from fisheries, hydroelectric and other interests. The long term future of Indian crocodilians is closely linked with their acceptance by the local people, who live around the few remaining habitats of crocodiles. Public education and means of benefits to people from crocodile conservation are needed.

Webb and Smith (1987) have dealt in a paper regarding maximizing the management value of a demographic study of a wild crocodilian population. They noted that the population structure, rates of survival, rates of reproduction and rates of immigration and emigration are the six most important to estimate.

Choquenot and Webb (1987) described a technique which gives a scaled photographic negative of crocodiles seen during spotlight surveys. They usually allow definitive species identification, and can be used to estimate the size of the crocodile photographed. The technique can be used to quantify observer bias, and with the improvements has the potential of being a primary method of recording data during spotlight surveys. It also provides a definitive and permanent record of many of the animals sighted on a survey. This means that changes in the size structure of a population over time can be assessed by one person interpreting series of negatives, rather than by one-off spotter estimates accumulated over a period of years.

Webb *et al* (1987) looked into the four areas of egg and embryo function, namely embryo orientation within eggs, the effects of rotating eggs, opaque banding and the reorganization of egg contents that occurs during development. All of these are intimately associated with each other and highly indicate a dynamic relationship between the embryo and egg contents.

Manolis et al (1987) studied the changing composition of egg contents that occurs during embryonic development in the Australian freshwater crocodile *Crocodylus johnstoni* in different stages such as the egg contents prior to embryonic development, the utilization of egg contents with time, the concentrations of major ions in egg fluids, the effects of varying incubation temperature and the effects of varying levels of water loss.

Rao (1987) reports that the information on gharial reproduction relates to the management programs for them and the success of the gharial management program to date has been directly related to the success with which eggs could be located, collected, incubated and the young raised until they could be released.

Rao (1988) studied the nesting ecology in a communal nesting site, Baroli and surveys in other nesting sites during and after nesting sites. The results indicated yearly increase in the nesting sites. Nesting was not found in the area where there is no sand. The banks opposite to the sand bank where nesting occurred during 1987 were muddy and hard soil (53.3 %) and rocky (40%). Nesting also occurred in the alluvial deposits in between rocks (6.6%).

3.0 Methods

3.1 Study Area

The study was carried out in Narayani river of Chitwan National park (27° 34' to 27° 68' N and 83° 87' to 84° 74' E) including the buffer zones from northern boundary of park (Sikrauli) to Tribeni barrage at international border with India. Chitwan National Park is renowned for the conservation of some of the world's most endangered species, including rhinoceros, tiger, gaur, gangetic dolphin, otter and gharial in their natural habitat (CNP Management Plan 1975- 1979). The Park occupies an area of 932 km² in the Rapti Valley of the Siwalik physiographic region, while the buffer zone (27° 28' N to 27° 70' N and 83° 83' E to 84° 77' E) extends 750 km² area (Figure 1).

