

1. INTRODUCTION

1.1 Background

Information on biodiversity such as wildlife status (abundance, distribution and home range), population and community interaction and their contribution to ecosystem development is essential for conservation management of wildlife and protected area (Basnet 1998). Such information is developed by regular monitoring and maintaining records from various scientific methods.

The crocodile were once very widely distributed in most of Tarai lowlands of Nepal. Habitat loss has been a leading cause for Nepal's declining crocodile populations. This was accelerated in the mid 1950s when an intensive malaria eradication program opened the Tarai for habitation. Intensive fishing has reduced food levels and affected crocodile numbers. They become entangled in nets introduced for fishing and either drown or are killed by fishermen. Subsequently, egg collection and slaughter of crocodile by tribal hunters have been on going as a deterrent to fishing competition, as a food item, and for body parts through to have medical value. Also the construction of dams and barrages has blocked migratory routes. Hatchlings which emerge during the monsoon season are flushed below the barrages and cannot return during post monsoon season. Adults are similarly affected as populations from upstream areas move into vacated habitats and are flushed below the barrage in subsequent years. Lack of trained man power, sanitation and availability of life fish for feeding seem to be the major constrains at the breeding centers.

At preset they are mainly concentrated in the big river systems of Nepal. Since Koshi river is not completely covered by protected areas is more or less disturbed by the human activities like fishing and cattle grazing. Likewise, change in direction of flow, siltation of river beds during monsoon, high water velocities of swift current during flood are the other factors for the low survival and sighting of crocodiles in the Kohsi river. Downward movement of crocodiles during the monsoon period has been reported from Koshi river to Ganges in India.

In the early 1970s, a need felt to establish Wildlife Reserve in Koshi Tappu, a Ramsar site which covers a narrow strip of land along the southern edge of the country. Through two batches of captive *Gavialis gangeticus* were released in the Koshi river in 1982 and 1986, they are observed rarely (WMI/IUCN 1994) and the status of *Crocodylus palustris* is not known at present.

1.2 Species

An order Crocodylia that includes the crocodiles derived from thecodontian (Thecodontia) ancestors and closely related to the dinosaurs and pterosaurs. They are first recorded from Triassic rocks and were the only archosaurs to survive the Mesozoic Era. There are 23 species of extant crocodylians divided into three families: Alligatoridae (eight species; Alligators and Caiman), Crocodylidae (14 species; “True” crocodiles and Tomistoma) and Gavialidae (one species; *Gavialis gangeticus*).

They have distinct features such as long jaws, protected armour, streamlined body and long tail. These, together with various anatomical and physiological adaptations, make the crocodile perfectly suited to an aquatic and predatory lifestyle. These modern crocodylians form a relatively conservative group and differ from each other mainly in snout properties and minor dental and osteological characters (Iordansky 1973 in Bellairs 1987). Alligatoridae are characterized by having large, broader and more robust snouts, than Crocodylidae, they are able to withstand colder temperatures than Crocodylidae also and the most important part, their fourth tooth of the lower jaw fits into a pit in the upper jaw. Crocodylidae are characterized by having relatively slender jaws, a triangular snout, both the upper and lower teeth visible and the most important part, their fourth tooth of the lower jaw being visible. The Crocodylidae is the largest and most diverse of the living crocodylians. Gavialidae have extremely slender snouts that are used for catching fish in fast moving waters.

Among the 23 species of crocodylians, only two species are found in Nepal, the gharial *Gavialis gangeticus* and the mugger *Crocodylus palustris*. Gharial is one of the seven of the most threatened crocodiles in the world, now the first crocodylians species to be recategorized as ‘Critically Endangered’ on the 2007 IUCN Red List and Appendix I of CITES. Mugger is listed as ‘Vulnerable’ on the IUCN Red List and Appendix I of CITES. The crocodiles are protected under the National Park and Wildlife Conservation Act 1973. Hunting of crocodiles is no longer permitted (Andrew and McEachern 1994).

Gavialis is a corrupted deviation from the Hindi word *ghariyal* which is a name for “crocodile”. *Gangeticus* means “of the Ganges”. The name gharial originated from the “ghara” which describes the earthenware pot common in India and Nepal. It refers to the swelling at the tip of the upper jaw of the male’s snout (Smith 1931 in Maskey 1989). *Crocodylus* is derived from the Greek *krokodeilos* which means literally “pebble worm” (*kroko*=pebble, *deilos*=worm) referring to

the appearance of a crocodile. *palustris* means “marshy” or “swampy” (Latin), referring to extensive habitat where it is found, and hence one of its common names “Marsh crocodile”. “Mugger” is a corruption of the Hindi word magar which means water monster.

The gharial is exclusively a fish-eater, with long slender snout. Variation in snout shapes occurs with age (longer and thinner with increasing age). An adult male gharial develops a large hollow, cartilaginous protuberance at the end of the snout which is known as ‘Ghara’. It is believed to act as a sound resonator. The elongated jaws are lined with many interlocking teeth. The gharial is one of the largest of all crocodilian species (4-7m), usually they will not reach maturity before 13 years for the male and 16 years for the female (Maskey and Mishra 1981). The gharial is poorly equipped for locomotion on land as an adult-the leg musculature is not suited to raise the body off the ground, although it can do this with some speed when required (Ross 1998). The mugger is a medium to large species (3 to 5m) and has the broadest snout among the group. They have been reported to migrate considerable distance over land in search of more suitable habitat.

The survival of crocodile in nature is very low. Therefore, unless the existing populations are supplemented with additional numbers, these crocodiles will soon disappear from the area. It is for this reason that crocodile are being bred in captive and released back into the wild when they are mature (Khawarey 1995).

1.3 Importance of crocodile

Crocodiles are important for several aspects, such as their existence indicates the healthy aquatic ecosystems and their hide and meat has a big commercial value (Ahmad 1988). The crocodile is an ideal animal for ranching and farming: it has a classical hide valuable on the world market. In addition, crocodile meat and eggs are used as food in certain parts of the world.

Crocodiles help to distribute nutrients from the bottom of the riverbed to the surface water. Crocodile generally predate on coarse fish (scale less fish), which are not preferred by human beings, and these scale less fish predate on fish which humans prefer. They also keep the water clean and uncontaminated by scavenging on dead animals matter. So, they increase primary production and fish populations and maintain the aquatic ecosystem (Rahman 1992, Das 1981 and Singh 1978).

In Nepal, local tribes believe that a ghara of gharial placed the pillow of expected women relieve pain and speed labor (Maskey and Mishra 1981). Similarly, incense made from the ghara is believed to act as repellent for insects and other pests from the agriculture field. Teeth of crocodiles are used in medicine and ornaments. Gharial eggs are believed to have medicine value in part of Nepal. For example, the dry power of the egg is considered to be effective as a cough medicine (Maskey 1989).

Crocodiles are also used as resources in the parks and the zoos in the world. Department of National Park and Wildlife Conservation (DNPWC) gave total 12 gharials, four muggers and 78 crocodile's eggs as gift for Atagawa Tropical and Alligator Garden in 1979, 1978 and 1983. In return of which the Kasara Breeding Center get ten thousand US Dollar in 1983. Similarly, six gharials were given to the National Zoo of USA in 1982 (DNPWC 1988). Animals are closely associated with deities in Indian and Nepalese mythology (Singh 1986 in Maskey 1989). Crocodiles were regarded and worshipped as the vahana (vehicles) of the goddess Ganges. However, the growth of human populations in more recently years has overshadowed religious attachments, and the animals have exploited for commercial values.

1.4 Distribution and range

Both gharial and mugger species exist in the Indian Subcontinent. Their historical ranges extend from Iran (for mugger) and Pakistan (for the gharial) to Bangladesh (Andrews and Preston 1994) (Figures 1 and 2).

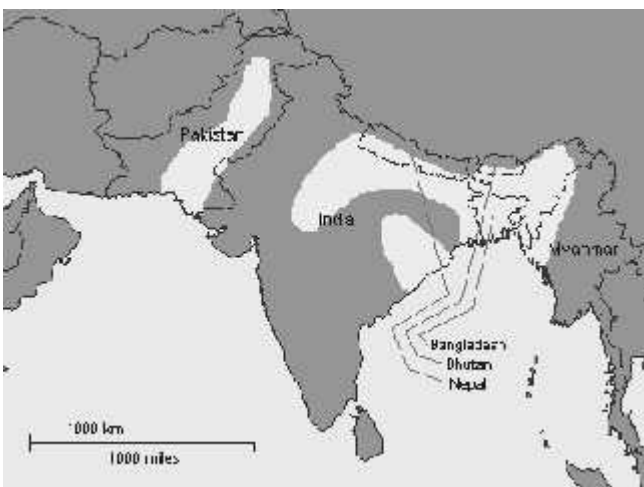


Figure 1. Distribution of Gharial in Indian Subcontinent

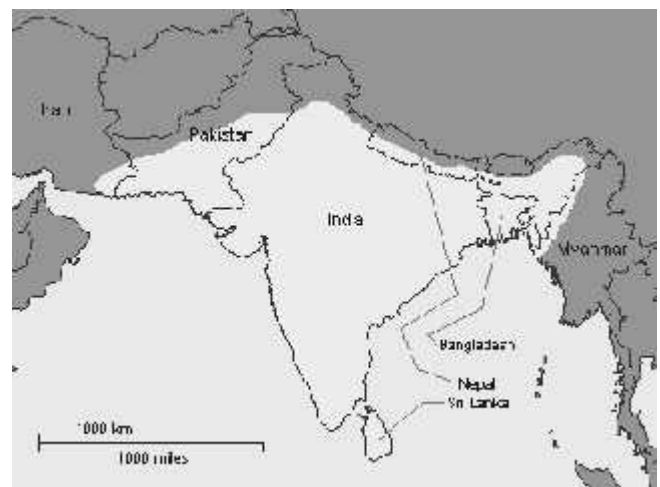


Figure 2. Distribution of Mugger in Indian Subcontinent

(Sources: www.flmnh.ufl.edu)

1.4.1 Gharial (*Gavialis gangeticus*)

Gharials were common locally during 19th and early 20th centuries in the major rivers of the Indian subcontinent (Whitaker 1975 and Whitaker and Daniel 1978). Because of habitat modification and disturbance, exploitation for hide and other commercial products, and coincidental netting in fishing operations, gharial is now extinct or extremely depleted throughout its former range (Groombridge 1982). Currently, the distribution of gharial is restricted only to Northern Indian Subcontinent where they are found within the rivers systems of the Brahmaputra (Bangladesh, India and Bhutan), the Indus (Pakistan), the Ganga (India and Nepal), and the Mahanadi (India), with small populations in the Kaladan and the Irrawaddy in Burma.



