Enhancing the Reproductive and Hatching Success of Critically Endangered *Gavialis gangeticus*

A Booster Grant Final Report Submitted to

The Rufford Small Grants Foundation, UK

Sunil L Rajbhandari, Team Leader

Paras M. Acharya, Team Member

Bed Bahadur Khadka, Team Member

17 September, 2017

Acknowledgement

We would like to thank to **THE RUFFORD FOUNDATION**, Small Grants Program, and U.K. for the funding of this research. We also express our sincere thanks to the Department of National Parks and Wildlife Conservation (DNPWC) and Chitwan National Park (CNP) for providing permission to carry out this research in the Narayani River. We are grateful to Prof. Dr. Jeffrey W. Lang of University of North Dakota, University of Minnesota and Prof. Dr. David Edds of Emporia State University for their guidance, encouragement and constant support to the successful implementation of this project. We are thankful to IDEA Wild for supporting with the equipment. Lastly, thanks also go to the fishermen of GCBC, Mr. Sante Bote, Mr. Bir Bahadaur Bote, Mr. Mama Bote and Mr. Mungre Bote for their help during the gharial survey.

Acronyms/Abbreviations

CITES	Convention on International Trade of Endangered Species
GCA	Gharial Conservation Alliance
GCBC	Gharial Conservation and Breeding Center
CNP	Chitwan National Park
CSG	Crocodile Specialists Group
DNPWC	Department of National Parks and Wildlife Conservation
IUCN	International Union for the Conservation of Nature

Table of contents

List of Tables

List of Figures

Abstract

The gharial crocodile is one of the key indicator species of river systems of Nepal. This study was carried out in Narayani River of Chitwan National Park to determine the breeding requirements and evaluate the insitu and exsitu incubations of G. gangeticus. The survey was conducted from February 2017 to June 2017 by using two dugout canoes with four citizen scientists and two experienced researchers. The survey recorded a total of 89 gharials including 1 juvenile, 46 subadults and 42 adults indicating the large representation of subadults and adults in the population. Of the 42 adults, 13 were identified as adult breeding females according to the count of the natural nests. Of the 7 exsitu nests monitored, the average percentage of eggs hatched was found to be 58.13. There was no significant difference in hatching success with respect to the locations. A total number of 160 hatchlings were hatched out from 6 insitu nests. This study strongly recommends the need of strengthening the insitu conservation of gharials in the river systems of Chitwan National Park to ensure minimum viable population.

Key words

Gharial crocodile, Gavialis gangeticus, Narayani River, Insitu incubation, Exsitu incubation, Chitwan National Park, hatching success

1. Introduction

The gharial, *Gavialis gangeticus* is a large crocodilian with a long, slender snout. Of the 23 species of crocodilians, which inhabit a range of aquatic ecosystems, the gharial is the only surviving member of the family, Gavialidae. The Gharial is a critically endangered reptile species endemic to Nepal and India (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 total population of gharial in the Narayani River of Nepal is estimated at 89 (CSG, 2017). 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 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 and construction of barrages at the border with India.

This study gives insight into the breeding status of gharial in Narayani River of Chitwan National Park.

2. Objectives

The overall objective of the study is to understand the breeding requirements, evaluate the hatching success and suggest appropriate conservation efforts to the park managers to ensure long term conservation of gharials in the river systems of Chitwan National Park.

Specific objectives

- Assess the breeding status of *Gavialis gangeticus* in the Narayani River of Chitwan National Park
- Assess the hatching success of gharials.

3. Study Area

This study was carried out in the Narayani River within Chitwan National Park (CNP) (27°16' 56" to 27°42' 14" N and 83°50' 23" to 84°46'25" E) with an area of 932 km² has a diverse terrestrial and aquatic ecosystems with elevation ranging from 110 to 850 m. The climate is subtropical and receives high precipitation during the monsoon season. The temperature reaches up to 38°C in summer (June-July) and drops up to 6°C during winter (December-January). About 70% of the park area is covered by *Shorea robusta* forest, and the remaining area is characterized by grasslands and riverine forests. The Narayani, Rapti, Reu are the major rivers and their flood plains including oxbow lakes, marshes and swamps (Fig. 1 & 2).