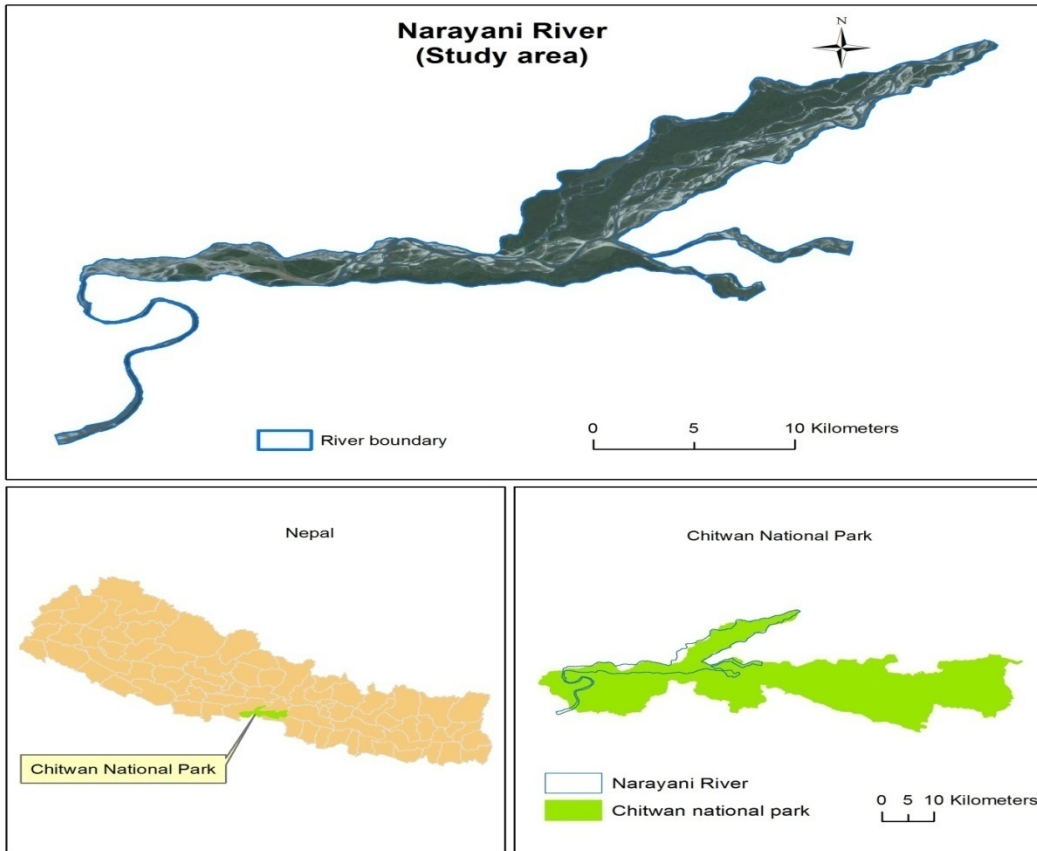


Figure 1: Narayani River

The Narayani River ((also called the Gandaki}) is a snow fed river, formed by the confluence of Kaligandaki and Trisuli rivers. The total length of this river is about 338 km, and the average flow ranges between 1000 to 1700 cum/s but maximum flow ranges from 10 to 700, 000 cum/s during the monsoon season from June to September (Panday, 1987; Maskey, 1989).

The Narayani river flows southwest for 30 kilometers from a gorge in the Mahabharat Range to the Rapti confluence and then flows westward for a further 25 kilometers along the base of the Someswar Hills before turning south through a very narrow gorge in the Siwaliks between the Dauney and Someswar Hills until it reaches the Nepal-India border (Laurie, 1978). The bed of the Narayani River is very broad consisting of a large number of channels and islands with a width of up to 4 kilometers. The floodplain varies with the altitude, ranging from 250 meters to 150 meters.

The climate of Chitwan is subtropical with a summer monsoon from mid-June to late September and a relatively dry winter. The average annual rainfall is about 250 cm, with the most occurring

between June and September. The post-monsoon season between November and January is cool with the daily average temperature reaching 24 °C during the day and droppings to about 7 °C at night.

3.2 Procedure

The survey was carried out with the help two dugout boats and the count of the gharials on both the banks was done two trained personels.

Assessment of population of gharials

The Narayani River was divided into four blocks for sampling purpose. A detailed survey was conducted during February 2014 in all the blocks throughout the whole riverine stretch by two dugout boats to identify the spatial distribution pattern and population status. The important habitat variables and their relationships to gharials was measured quantitatively. This survey followed the methods of Hussain, 1991. The location of the gharial sighted was recorded by Garmin GPS. The size of each gharial sighted was estimated from the nearest distance possible with 30 cm increment. The gharial sighted and counted was assigned to general sizes and age classes. Other parameters such as time, location of sighting, activity of sighted animal, and weather condition were also noted.

Habitat Use

During the population survey, the factors affecting the habitat selection by gharials was assessed. After the identification of basking sites, the habitat variables such as substrate, river depth, river width, and the extent of human disturbances were recorded.