Figure 3. Past and present distribution of Gharial in Nepal
(Source: IUCN-Nepal 1993)

Until the early 1960s, gharials were found in all major river systems of Nepal including the Mahakali, the Karnali, the Babai and Bheri to the west; the Narayani and its tributaries including the Kali Gahdaki in central Nepal; and in the Sapta Koshi to the east Nepal (Maskey and Mishra 1981). By the late 1970s, there has become a drastic depletion in their abundance and

distribution; in fact, the wild gharial had become extinct in the Mahakali and Rapti and Koshi rivers (Figure 3). Presently, distribution and habitat is mainly restricted in or adjacent to two protected areas with a total estimation number of 96 to 103, Karnali and Babai rivers in Bardia National Park and Rapti and Narayani/Kali rivers of Chitwan National Park (Mishra 2002).

1.4.2 Mugger (*Crocodylus palustris*)

According to Whitaker *Crocodylus palustris* is widely distributed, but population is mostly small and isolated in India. Distribution outside India includes as isolated remnant population in Iran and a few animals in Pakistan, Nepal and Bangladesh (Whitaker and Daniel 1978). Sri Lanka has largest population of mugger than remainder of the Indian subcontinent and they are concentrated mainly in its two largest National Parks, Yala and Wilpattu (Whitaker and Whitaker 1979).



Figure 4. Past and present distribution of Mugger in Nepal
(Source: IUCN-Nepal 1993)

Historically mugger crocodile was relatively common through out the Tarai of Nepal in marshy lakes, ponds and small rivers (Groombridge 1982). Presently, there are small populations of mugger surviving in tributaries of Koshi, Karnali, Narayani and Mahakali rivers (Figure 4). In Karnali, Narayani and Babai the marsh crocodile are coexisted with gharial and now it is reduced to isolated population primarily in protected habitat such as Suklaphanta Wildlife Reserve, Koshi Tappu Wildlife Reserve, Bardia National Park and Chitwan National Park (Andrews and McEachern 1994). Where found together with gharial, mugger tends to bask in midstream on rocks or muddy banks (Groombridge 1982). Beeshajari Tal and Ghodaghodi Lake provide excellent habitat for mugger.

1.5 General habitat of crocodiles

Gharial is riverine more adapted to an aquatic lifestyle in the calmer areas of deep, fast-moving rivers. It only leaves the water to bank and nest, both of which usually occurs on sandbanks. Nesting is done during the dry season in holes excavated in river sandbanks (Whitaker and Basu 1983). The marsh crocodile has been the most successful species in ecologically adopting to a wide range of habitats from hill streams and rivers to ponds, marshes and lakes (Whitaker and Daniel 1978). Bustard (1974) (cited in Whitaker and Whitaker 1984) noted the adaptability of the marsh crocodile to village and irrigation tanks in addition to rivers, swamps and lakes. Deraniyagala (1936 and 1939) (Cited in Whitaker and Whitaker 1984) reported about the habitat of the marsh crocodile in Sri Lanka and that it was found mainly in lowland rivers, lakes, forest pools and remarkably in the slat pans and associated lagoons.

1.6 Crocodile conservation history

During the early 1970's the number of gharials in Asia dropped down 200; 129 in India, 51 in Nepal and 20 in Pakistan. The period depletion from the world caused anxiety to naturalists. The first working meeting of crocodile specialist at Bronx Zoo, New York held in March 1971 expressed major concern over the extinction of this animal (Das 1981).

The actual conservation of gharial was started in 1972. The survival of crocodiles in nature was very low. Therefore, unless the existing populations are supplemented with additional numbers, these crocodiles will soon disappear from the area. It is for this reason that crocodiles are being in captivity and released back into the wild when they are mature. In 1972, Indian government started captive breeding programme with the help of FAO and UNDP. The species was literally brought back from the brink of extinction by this restocking program.

Nepal started a captive breeding in 1978 with support from the Frankfurt Zoological Society. The rearing project, originally for gharial, was set up in Chitwan National Park (Kasara). Eggs are harvested from the wild and incubated in protected areas. Newly hatched crocodiles are reared in specially designed rearing pools. Hatchlings are raised to 1-1.5 meters, and then released. Released began in 1981 (Andrew and McEachern 1994).

Released sites are chosen by the project are all known habitats of the concerned species, within the limits of their former distribution range. Sites chosen are all protected areas without irreversible degradation of the habitat and have such requirements as: food, basking and nesting grounds, proper water depth and flow, good nursery grounds for the young hatchlings and protection from extremes of flood. Reintroduction sites were also ensured to be free from all kinds of detrimental human disturbances factors such as set net fishing, robbing of eggs, illegal hunting and destruction of habitat by change in water flow and depth (Choudhury and Bustard 1982).

The facilities in Kasara now hold both gharial and mugger. In 1982, facilities were added at Bardia National Park for gharial and mugger. The objectives of the program are to rebuild populations of both species in protected and unprotected areas, and to determine the status, ecology and behavior of crocodile in Nepal.

The decision of the government for wildlife farming, breeding and research policy 2003 in execution is in conformity. With the tenth plan which mentions about farming high value wild animals and birds. This specially points out the need for improving livelihoods of women, the poor and disadvantage groups by conserving biological diversity through farming of high value wildlife, and promoting involvement of individuals, groups, non-governmental organization and institutions in wildlife farming, breeding and research.

1.7 Justification of the study

Gharial is categorized as 'Critically Endangered' on the 2007 IUCN Red List and Appendix I of CITES. Mugger is listed as 'Vulnerable' on the IUCN Red List and Appendix I of CITES. The crocodiles are protected under the National Park and Wildlife Conservation Act 1973. And the limited distribution of crocodile itself is a major threat for conservation. The Gharial Conservation Project is concentrated only in the Narayani and Rapti rivers of Chitwan National Park and little in the Bardia National Park. Information on the status of the crocodiles in the Koshi Tappu Wildlife Reserve (Koshi river) is scanty, and no effective measures are in place to determine its status. So this study aims to carry out the status survey in reserve, which will be helpful to the concerned stakeholders in protecting and conserving the species.

1.8 Objective

The main objective of the study was to assess the present status of crocodiles present in the Koshi Tappu Wildlife Reserve and provide information required for management prescriptions.

The specific objectives of this study were as follows:

- To estimate the population of crocodiles in the reserve
- To identify the habitat preference of crocodiles in the study area
- To assess the threats associated with crocodile in the reserve, and
- To provide management recommendations for conservation

2. LITERATURE REVIEW

Both species gharial and mugger exist on the Indian subcontinent. The gharial are distributed in isolated remnant populations in the Karnali, Babai and Narayani river systems, all of which are in or adjacent to protected areas. Gharial populations in the Mahakali and Sapta Koshi Rivers are low. A survey conducted in 1989 found that nine gharial in the Karnali River and seven in the Babai river (Maskey 1990 in Andrew and McEachern 1994). The mugger is reduced to isolated populations primarily in protected habitats, such as Suklaphanta Wildlife Reserve, Bardia and Chitwan National Parks which contain the last viable populations. A limited number have been reported from the Sapta Koshi area and the Lumbini district. The Mahakali and Bahuni Rivers adjacent to Suklaphanta represent excellent habitat and are contiguous with areas in Uttar Pradesh where an effective rehabilitation program is in operation. Recent survey by IUCN Nepal revealed depressed numbers in this area (Andrew and McEachern 1994). In some areas of northern India and Nepal, Mugger crocodile are sympatric with gharial but the two species tends to be segregated by habitat. Where found together with gharial, mugger tends to bask in midstream on rocks or muddy banks (Groombridge 1982).

The gharial has remained one of the last known reptiles despite their abundance in the past. Many naturalists have attempted to study facets of the biology of these fascinating animals. Hornaday (1885) gave an illuminating amount of the life of crocodiles. Many investigators have enriched the literature on capturing and sexing of crocodilians. Dharmakumarsinhji (1947) was the first to observe breeding of wild mugger. He noted the tail up and head emerged posture of the male and head up posture of the female prior to copulation.

Crocodiles of Nepal have attracted attention of many herpetologists in the past. Biswas (1970) gave an account of collection and hunting of mugger in the Koshi river. Whitaker and Whitaker (1977) gave an account of collection and hatching of mugger crocodile.

Nepal started a captive program in 1978 with support from the Frankfurt Zoological Society. Since 1981, through this program, young gharials reared in captivity were introduced into their original environment and thus reinforced the wild population. Most of the gharials were introduced into the Narayani and Rapti rivers inside Chitwan National Park. However, in spite of 432 young gharials having been introduced into Nepal's rivers, only 58 wild gharial and 75 reintroduced gharials were accounted for (Maskey and Percival 1994). Up until 2001, in spite of

young gharials being released every year, sightings were relatively infrequent (Ballouard and Cadi 2005).