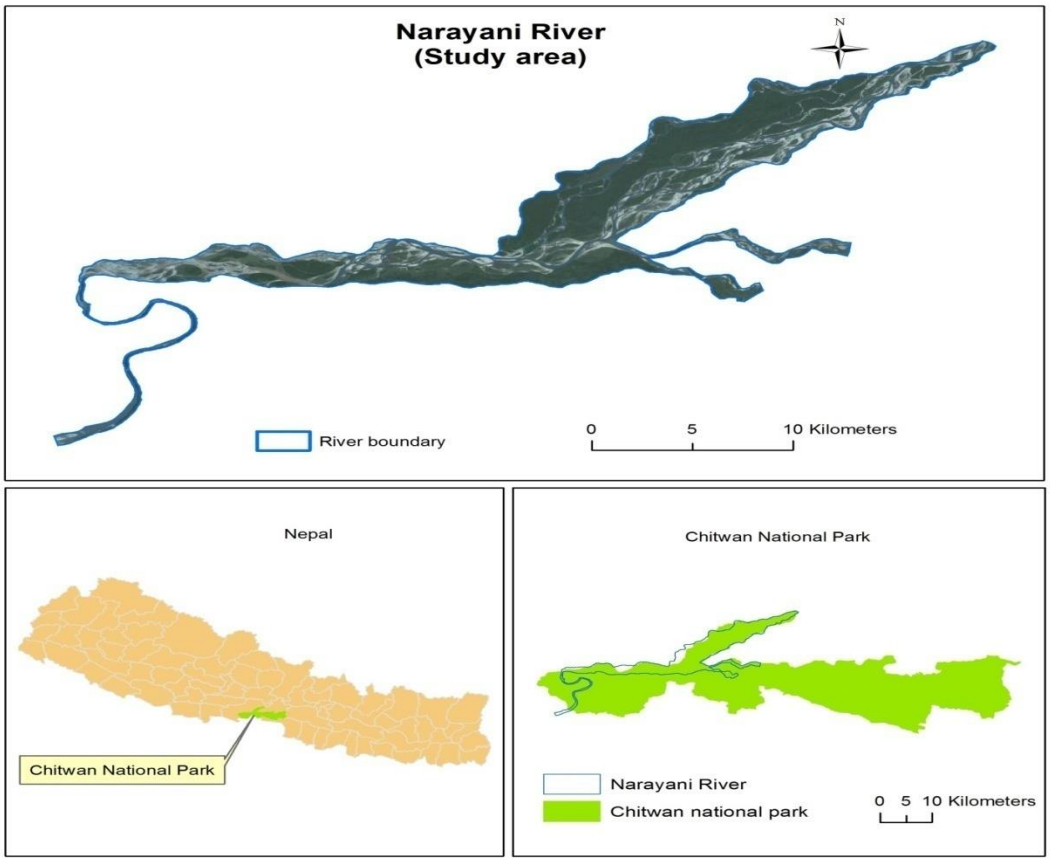

Figure 1. Chitwan National Park showing Narayani River

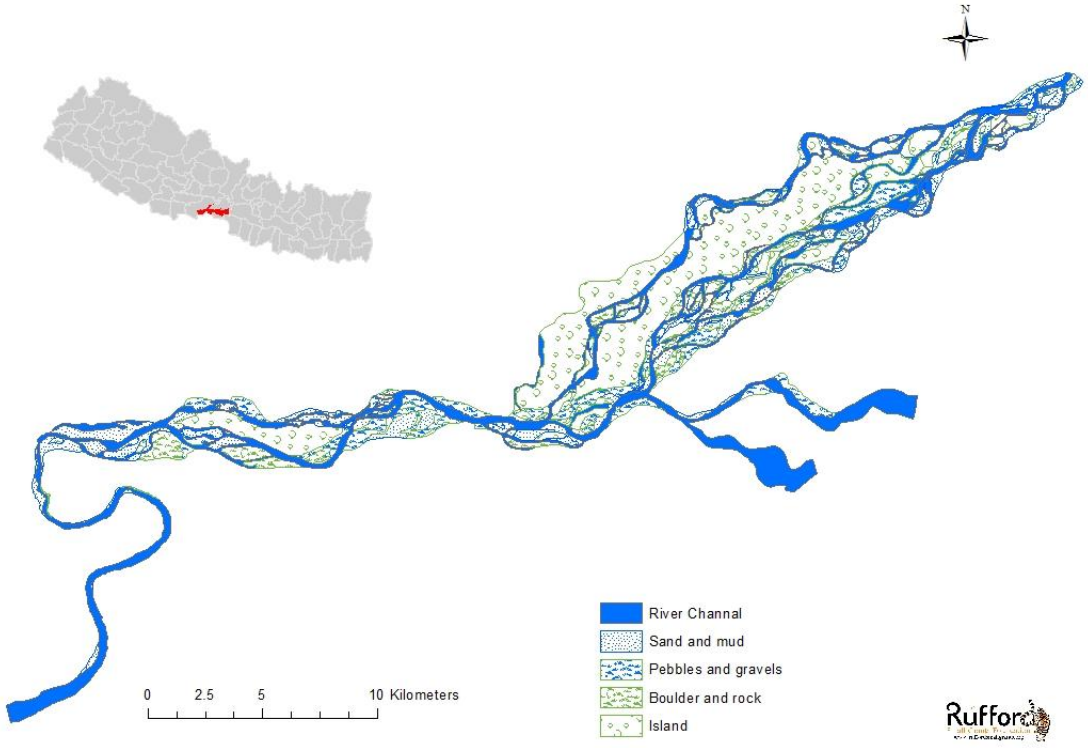

Figure 2. Narayani River morphology

This study was conducted during from February, 2017 to June, 2017 in the Narayani River. The study area was divided into 3 sectors. A total of 100 km (from Sikrauli to Tribeni barrage) was intensively surveyed for the population count and monitoring of gharials during February, 2017 to June, 2017. The 3 study sectors included- Sector A (Sikrauli to Amaltari via western branch); Sector B (Sikrauli to Amaltari via eastern branch); and Sector C (Amaltari to Tribeni barrage) (Table 1).

Table 1: Survey Sectors within the Narayani River, CNP

River	Zone	Survey sectors and its GPS location						Length
		From	Easting	Northing	To	Easting	Northing	
Narayani	A	Sikrauli	84.323735	27.690551	Amaltari via western branch	84.120833	27.554696	27 km
Narayani	B	Sikrauli	84.323735	27.690551	Amaltari via eastern branch	84.120833	27.554696	31 km
Narayani	C	Amaltari	84.120833	27.554696	Tribeni	83.935182	27.451963	42 km

4. Materials and Methods

Population count: Two dugout canoes were used for the survey of gharials in the Narayani River from Sikrauli to Tribeni barrage, at the international border with India. The route followed from Sikrauli to the Rapti Narayani confluence near Amaltari via eastern branch and Sikrauli to Amaltari via western branch. The survey then followed from Amaltari to Tribeni including shallow branches of the Narayani River.

The survey team included four experienced researchers and four citizen scientists. The 3 Sectors were surveyed in the same order. The speed of the travel was in a range of 3.0 km/hr to 3.85 km/hr depending on the length of river segments. The survey was completed within 4 days. The survey started from 10 A.M. to 5 P.M. The total hours spent during the survey was 28 hours. During the foggy weather, gharial counts were done only when visibility up to the distance of 100 m became clear. 7x35 Olympus DPSR binoculars/10x50 DPS1 OLYMPUS were used for gharial day counts.

During the breeding season (23rd March 2017 to 7th April 2017), adult breeding females were monitored for locating the natural nests.