Hatching Success

During the breeding season (March, 2014), the behavior of the breeding females was monitored to locate the trial nests and egg laid nests. The parameters such as inter-nest distance, depth and circumference of nest, distance from the edge of water, heght from the water level, river depth, river width and bank slope etc were recorded. The hatching success of the artificial dugout pits in Amaltari Gharial Egg Collection Center was monitored and the data such as mean clutch size,

infertile eggs, and eggs not hatched, pre-hatching mortality and the number of eggs hatched was noted.

Awareness Generation

Focal group meetings were conducted to generate awareness on the importance of gharials.

4.0 Results

Population status and spatial distribution

The population monitoring carried out in Narayani River during the month of February 2014 recorded a total number of 60 gharials including 1 hatchling, 16 juveniles, 31 sub-adults and 12 adults (Tables 1 & 2). The adult population includes 1 breeding male and 11 breeding females. This number is higher than the number of gharial census that was carried out in winter 2013, possibly due to the total count of wild gharials and the population of the reintroduced gharials (Table 3).

The population monitoring in the Block A (Sikrauli–Amaltari, Nawalparasi branch) recorded a total number 10 gharials (Table 4) followed by 33 gharials in the Block B (Sikrauli-Amaltari, Chitwan branch) (Table 5), 6 gharials in the Block C (Amaltari Ghat-Malebagar) (Table 6), and 10 gharials in the Block D (Malebagar–Tribeni) (Table 7).

River	Hatchlings	Juveniles	Sub-adults	Adults	Totals	Remarks
<i>Narayani River</i>	1	16	31	12	60	One breeding male
Total	1	16	31	12	60	

Table 1: Gharial survey in the Nayanari River, February 2014

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S. No.	Latitude	Longitude	Number	Size (m)	Depth	Width	Habitat
1	27.37364	84.124227	1	2.43	1.37	152.40	Sand bar
2	27.33780	84.09178	2	2.13	3.04	213.36	sand
3	27.33592	84.08316	2	1.82-2.13	1.52	91.44	rock
4	27.38445	84.12610	1	2.13	1.06	60.96	sand
5	27.38347	84.11987	1	1.82	3.35	91.44	sand
6	27.34180	84.07854	1	2.13	1.82	121.92	sand
7	27.33821	84.07414	2	1.67-1.98	2.59	106.68	sand
8	27.33588	84.08375	2	1.98-2.28	1.82	45.72	sand
9	27.33736	84.09189	2	1.98-2.13	1.52	304.80	Sand bar
10	27.33495	84.08665	1	1.82	1.67	274.32	sand

11	27.33333	84.08255	1	1.52	1.37	60.96	sand
12	27.33123	84.08290	18	1.82-3.65	2.43	91.44	Sand bar
13	27.32823	84.08053	4	1.37-2.59	1.06	243.84	sand
14	27.32795	84.07967	1	2.74	3.20	304.80	sand
15	27.33043	84.07868	2	1.82-1.98	2.13	91.44	sand
16	27.33112	84.07044	1	1.21	1.67	121.92	rock
17	27.33098	84.06741	1	1.52	1.82	137.16	rock
18	27.32298	84.02176	1	1.21	3.64	30.48	sand
19	27.32197	84.01420	2	1.06-1.21	5.18	152.40	sand
20	27.32248	84.01264	1	2.13	2.13	121.92	sand
21	27.32663	84.00426	2	1.21-1.52	2.13	182.88	sand
22	27.31039	83.50613	1	2.13	2.89	121.92	sand
23	27.31171	83.56850	1	1.82	1.52	76.20	sand
24	27.31577	83.57106	1	1.82	5.82	91.44	sand
25	27.31422	83.57681	7	1.52-2.28	2.89	121.92	sand

Table 2: The total population of gharials and their sizes in Narayani River, CNP, 2014

River	Hatchlings	Juveniles	Sub-adults	Adults	Totals	Remarks
<i>Narayani River</i>	3	8	12	15	38	One breeding male
Total	3	8	12	15	38	