To determine the main difficulties of that reintroduction program, the gharials reintroduced in the park were to be followed with an individual identification system and radio monitoring system (Cadi et al. 2002). Between 2003 and 2004, two successive teams of French research studied the gharial population in the wild (Ballouard and Cadi, 2005). During this period, recommendation concerning the release site and period of release site and period of release were formulated (Priol et al. 2003). However, in 2003, in spite of 417 gharials having been released in Chitwan National Park, only 40 of them have been counted and monitored. In 2004, population disturbance, fishing nets which kill the young gharial directly, water quality and a dam downriver from the park have been identified as the main threats for the gharials (Ballourd et al. 2004).

Gahrial could be too weak to be reintroduced in natural habitat. According to the study of zoo technical and pathological problems on gharials from the Kasara breeding centre (Le Foll 1982) particularly attention should be done on clinical rearing conditions.

All the young gharials observed in the Chitwan National Park come from the Breeding Centre, as releasing young gharials has become the only method to improve the gharial distribution in Nepal (Maskey, 1989). The rearing project, originally for gharial only, was set up in Chitwan National Park. The facilities in Kasara now hold both gharial and mugger. In 1982, facilities were added at Bardia National Park for gharial and mugger. The objectives of the program are to rebuild populations of both species in protected and unprotected areas, and to determine the status, ecology and behavior of crocodile of Nepal.

Since crocodile management commenced in Nepal, the program has maintained data on species, numbers involved and location of release. Some 671 gharial and 164 mugger have been released from rearing stations to the wild (DNPWC 2005). Gharials have been successfully re-stocked into the Narayani, Babai and Karnali rivers. Reintroduced mugger has not been monitored (Andrew and McEachern 1994).

A study carried out by Mishra (2002) showed that distribution and habitat of gharial was mainly restricted to Karnali and Babai rivers in Bardia National Parks and Rapti and Narayani rivers of Chitwan National Park.

Habitat loss has been a leading cause for Nepal's declining crocodile populations. This was accelerated in the mid 1950s when an intensive malaria eradication program opened the Tarai for habitation. Intensive fishing has reduced food levels and effected crocodile numbers. They become entangled in nets and either drown or are killed by fishermen. Subsequently, egg collection and slaughter of crocodile by tribal hunters have been on-going as a deterrent to fishing competition, as a food item, and for parts thought to have medical value. In recent years, the construction of dams and barrage has blocked migratory routes.

During recent years, crocodile farming has gained increasing importance. The health and disease in farm-bred have been the major concern in all parts of the world (Lal 1981). Management of crocodile in wild and captive conditions has attracted the attention of investigators. Recently, various techniques have been developed for their management. Shrestha (1981 and 1990) gave an interesting account of management and conservation of crocodiles in Nepal (Shrestha 2001). Le Foll (1982) studied zootechnical problem of mugger in Chitwan National Park.

IUCN Nepal initiated a program for mugger in 1992 which derived from the accelerated decline of Wetland habitats and lack of declined information on the status of crocodiles. The recently created Wetland Inventory and Conservation Programme augment the Crocodile projects by supplying logistic support and facilities.

3. STUDY AREA

3.1 Description of study area

Koshi Tappu Wildlife Reserve extends between 86°55'-86°05'E longitude and 26°34'-26°45' latitude, on the alluvial flood plain of the Sapta Koshi (or simply Koshi) river in Saptari, Sunsari and Udayapur districts of Eastern Nepal. The reserve was officially established in 1976 and extends in 1980, primarily for protection of the last remnant population of wild water buffaloes (*Bubalus bubalis*) and their habitat. The reserve is rectangular in shape, 16.3 km long and 9.3 km wide running along the Sapta Koshi river for some 17 km consisting of sandbars and mudflats and fringing marshes. It has an area of 175 km² (149.3 km² WMI and IUCN/Nepal 1994) and its elevation ranges from 75 to 100m above mean sea level. It has two parallel embankments, one to the west and one to the east of the Koshi river constructed by the Koshi Dam Project to control flooding.

Realizing the importance of the site, Koshi Tappu Wildlife Reserve was designated as wetland of international importance and added to Ramsar list on 17th December 1987. Despite the declaration, illegal activities such as trapping, hunting and poisoning of birds are common in the barrage and buffer zone. This has led various researchers/scientists and institutions to advocate an extension of the protected area's boundaries (Suwal 1993, WMI/IUCN 1994 and BPP 1995). However, the area between the southern boundary of the reserve and the Koshi barrage leased to the Indian Government (Scott 1989) and this presents a legal complication requiring inter-governmental co-operation.

The river meanders between the two embankments, however its course and size varies greatly with seasons. During the monsoon the river floods much of the land between the embankments and after the water recede the course of the river is likely to be much different to that prior to rains.

3.2 Climate

The climate of the study area is tropical, mainly dominated by the south east monsoon. The average daily maximum temperature ranges from 23.5°C to 33.4°C, the minimum from 7.8°C to 25.3°C, and the mean monthly temperature ranges from 15.7°C to 29.2°C (Sah 1997). The rainfall and maximum and minimum temperatures of the study area is graphically presented in figures 6 and 7.

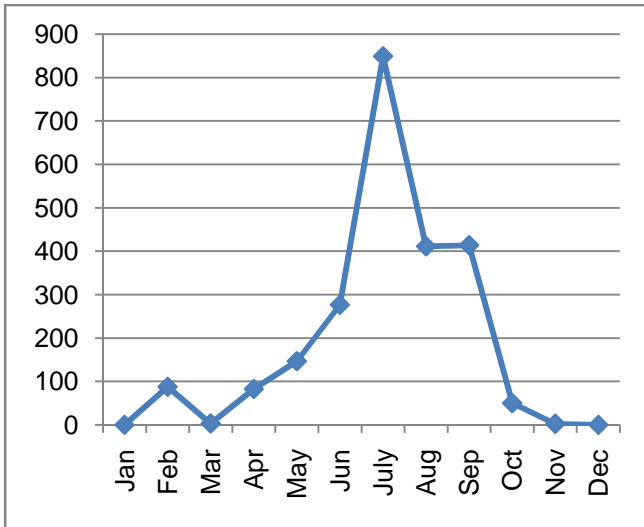


Figure 5. Rainfall (mm) for Phatepur 2007

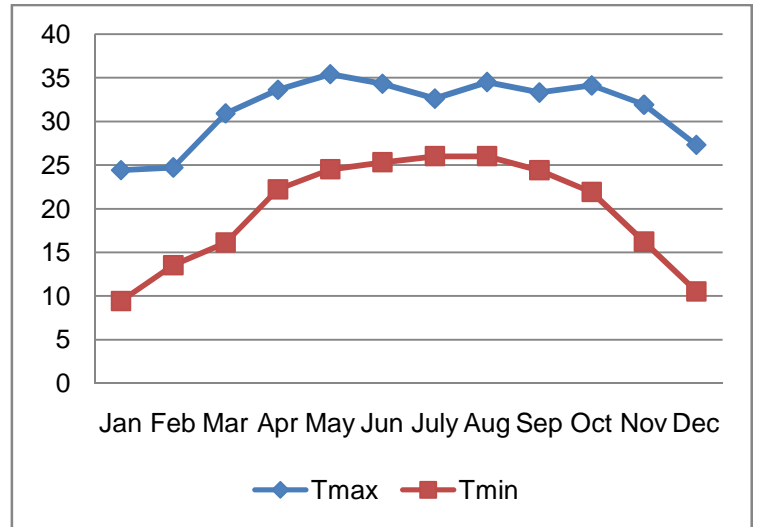


Figure 6. Maximum and Minimum Temperature (°C) of Phatepur 2007

(Sources: Department of Hydrology and Meterology)

3.3 Hydrology

The Koshi River is one of the three largest rivers that flow from the Himalayas of Nepal and feed to the Ganges River. The Koshi river basin consists of seven main rivers, which are finally drained out by the Sapta Koshi River. The total catchment of the Koshi river up to the Koshi Barrage is estimated to be 60,400 km² out of which 27,553 km² (45.6%) lies in Nepal and remaining 32,847km² (54.4%) lies in Tibet (WECS 1999).

3.4 Floral diversity

Approximately 70% of the reserve's area is covered by grasslands (Heinen 1993), although during flood years a large area of grassland is destroyed and replaced by new alluvial deposits. *Typha* and *Saccharum* are major grassland types found here, although patches of *Imperata* and

Phragmites are often seen. Medium size *Phantas* interspersed with young *Acacia* trees are found in sandy islands. Riverine vegetation with *Acacia catechu/Dalbergia sissoo* forest dominates on the islands and edges of the reserve. Mostly young trees grow inside and on the edges of the reserve within embankments, the older mature trees being swept away by annual floods.

3.5 Faunal diversity

KTWR is a small reserve but it offers important habitat for a variety of wildlife. The reserve is an important habitat for Nepal's last surviving population of Asian Buffalo (*Bubalus bubalis*), a globally threatened species. Other globally threatened species include Ganges River Dolphin (*Platanista gangetica*). Large animals like Gaur (*Bos gaurus*) and Nilgai (*Boselaphus tragocamelus*), which are considered as vulnerable species. Spotted Deer (*Axis axis*), Hog Deer (*Axis porcinus*) and all three Nepalese otter species (*Lutra lutra*, *Lutrogale perspicillata* and *Aonyx cinerea*) are still found in small numbers, small carnivores, including the Fishing Cat (*Felis viverrina*), Jungle Cat (*Felis chaus*), Indian Fox (*Vulpes vulpes*) and Jackal (*Canis aureus*) are also found in the reserve (Sah 1997).

A total of 487 bird species has been recorded in the Koshi Tappu and Barrage area. Koshi is by far the most important wetland staging post for migrating wader and waterfowl in Nepal (Inskipp and Inskipp 1991) and was considered one of the most important in Asia (Scott 1989).

In the study of WMI/IUCN (1994), 83 species of fish comprising 24 families were recorded from 13 different sites of the reserve and surrounding area. The most common species in the Koshi river are *Puntius conchonioides*, *P. ticto*, *Barilus barna* and *Badis badis*, *Chanda nama* and *Esomus danricus* are common in marshes and swamps.