Mature female individuals of *G. gangeticus* populations have often been estimated based on nest counts as they are easily visible and can be counted at well known locations that have been monitored for decades. This is considered a more accurate assessment of mature female gharial numbers because of the unknown number of immature males (which take five or more years longer to mature than do females) and which have often upwardly biased the estimation of 'adult' *G. gangeticus* (Choudhury *et al.* 2007).

The study found 13 natural nests in the upstream and downstream water courses of Narayani River. Of the 13 natural nests, 6 nests were left intact for insitu incubation. The remaining wild nests were immediately shifted by Gharial Conservation and Breeding Center (GCBC) to the nearby upstream sand bank for artificial incubation. These nests were finally transfered to the sand bank of Gharial Monitoring Station in Amaltari for stringent protection of the exsitu eggs. The insitu nests were regularly monitored by the park fishermen.

5. Results

Population Status

The study has recorded 89 individuals of gharial. Of the 3 Sectors surveyed, Sector B represents 61.79 % of the total day count. The relative density of the gharials in the Narayani River is 0.89 individual/km. Sector B represents the the highest relative density with 1.77 individuals/ km as compared to other sectors (Table 2).

Table 2. Day count of G. gangeticus during February, 2017 in Narayani River, Chitwan National Park, Nepal

Sectors	**Sector A**	**Percentage**	**Sector B**	**Percentage**	**Sector C**	**Percentage**	**Total**	**Relative Density ind./km**
No. of gharials	6	6.74	55	61.79	30	33.70	89	0.89

Figure 3. Adult breeding male basking in sand bank of Narayani River

Figure 4. Adult breeding female gharials at the edge of Narayani River

Habitat Utilization

About 88 % of the gharials used sand bank for basking purpose and 12 % of the gharials use rock. This result also matches with the findings of Rajbhandari & Acharya (2013) with 85 % of the gharials using sand bank for basking (Table 3).

Table 3. Habitat use of G. gangeticus during February, 2017 in Narayani River, Chitwan National Park, Nepal

Habitat	No. of gharials	Percentage
Sand bank	78	87.64
Rock	11	12.35

Size Structure

Of the total population counts of gharials, juvenile comprised 1.12 % followed by subadult 51 % and adults 47.19 % (Table 4).