Table 3: Gharial survey in the Nayanari River, January 2013

S. No.	Latitude	Longitude	Number	Size (m)	Depth	Width	Habitat
1	27.37364	84.124227	1	2.43	1.37	152.40	Sand bar
2	27.33780	84.09178	2	2.13	3.04	213.36	sand
3	27.33592	84.08316	2	1.82-2.13	1.52	91.44	rock
4	27.38445	84.12610	1	2.13	1.06	60.96	sand
5	27.38347	84.11987	1	1.82	3.35	91.44	sand
6	27.34180	84.07854	1	2.13	1.82	121.92	sand
7	27.33821	84.07414	2	1.67-1.98	2.59	106.68	sand

Table 4: Gharial census during winter 2014 in Block A (Sikrauli-Amaltari, Nawalparasi branch)

8	27.33588	84.08375	2	1.98-2.28	1.82	45.72	sand
9	27.33736	84.09189	2	1.98-2.13	1.52	304.80	Sand bar
10	27.33495	84.08665	1	1.82	1.67	274.32	sand
11	27.33333	84.08255	1	1.52	1.37	60.96	sand
12	27.33123	84.08290	18	1.82-3.65	2.43	91.44	Sand bar
13	27.32823	84.08053	4	1.37-2.59	1.06	243.84	sand
14	27.32795	84.07967	1	2.74	3.20	304.80	sand
15	27.33043	84.07868	2	1.82-1.98	2.13	91.44	sand
16	27.33112	84.07044	1	1.21	1.67	121.92	rock
17	27.33098	84.06741	1	1.52	1.82	137.16	rock

Table 5: Gharial census during winter 2014 in Block B (Sikrauli-Amaltari, Chitwan branch)

18	27.32298	84.02176	1	1.21	3.64	30.48	sand
19	27.32197	84.01420	2	1.06-1.21	5.18	152.40	sand
20	27.32248	84.01264	1	2.13	2.13	121.92	sand
21	27.32663	84.00426	2	1.21-1.52	2.13	182.88	sand

Table 6: Gharial census during winter 2014 in Block C (Amaltari Ghat-Malebagar)

22	27.31039	83.50613	1	2.13	2.89	121.92	sand
23	27.31171	83.56850	1	1.82	1.52	76.20	sand
24	27.31577	83.57106	1	1.82	5.82	91.44	sand
25	27.31422	83.57681	7	1.52-2.28	2.89	121.92	sand

Table 7: Gharial census during winter 2014 in Block D (Malebagar-Tribeni)

In Khoriya, the population recorded was altogether 18 gharials which accounts for the highest aggregation within the whole stretch of Narayani River within Chitwan National Park. Although this is widely used for basking in winter, it is not preferred for nesting purpose as this area receives high human disturbances throughout the year. The breeding females normally move downstream in areas such as Seri and Velaunji. One nest was located in Bhosar Island of Chitwan Branch which is characterized by elevated sandy banks and less human disturbances.

In Velaunji, altogether 7 gharials were recorded of which 5 were sub-adults and 2 adults. During the months of breeding season 4 nests were located in the Velaunji area. This shows, 2 adult females have come to this place from upstream in search of safer place for egg laying purpose.

Of the total population recorded in Narayani River, the sub-adults represent 51.66 % followed by 26.66 % of juveniles, 20 % adults and only 1.66 % of hatchlings (Table 8). During the year 2013, out of 38 individuals, the adults dominated the population with a representation of 39.47 % (Table 9).

Size class of gharial	2014
<120 cm	1
>120 – 180 cm	16
>180 – 270 cm	31
>270	12
Total	60

Table 8: Size classes of gharial seen in the Narayani River, CNP during 2014.

Size class of gharial	2013
<120 cm	3
>120 – 180 cm	8
>180 – 270 cm	12
>270	15
Total	38

Table 9: Size classes of gharial seen in the Narayani River, CNP during 2013.