Gharial (*Gavialis gangeticus*) and Mugger (*Crocodylus palustris*) has also been reported from the Koshi river (Hilton-Taylor 2000). The Monitor Lizard (*Varanus bengalensis*), Garden Lizard (*Calotes versicolor*) and Roofed Turtle (*Kachuga kachuga*) are also found there (WMI/IUCN 1994).

3.6 Socioeconomic context

The reserve is surrounded by a human population of 77,950 of 10,693 households of sixteen VDCs. There are now nine user communities and 543 user groups are working under the single buffer zone management community (DNPWC 2005). After buffer zone declaration, local people are authorized to use 50% of total revenue collected from different sectors including tourism. Apart this, local user groups have right to use natural resources as a sustainable basis within the Buffer Zone area.

Migratory people from hills and different parts of India live in the adjoining settlement of the reserve. The communities consist of about 18 ethnic groups, of which Bantar and Ghongi (Malah) are dependent on wetlands for their livelihoods. With regards to the use of wetlands, wetland resources are used by local inhabitants in a number of ways. Some of the important uses include fishing, use for livestock and humans and firewood/timber collection. Major issues of conflict with the reserve management comprises of crop, depredation, fishing, poaching to wild animals, illegally grazing livestock and fuel wood collection.

With the aim to promote community based conservation practice, the Nepal Government in 2004 declared the surrounding areas (173 Km²) of the Koshi Tappu as a buffer zone. The direct beneficiaries are now considered part of three districts (Saptari, Udayapur and Sunsari) population.

4. METHODS

4.1 Preliminary survey

Preliminary survey was conducted in Koshi Tappu Wildlife Reserve from 1st to 6th November 2007 to explore the potential sites of crocodiles. Reserve staff, nature guides and local people (fishermen, cattle grazers, timber/firewood collectors, boatmen etc.) were consulted.

4.2 Direct Field Observation

4.2.1 Crocodile survey

The detail survey was commenced from 1st to 9th January in winter and from 15th to 20th March in spring in the reserve. Survey was carried out during the daytime from 09:00 to 16:00. The presence of crocodiles in segmented areas was based on sighting as well as indirect evidence. Observation was made along the river and from the eastern bank. Binoculars and photo shot were used for observation.

In order to count the crocodile's population and its signs, the study area was divided into three (stretches) transects on the basis of the main river and its branches (Figure 7).

Transect I: Includes the main river where the river course is deep and fast moving with wide width from Prakashpur to Kusha. The riverine vegetation with *Dalbergia sissoo-Acacia catechu* forest dominates on the western edge of the river in this area. This forest is mainly associated with *Saccharum-Phragmitis* grassland with other grassland species like *Setaria pallidifusca*, *Cyperus* sp, *Eclipta prostrata*, *Alternanthera sessilis*, *Desmodium* species.

Transect II: Includes western branch of the river from Madhuban to Kusha. In this branch of the river the water velocity is slow. In these areas, vegetation like tall elephant grasses *Imperata cylindria* and *Saccharum spontaneus* along with scattered *Dalbergia sissoo* were found.

Transect III: Includes eastern branch of the river from Prakashpur to Shripur. The structure and vegetation of this area is same as in Transect II.

This part also includes marshes areas which are situated between the river and the eastern embankment of the reserve from Madhuban to Shripur VDCs. This area is wide with shallow water at the margin and deep water in the middle areas with elevated patches of lands. In this area, vegetation like *Imperata cylindria* and *Saccharum spontaneus* along with emergent

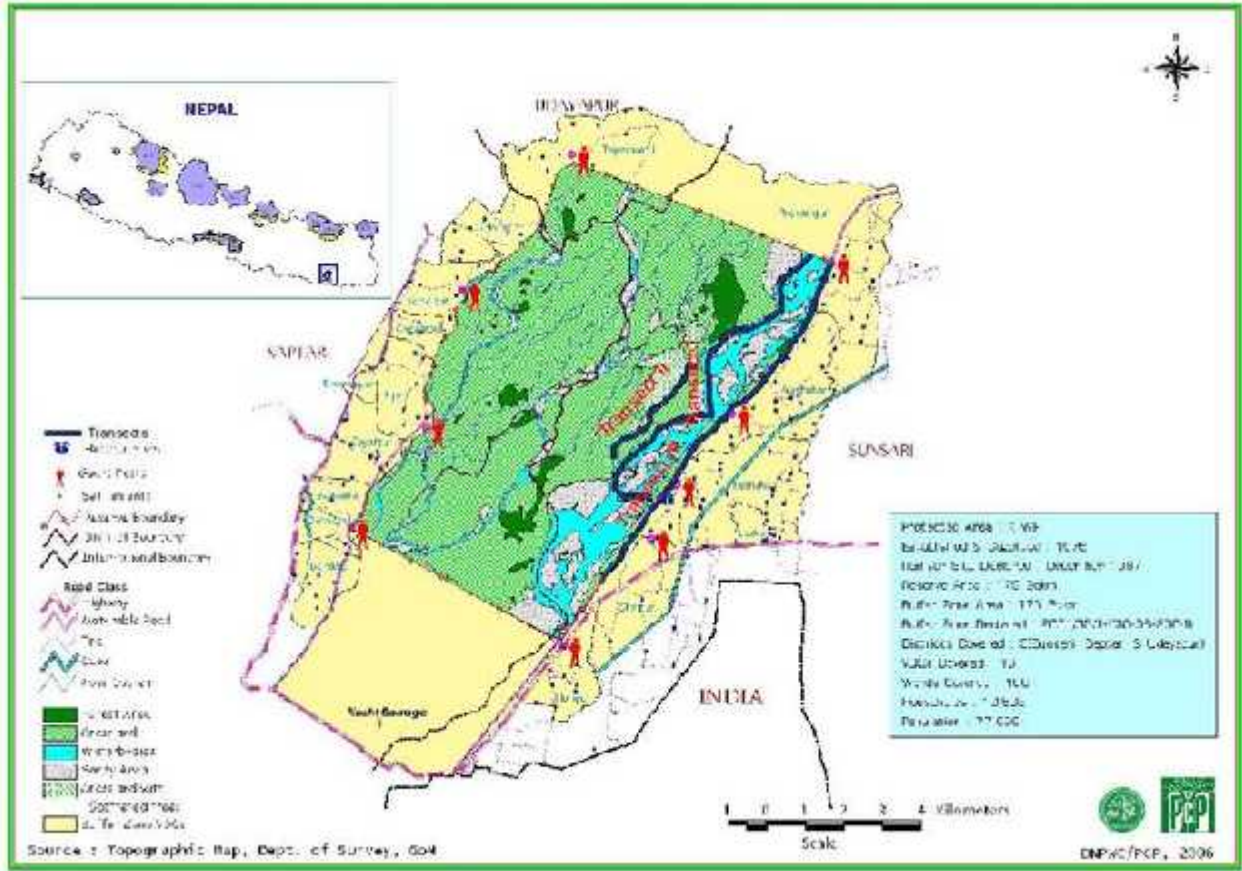


Figure 7. Map showing study area in Koshi Tappu Wildlife Reserve

species *Fimbristyllis squarrosa*, *Saccharum spontaneum*, *Persicaria lapathifolia*; floating species *Nymphoides hydrophyllum* and submerged species *Hydrilla-Ceratophyllum* are found profusely.

Specific river stretches (transects) were repeatedly surveyed. If animal or signs were seen in the same locations as previously observed, then those were classified as repeat counts. If the number was more than previous or its size and shape was different than the previously seen or the sign was found in different places, it was counted as different animal or sign. During the survey a multiplatform count was done to increase the chances of recording all the individuals and to reduce sampling biases. There were two persons deployed in each of its three potential habitats (Sixth Tower, Madhuban and Prakshpur in winter; and Kusha, Madhuban and Prakshpur in spring). During the fixed time period, observers noted the number of individuals in each area to get less biased results. The maximum count in any one count effort on a particular site was taken as the final count unless the individual's size and shape was different than the previously seen. Adult and sub-adult were estimated on the basis of ocular estimation. If crocodile was observed and the situation allowed, the attempted was to approach the individuals as closely as possible. In some instances, in close proximity to individuals, behavioral observations could be recorded. Annex 3 and 4 were used for each observation.

For indirect evidence of crocodile presence in an area "U" shaped marking was checked. Generally crocodiles leave "U" shaped marking on the sand bank along the riverbanks (Whitaker and Basu 1983).

The coordination of the observation of the crocodile and its signs were recorded by Garmin GPS. The coordination was recorded as close as possible to the animal paying attention not to scare it.

4.2.2 Habitat preference of crocodile

In each transects its habitats were classified into five categories: sand banks (SB), grass banks (GB), sand grass banks (SGB), rocky banks (RB) and river channel (RC) (Maskey 1989). Sand banks were high banks of fine sand that lacked vegetation. Grass banks principally were composed of sand with a vegetation cover of grasses. Sand grass banks were those having more sparsely distribution *Saccharum sp.* and other grasses. Rocky banks consisted mainly of stones ranging from 50 mm to 250mm in diameter. River channels are the permanent flooded waterways within the river banks.

4.2.3 Natural and anthropogenic disturbances threatening crocodiles

Both natural and anthropogenic disturbance factors were identified by field observation, questionnaire survey, and literature review.

4.3 Secondary information about status and distribution

The past and present status and distribution of crocodile in the reserve was based on the secondary information like literature review, crocodile specialist group's newsletters and other publications, personal communication with warden and reserve staff.

4.4 Conservation issues

4.4.1 Group discussion

Focus group discussion was done with park staff and nature guides of neighboring hotels. Similarly, a series of group discussions were organized with local inhabitants, especially with targeted communities like fishermen, cattle grazers, timber/firewood collectors, boatmen and other interested persons. Group discussions were aimed to exchange idea about their traditional knowledge regarding crocodile history, habits and habitats. Discussions were also held to understand people's perception and identify conservation problems as well as suggestions for means crocodile conservation.