Table 4: Size distribution of G. gangeticus during February, 2017 in Narayani River, Chitwan National Park, Nepal

Size class	Age class	No. of gharials	Percentage
<120 cm	Hatchling	-	-
>120-180 cm	Juvenile	1	1.12
>180-270 cm	Subadult	46	51.68
>270 cm	Adult	42	47.19
Total		89	100

Of the 3 Sectors surveyed the Sector B (Sikrauli to Amaltari via eastern branch) showed 24.71 % of the total count. Similarly, Sector B has the highest number of adults with 34.83 % (Table 5).

Table 5: Size class of G. gangeticus in river sectors during February, 2017 in Narayani River, Chitwan National Park, Nepal

Size class	Age class	Sector A	Percentage	Sector B	Percentage	Sector C	Percentage
<120 cm	Hatchling	-	-	-		-	
>120-180 cm	Juvenile	-	-	-		1	1.12
>180-270 cm	Subadult	5	5.61	22	24.71	19	21.34
>270 cm	Adult	1	1.12	31	34.83	10	11.23
Total		6		53		20	

Breeding status

The study recorded 13 natural nests of gharials in the Narayani River. Of the 13 natural nests, 6 nests were recorded from Velaunji at the downstream watercourse of Narayani. The Narayani River in the Velaunji area flows in between the gorge, with deep water and rocky banks with patches of elevated sand banks. This area of Narayani is used by 6 breeding females for nesting purpose. Even though the impact of Gandak barrage to the Gharial population is rampant, these adult breeding females constantly use these sites for nesting.

One natural nest was recorded from Gaindakhasa (Seri) near the Bagban Post.

4 natural nests have been recorded near Rapti and Narayani confluence with 4 adult breeding females preferring this site for nesting. Of the 4 nests, 3 are in Khoria Muhan and 1 in Banderjhoola. 1 natural nest was also recorded in Hirapur area of Narayani Rivetr. The river channel in these areas represents shallow channel with large sand bars with less human disturbances.

Out of 13 nests, eggs from 7 natural nests were collected by the park fishermen from Velaunji, Banderjhoola, Khoria Muhan and Malebagar and transported to Gharial Project, Amaltari for ex-situ incubation (Fig. 5 & 6). It was kept in artificial dug out pits in the sand. It was regularly monitored by the fishermen of the gharial monitoring center.

Six natural nests were left for in-situ incubation in Velaunji and Gaindakhasa. These in-situ nests were regularly monitored by the park fishermen.

Figure 5. Location of natural nests of gharial in Khoria Muhan of Narayani River

Figure 6. Location of natural nests of gharial in Velaunji of Narayani River

Exsitu Incubation

The clutch size of the laid eggs ranged from 28 to 44 in each of the probed natural nest from where all the eggs were collected for ex-situ incubation. The number of trial nests ranged from 1 to 3 in each of the egg laid areas.

The average clutch size of the collected eggs was 29 eggs and the maximum and minimum clutch size was 43 and 17 respectively. The average percentage of eggs hatched is 58.13 and the maximum and minimum percentage was 75 and 42.86 respectively. The average number of hatchlings was 17 % with maximum and minimum values of 25 and 12 respectively (Table 6; Fig. 7).

Table 6: Nest location, clutch size and hatching success of G. gangeticus in exsitu incubation during 2017 in Narayani River, Chitwan National Park, Nepal

Nest No.	Location	Northing	Easting	Clutch size	Incubation period	Hatched no.	Hatched no.	Remarks
1	Khoria Muhan	217443	3050542	28	80	21	75.00	Exsitu incubation
2	Khoria Muhan	217443	3050542	35	82	15	42.86	Exsitu incubation
3	Khoria Muhan	217443	3050542	17	87	12	70.59	Exsitu incubation
4	Velaunji	792831	3048130	43	85	25	58.14	Exsitu incubation
5	Malebagar	206936	3049480	26	70	12	46.15	Exsitu incubation
6	Bandarjhula	221123	3055686	32	81	22	68.75	Exsitu incubation
7	Khoria Muhan	217443	3050542	22	86	10	45.45	Exsitu incubation