Habitat Utilization

In the basking areas, the water channels were from 1.06 m – 5.82 m deep. In Khoriya population, the gharials used the sand bars and rocks for basking with the river channels having 1.06 m – 3.20 m deep whereas in Velaunji, the basking sites were only on sand with maximum water depth of 1.52- 5.82 m (Figure 2).

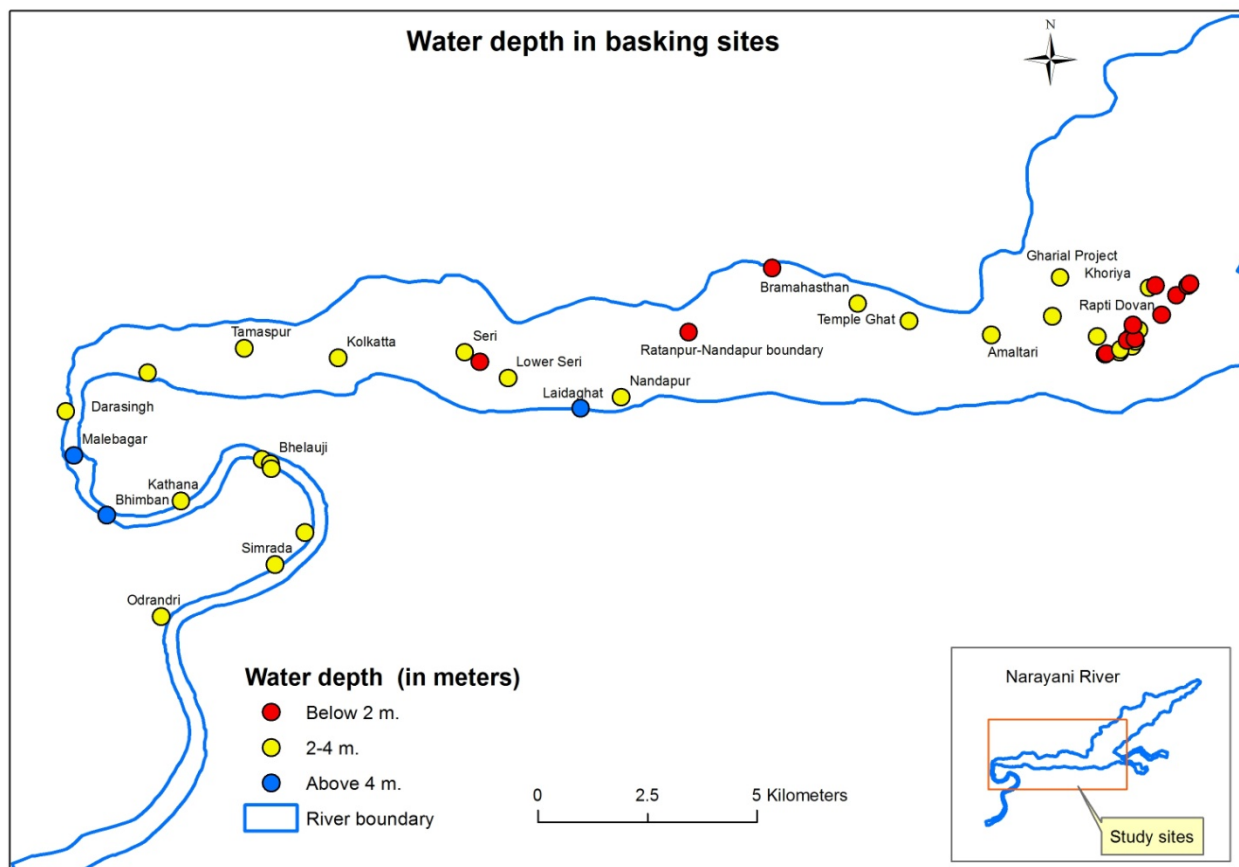


Figure 2: Water depth selection by gharials

Source: Rajbhandari & Acharya, 2013

Our result indicates that more than 86 percent of gharials select sandy areas for basking activities followed by rocks with about 13 percent (Table 10) (Figure 3) whereas during the survey of

2013, 84.21 % of the gharials used sand banks (Table 11). No gharials were seen on the clay areas for both surveys of years 2013 and 2014.