4.4.2 Questionnaire survey

A standard set of questions were asked and answers were recorded on a questionnaire form (Annex 3). The objective of this survey was to understand the historical distribution, recent sightings and general knowledge of crocodiles as well as the perception and attitude towards crocodile conservation in the reserve. Interviews were carried out with army (patrolling in the reserve), officials, fishermen and local residents. Interviews were conducted in the field or at their home, but were focused on individuals who lived or worked in the area and had direct knowledge of crocodiles.

5. RESULTS

5.1 Population of crocodile in the reserve

A total of 21 muggers observed which included 14 adults and seven sub adults in five different locations and eight marks of animal in winter (Table 1). In spring, only five adult muggers observed in four different locations with 14 mark (Table 2). In both the season gharial was not observed. In this study marks were found near the side where animals were observed. So, the marks were not counted as animal.

A chi-square goodness of fit test indicated number of adult and sub adult muggers in winter and spring were significantly different ($\chi^2 = 2.751$; $df=1$; $p=0.09$). In winter, six adults, three sub adults and seven marks were found in Madhuban. Tetriganchi Tal had the five muggers of which two were adults and three were sub adults. Similarly three muggers which included two adults and one sub adults were observed in each branch (Sixth Tower and Madhuban#) of the river while only one mugger was found in the Prakashpur. In spring, only three adult muggers were found in the Madhuban with six marks and two adult muggers with four marks were found in the Kusha. Prakashpur and fifth tower had only two/two marks (Figure 3).

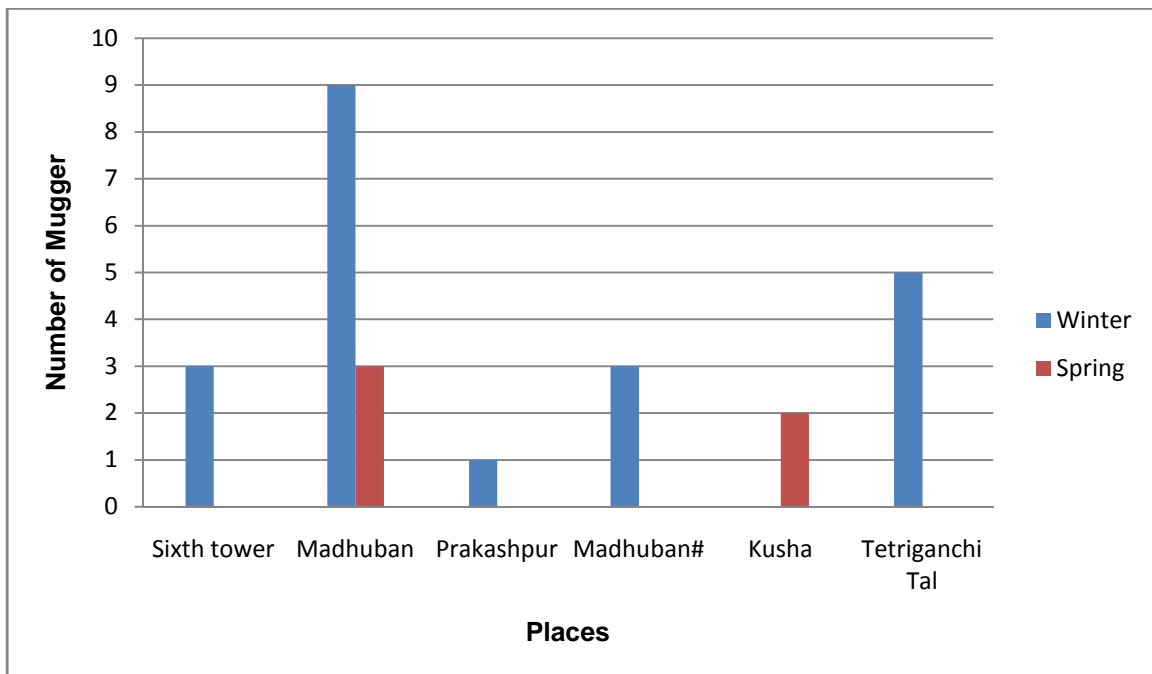


Figure 8. Comparison of counts of mugger crocodile in winter and spring season (2008)

Table 1. The result of survey in winter 2008

Date	Time	Number	Type	Habitat	Position	Place
2 Jan	14:30	2	Adult	GB	Basking	Titriganchi Tal
2 Jan	14:30	1	Sub-adult	SGB	Seeking	„
3 Jan	11:00	1*+1	Sub-adult	SGB	Sub-merged	„
3 Jan	11:00	2*	Adult	GB	Basking	„
4 Jan	10:00	2*	Adult	GB	Basking	„
4 Jan	15:00	2*+1	Sub-adult	SGB	Sub-merged	„
5 Jan	09:30	1	Mark	SB	Dry	Kusha
5 Jan	10:30	1	Adult	SB	Basking	Sixth Tower
6 Jan	10:15	5	Adult	SB	Basking	Madhuban
6 Jan	10:35	7	Marks	SB	Fresh	„
6 Jan	14:00	5*+1	Adult	SB	Gaping	„
6 Jan	14:00	1	Sub-adult	SB	Basking	„
6 Jan	15:00	1*+1	Adult	SB	Seeking	Sixth Tower
6 Jan	15:00	1	Sub-adult	SB	Sub-merged	„
7 Jan	12:00	5*	Adult	SB	Basking	Madhuban
7 Jan	12:55	1*+2	Sub-Adult	SB	Basking	„
7 Jan	02:00	1	Adult	RC	Sub-merged	Prakshpur
8 Jan	13:00	2	Adult	SB	Gaping	Madhuban#
8 Jan	13:30	1	Sub-adult	SB	Basking	„

Table 2. The result of survey in spring 2008

Date	Time	Number	Type	Habitat	Position	Place
18March	10:00	2	Marks	SB	Fresh	Kusha
18March	10:20	1	Mark	SB	Fresh	„
18March	11:10	2	Marks	SB	Dry	Fifth Tower
18March	11: 50	6	Marks	SB	Fresh	Madhuban
18March	1: 15	2	Marks	SB	Fresh	Prakshpur
18March	2:10	2	Adult	SGB	Running	Madhuban
18March	2:40	1	Adult	SGB	Running	Kusha
19March	10:45	3*	Marks	SB	Fresh	Kusha
19March	10:50	1	Mark	SB	Old	„
19March	12: 15	1	Adult	SB	Running	Madhuban
19March	2: 10	1*+1	Adult	SGB	Running	Kusha

* Repeated count # River branch

GB= Grass Bank, RC= River Channel, SGB= Sand Grass Bank, SB=Sand Bank

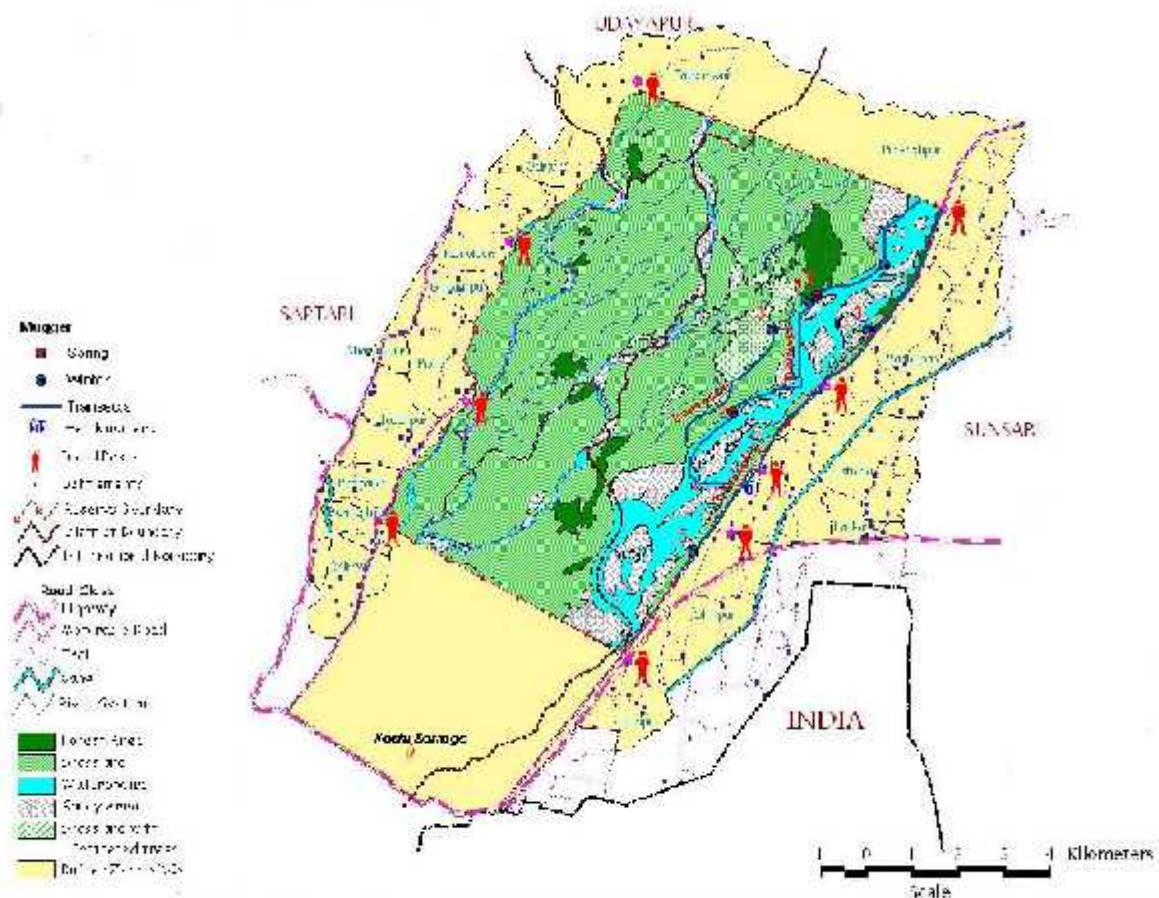


Figure 9. Map showing the distribution and number of Mugger in winter and spring in Koshi Tappu Wildlife Reserve

5.2 Field characteristics of the mugger crocodile

Muggers were mainly observed during the basking, gaping, seeking, submerged position on the western banks of the river and its branches and the marshes (Tetriganchi Tal) in the winter while all the muggers were observed in the spring were in motion (running) from the bank towards the river. A chi-square goodness of fit test indicated mugger crocodiles activities basking, gaping, running, seeking and submerged positions were significantly different in the field ($\chi^2 = 26$; $df=4$; $p<0.001$). Observations from a hide-out from late morning to the late evening showed that most of the time muggers exhibited little or no activity (Tables 1 and 2).