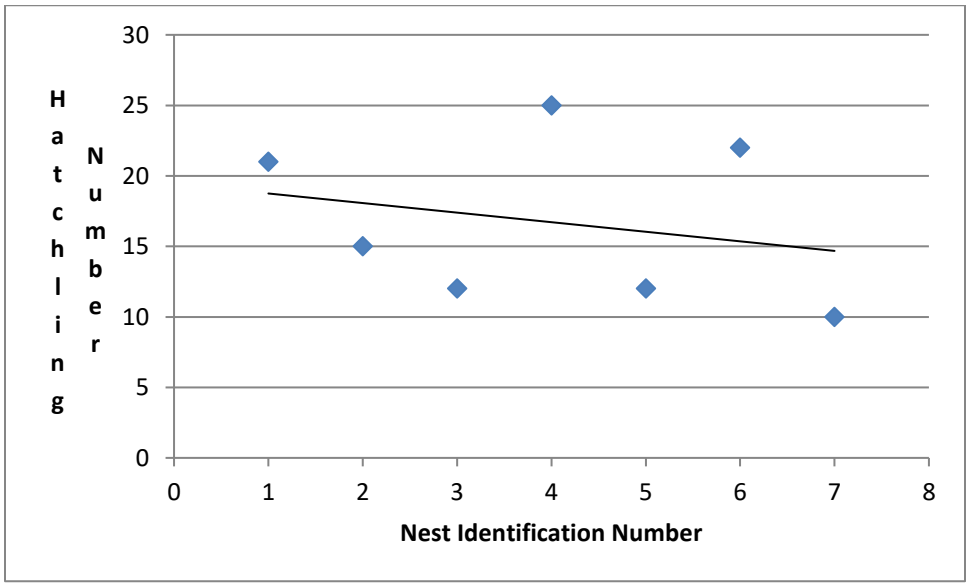

Figure 7. Hatchling success of G. gangeticus in exsitu incubation in Narayani River

Hatchling success did not varied with the nesting sites (Chi. Square = 12.38, P = 0.053). The average percentage of eggs hatched was 58.13. Rajbhandari & Acharya (2013; 2015) estimated an average of hatching success as 26.94% and 16.60% respectively thus indicate increased hatching success (Fig. 8, 9 & 10).

Figure 8. GCBC staff collecting eggs for exsitu incubation

Figure 9. Collection of gharial eggs from Narayani River

Figure 10. Gharial hatchlings emerging from exsitu incubated eggs in Amaltari

Insitu Incubation

Of the 6 wild nests left intact for insitu incubation, 182 hatchlings emerged from the eggs. The average number of hatchlings is 30 individuals with maximum and minimum values 40 and 20 respectively (Table 7; Fig. 11).

Table 7: Nest location and hatching success of G. gangeticus in insitu incubation during 2017 in Narayani River, Chitwan National Park, Nepal

Nest No.	Location	Northing	Easting	Nest No.	Hatched No.	Remarks
1	Velaunji	792547	3048464	1	35	Insitu incubation
2	Velaunji	792547	3048464	1	30	Insitu incubation
3	Velaunji	792202	3048266	1	40	Insitu incubation
4	Velaunji	792202	3048266	1	35	Insitu incubation
5	Gaida Khasa	206936	3049480	1	20	Insitu incubation
6	Hirapur			1	22	Insitu incubation

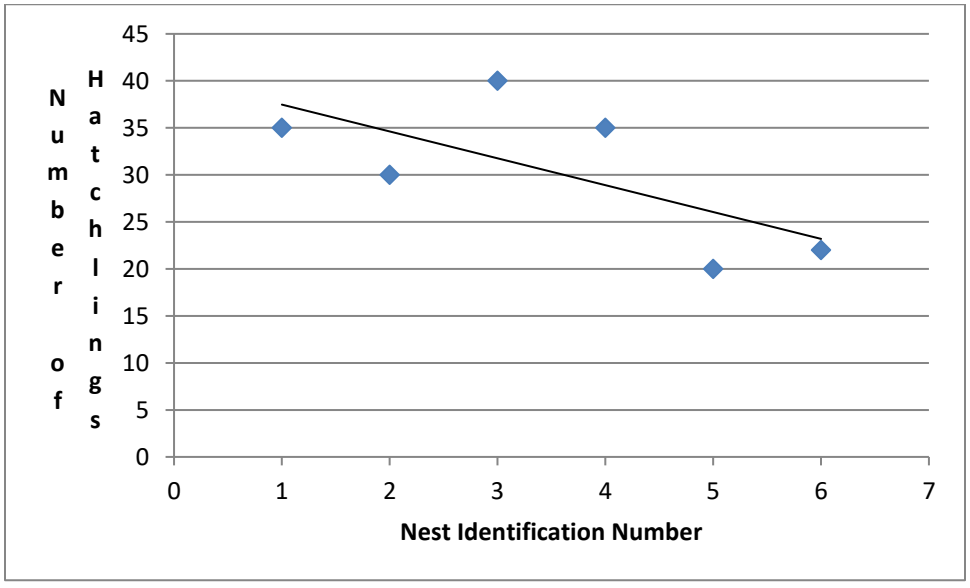

Figure 11. Hatchling success of G. gangeticus in insitu incubation in Narayani River

The hatching success did not differed with the nesting sites (chi. Square = 10.29, P = 0.066).