Basking site type	Number of gharial observed	Percentage of habitat use
Sandy	52	86.66
Rocky	8	13.33
Clay	0	0
Total	60	100

Table 10: Preference of basking types by gharials in the Narayani River, CNP during January 2014

Basking site type	Number of gharial observed	Percentage of habitat use
Sandy	32	84.21
Rocky	6	15.78
Clay	0	0
Total	38	100

Table 11: Preference of basking types by gharials in the Narayani River, CNP during January 2013

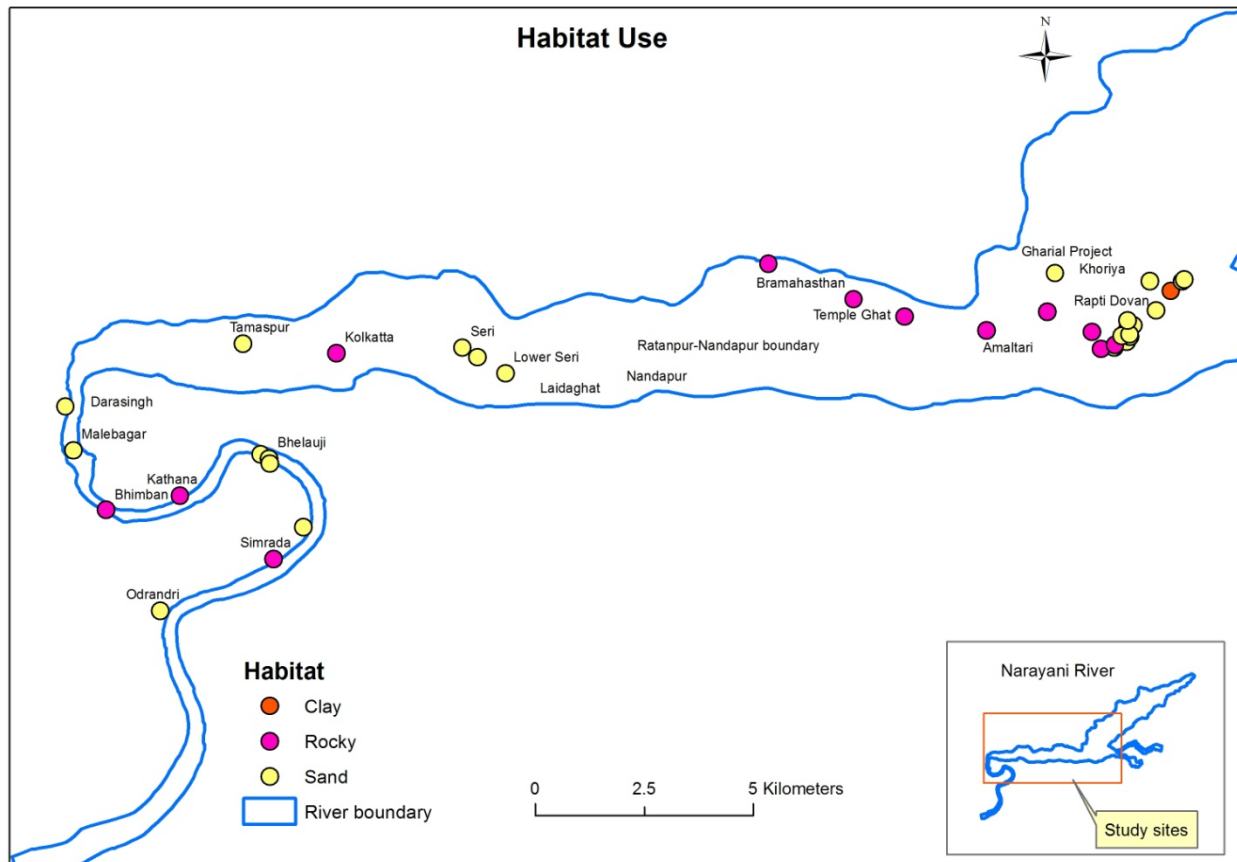


Figure 3: Habitat utilization by gharials

Source: Rajbhandari & Acharya, 2013

Hatching success

During the months of March/April 2014, a total of 7 nests were located including 4 nests in Velaunji followed by one each in Siswar (Chitwan Branch of Narayani River), Seri and Khoriya (Table 12). 2 nests of Velaunji contained all infertile eggs. The gharials started laying eggs from 29 March to 7 April 2014. The incubation period varied from 67 days to 76 days. The clutch size ranges from 6 eggs to 50 eggs. A total number of 42 eggs were hatched which accounts only 16.6 % hatching success in the Narayani River.

S. No.	Location	Egg laying date	Clutch size	Hatched date	Incu. Period In days	No. Hatched	Hatching Success in %	Death during hatching
1	Velaunji	29 March	49	11 June	75	16	32.6	0
2	Velaunji	30 March	50	13 June	76	10	20.0	0
3	Velaunji	30 March	39	15 June	0	0	0	0
4	Velaunji	7 April	39	15 June	0	0	0	0
5	Siswar	2 April	47	15 June	75	1	2.1	0
6	Seri	6 April	22	11 June	67	11	50.0	0
7	Khoriya	7 April	6	15 June	70	4	66.6	0
		Sub-Total	252			42	16.6	0

Table 12: Nest locations, egg laying dates, clutch sizes, incubation periods and hatching success of gharial nests, 2014

The average clutch size of the gharials that were collected during 2013 is 31.6 with a maximum clutch size 41 and a minimum of 18 (Table 13). The average percentage of eggs hatched is 19.6 with a maximum 50 percentage and a minimum 0. Almost 50 percent of the eggs that were hatched were lost by death.

S. No.	Egg laying date	Location	Clutch size	Hatched date	Incubation period	Hatchling no.	% of eggs hatched	Death during hatching	Post-hatching mortality	Infertile eggs
1	5 April	Khoriya Muhan	18	14 June	71	9	50.0	0	0	9
2	31 March	Hattisar,Khoriya	36	16 June	78	8	22.2	0	7	21
3	31 March	Bhelauji	41	16 June	NA	0	0.0	0	40	1
4	4 April	Bhelauji	33	15 June	71	12	36.3	0	19	2
5	5 April	Bhelauji	30	15 June	70	2	6.6	0	10	18
	Sub-Total		158			31	19.6	0	76	51

Table 13: Reproductive effort of gharial in Narayani River, CNP in 2013

5.0 Discussion

The park management needs to focus in the protection of prime habitats which the gharials use for basking and nesting activities.

Most of the gharials in Narayani River used sand bank for basking. Only about 3.3 percent used rock bank which included the juveniles.

During the monsoon season to withstand from flooding the gharials were seen in Arun Khola and Gundre Khola.

The population represents both the wild and reintroduced gharials and therefore assumes this number as stable. The presence of only one breeding male for years could be disastrous to the continued existence of this critically endangered species. The gharial breeding conservation center must adopt effective conservation measures such as ban of fishing activities in nesting sites and other key gharial bearing areas, strict patrolling and monitoring in each block of the river to discourage illicit human activities (use of gill nets, stealing of eggs, human movements, poisoning and sand/stone mining). There has been very little effort in investigating the populations, habitats, ecology, breeding ecology, dispersal, home range of reintroduced gharials in Narayani River. Therefore, the Gharial Conservation and Breeding Center should initiate the radio-tracking of breeding male and females to monitor their dispersal and behavioral activities. Such information could be extremely beneficial in designing the conservation strategy to ensure the long term conservation of gharials.

Regular monitoring of wild and reintroduced gharials needs to be carried out to evaluate its population status, habitat requirements and effects of existing conservation practices to gharials and assess the impacts of overfishing to the survival of gharials in the Narayani River.

The gharials are mostly active during the months of February to March. This is because of the appropriate season when gharials spend most of their time in basking in order to keep their body warm, while in the summer months, they prefer to be in the water to avoid excessive heat.