Mugger practiced a thermotaxis activity (basking) on land (Plate 1 A and B) or in submerge position (Plate 1 C) during the day. So, temperature selection (either heat seeking or heat avoidance) within available habitats was an important daily activity of the muggers. They sought shade lying near the basking spot (Plate 1 E). The shade seeking activity started at about 14:00 (Table 1). At noon, the muggers were seen gaping by opening their buccal cavity to the sun for long periods (Plate 1 F). Field observations showed that mugger used one and same basking platform (Plate 2 G and H), finding the area by leaving a trail (Plate 2 J, K and L).

Muggers appeared to be sluggish and heavy built animals, but they were very active and alert in the event of danger. They were able to dive and remain underwater with little surface disturbance. During diving, the head and throat of the animal slinked first and tail rose above the water (Plate 3 M, N, O and P). Mugger swam at the water surface in a characteristic sinuous bending or undulating movement with its limbs folded against the body and snout project upward and forward. The development of the intrinsically powerful muscular tail webbed hind foot and elongated body offered made their swimming easier. It crawled slowly on the bottom of river, using "belly walk" gait on the land. Muggers were extremely difficult to approach because they ran with speed from the height towards water when they detected approaching man or boat from several hundred meters (Plate 4 U and V). The mugger was also seen climbing bole of submerged tree trunk and little height.



A



B



C



D



E



F

PLATE 1: A) An adult mugger basking on the sand grass bank B) An adult mugger basking on the sand bank C) An adult mugger basking on the submerged position D) A sub adult mugger basking on the sand bank E) A mugger seek shade lying near the basking area F) An adult mugger gaping on the submerged position



G



H



I



J



K



L

PLATE 2: G and H) The mugger using the same basking platform I) An adult mugger crawling on the sand bank J) A mark due to its crawl K and L) "U" shaped marks due to its crawl



M



N



O



P



Q



R

PLATE 3: M- P) The movement of mugger Q) Movement of the livestock along the shoreline R) People came to collect the firewood



S



T



U



V

PLATE 4: S) Human activities along the bank of the edge of the river T) Low level of water in the Tetriganchi tal in summer U and V) Marks due to the movement of mugger from bank to edge of the river

5.3 The habitat preference of mugger

The habitat used by the mugger was varying with type and season (Tables 1 and 2). A chi-square goodness of fit test indicated crocodiles were not randomly distributed between the habitat types ($\chi^2 = 8.928$; $df=3$; $p < 0.05$). Of the 21 muggers that were observed in winter; 15 (71%) were in sand bank, three (14%) were in sand grass bank, two (10%) were in grass bank and one (5%) in the river channel (Table 2). In the spring season, four (80%) muggers were observed in the sand grass bank and two (20%) were observed in the sand bank (Table 2). In both the season no mugger was recorded in the rocky bank.

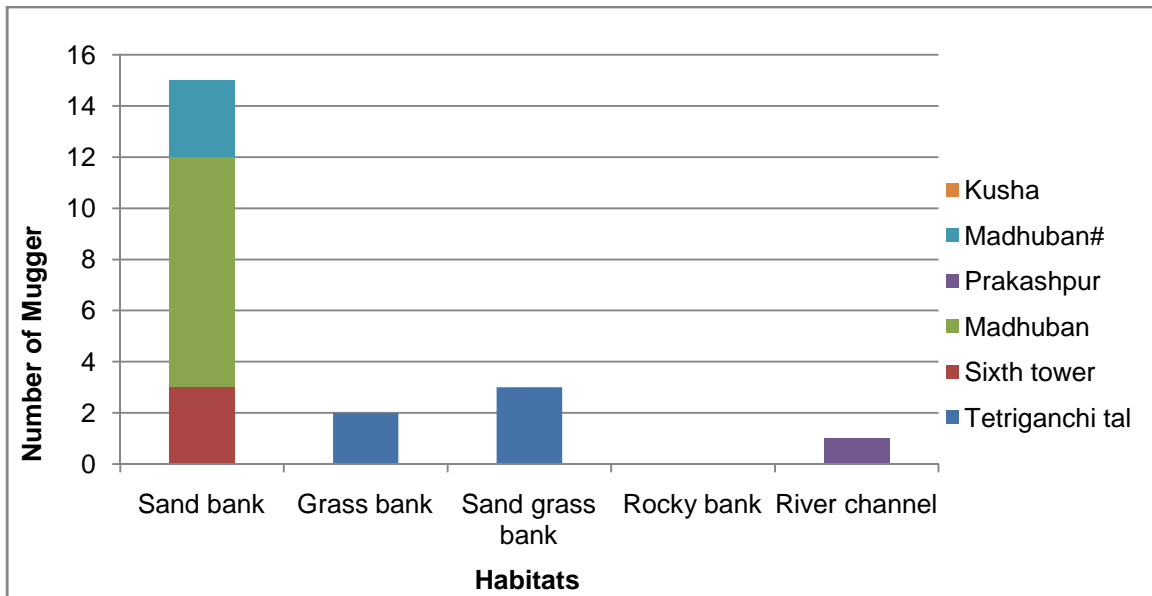


Figure 10. Habitat preference of mugger in winter

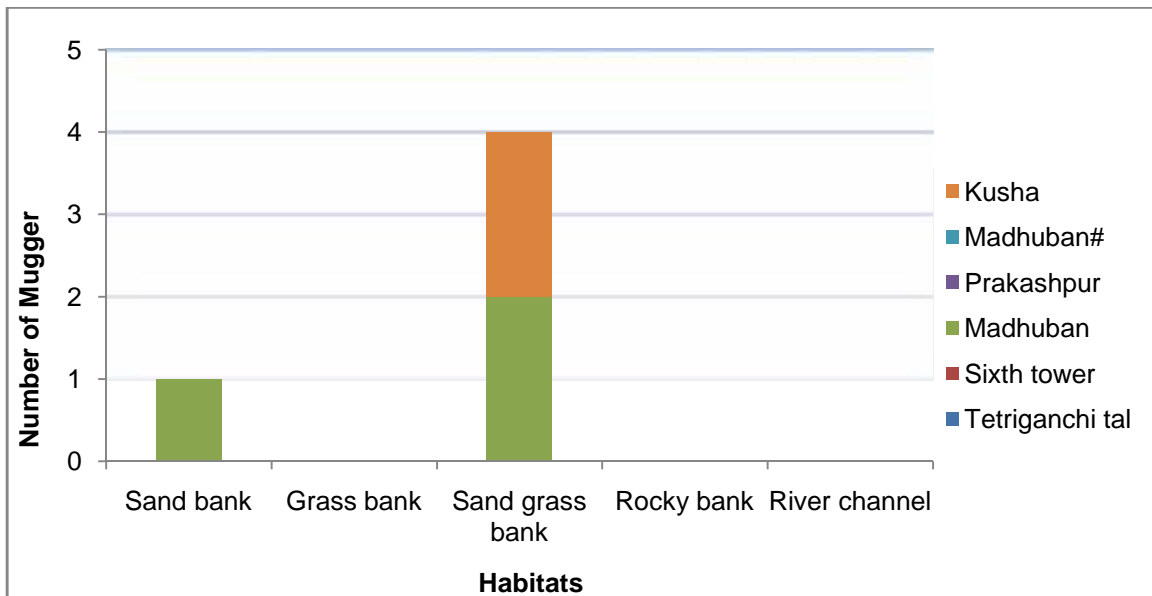


Figure 11. Habitat preference of mugger in spring

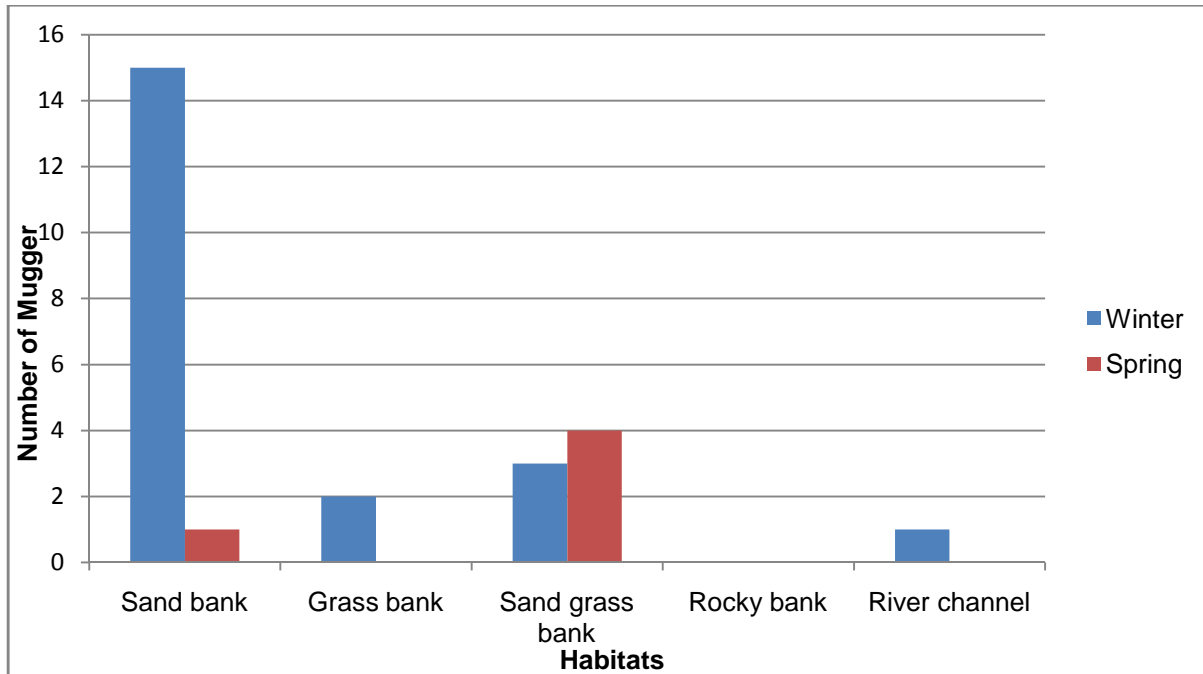


Figure 12. Comparison of habitat distribution of mugger crocodile in winter and spring seasons