The hatching of the eggs differed significantly between natural hatching and artificial hatching (t-test, P = 0.004).

6. Discussion

This study recorded a total of 89 gharials including 1 juvenile, 46 subadults and 42 adults (2 Males and 40 females) in the Narayani River. A study of gharials in Narayani River by Acharya et al, 2017 indicated 84 gharials including 48 females,1 male and 35 subadults. The female counts also include non-breeding individuals. Their study does not identify the number of adult breeding females according to the natural nests. There was a slight difference in population counts of 2016 and 2017. The survey of gharials carried out in the Narayani River by Rajbhandari & Acharya (2013 & 2015) recorded 13 individuals. It shows an increase in the population of gharials in the Narayani River. Rajbhandari & Acharya (2013) in a study of gharials in Narayani River also found highest number of subadults. The study in 2012 recorded 7.89 % of hatchling, 21.05 % of juvenile, 37.5 % of subadult and 47.87 % of adults (Rajbhandari & Acharya, 2013). Similarly, their study during 2014 gharial survey recorded 1.66% of hatchling, 26.66% of juvenile, 51.66% of subadults and 20.0% of adults indicating the large representation of subadults in the population.

The survey recorded 13 natural nests thus indicating 13 adult breeding females in Narayani River as compared to the count of natural nest found in 2014 (Rajbhandari & Acharya, 2015). Only 6 natural nests were located in Narayani River during 2014 (DNPWC, 2015) and thus indicating only 6 mature breeding females. Altogether 53 nests were collected from the Narayani River during the 6 nesting seasons of 1977-81 and 1987 (Maskey, 1989). The reduction of the natural nests since then is due to loss of nesting and basking sites, sand-mining, the construction of dams, barrages and irrigation structures, industrial pollution, artificial embankments, river-bank land use changes, modification of river morphology, riparian agriculture, egg collection, over fishing, drowning in gill nets, killing for indigenous medicine, domestic and feral livestock and retaliatory measures by fishermen have all contributed to the decline of this enigmatic species (Biswas 1970, Whitaker 1975, Whitaker 2007, Choudhury *et al.* 2007; Taigor 2007; Whitaker and Stevenson, 2010; Nair *et al.* 2012; Rajbhandari and Acharya, 2013).

This study revealed the clutch size ranging from 28 to 44 eggs collected for ex-situ incubation with an average of 29 eggs. Rajbhandari & Acharya (2013) recorded the maximum clutch size of 41 eggs and minimum of 18 eggs. Comparing the data of Rajbhandari & Acharya (2013), the clutch size of the eggs has increased overtime.

The existing practice of collecting the laid eggs from each nest and relocating to other places presumably bear risk of damaging the eggs, the females will be disturbed and there is no guarding of the nests by the females. Lack of care of nest and handling of the eggs will lead to high mortality (Rajbhandari & Acharya, 2013; Rajbhandari & Acharya, 2015).

There is a considerable increase in the number of natural nests in the Narayani River as compared to the natural nests number that was recorded in 2012 which numbered to 5 natural nests (Rajbhandari & Acharya, 2013). The study shows the increase in the number of adult breeding females totaling 13 in 2017.

According to Rajbhandari & Acharya, 2013, only 5 nests with a total of 158 eggs were collected from Velaungi, Khoria Muhan and Hattisar Khoria. The reduction in the number of nesting sites over years is due to high fishing pressures. The fishermen use large gill nets (Tiyari) for fishing which collect many small to large fish causing reduction in the prey base. Occasionally, the gharials get entangled in these nets. Rajbhandari & Acharya, 2015 recorded 7 natural nests with a total of 252 eggs from Velaunji, Siswar, Seri and Khoria Muhan. This study showed an increasing trend of natural nests in the Narayani River from 2013 to 2017.

7. 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 isssues.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.

8. Conclusion

The number of breeding females in the Narayani River has increased and thus the number of natural nests has also increased accordingly. The hatching success is also in the increasing trend in exsitu condition.

9. References

Biswas, S. 1970. A preliminary survey of Gharial on the Kosi River. *Indian Forester* 96(9): 705-710.

Choudhury, B.C., Singh, L.A.K., Rao, R.J., Basu, D., Sharma, R.K., Hussain, S.A., Andrews, H.V., Whitaker, N., Whitaker, R., Lenin, J., Maskey, T., Cadi, A., Rashid, S.M.A., Choudhury, A.A., Dahal, B., Win Ko Ko, U., Thorbjarnarson, J. and Ross, J.P. (2007). *Gavialis gangeticus*. *In* IUCN 2009. IUCN Red List of Threatened Species. Version 2009.

DNPWC. (2015). Annual Report (Shrawan – Asadh).