The basking sites of gharials are under severe pressure from overfishing and human disturbances. This study emphasis the need of regulating fishing activities during basking and breeding season

(February-March) to the improvement of habitats and ensuring the survival of this species. The respective park posts should be involved in the monitoring of habitats and population.

The park management during breeding season monitors the movement and behavior of breeding females in order to locate the selection of nesting sites by these females. The fishermen of the local community (Bote and Majhi) are deployed by the park from the beginning of March to end of June. These fishermen are stationed at Bhosar, Seri and Malebagar and regularly monitor their respective area till the completion of egg laying period.

The current management practice adopted by the CNP is first the location of nesting sites including the trial nests and nests. After probing the nests, the eggs are taken out and transported to other areas said to be safer from the poachers. The eggs are kept for a period of 4 weeks before being transported to dugout pits on the sand bank near the Gharial Project at Amaltari. The eggs are hatched here on the completion of incubation period. The hatchlings begin to make noise prior to hatching.

The frequent handling of eggs from the natural nests is inappropriate that could result in the damage of eggs due to jerking of egg contents as well as change in the climatic conditions such as temperature, humidity and the quality of the sand.

The existing management measures are not focused on the environmental factors such as temperature of the nest, humidity and quality of sand which are the important requirements for the incubation. This is one of the reasons for decline of hatching success. The park management must carry out detailed assessment of environmental factors affecting the incubation.

6.0 Conservation threats

Despite of all the conservation actions, gharial population in Nepal is staying at a critically low level. The major threats to the gharials are identified as:

Industrial pollution: The most widespread form of pollution is organic waste from domestic and industrial sources. There is a little doubt that pollution could be the cause of gharial population decline. Increasing industrialization is leading to increase in pollution loads from factories. The discharges from the industries directly in the Narayani River could be harmful to the gharial population.

Dams: The Tribeni dam at the international border with India has created a large expanse of stagnant condition of water between Malebagar and Tribeni. This may lead to negative consequences to the survival of gharials which mostly prefer fast flowing deep water. Besides this, the dam acts as a barrier to the movement of spawning fishes and gharials. Once flushed by the monsoon flood the gharial cannot come back into Nepal through this dam. A transboundary dialogue should be arranged to address these issues. The large dam in Tribeni has been built between Nepal and India that allow gharials to go in India following the stream, but once in the Indian side, they can't go back in Nepal. During the monsoon season, the huge stream bring a large number of gharial to India. Thus, it's impossible for them to return to their original habitat, decreasing the Nepalese population.

Overfishing: The Chitwan National Park have provided the fishing license to the traditional fishermen to support their livelihood. Besides, this wetland dependent communities, others are also intensively fishing in the river on both banks resulting to scarcity of fish prey base, disturbances to the gharials and loss of habitat. The fisher men use large fishing net (gill net) which largely threatens the gharial population due to risk of being entrapped. Small sized mesh nets are often used which removes both adult breeding stock and fingerlings from the populations reducing the possibilities of future breeding and recruitment from the areas.

7.0 Conclusion and recommendations

Very little efforts have been made to address the growing anthropogenic pressures in the river systems of Chitwan National Park including the Narayani River due to which the gharial population is declining to a critical situation. There is no regular monitoring and conservation measures to the reintroduced gharials which hinder the conservation of this critically endangered species. Therefore, the upcoming Gharial Conservation Plan should focus on these issues.

A detailed study of habitat requirements, population, reproductive efforts, hatching success of gharials should be carried out through radio tagging.

The population monitoring, seasonal movement, home range and dispersal and effects of Gandak Barrage on gharials should be studied with radio-telemetry.

The Gharial Breeding Center should carry out intensive monitoring and implement appropriate management interventions during the breeding period (March – June).

The Gharial Breeding Center should monitor the nest temperature and humidity and human disturbances of the nesting sites of the gharials.

Training on gharial census and monitoring, egg probing, egg collection techniques, egg transportation and handling of essential equipments.

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