5.4 Natural and anthropogenic disturbances threatening mugger

There was very little historical information on the population of crocodile in KTWR. So the finding about factors responsible for decreasing crocodiles were based on questionnaire survey with community people as well as with reserve staff and other crocodile experts and interested persons. The destruction and degradation of crocodile in the reserve was caused by many human activities, as well as by some natural processes.

5.4.1 Habitat losses

Seepage areas on the eastern embankment adjacent to the agricultural fields were severely affected by agricultural run-off. These were now hypereutrophic, being almost completely covered by water hyacinth (*Eichhornia crassipes*) and other microphytes. Many of the wetlands had changed from mesotrophic to eutrophic due to the accumulation of nutrients from natural and human activities. So, there was only a Tetraganichi tal as marshes which was used by the mugger.

5.4.2 Barrage

The Koshi barrage is not equipped with devices to facilitate the migration of crocodile. During the monsoon season high current of water sweep away downward most of the juvenile and

released crocodile into the Indian river systems. Downstream movement of crocodile was also reported from Koshi river to India. During this study one adult gharial was found in Bhimnagar (Zero kilometer), Bihar which GPS reading was E086°56'39.7" longitude and N26°30'43.9" latitude where crocodiles were not recorded previously.

5.4.3 Human activities

Though there was lack of conservation awareness among the local people towards the crocodile, illegal poaching was not reported in the reserve. Since there was no clear reserve boundary crocodiles were heavily disturbed due to human activities inside the reserve.

There was no fences and no regular patrolling, people from the buffer zone and near villages illegally came to the reserve to collect firewood, timber, leaf litter, and other forest products as well as for illegal hunting of the wild animals. More than 100 people came to the reserve for firewood for personal use or to buy in the near market (Plate 3 Q). In the Madhuban area local inhabitants from the buffer zone of the reserve cut down the trees and branches and collect the drooping branches along the riverbanks for firewood which offer resting and holding as well as hiding platforms for crocodiles (Plate 4S). In the eastern dam of the reserve more than 1000 people came to collect the firewood, timber leaf and to eat/collect bair (*Zizyphus mauritiana*) in the winter. So the disturbances due to people walking caused stress and significant disruption in basking activity of mugger found in the Tetriganchi tal and the branch of the river in the Madhuban. In spring more than 1000 people entered to the reserve for grass cutting with permit. Most of the areas for cutting grasses were across the river. So during this period mugger were more disturbed.

Animal commonly kept by local people were cows, buffaloes and goats. During winter, more than 50,000 animals including goats were grazed in the reserve. Over grazing and movement of livestock along the shoreline contribute to soil erosion which leads to loss of suitable habitat for crocodile (Plate 3 Q). Village children and cattle graze chased the mugger and disturbed by stoning from the dam (Tetriganchi Tal) of the reserve when muggers were basking.

The other common activity observed in the reserve was the fishing by indigenous community, from children to adult for subsistence living and selling. They used different techniques for fish capture such as net, hook, traps and biological and chemical poison but the most common method was by using the net. The majority of the fish collectors were the Ghongi (including

Majhi and Malah) because their poverty and limited land driven them to do this for subsistence living. Though some had permission from headquarter, most of fish collectors were illegally fishing. According to National Parks and wildlife Conservation Act 1973 no one can hunt in the night in the protected areas but in reserve it was shown that fisherman fishing in night and sent for sell in the market early in the morning. This type of fishing was increasing day by day which shortage the food of mugger in the reserve.

5.5 Crocodile conservation and issues

The respondents from the local community as well as reserve staff indicated that crocodile conservation in reserve was needed for saving the crocodile from extinction. Lack of awareness in the community was the main obstacle for crocodile conservation in the reserve (Figure 13). Other included lack of release of gharial in the river, regular monitoring and skilled staff.

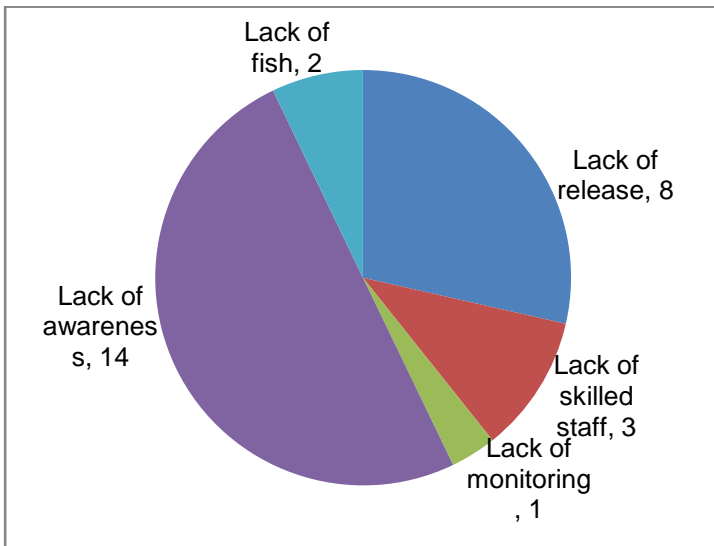


Figure 13. Responses about constraints for crocodile conservation

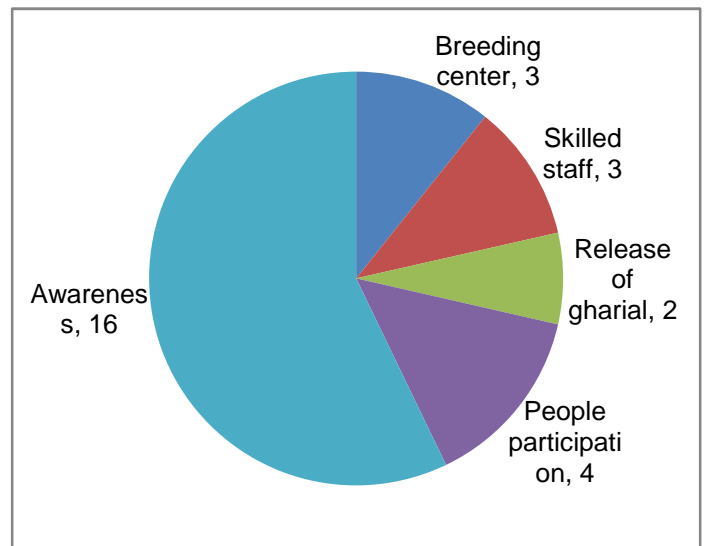


Figure 14. Conservation of crocodile according to community perceptions

5.6 Ways of crocodile conservation

Community people suggested that joint efforts for crocodile conservation would be effective such as sharing conservation and management responsibility and incentives to local community (Figure 14). The constraints for crocodile conservation could be solved to some extent by establishing the breeding center in the reserve as tourist centers. These could play a role in awareness creation and provide increasing sources of income.

People participation in crocodile conservation can be obtained by providing some alternative income with awareness creation among local ethnic groups. By identifying the hotspots of crocodile in the river, protection of these areas could be handed over to the local communities. They could be responsible for protection, monitoring and egg collection. The reserve should encourage the local people for participation in the protection of crocodile.

6. DISCUSSION

The only crocodylian confirmed to inhabit the Koshi Tappu Wildlife Reserve was *C. palustris*. There was a seasonal variation. This might be due to several reasons. First, season for crocodile survey was post winter and pre summer months i.e. December-February. During this period, temperature condition was such that crocodiles basked for longer periods and visibility was good for sighting. This was also the courtship season and breeding groups appeared in the bank in groups (Choudhury and Rao 1982). Second, in spring season both the eastern and the western branches of river and the marshes had low level of water. Therefore, the animals shifted from the branches of the river (6 no. pole and Madhuban#) and the marshes (Tetriganchi tal) to the main river. Some species aestivated by remaining quiescent for days buried in mud, leaf litter or in underground burrows excavated as water levels fell (Whitaker and Whitaker 1984). In dry season, muggers used their burrows to avoid heat during the daytime but at night they came out and wandered the area in search of food (Mobaraki 1999). Third, crocodiles are cryptic, secretive, and historically hunted populations are likely to be wary of humans (Messel, Vorlicek, Wells and Green, 1981 in William et al. 1997). Spring was followed by Kharkhadai (Grass Cutting) season (February) where people were permitted to enter the reserve for two weeks. Most of the areas for cutting grasses were across the river. During this period mugger habitats were more disturbed and the number of individuals moved out of the study area.

In this study numbers of adults were seen easily compared to the sub-adults because movement and other activities of sub adult muggers were less because most of the time they were in hiding in position behind the grasses or the behind the fallen trees.