GCA (Gharial Conservation Alliance) (2008). International Gharial Recovery Action Plan. http://www. gharialconservation.org/PDF/GRAP.pdf.

Maskey, T. M. (1989). *Movement and survival of captive-reared gharial Gavialis gangeticus in the Narayani River, Nepal* (Doctoral dissertation, University of Florida).

Nair, T. (2010). *Ecological and anthropogenic covariates influencing gharial Gavialis gangeticus distribution and habitat use in Chambal River, India* (Doctoral dissertation, Thesis submitted in partial fulfillment of Master of Science in Wildlife Biology and Conservation. Tata Institute of Fundamental Research, National Centre for Biological Sciences, India).

Rajbhandari, S.L. & Acharya, P.M. 2013. Study of Habitat and Population of Endangered *Gavialis gangeticus* in Narayani River of Chitwan National Park, Nepal. A First phase research report submitted to Rufford Foundation, U.K. 25 pp.

Stevenson, C. and Whitaker, R. (2010). Indian Gharial *Gavialis gangeticus.* Pp. 139-143 *in* Crocodiles. Status Survey and Conservation Action Plan. Third Edition, ed. by S.C. Manolis and C. Stevenson. Crocodile Specialist Group: Darwin.

Taigor, S. 2006. Threats of Sand Mining on the nesting of Turtles and Gharial in the National Chambal Sanctuary, Madhya Pradesh. Submitted to Madhya Pradesh State Biodiversity Board, Bhopal.

Whitaker, R. 1975. Status and conservation of the Gharial. Herpetological Review 6:1–3.

Annex 1. Gharial census, 2017											
Date	**Gharial number**		**GPS Location**	**Place**	**Habitat**	**Size**	**Sex**	**River width (m)**	**River depth (m)**	**Human disturbance**	**Remarks**
23-Feb	1	227637	3059234	Bhagadi	Sandbank	Adult	Female	70	2.3	Human movement	
23-Feb	1	227296	3059329	Bhagadi	Sandbank	Subadult		100	1.7	Human movement	
23-Feb	1	225765	3058664	Bhagadi	Sandbank	Subadult		60	1.25	Human movement	
23-Feb	1	223772	3055829	Dadreni	Sandbank	Subadult		70	1.5	Human movement	
23-Feb	1	222764	3055719	Dadreni	Sandbank	Subadult		50	2.75	Human movement	
23-Feb	1	220504	3053920	Sissabans	Sandbank	Subadult		70	0.75	Thatch collection	
23-Feb	1	216312	3052087	Below Rapti confluence	Sandbank	Subadult		200	2.7	Overfishing	
23-Feb	1	218313	3051595	Below Rapti confluence	Sandbank	Adult	Female	150	2.5	Overfishing	
23-Feb	4	218313	3051595	Below Rapti confluence	Sandbank	Adult	Female	150	2.5	Overfishing	
23-Feb	5	217527	3050621	Khoriya Muhan	Sandbank	Subadult		50	1.9	Fishing activities at	

										night	
23-Feb	11	217461	3050582	Khoriya Muhan	Sandbank	Adult	Female	50	1.9	Fishing activities at night	
23-Feb	1	217461	3050582	Khoriya Muhan	Sandbank	Adult	Male	50	1.9	Fishing activities at night	Hermon smell
23-Feb	2	217461	3050582	Khoriya Tudo	Sandbank	Adult	Female	50	1.9	Fishing activities at night	
23-Feb	1	216603	3050396	Khoriya Tudo	Sandbank	Adult	Female	80	1.7	Fishing activities at night	Abnormal body shape
23-Feb	7	216603	3050396	Khoriya Tudo	Sandbank	Adult	Female	80	1.7	Fishing activities at night	
23-Feb	3	216440	3051298	GMC east	Sandbank	Subadult		100	1.45	Fishermen camping at sandy island	
23-Feb	3	216014	3051264	GMC east	Stone bank	Subadult		100	2.3	Fishermen camping at sandy island	
23-Feb	2	215290	3051138	GMC south	Sandbank	Subadult		75	1.9	Fishermen camping at	

										sandy island	
23-Feb	1	214763	3050790	Amaltari	Stone bank	Subadult		200	2.75	Fishermen camping at sandy island	
23-Feb	2	213399	3050559	Amaltari Ghat	Sandbank	Subadult		50	2.25	Fishermen camping at sandy island	
23-Feb	1	213399	3050559	Amaltari Ghat	Stone bank	Subadult		50	2.25	Fishermen camping at sandy island	
23-Feb	2	211961	3051588	Below Amaltari Ghat	Stone bank	Subadult		300	2.2	Overfishing	
23-Feb	1	210719	3052247	Brahmasthan	Stone bank	Adult	Female	250	2.3	Overfishing	
23-Feb	1	209283	3051563	Ratanpur	Stone bank	Subadult		75	2.1	Overfishing, livestock grazing	
23-Feb	1	207479	3050277	Nandanpur	Stone bank	Subadult		100	1.9	Overfishing, livestock grazing	
23-Feb	1	207586	3049886	Gaindakhasa	Stone bank	Subadult		75	1.6	Overfishing	
23-Feb	3	206936	3049480	Seri	Sandbank	Subadult		75	4	Human movement	
23-Feb	1	203992	3050421	Badagadi	Sandbank	Subadult		200	1.3		

24-Feb	1	792106	3050760	Tamaspur	Sandbank	Subadult		200	2.3	Overfishing	
24-Feb	1	790553	3049725	Nunah	Sandbank	Subadult		100	3	Overfishing	
24-Feb	2	789508	3050599	Materi	Sandbank	Subadult		100	3	Overfishing	
24-Feb	1	788309	3019295	Darasing	Sandbank	Subadult		100	3		
24-Feb	1	788664	3047362	Malebagar	Sandbank	Adult	Female	100	4		
24-Feb	1	791419	3047926	Kathauna Tundo	Sandbank	Juvenile		100	4	Natural recruitment	
24-Feb	2	792199	3018197	Velaunji	Sandbank	Subadult		150	5		
24-Feb	7	792199	3018197	Velaunji	Sandbank	Adult	Female	150	5		
24-Feb	1	792199	3018197	Velaunji	Sandbank	Adult	Male	150	5		
26-Feb	1	217048	3053044	Jogimara	Sandbank	Subadult		50	1.3		
26-Feb	1	220961	3058893	Bhosar Ghat	Sandbank	Subadult		50	3		
26-Feb	3	224408	3060474	Sirki Tappu	Sandbank	Subadult		75	3		
26-Feb	1	226449	3063103	Chippani	Sandbank	Adult	Female	75	3		
27-Feb	1	230629	3061478	Sisuwar	Sandbank	Subadult		150	2		
27-Feb	2	230236	3061310	Sisuwar	Sandbank	Adult	Female	150	1.4		
27-Feb	1	228503	3059556	Sisuwar	Sandbank	Subadult		150	1.85		
27-Feb	1			Bandarjhula	Sandbank	Adult	Female	100	1.9		

Annex 2. Natural nest of G. gangeticus with depth, circumference, substrate, distance and height from water edge in Narayani River, Chitwan National Park, Nepal									
Nest No.	Location	DFEW*	River depth (m)	River width (m)	HFWL*	Substrate	Nest depth (m)	Nest circumference (m)	Remarks
1	Khoria Muhan	6.8	2.8	60	1.8	Sand	-	1.25	Exsitu incubation
2	Khoria Muhan								Exsitu incubation
3	Khoria Muhan								Exsitu incubation
4	Velaunji	10	-	100	2.65	Sand	0.55	1.45	Exsitu incubation
5	Malebagar								Exsitu incubation
6	Bandarjhula	2.35	5.0	60	1.25	Sand	0.60	1.35	Exsitu incubation
7	Khoria Muhan								Exsitu incubation
8	Velaunji								Insitu incubation
9	Velaunji								Insitu incubation
10	Velaunji								Insitu incubation
11	Velaunji								Insitu incubation
12	Gaida Khasa								Insitu incubation

Annex 3. Status of Gharial Hatching in Narayani River, 2017									
S. No.	**Lay Date**	**Location**	**Clutch size**	**Hatched Date**	**Incubation Period (days)**	**Hatchling no.**	**Hatchling Percentage**	**Death**	**Infertile Eggs**
1	24-Mar	KH	28	11-Jun	80	21	75	3	4
2	24-Mar	KH	35	13-Jun	82	15	42.86	1	19
3	24-Mar	KH	17	18-Jun	87	12	70.59	2	3
4	27-Mar	VL	43	19-Jun	85	25	58.14	3	15
5	07-Apr	ML	26	16-Jun	70	12	46.15	4	10
6	28-Mar	BJ	32	16-Jun	81	22	68.75	3	7
7	25-Mar	KH	22	18-Jun	86	10	45.45	4	8
	Total		**203**		**81.57**	**117**			

Narayani River locations: KH-KhoriaMuhan; VL-Velaunji; ML-Malebagar; BJ-Banderjhoola; KH-KhoriaMuhan

Annex 4. Status of Gharial Hatching (in-situ condition) in Narayani River, 2017			
S. No.	**Location**	**Nest No.**	**Hatchling No.**
1	Velaunji	1	35
2	Velaunji	1	30
3	Velaunji	1	40
4	Velaunji	1	35
5	GaidaKhasa	1	20
Total			**160**