The highest population of mugger (nine) was found in Madhuban in the winter. In this region, the river course was deep and fast moving with wide width. The riverine vegetation with *Dalbergia sissoo-Acacia catechu* forest dominated on the western edge of the river. This forest was mainly associated with *Saccharum-Phragmitis* grassland with other grassland species like *Setaria pallidifusca*, *Cyperus* sp, *Eclipta prostrata*, *Alternanthera sessilis*, *Desmodium* sp, which provided a secure shelter to mugger during its seeking, hiding and sometimes resting on the submerged tree trunk (Tables 1 and 2).

The second highest population (five) was found in marshes area (locally known as Tetriganchi Tal) situated besides the eastern embankment of the reserve between the Kushaha and

Shripur. This area was wide with shallow water at the margin and deep water in the middle areas with elevated patches of lands which helped the mugger for its daily activities. This area had adequate fish, mollusk and arthropods which were used as food for mugger. In this area, vegetation like *Imperata cylindrica* and *Saccharum spontaneum* along with emergent species *Fimbristylis squarrosa*, *Saccharum spontaneum*, *Persicaria lapathifolia* floating species *Nymphoides hydrophyllum* and submerged species *Hydrilla ceratophyllum* were found profusely. This area was also dominated with large number of wetlands birds. Among them *Anser anser*, *Anser indicus*, *Dendrocygna javanica*, *Tadorna ferruginea*, *Tadorna tadorna*, *Anas strepera*, *Anas falcata*, *Anas penelope*, *Anas platyrhynchos* were dominated. In the spring muggers migrated to the main river due to low level of water in the marshes.

The third highest numbers were found in the Sixth Tower and the Madhuban. Both of these were the branches of the main river. In these areas, vegetation composed of tall elephant grasses *Imperata cylindria* and *Saccharum spontaneum* along with scattered *Dalbergia sissoo*.

In winter most (71%, n=21) sighting was in sand bank compared to the other habitat. Most of the animals were found during basking while other as gaping. According to Whitaker and Basu (1983), gaping has possible significance in the thermoregulation. It is perhaps a device to rid the oral cavity of infection, algae, bacterial, fungus and other pathogens and parasites. The gaping probably has other functions as well (for example a social signal), because it also occurs in the rain and at night (Loveridge 1984 in Lang 1987).

Though two batches of captive gharials (42/43) were released in the Koshi river in 1983 and 1986 respectively, but no animal had been sighted in the study. Generally released juvenile gharials are highly mobile and very sensitive to external disturbances. Since the Koshi river originate from the high Himalayas and have very high water velocity which may escalate the downstream mobility of juvenile and young gharials after release in the wild. Downstream movement of crocodile during the monsoon period has also been reported from Koshi river to Ganges river in India (Biswas 1970). During this study one adult gharial was found in Bhimnagar (Zero kilometer), Bihar which GPS reading was E086°56'39.7" longitude and N26°30'43.9" latitude where there was no previous record of crocodile. The presence of dams allows downstream movement but obstructs upstream movement of the gharials. If the collaboration with the Indian Government for mutual aquatic faunal conservation is effective then it might be possible to bring back to the animal in the reserve. Reintroduction of gharial in the river is

needed because releasing young gharials has become the only method to improve its distribution.

The constraints for crocodile conservation can be solved to some extent by joint efforts such as sharing conservation and management responsibility and economic incentives to local community. People's participation in conservation of crocodile can be obtained by providing some alternative income with awareness creation among local people. By identifying the hotspots of crocodile in the river, protection of these areas could be handed over to the local communities. They should be responsible for protection, monitoring and egg collection. The reserve should encourage the local people for participation in the protection of crocodile.

The crocodiles can be an attraction of visitors and create employment opportunities for the local community. The revenue collected through the tourism may contribute to effective conservation. Ecotourism may be a good solution for involving people with their traditional knowledge about crocodile conservation and will be helpful to uplift the local socio-economic conditions.

7. CONCLUSION AND RECOMMENDATIONS

This study explored the population and distribution of crocodiles, identified the threats associated and mapped out its potential habitat in the KTWR. The only crocodilian confirmed to inhabit the reserve was *C. palustris*. I recorded 21 muggers in the winter while only five in the spring. The muggers were observed in the main river and its branches between the Prakashpur and Kusha and Tetriganchi Tal (the marshes area) in Shripur of the reserve. Muggers were observed during the basking, gaping, seeking and submerged position on the banks of the river and the marshes as well as running from the bank towards the river. They preferred mainly sand bank over grass bank, sand grass bank and river channels as their habitat in the winter. They were found only on sand grass bank and sand bank in the spring.

The Koshi river was subjected to severe natural and anthropogenic stresses causing pronounced habitat degradation in the reserve. Siltation of river beds during monsoon, high water velocity of swift current during flood, and change of mesotrophic marshes to eutrophic marshes were the natural factors for the low survival and sighting of crocodiles in the Koshi river. Fishing, firewood collection and grazing significantly disturbed the habitat in the reserve. Downward movement of crocodiles during the monsoon period had been reported from Koshi river to Bihar (India) because one gharial was seen in the marshes in Bhimnagar (Bihar) where was no previous record.

Reserve staff as well as local community demanded better conservation of crocodiles in the reserve. So the following measures are essential to protect the crocodiles in Koshi Tappu Wildlife Reserve:

1. Controlling illegal activities

While increasing control of illegal activities (fishing, firewood collection and grazing) throughout the entire reserve, some designated areas such as Madhuban, Kusha and Shripur (Tetriganchi Tal) must be strictly protected and such activities must be prohibited.

2. Stopping direct disturbance to the species

Direct disturbances such as throwing stones to the species by the locals just for the fun will cause harm to the species. This will seriously affect the species.

3. Maintenance of wetland periodically.

The water level and food availability in the wetland determines the suitability for the habitat environment. So, the wetlands should be periodically cleaned and maintained properly.

4. Launching awareness program for the species and its habitat conservation

The importance of the species should be disseminated to the locals through awareness campaign for species conservation and habitat protection.

5. Developing and implementing ecotourism in the reserve can attract visitors and generate income for sustainable conservation of crocodile in the reserve and also create employment opportunities among the local community.

6. Continuous release and trans-boundary conservation effort should be initiated for the protection of gharial.

7. Initiating long term research and monitoring

Regular monitoring and further long term research should be conducted periodically along the entire stretch of the river and its branches and marshes for actual estimation of the crocodiles and its conservation and management.

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Annex 1. Summary of result of crocodile surveys

Study site	Winter season		Spring season		Ranges	Total gharial
	Adult	Sub-adult	Adult	Sub-adult	Ranges	
Tetriganchi	2	3	0	0	5-0	0
6 No. pole	2	1	0	0	3-0	0
Madhuban	6	3	3	0	9-3	0
Prakashpur	1	0	0	0	1-0	0
Madhuban#	2	1	0	0	3-0	0
Kusha	0	0	2	0	0-2	0

Source: Present study

Annex 2. Number of crocodiles released in different river systems of Nepal

Species	Year	Narayani	Kali	Rapti/Tamor	Koshi	Karnali	Babai	Total
Gharial Crocodile	1981	50						50
	1982	50						50
	1983	25	35		42			102
	1984	15						15
	1985			5				5
	1986				43			43
	1987	43						43
	1988							0
	1989							0
	1990	25					30	55
	1991						20	20
	1992	38				20		58
	1993	5						5
	1994							0
	1995	27					3	30
	1996	19						19
	1997	10						10
	1998	15		5				20
	1999			7				7
	2000/01	7						7
	2002	20						20
	2003	26	10	36				72
	2004	10						10
2005	0	0	20				20	
2006	11	0	29				40	
Total	396	45	102	85	23	50	681	
Mugger Crocodile	Up to 2002	51		29				80
	2003			62	0			62
	2004	0	0	0	0			0
	2005	0	0	0	0			0
	2006	0	0	22	0			22
	Total	51	0	113	0			164

Source: Annual report (DNPWC 2005/2006)

Annex 3. Questionnaire about crocodile conservation

This questionnaire had designed for research work for Master Degree study and information was used in the thesis writing on the topic “Status and Conservation of Crocodiles in Koshi Tappu Wildlife Reserve, East Nepal”.

Name (Optional):	Age:	Sex:
Occupation:	District:	VDC:
		Ward no:
1. How many types of crocodile have you seen?		
Gharial	Mugger	Both
2. Can you differentiate between gharial and mugger?		
Yes	No	
3. If yes, which one have you seen frequently?		
Gharial	Mugger	Both
4. Have you any idea about crocodile's number?		
Yes	No	
5. If yes, is crocodile population?		
Gharial increasing	Decreasing	As it is
Mugger increasing	Decreasing	As it is
6. If it is decreasing, what are the causes?		
Illegal collection of eggs	Entrapment in fishing net	Predators
Food shortage	Habitat destruction	Dam (Barrage)
All above	No idea	
7. Is it necessary to protect crocodile in KTWR?		
Yes	No	
8. If yes, why?		
Biodiversity conservation	Medicinal	Tourism
Save from extinction	All above	
9. If yes, how can it be protected?		
Reserve is responsibility	With people participation	
Local community/NGO/INGO	Jointly	
10. What are the main difficulties in crocodile protection?		
Lack of awareness	No compensation	Lack of fish in the river
Fish poisoning	Lack of monitoring	Lack of these all

11. Is it necessary to establish breeding center in KTWR?

Yes

No

12. Any suggestion about the animal?

Annex 4. Habitat utilization of crocodile

Site code:

Date and Time:

Number:

Photography:

Physical parameter:

Altitude

Latitude

Longitude

Types of animal:

Adult

Sub adult

Types of Habitat:

Sand Bank (SB)

Grass Bank (GB)

Rocky Channel (RC)

Sand Grass Bank (SGB)

River Channel (RC)

Permanent water resources:

River

Marshes

Vegetation composition:

Forest

Grassland

Shrub

Types of human disturbances:

Wood collection

Grass cutting

Timber harvesting

Cattle grazing

Fishing

Others: