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Aquatic Biodiversity in the Karnali & Narayani River Basins – Nepal

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and Kumar Sapkota

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Preface

The ecology of floodplain rivers in Nepal and India is critically threatened by the effects of human use. Populations of megafauna species, such as the Ganges river dolphin, gharial and mugger crocodiles, soft- and hardshell turtles, and Asian smooth otter, have declined to the extent where much of their range has been lost and local extinction is a constant threat. The loss of aquatic biodiversity indicates serious problems with the ability of river basins to provide important resources for local people.

The focus of this report is on aquatic biodiversity in the Karnali and Narayani rivers. These rivers still preserve, albeit tenuously, the essential physical and biotic elements necessary for sustaining diverse aquatic fauna including endangered species like Ganges river dolphin and gharial crocodiles. The partial inclusion of both rivers within national parks and wildlife sanctuaries provides the institutional structure for implementing effective conservation action. I feel that this publication will be of great help for park managers and researchers alike.

The Department of National Parks and Wildlife Conservation, which is Nepal state member, joins with IUCN Nepal in highlighting the importance of these riverine wetlands to the nation's biodiversity heritage.

Dr. Tirtha Man Maskey
Director General

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1.1 General Characteristics

In the Nepal Himalaya, a vast network of glacial torrents and mountain streams come together to form the Karnali and Narayani river basins (Figure 1). Eventually converging with the Ganges River in India and emptying into the Bay of Bengal, both rivers meet the Gangetic plain below the steep gorges of the Siwalik or Churia foothills. Below the foothills, both rivers become transformed, from single narrow waterways contained within well defined banks, into an expansive network of alluvial braided channels. This environment provides habitat for the farthest upstream range of Ganges river dolphins (*Platanista gangetica*), gharial (*Gavialis gangeticus*) and mugger (*Crocodylus palustris*) crocodiles, smooth Indian otters (*Lutra perspicillata*), and several species of hard-and softshell turtles (see Tables 1 and 2 for the taxonomic classification and protected status of aquatic mammals and reptiles, respectively). Habitat within these river basins also support diverse communities of riverine birds (Table 3), economically important fish species (Table 4) and several endangered terrestrial mammals, including the Royal Bengal tigers (*Panthera tigris*) and the one-horned rhinoceros (*Rhinoceros unicornis*). Aquatic species are threatened with local extinction from the effects of habitat degradation, segregation of breeding groups by downstream barrages, incidental catches during fishing operations, declines in prey fish populations, and a proposed high dam in the Karnali River would further aggravate the problem.

1.2 Location and Protected Status

Below the Siwalik foothills, the lower Karnali (Figure 2) is located in west Nepal (81° 10 ' E and 28° 30' N). The river drains approximately 43,000 sq km of the Himalaya before it cuts through the foothills at the Chisapani gorge. Below Chisapani, the river diverges into the Geruwa and the Karnali branches. The Geruwa branch contains, by far, the greater flow of the two branches and, within Nepal, is bordered on the east and partially included within Royal Bardia National Park. In India, the Geruwa branch is contained within and surrounded on both sides by the Katarniyaghat Gharial Reserve.

The Narayani or Sapta Gandaki River (Figure 3) is located in central Nepal (84° 00' E and 27° 30' N). The river basin drains approximately 35,000 sq km of the Himalaya before the convergence of the Trisuli and Kali Gandaki tributaries at the Hindu sacred place of Devghat, slightly upstream of where the river meets the Gangetic Plain at Narayanghat. A large portion of the Narayani river basin below Narayanghat is contained within Royal Chitwan National Park in Nepal. This park was declared a World Heritage Natural Site by UNESCO (United Nations Educational, Scientific and Cultural Organization) in 1984 because of its rich biodiversity, including many endangered species.

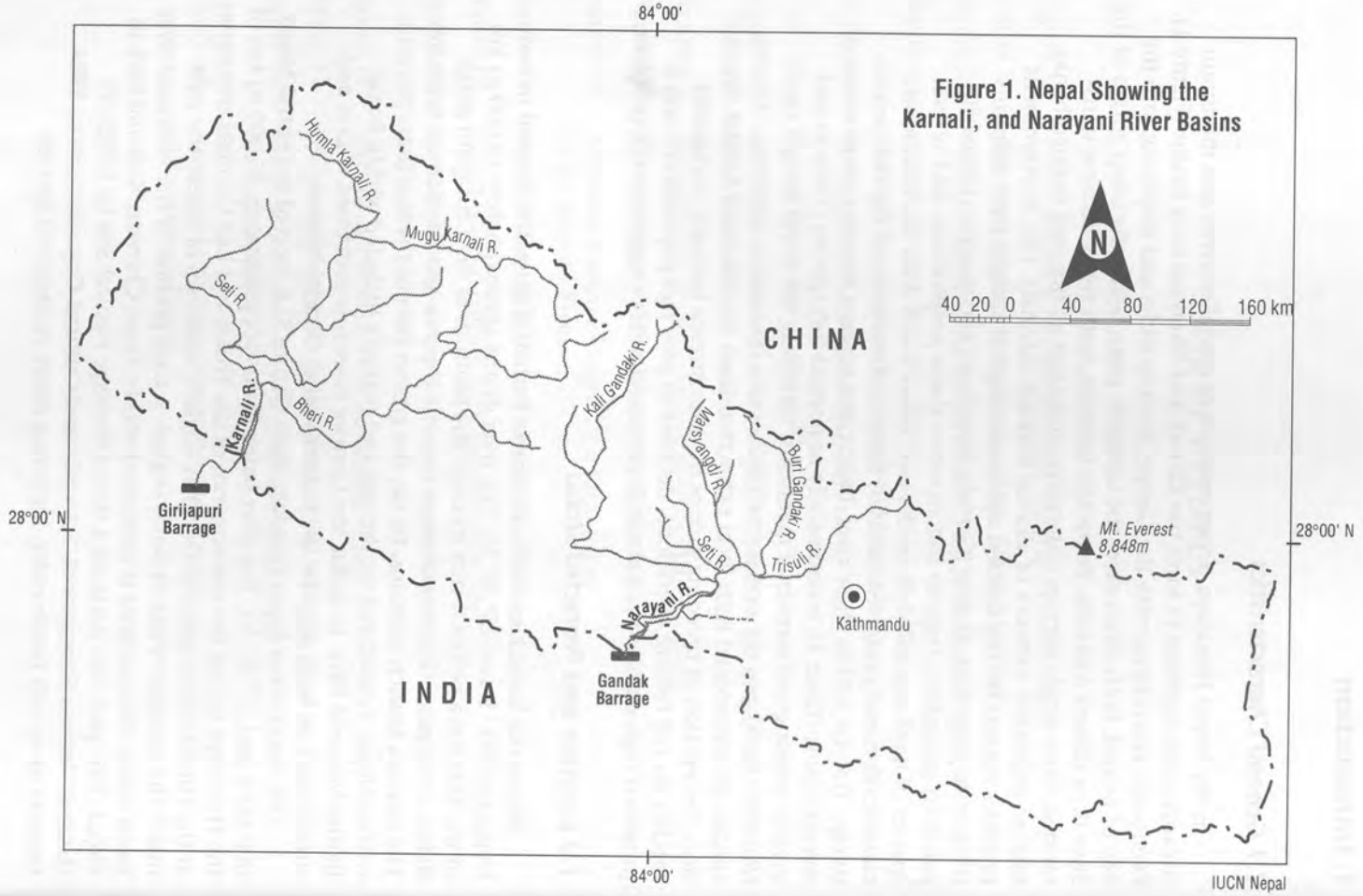
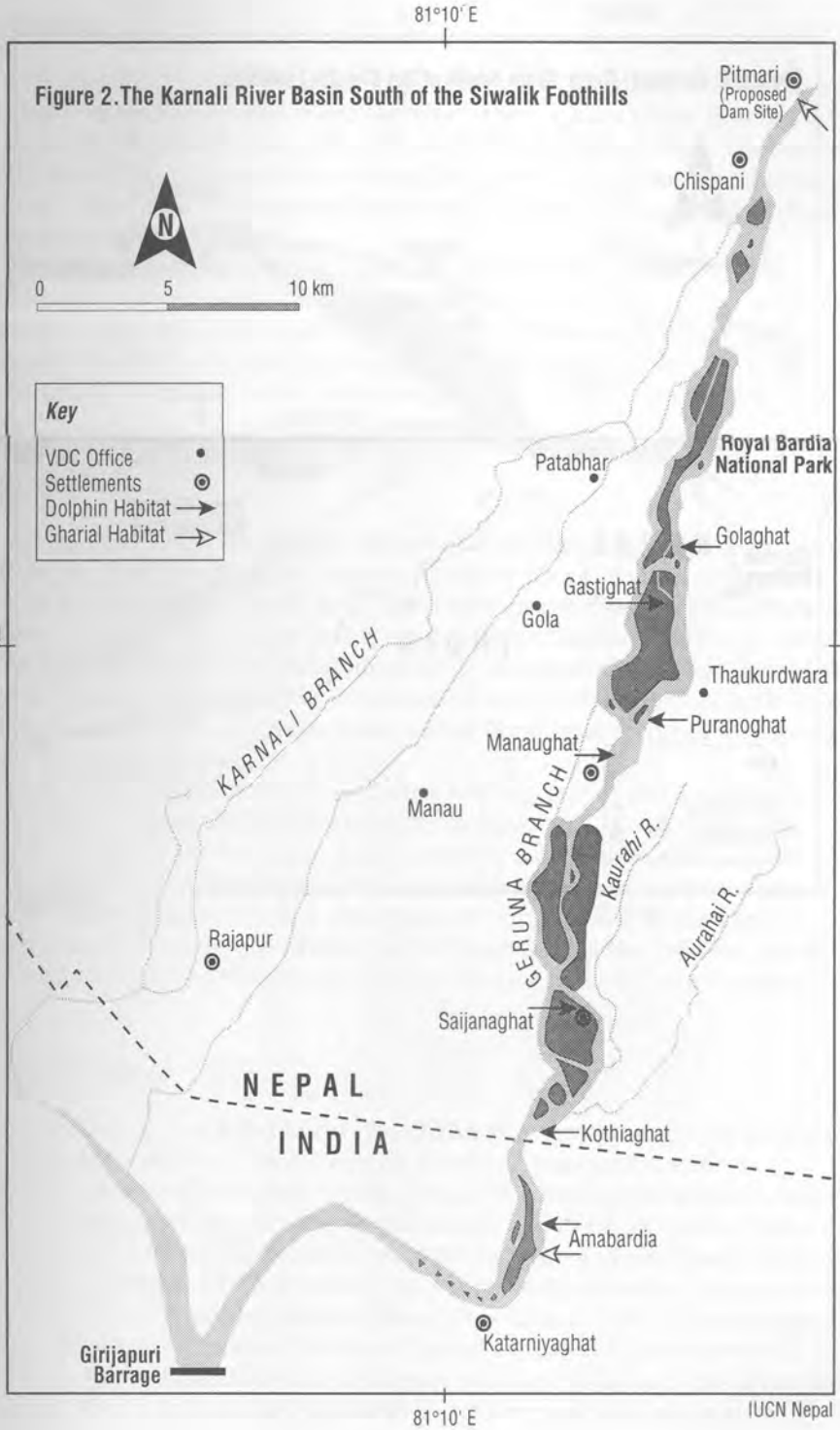
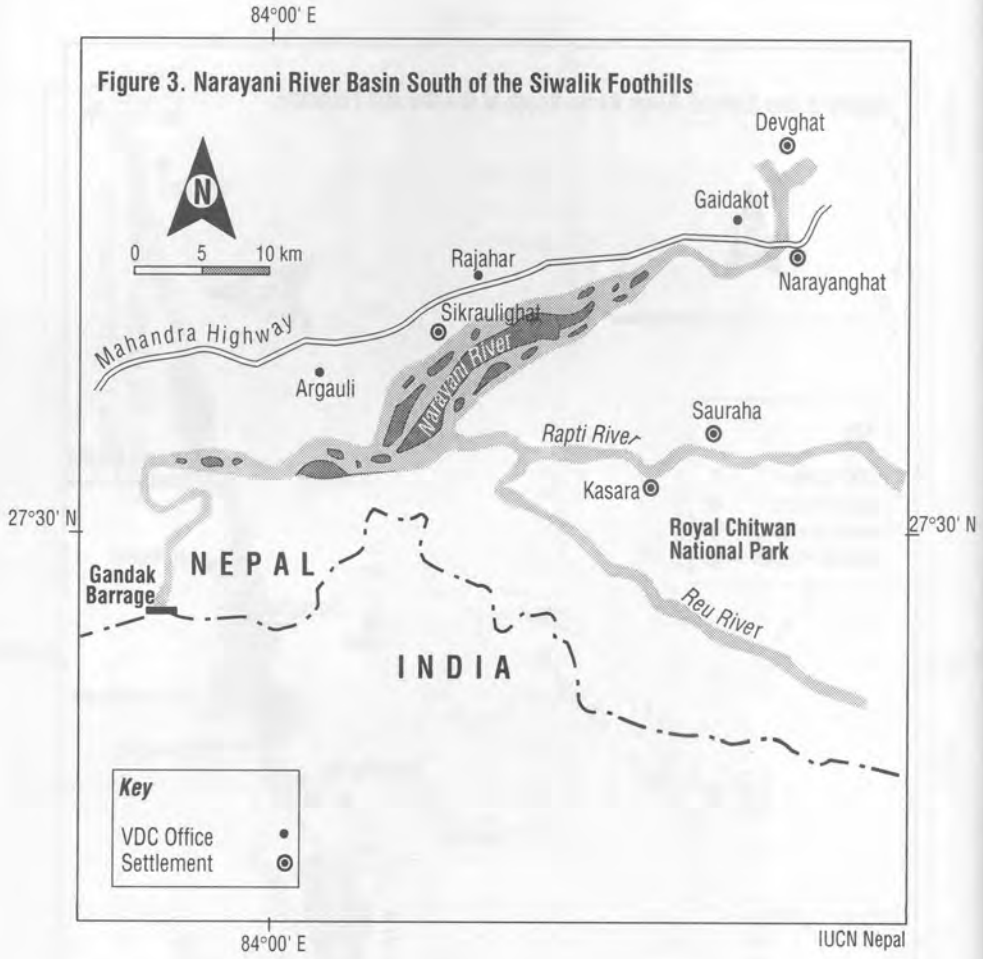


Figure 1. Nepal Showing the Karnali, and Narayani River Basins


81°10' E
Figure 2.The Karnali River Basin South of the Siwalik Foothills
Pitmari
(Proposed
Dam Site)
Chispani
N
0
5
10 km
Key
VDC Office
Settlements
Dolphin Habitat
Gharial Habitat
Royal Bardia
National Park
Patabhar
Golaghat
Gastighat
Gola
28°30' N
28°30' N
KARNALI BRANCH
Thaukurdwara
Puranoghat
Manaughat
Manau
GERUWA BRANCH
Kaurahi R.
Aurahai R.
Rajapur
Saijanaghat
NEPAL
INDIA
Kothiaghat
Amabardia
Katarniyaghat
Girijapuri
Barrage
81°10' E
IUCN Nepal


84°00' E
Figure 3. Narayani River Basin South of the Siwalik Foothills
Devghat
Gaidakot
Narayanghat
Rajahar
Sikraulighat
Mahandra Highway
Argauli
Narayani River
Sauraha
Rapti River
Kasara
27°30' N
Royal Chitwan
National Park
Gandak
Barrage
NEPAL
Reu River
INDIA
Key
VDC Office
Settlement
0 5 10 km
84°00' E
IUCN Nepal

1.3 Geology

The dominant influence on the creation of these river basins is the geologic uplift of the Himalayan range caused by the collision of the Indian and the Eurasian continental plates. Even though the Himalayan range contains the world's largest mountains, the recent beginning of the continuing collision, in the Cretaceous-Pleistocene period, means that the mountains and foothills are highly unstable and erodible.

The Siwalik foothills are composed of clay, sand, small pebbles, and boulders with a conglomerate appearance. Rock types are alternating layers of sandstones, siltstones, and mudstones (Himlayan Power Consultants 1992). The river bed and adjacent terraces are composed of sediments carried by river flow and deposited where the water meets the Gangetic Plain. Sediment size tends to decrease with increasing distance from the foothills.

1.4 Hydrology

The climate of the Himalayan watershed determines the hydrologic regime of its rivers. Local precipitation patterns normally do not significantly affect seasonal flood patterns of these large catchment basins because glacial melt and networks of mountain streams buffer short-term fluctuations. Although large year-to-year variations in the magnitude of floods are common, hydrographs of water discharge in the Karnali and Narayani rivers show a rather smooth and predictable flood curve, with one pronounced flood peak each year occurring during the monsoon rains.

High flows in both rivers occur during July-September and low flows in January-March. Using hydrological data recorded from 1981 through 1990, mean discharge for the low water season was calculated to be 346 cms and 331 cms for the Karnali and Narayani rivers, respectively, and mean discharge for the high water season was 3,534 cms and 4,481 cms, for the Karnali and Narayani rivers, respectively. Maximum discharge during the ten year period was 14,600 cms and 16,900 cms for the Karnali and Narayani rivers, respectively.

1.5 Physiography

In a relatively thin band of braided channels, the steep erosional streams of the Himalayan watershed are transformed into the less constrained depositional rivers of the greater Ganges basin. The interaction between highly erodible sediments of the Himalayan mountains and the flood-pulse character of the seasonal flow regime creates a spatially complex and temporally dynamic stream physiography. Variable flow regimes increase bank erosion and provide the sediments that form depositional bars (Leopold *et al.* 1964). The morphologic characteristics of braided rivers are locally adjusted to conditions that rapidly change as streambeds lose or capture sediment load from the upstream catchment (Sullivan *et al.* 1987). Sediments are temporally stored in the

floodplain and an equilibrium is established between deposition and erosion (Leopold *et al.* 1964).

2. Aquatic Wildlife

2.1 Ganges River Dolphins

The Ganges river dolphin (*Platanista gangetica*; Figures 4), also known as 'susu,' is a freshwater dolphin distributed throughout the Ganges, the Brahmaputra, the Megna, and Karnaphuli river systems in India, Bangladesh, and Nepal (Jones 1982, Reeves and Brownell 1989, Reeves and Leatherwood 1994, Shrestha 1995). Although the total population of the species is unknown, the IUCN regards the species as vulnerable (Klinowska 1991). Susu populations have declined in much of their range as threats to their survival continue to grow (Reeves and Leatherwood 1994).

Susu is a fairly robust dolphin with a small head, long narrow beak, dorsal fin reduced to an indistinct triangular hump, and broad spathulate flippers. The dolphin is uniformly grey with a slight pinkish hue in some younger animals. The eye is only slightly larger than a pinhole and lacks a crystalline lens. Although the dolphin may be able to detect the direction and intensity of light,

Figure 4. A Ganges river dolphin showing its flukes while attempting to capture a bottom dwelling fish.

vision has largely been replaced by a sophisticated echolocation system (Pilleri and Pilleri 1972). Females can grow to a length of 2.5 m and males to 2.1 m (Leatherwood and Reeves 1983).

Susus are most frequently observed alone or, less frequently, in groups of 2-3 (Jones 1982, Smith 1993). Infrequent sightings of pairs are generally mother and calf (Kasuya and Haque 1972, Haque 1976, Jones 1982).

The dolphins are normally found downstream of shallow areas or tributary junctions (Kasuya and Haque 1972). Smith (1993) observed susus most often in "primary habitats" where convergent streams create an eddy counter-current system in the mainstream flow. Less often the dolphins were found in "marginal habitats" where a sharp upstream bend creates a similar eddy counter-current system but of smaller dimensions. The location of dolphins in eddy counter-current systems, that are also areas of high human use, make them particularly vulnerable to local environmental disturbances (Smith 1993). During the low water season dolphins frequent main river channels and move to smaller tributaries during high water periods of the monsoon (Kasuya and Haque 1972).

It has been reported that the Mallah people of the Tribeni area in Nepal never touch a dolphin because of their belief that the touch of a human will blind the animals, which would be a great sin. If the animal is accidentally trapped in a fishing net, these people will cut the net and release the dolphin without touching it. A Bote man in Nepal reported that his people do not eat the meat of a dolphin because they believe that the animal is the form of a dead Tharu woman and also because the meat of a dolphin has unpleasant smell. Another Bote man insisted that killing a dolphin would be one of the greatest sins of life. When pressed to explain why, he could not answer; the belief may be so deeply ingrained that no reason was needed.

A recent census survey in 1993 counted between 21 and 30 dolphins in the Karnali River and only one dolphin in the Narayani River (Smith *et al.* 1994). Even if a few dolphins were missed during these surveys, these results indicate a nonviable population in the Narayani River and only a marginally viable (?) population in the Karnali River.

Dolphins in the Karnali River are the last remaining population in Nepal that have a chance for long-term survival. These animals have special conservation value because: (1) their close proximity to Royal Bardia National Park in Nepal makes them a valuable asset for local ecotourist development; (2) preservation efforts aimed at maintaining the viability of a small isolated population of Ganges river dolphins will yield useful knowledge for preserving more critically endangered river dolphin species, such as the baiji (*Lipotes vexillifer*) and Indus river dolphin (*Platanista minor*), (3) preliminary indications of behavioral observations made by one of the authors (Brian D. Smith) indicate that dolphins inhabiting the Karnali River may have developed unique behavior patterns and habitat preferences as an adaptive response to the local conditions of an upstream environment (e.g., greater energetic constraints of high velocity flows and greater habitat complexity of a braided channel environment); and (4) upstream animals inhabiting relatively uncontaminated

waters of the Karnali River might serve as useful 'controls' for comparison studies of contaminants in susus from downstream waters of the Ganges system (Smith *et al.* 1994).

2.2 Crocodiles

Gharial

The gharial (*Gavialis gangeticus*; Figure 5) is one of the most unusual crocodile species. The snout is long and narrow compared to other crocodilians and is armed with numerous slender, interlocking teeth, which are likely adaptations to a primarily fish eating diet (Buffetaut 1979). Mature males have a distinct protrusion on the tip of their snout known as a *ghara* (mud pot in Hindi). Gharials are probably the most aquatic of all crocodile species with extensively webbed rear feet (Bustard and Singh 1978). Together with the saltwater crocodile (*Crocodylus porosus*), gharials are the largest of the living crocodiles; males can attain a length of 6-7 m. Sexual maturity is reached at a length of 2.6 m (7-8 years) and 4.0 m (15-18 years) for females and males, respectively (Ross *et al.* 1989).

Gharial distribution is restricted to the northern part of the Indian subcontinent where the animals inhabit areas of reduced current in deep fast-flowing rivers (Whitaker and Basu 1983). Declines in gharial populations have been attributed to loss of habitat from the encroachment of humans, hunting for

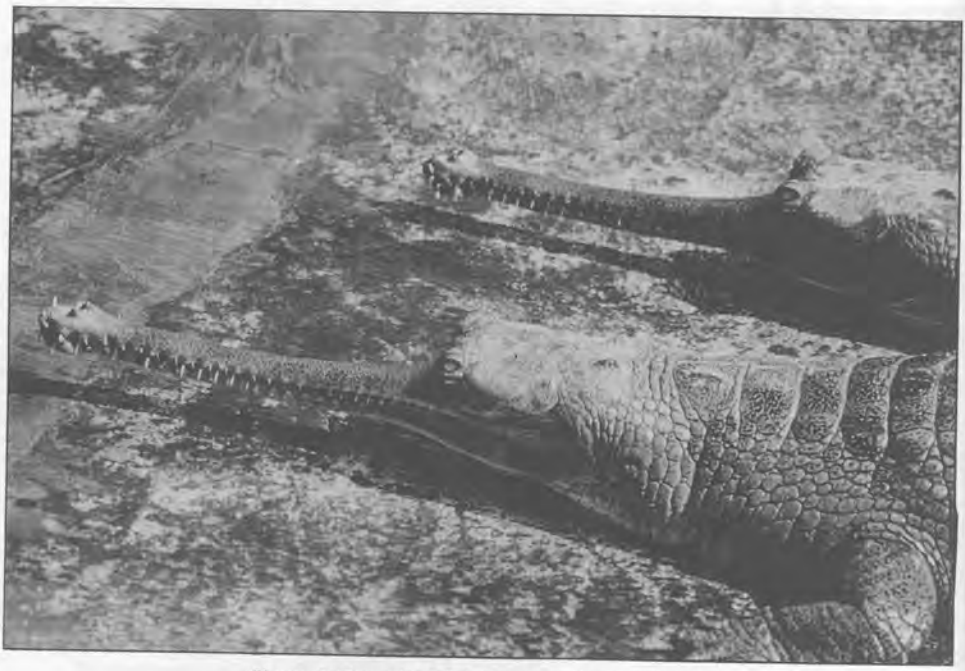


Figure 5. Two gharials basking on the river bank.

skins and body parts believed to have medicinal value, and incidental catches in fishing nets (Thorbjarnarson *et al.* 1992).

Gharials were brought back from the brink of extinction in 1974 by successful captive breeding and restocking programs (Whitaker 1987). These programs are based primarily on collecting eggs from the wild, incubation and rearing in hatcheries until the gharials are a meter or more in length, and then reintroducing the captive-reared animals. Restocking of captive-reared juveniles was initiated in India during 1975 and in Nepal during 1978. Although substantial conservation progress has been made, the 1992 IUCN Action Plan for Conservation of Crocodiles classifies gharials as one of the highest priority species for conservation action and rates the population status in Nepal as severely depleted/endangered (Thorbjarnarson *et al.* 1992).

The Gharial Conservation Project in Nepal is located near the headquarters of Royal Chitwan National Park in Kasara. By 1993 the hatchery had released 278 gharials in the Narayani and Rapti rivers and 20 gharials in the Karnali River (Maskey and Percival 1994). A similar project in the Katarniyaghat Gharial Sanctuary of India released 436 gharials from 1975-1985 (according to a sign at the hatchery). The project is still operating but the number released since then is unknown.

During surveys in 1993, five gharials were counted in the Karnali River upstream of the Nepal/India border, all within the Chisapani gorge, and 30 gharials in the Narayani River (Maskey and Percival 1994). During surveys for river dolphins in 1993 (Smith *et al.* 1994), one of the authors of this report (Brian D. Smith) counted 24 gharials in the Karnali River (only one gharial was located upstream of the Nepal/India border) and six gharials in the Narayani River. Only one adult male was observed in each river.

Considering the large number of gharials released from hatcheries in Nepal and India, the low number of gharials observed in both rivers may indicate serious problems with the ability of these rivers to support gharial. Reasons for this could include: (1) disturbance from human activities, (2) a decline in the availability of prey, and (3) poaching. The low number of adult males is also reason for concern. A sex ratio of 1 male to 10 females has been estimated for gharials in Nepal (Maskey and Percival 1994). The difference in the ratio between males and females was attributed to poaching being focused on males for their "ghara" and to artificial incubation conditions in hatcheries. The temperature during early embryo development is the major determinant of sex in crocodiles (Lang 1989).

Hatchery/rearing centers have been the primary strategy for preventing the extinction of gharials. This strategy will eventually fail unless there are an adequate number of crocodiles of both sexes and environmental conditions in the rivers are sufficient to support a reproductively active population. Research is needed to determine the reproductive success of captive released animals and the ability of the rivers to provide the necessary habitat requirements for a viable population.

Mugger

The mugger crocodile (*Crocodylus palustris*; Figure 6) is a medium to large crocodile with a broad heavy snout, reaching a length of over 4 m. Distribution is primarily restricted to the Indian subcontinent, where they are found in a variety of habitats, including cool hillstreams, large rivers, lakes, and marshlands. In some areas mugger crocodiles are sympatric with gharials, particularly in the Narayani River (Groombridge 1982). The species is known to dig burrows to escape hot and cold weather. Muggers lay 25-30 eggs in holes dug in the sand during the dry season about 40 days after mating (Whitaker and Whitaker 1989). Incubation typically lasts 55-75 days (Whitaker 1987). Muggers eat fish, frogs, snakes, crustaceans, and large mammals.

The IUCN Red List rates mugger crocodiles as a vulnerable species (Thorbjarnarson *et al.* 1992). The 1992 IUCN Action Plan for Conservation of Crocodiles classifies muggers as a high priority species for conservation action and rates the population status in Nepal as severely depleted/endangered (Thorbjarnarson *et al.* 1992). Principal threats are incidental catch in fishing nets, egg predation by people, habitat destruction, and hunting for the use of crocodile body parts for medicinal purposes (Groombridge 1982).

The largest number of mugger crocodiles in Nepal are found in the Narayani and Rapti rivers, within Royal Chitwan National Park. Muggers are not believed to inhabit the Karnali River but may be found in its tributaries (Thorbjarnarson *et al.* 1992). Some mugger crocodiles have been reared at the Gharial Conservation Project in Chitwan National Park and released into the

Figure 6. A juvenile mugger crocodile.

Narayani and Rapti rivers, but accurate records of numbers and location of release have not been kept (Andrews and McEachern 1994).

2.3 Otters

The only species of otter known conclusively to inhabit the Karnali and Narayani rivers is the smooth Indian otter (*Lutra perspicillata*). The Asian small-clawed otter (*Aonyx cinerea*) and Eurasian otter (*Lutra lutra*) may also inhabit these rivers but information on their existence and whereabouts is unknown (Foster-Turley and Santiapillai 1990).

The smooth Indian otter, Asian small-clawed otter, and Eurasian otter are classified in the 1990 IUCN Action Plan for Conservation of Otters as a species of local conservation concern (Mason and Macdonald 1990). The specific action plan for conserving Asian otters states that otters have been declining throughout Nepal (Foster-Turley and Santiapillai 1990).

Smooth Indian otter

The smooth Indian otter measures up to 1.2 m in length and weighs about 10 kilograms (Mishra and Jeffries 1991). The pelage is velvety in texture and color is raw umber to smokey grey-brown with a lighter drab color on the underside (Foster-Turley *et al.* 1990). Their feet are quite large with well developed thick webbing. The species is mostly nocturnal. During daytime hours, the otters burrow in sandy banks with dense vegetation or hide in the roots of riparian trees. Breeding takes place between November and February with a gestation period of two months (Mishra and Jeffries 1991). The otters mark individual territories with spraints, deposited singly on prominent rocks or sand mounds, or in groups on dry sand and rocky banks (Mishra and Jeffries 1991).

Asian small-clawed otter

The Asian small-clawed otter is the smallest of all otter species, normally weighing less than 5 kilograms (Foster-Turley and Santiapillai 1990). They have small hand-like front paws with reduced webbing to forage for their diet of crustaceans, mollusks and small fish (Foster-Turley and Santiapillai 1990). Their color is a burnt umber to dusky brown with a noticeable lighter throat area (Foster-Turley *et al.* 1990). The otters are often found in large groups of up to 15 animals (Furuya 1977).

Eurasian otter

The Eurasian otter is a medium size otter. They are brownish grey to dusky brown in color with a lighter well demarcated throat (Foster-Turley *et al.* 1990). They primarily eat fish but have been known to take other vertebrates and crustaceans (Foster-Turley and Santiapillai 1990). Although well studied in Europe, their elusive nature and the small numbers present in Asia make their ecology unknown in this region (Foster-Turley and Santiapillai 1990).

2.4 Turtles

The Karnali and Narayani rivers and their tributaries provide ideal habitat for several species of freshwater turtle. Turtles recorded in the rivers include softshell and flapshell turtles [family Trionychidae: narrow-headed softshell turtle (*Chitra indica*), Indian softshell turtle (*Aspideretes gangeticus*), Indian flapshell turtle (*Lissemys punctata andersoni*)], and hardshell turtles [family Emydidae: three-striped roofed turtle (*Kachuga dhongoka*), red-crowned roofed turtle (*Kachuga kachuga*), brown roofed turtle (*Kachuga smithii pallidipes*), Indian tent turtle (*Kachuga tentoria flaviventer*), and crowned river turtle (*Hardella thurjii*)] (Das 1991). Three other species [family Trionychidae: Indian peacock softshell turtle (*Aspideretes hurum*) and family Emydidae: Indian roofed turtle (*Kachuga tecta*) and spotted pond turtle (*Geoclemys hamiltonii*)] are also believed to inhabit the Karnali and Narayani rivers; these species were identified in the neighboring Sharda River of India during river dolphin surveys conducted by one of the authors (Brian D. Smith).

Narrow-headed softshell turtle

The largest among turtle species in these rivers is the narrow-headed softshell turtle with a carpace length that may reach 183 cm (Annandale and Shastri 1914 as cited in Das 1991). Similar to other softshells, the turtle has a leathery carpace. The shell is gray to olive in color with a variable pattern of wavy reticulations that continue in a V-shaped pattern up to the neck and forelimbs (Das 1991). As the name suggests, the head is narrow and ends in a snout with a short proboscis. The turtle inhabits sandy sections of large rivers and is seldom seen on land except during egg laying activities (Ernst and Barber 1989). Nesting is thought to take place during the monsoon (Mishra and Jefferies 1991) and 60-110 eggs are laid (Ernst and Barbour 1989). Fish, mollusks, crabs, shrimps, and probably some plants are contained in the diet of this species (Ernst and Barbour 1989).

Indian softshell turtle

Similar in appearance but smaller in size, the Indian softshell turtle (Figure 7) is distinguished by black oblique stripes on the head and well-defined black reticulations on the carpace. This turtle inhabits deep rivers and streams with mud and sand bottoms and may emerge to bask on sandbanks (Minton 1966). Mishra and Jefferies (1991) report that nesting occurs during the monsoon season or shortly after with up to 35 eggs being laid. The turtle is omnivorous, eating fish, amphibians, carrion and aquatic plants and is heavily exploited, primarily for consumption of its flesh (Das 1991).

Indian peacock softshell turtle

The smallest of the softshell turtles believed to inhabit these rivers is the Indian peacock softshell turtle. This species attains a length of 60 cm, has an

Figure 7. An Indian softshell turtle caught on a baited hook by local fishers in the Karnali River.

olive colored carpace with a yellow rim, and an olive-colored head with black reticulations and orange or yellow patches (Das 1991). The turtle can be found buried in the mud or sand bottom of rivers and streams. (Ernst and Barbour 1989). Nesting takes place during the winter months of the low water season (Das 1991).

Indian flapshell turtle

The Indian flapshell turtle has a pair of flaps on the carpace under which the hindlimbs can be retracted. The shell is low and domed shaped, olive-brown, grey-green, or pale green in coloration with three parallel black stripes that tend to disappear with age (Das 1991). The turtle inhabits fast flowing rivers (Alderton 1992) and is omnivorous, sometimes resorting to cannibalism (Das 1991). The species has been reported to hibernate during the dry season and nest during the late monsoon (Das 1991). Distribution is widespread because of the turtle's adaptability to drought conditions and areas modified by human activities (Das 1991). The species is heavily exploited for its meat, which is thought to have medicinal value (Das 1991).

Three-striped roofed turtle

The three-striped roofed turtle has a carpace length reaching 48 cm in females and 26 cm in males (Smith 1931 as cited in Ernst and Barbour 1989). The carpace is rough in texture and olive or brown in color with three black

stripes running along the vertebral keel. The head has a projecting narrow snout and is olive to brown with a yellow stripe on each side (Ernst and Barbour 1989). Nests are dug in riverbanks during the late dry season in March and contain 30-35 eggs. Hatchlings emerge in May and June (Chaudhuri 1912 as cited in Ernst and Barbour 1989). The species is thought to be mostly herbivorous (Das 1991) with males sometimes preying upon mollusks (Moll 1986).

Red-crowned or painted roofed turtle

The red-crowned or painted roofed turtle is similar in size and appearance to the three-striped roofed turtle but with a smooth unmarked carpace (Das 1991). Breeding males have a red head with blue sides, red longitudinal stripes on the neck and red or yellow spots on the throat. The head and neck of females is olive brown (Ernst and Barber 1989). The turtles are found in fast flowing rivers and are sometimes observed basking on sandbanks, rocks, and logs (Das 1991). Habitat and breeding patterns are reported to be similar to the three-striped roofed turtle (Chaudhuri 1912 as cited in Ernst and Barbour 1989). In captivity the turtles are herbivorous (Das 1991).

Brown roofed turtle

The brown roofed turtle attains a length of 23 cm and has an oval brownish olive shell. The head is yellowish grey to pinkish-grey with a reddish-brown spot on the temple and neck grey with yellowish stripes (Ernst and Barbour 1989). The turtle is normally found in muddy river channels (Das 1991) but also inhabits backwater lakes (Moll 1987). Nesting is believed to occur in August-November with a clutch size of 3-11 eggs (Das 1991). The species is omnivorous with prawns and macrophytes being recorded in stomach contents (Prashad 1914 as cited in Das 1991).

Indian roofed turtle

The Indian roofed turtle is similar in size and coloration to the brown roofed turtle. The species can be distinguished by its black head with a large crescent shaped orange to yellowish-red blotch on each temple (Ernst and Barbour 1989). The turtle prefers quiet waters of slow moving streams, ponds, canals, and oxbow lakes with abundant aquatic vegetation. Little is known about breeding patterns except for a report by Ahmad (1955), as cited in Ernst and Barbour (1989), of nine fully developed eggs in a female collected in March.

Indian tent turtle

The Indian tent turtle can attain a shell length of 26.5 cm and be distinguished by a distinctly spiked vertebral keel and a narrow red to orange medial stripe (Das 1991). The turtle is found in large and small rivers, basking on rocks and tree trunks (Das 1991). Adult turtles are generally herbivorous, feeding on a

variety of aquatic macrophytes (Das 1991), but may also feed on prawns (Moll 1987). Nesting activity has been recorded in December with 6-10 eggs per clutch (Moll 1987).

Crowned river turtle

The crowned river turtle exhibits extreme sexual dimorphism; the adult male has a carpace length of about 18 cm and females are more than three times larger than males (Ernst and Barbour 1989). The carpace is dark grey, brown, or black with a yellow outer rim, and a low blunt medial keel, especially in juveniles (Ernst and Barbour 1989). The head is black with several yellow stripes (Ernst and Barbour 1989). The species prefers slow moving or still water and rarely emerges on land to bask. The turtles are herbivorous. Nesting takes place on sandy soil among bushes (Vijaya and Manna 1982) in August and September when the water subsides at the end of the monsoon (Chaudhuri 1912 as cited in Das 1989). Commercial exploitation of this turtle is probably the highest of all the hardshells (Das 1991).

Spotted pond turtle

The spotted pond turtle has an elongated dome-shaped black shell with three keels, yellow streaks, and wedge-shaped marks and has been known to attain a shell length of 36 cm (Das 1991). The head is black with yellow spots and neck grey with white spots (Das 1991). The turtle inhabits shallow standing water bodies and can be found basking on reed covered banks (Das 1991). Nesting activity has been reported to take place twice a year, just prior to and after the monsoon (Das 1991).

The IUCN Action Plan for the Conservation of Tortoises and Freshwater Turtles (Stubbs 1991) recommends that the red-crowned roof turtle and spotted pond turtle be listed as endangered and that specific conservation projects and status surveys are required. These species are threatened from over-exploitation of eggs and meat and may be particularly vulnerable at colonial nesting sites. The action plan for tortoise and freshwater turtles also rates the narrow-headed softshell turtle, three-striped roof turtle, and crowned river turtle as species believed to be in need of conservation action but with insufficient information to evaluate their status or to develop detailed conservation proposals (Stubbs 1991). The status of these species is not known in the Karnali and Narayani rivers. Other turtle species may inhabit these river basins but their presence has not been recorded.

3. Riverine Birds

Although not strictly aquatic, a wide variety of shorebirds and riparian forest birds depend upon riverine habitat. Some of the birds are resident while others are migratory. Migratory species utilize the rivers seasonally or during brief stopovers while on their way to feeding or breeding grounds.

No detailed surveys of riverine birds have been conducted on the Karnali and Narayani rivers. During aquatic wildlife surveys in February-March 1993 and 1994 and December 1994, one of the authors (Brian D. Smith) identified 73 riverine bird species, representing 17 different families (Table 3). Several of the more common bird species observed on the rivers and a few rare and endangered species are described below.

Cormorants and darters

Large cormorants (*Phalacrocorax carbo*) and little cormorants (*Phalacrocorax niger*) are frequently seen perched on fallen trees drying their wings. Large cormorants are black with a blue-green sheen, white facial area, and a bright yellow throat. These birds are normally found alone or sometimes in pairs. Little cormorants are smaller birds with a short thick neck. They are the same color as large cormorants but breeding adults have silky white head feathers. Little cormorants generally occur in small scattered flocks.

Darters (*Anhinga rufa*) are related to cormorants and can be seen swimming low in the water with their thin neck moving back and forth in a snake-like motion. These birds are especially adapted for spearing their fish prey underwater with rapier-like thrusts of their pointed bill (Grewal 1993).

Egrets and herons

Large egrets (*Egretta alba*) are commonly observed standing motionless on the shore with their necks outstretched while waiting patiently for prey. These birds often occur in mixed flocks with little egrets (*Egretta garzetta*) and less often with intermediate egrets (*Egretta intermedia*). Grey herons (*Ardea cinera*) and purple herons (*Ardea purpurea*) are close relatives to the large egret. These birds are generally seen standing alone along the streambank. In flight, purple herons fly with their long and slender necks outstretched, while grey herons fly with their head pulled in and long legs trailing. Resident populations of purple herons are augmented in the winter by migant birds (Grewal 1993).

Lapwings

One of the most common birds occuring along rocky streamsides are spur-winged lapwings (*Vanellus spinosus*). These birds congregate in small scattered flocks and are good runners, as well as strong fliers. Less common are redwattled lapwings (*Vanellus indicus*), vigilant and loud birds, sometimes found associated with the rarer and quieter yellow lapwing (*Vanellus malabar*).

Ducks and geese

Several ducks and geese are winter migrants, using the rivers as a stop-over on their journey south, or remaining as seasonal residents. Brahminy ducks (*Tadorna ferruginea*) are noisy winter visitors occurring in pairs on banks adja-

cent to fast flowing open water. Their diet of algae and fidelity to a life-long mate give them protected status among most Hindus. Merganser ducks (*Mergus merganser*) fish in small parties, segregated by sex, below rapids in large river courses (Grewal 1993). The wings of northern pintails (*Anas acuta*) hiss as they fly over during crepuscular and nocturnal flights. These ducks are frequently seen floating down the river and tipping their rump up while feeding on vegetable matter, water insects, and mollusks (Grewal 1993). Northern shovelers (*Anas clypeata*) occur in small flocks and can be identified by their long broad beaks. Common teal (*Anas crecca*) are tiny ducks with a bright green speculum. They are swift fliers and much sought after by sportsmen (Grewal 1993). Spotbills (*Anas poecilorhyncha*) can be identified by their conspicuous black and yellow bill with a black tip and red spot at the base of the forehead (Flemming *et al.* 1984). These resident ducks sometime remain underwater while foraging, only exposing their beaks to breathe (Grewal 1993).

Barheaded geese (*Anser indicus*) migrate in large flocks, flying in a V-formation, and are commonly seen along the banks of broad river channels. Greylag geese (*Anser anser*) are large with a pink bill. These birds vocalize a clear honk on the wing and gurgle when they feed at the edge of sandbanks (Fleming *et al.* 1984).

Ibises and spoonbills

Black ibis (*Pseudibis papillosa*) have long downturned bills, glossy black plumage, and a red crown. These birds forage in small groups, feeding on small fish, frogs, worms, and crustaceans along the river edge or in shallow water.

Elegant Eurasian spoonbills (*Platalea leucorodia*) are sometimes found in the same area as black ibis, probing the mud with their prominent spoon-shaped bills or resting with their bills tucked under one wing.

Terns

Black-bellied terns (*Sterna acuticauda*) are seen in small groups patrolling along the river course, frequently in association with larger Indian river terns (*Sterna aurantia*). Black-bellied terns catch small fish by skimming the water with their beaks. Indian river terns plunge after prey from high above.

Kingfishers

White breasted kingfishers (*Halcyon smyrnensis*) have a chestnut brown head, coral-red beak, white breast, and spectacular turquoise-blue wings. These birds are frequently seen perched over river channels, occasionally dropping down to catch small frogs and fish. The much smaller common or small blue kingfisher (*Alcedo atthis*) has equally bright blue wings, a blue head, dark beak, rust cheeks, and a light-brown breast. This bird is generally seen perched on overhanging branches always near water (Grewal 1993). The small pied kingfisher (*Ceryle rudis*) has a speckled black and white plumage and is frequently

seen hovering high above slow moving stretches of river with its bill pointed down, and then plunging into the water to catch a fish.

Storks

The black-necked stork (*Ephippiorhynchus asiaticus*) is the largest and arguably the most elegant stork occurring in the Indian subcontinent. It is rarely seen on the rivers, but when sighted it occurs solitary or in pairs. The bird is unmistakable with its large black beak, blue-green black head and neck, white body, wings with a dark black band, and long coral red legs. It is a resident species and becoming uncommon (Grewal 1993). Smaller white-necked storks (*Ciconia episcopus*) are more commonly seen. These birds occur solitary or in small groups and have a purplish-green black head, body, and large wings. They sometimes feed in association with other storks, ibises, and egrets. Black storks (*Ciconia nigra*) are seen occasionally along the streambanks in large groups. These birds have a white belly, black neck, and bright red bill. They can also be found in valleys deep inside the Himalayas (Fleming *et al.* 1984). Open-billed storks (*Anastomus oscitans*; Figure 8) are pale gray with black wings and can be recognized by the opening between their mandibles. These birds are generally found near small ponds but can occasionally be seen perched high on trees or circling above large rivers (Fleming *et al.* 1984).

Figure 8. An open-billed stork circling over the Karnali River.

Cranes

Sarus cranes (*Grus antigone*) stand stately tall and run in slow loping gaits before taking off in a graceful flight. These birds are unmistakable due to their tall height, red head, and white crown. They are commonly found in pairs with their lifelong mate. Habitat loss is a grave threat to their continued survival (Grewal 1993). Smaller demoiselle cranes (*Anthropoides virgo*) can be seen flying over river channels in loose V-formations and standing along the river bank during brief stopovers when the weather is bad (Fleming *et al.* 1984). These birds have long black feathers on their neck and prominent white ear tufts on an otherwise black head with a red crown.

Ospreys and eagles

The most common bird of prey observed circling over the river course is the osprey (*Pandion haliatus*). When an osprey sees a fish, it hovers over the spot and then dives with its sharp talons dangling below. The bird then returns to its nest to feed on fish that are sometimes heavier than the bird itself (Grewal 1993).

Himalayan grey-headed fishing eagles (*Icthyophaga nana*) are normally seen perched alone in large trees overhanging the river bank. These birds vocalize a human-like cry (Fleming *et al.* 1984). A Himalayan grey-headed fishing eagle was once observered by one of the authors (Brian D. Smith) attempting to steal a fish from a surfacing Ganges river dolphin.

Martins and pratincoles

At dusk large loose flocks of sand martins (*Riparia paludicola*) leave their cavity nests in the river banks and join small Indian pratincoles (*Glareola lactea*) catching insects over the water surface.

4. Terrestrial Wildlife

Riparian forest and sandbar environments are utilized extensively by a large assortment of terrestrial mammals. The riparian environment supports higher numbers of chital (*Axis axis*), nilgai (*Boselaphus tragocamelus*), hog deer (*Axis porcinus*), barking deer (*Muntiacus muntjak*), wild boar (*Sus scrofa*), one-horned rhinoceroses (Figure 9), and Royal Bengal tigers than interior forests and grasslands (Dinerstein 1979). Herbivorous mammals depend upon the high nutritional content and cover provided by dense early and mid-successional vegetation that characterize riparian habitat. The fishing cat (*Felis viverrina*) also depends directly upon fish for their prey. Detailed account of terrestrial animals inhabiting the Karnali and Narayani river basins is found in the work of Dinerstein (1979), Dinerstein (1980), Majupuria (1981), Majupuria (1990), Mishra and Jeffries (1991), and Upreti (1994).

Figure 9. A one-horned rhinoceros crossing the Narayani River.

5. Fish Species and Fisheries

5.1 Species Diversity

A total of 121 and 135 fish species have been recorded in the Karnali and Narayani river basins, respectively, below and within the Himalayan foothills (Table 4). Represented in the species list are 10 orders and 24 families. The great diversity of fish species recorded in these rivers is related to their location in a transitional zone, where cool torrential waters of Himalayan hillstreams are transformed into the warm and slow flowing waters of the Gangetic Plain. Species normally associated with mountain streams (e.g., *Schizothorax* spp.) inhabit the same waters as species normally associated with alluvial corridors of the tropical lowlands (e.g., *Labeo* spp.).

Complex physiography and large temporal variations in water discharge, temperature, and turbidity provide an assortment of ecological niches that satisfy the environmental requirements of a large number of fish species. Many fish exhibit morphological adaptations to microhabitats occurring within the river. For instance, *Schizothorax* spp. have lips that form a suctorial disc, which allow them to attach themselves to stones, and are highly streamlined, which facilitates swimming in swiftly flowing waters, and *Labeo* spp. have well developed air bladders, which allow them to adjust their position in deep and slower flowing water (Edds 1986).

5.2 Economically Important Species

In an unpublished study, conducted during the low water season of 1990 in the Karnali River, one of the authors (Brian D. Smith) identified golden mahseer (*Tor putitora*; Figure 10), mrigal carp (*Cirrhinus mrigala*), and sucker catfish (*Bagarius bagarius*; Figure 11) as species that held the highest value for local artisanal fishermen. The golden mahseer is the best known of the economically important species and had the highest value to artisanal fishers.

Golden mahseer

Mahseer are a highly sought after gamefish that are endangered throughout their distribution (Tripathi 1978, Sen 1982, Nautiyal and Lal 1982, 1988, Joshi 1987, Nautiyal 1989). Hindus consider mahseer to be a holy fish that propitiate the souls of their deceased ancestors (Nautiyal 1989).

Golden mahseers (*T. putitora*) have been reported to attain a maximum size of 2.7 m in length (Misra 1959; Jhingran 1982) and 1.8 m in length in Nepal (Shrestha 1981). Scales are so large that they are sometimes used as gaming cards (M'Clelland 1980).

The species exhibits great diversity in food and feeding habits. They may feed extensively on one type of food throughout their life history, feed on a variety of foods, or exhibit a transition from animal to plant material or vice versa. Flexible food habits are thought to be a response to seasonal availability of different foods in the same or different environments (Nautiyal 1989). High growth rates of juvenile fish during the first year of maturation result from the high quantity and quality of insect prey fauna available in springfed streams during nonmonsoon periods (Nautiyal 1989).

Figure 10. A golden mahseer caught by a local fisher in the Karnali River.

A tri-phased migration pattern was recorded for golden mahseer in the Garhwal Himalayas (Nautiyal and Lal 1984, Nautiyal 1989). Adults and juveniles nearing maturity inhabit feeding grounds of the Ganges River below the mountain foothills, while younger juveniles inhabit shallow spring-fed hillstreams during the low water season from September to February. The first phase of the migration begins in March-April when sexually immature semi-adults and a few younger brood-fish (length 20-70 cm) ascend to snow-fed

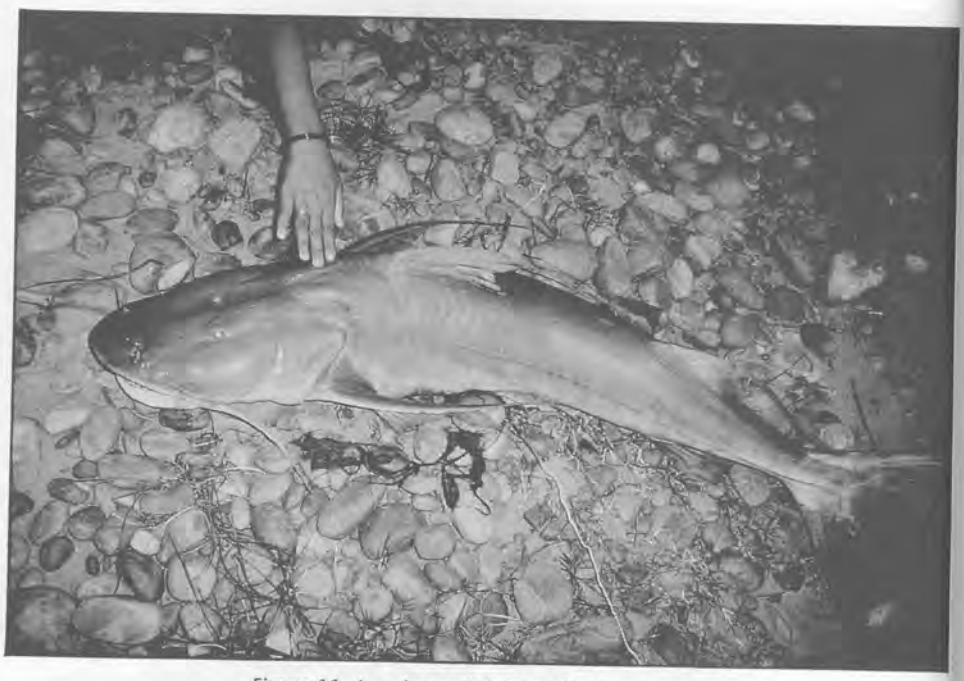


Figure 11. A sucker catfish from the Karnali River

tributaries. These fish remain in the tributaries until June-July. The migration occurs during a general rise in water temperature from 16° to 20° C. The second phase of the migration commences in July, during the monsoon, when there is a marked increase in stream discharge. Brood-fish from the Ganges River and snowfed tributaries move into the spring-fed streams of the foothills that possess suitable spawning grounds. Simultaneously, the younger juvenile fish migrate in the opposite direction, from the spring-fed hillstreams into the torrential snow-fed tributaries, and join the older juveniles in returning to the Ganges feeding grounds. In the third phase of migration, sexually mature adults return to the Ganges River after spawning. During spawning, eggs are attached to stones and leaves or are deposited loosely on top or below gravel and sand in semi-stagnant water downstream of hillstream confluences (Shrestha 1986 and Badola and Singh 1980).

The fry of the golden mahseer hide under big boulders close to the stream banks. Fingerlings prefer the faster currents of midstream waters, hiding beneath stones and often running in shoals. Larger fish inhabit deep pools of large rivers (Jhingran 1982).

Fishermen mainly target individuals ascending streams for breeding purposes or fish returning to their perennial pools after spawning (Sehgal 1972). The probable factors for the decline of mahseer in hillstream areas are destructive fishing methods, catching broodfish and juveniles, construction of dams that interfere with migration, siltation of spawning grounds, and pollution (Joshi 1987).

Mrigal carp

Mrigal (*C. mrigala*) is a major Indian carp species and is dominant fish in the upper stretches of the Ganges. Habitat is confined to rapids, pools, and sandy stretches in the upper and middle reaches of rivers. Mrigal adults and fingerlings are omnivorous bottom feeders (Jhingran 1982), feeding on decaying vegetable debris and phytoplankton with a small proportion of animal matter (Woynarovich 1975). The fish breed during floods and do not migrate more than a few kilometers. The predictability of breeding in these species is so pronounced that large 'fish seed' industries have developed in some cultures that exploit them (M'Clelland 1980). During autumn months, fish catch in the Ganges river system consists of a sizable percentage of mrigal fingerlings (Jhingran 1982). Mrigal growth is slow and fish become sexually mature at approximately two years old. The fish has been grown in commercial aquaculture production ponds (Bardach *et al.* 1972, Woynarovich 1975).

Sucker catfish

The sucker catfish (*B. bagarius*) is the heaviest freshwater species in the Indian subcontinent (maximum recorded weight 120 kg). The fish mainly inhabits the upper reaches of major rivers but migrates downstream during the monsoon (Jhingran 1982). In slow moving water, it hides under logs and floating debris; in fast water, it inhabits rapids amongst the boulders. The fish is generally found in regions frequented by mahseer (Wheeler 1985).

5.3 Artisanal and Commercial Fisheries

Local artisanal fisheries (Figure 12) provide a protein and income source for rural subsistence communities but the status of these fisheries has not been assessed. Similar to other tropical riverine fisheries worldwide, overexploitation, immigration of non-local fishers, and environmental modifications (most significantly the effects of dams) threaten their viability (Scudder and Conelly 1985). The noncommercial nature of riverine fisheries tends to reduce the attention they receive in river management plans. Although these fisheries do not generate tax revenue for the government or earn foreign exchange, a decline in fish catch directly reduces protein consumption (Bernacsek 1981).

Fisheries in floodplain rivers have three characteristics: (1) a diffusely clumped distribution of fish resources determined by river channel physiography, tending to make fisheries labor intensive, with fishing effort concentrated in small settlements along the stream terrace or channel islands; (2) temporally clustered effort distributed according to the seasonal nature of the flow regime, which tends to make the fisheries a temporary or casual occupation practiced by subsistence villagers between agricultural activities in the dry season and early rising flood, or a professional migratory occupation, and (3) the practice of diverse fishing methods to optimize catch within diverse fish communities (Welcomme 1979, 1989).

The Mushahar, Bote, and Tharu people of the Narayani basin consider

Figure 12. Tharu women fishing with *haluka* hoop nets.

access to riverine fisheries to be an inalienable right. A Mushahar fisherman told one of the authors (Bishnu Bhandari) that several generations ago, the prime minister put all the *ghats* (ferry crossings) under their control, instructed them to provide ferry services for local people and to conduct hunting trips for royalty and their guests. For compensation, they were allowed to collect a *pathi* (about 2.5 kgs) of paddy (unhusked rice) from each resident and were allowed to harvest fish freely from the river. Fishing rights were later extended to the Bote and Tharu people.

Currently, fishers in the Narayani River must obtain a permit from Royal Chitwan National Park costing NRs 25 (US$ 0.5) per person per month. Permits are not issued during the summer spawning season (June thorough August). In the reservoir area behind the Gandak Barrage, one large fishing contractor gives sub-contracts to local people, charging fees ranging from NRs 100 to 1500 (US$ 2 to US$ 30) per month, depending on the fishing technique being used.

Interviews with artisanal fishers in the Karnali and Narayani rivers indicate a decrease in catch per unit effort. Scarcity has let to a significant increase in the price of fish, which was also reported in village markets. Decreasing fish populations are probably related to overexploitation, blocking of fish migratory routes by downstream barrages, and habitat degradation.

Population increases in subsistence villages within the river basins and the use of more efficient fishing gear by migrant fishers have resulted in overexploitation of riverine fisheries. Fishing pressure is further augmented by

'professional' fishers that temporarily migrate upstream from India.

During dolphin surveys in 1993, one of the authors (Brian D. Smith) interviewed a fishing contractor from India who maintains a large camp of approximately 25 to 30 professional fishers and ten small boats at Kothiaghat. The contractor paid the local District Development Committee NRs. 34,000 (US$ 680) for exclusive fishing rights on the river from Manaughat to the Nepal/India border. These fishers use gill nets (Figure 13), whereas local artisanal fishers normally fish with hook and line, cast nets and *haluka* hoop nets. A rough estimate of the total catch from the fishing contractor is 400 kg/month. In contrast, the fishing pressure from local part-time fishermen appears to be relatively small. One local fisher complained that local people are not allowed to fish in the lower Karnali of Nepal, nor are they hired to do so by the contractors. Fishers, boats, and nets are all brought from India.

Figure 13. Visiting biologists examining an environmentally destructive gillnet.

Scudder and Conelly (1985) stress the detrimental impact on riverine fish populations of the expansion of professional fishers into subsistence fisheries. Cumulative factors of high fishing pressure and environmental degradation can cause the collapse of riverine fisheries (Welcomme 1979). Increased fishing effort targeting ripe adult fish congregated during spawning migrations puts migratory species at a higher risk than more sedentary species (Welcomme 1979).

6. Ecosystem and Community Dynamics

6.1 Characteristics of Large Alluvial Rivers

Large alluvial rivers have some common characteristics: (1) the tendency of biological productivity and diversity to be concentrated in specialized habitat associated with river edges and backwater areas (Stalnaker *et al.* 1989), (2) the importance of hydrologic interactions between the floodplain and stream channel in maintaining biological productivity and diversity (Sedell *et al.* 1989 and Junk *et al.* 1989), and (3) the importance of riverine-riparian forest interactions in stabilizing streambanks and providing organic material for primary

production, substrate for planktonic flora and insect fauna, cover for fish and other aquatic biota, and shade for reducing water temperatures (Sedell *et al.* 1984, 1989).

6.2 Distribution of Biodiversity

The complex morphology of river channels in braided rivers concentrates biodiversity within the confines of eddy counter-currents. These hydraulic refuges are generally located below stream convergences, meanders, and depositional islands and are preferred fishing grounds and ferry crossing sites. In contrast to productive backwater areas, biologically impoverished main river channels function mainly as upstream migration and downstream transport corridors.

Nutrient cycling in lotic ecosystems takes the form of spirals that move downstream as nutrients are absorbed, metabolized, and released by microbes associated with inorganic sediments and detritus of the streambed (Elwood *et al.*, 1983). The distance over which one cycle occurs determines how often a nutrient can be utilized within a portion of a stream reach. Decreased stream velocity shortens spiraling lengths and results in increased resource abundance and stability, such as phosphorous and reduced organic carbon. Eddy counter-currents retain stream nutrients to create a patchy distribution of biotic productivity and diversity at all trophic levels, from single cell organisms to aquatic megafauna, such as dolphins and crocodiles.

6.3 River Channel and Floodplain Dynamics

The wetted area of a stream channel is probably more important than the water itself in determining the nature and productivity of aquatic biota. Flow conditions governing the transport of alluvial materials and timing of streambed inundation have considerable influence on biological productivity and diversity. The erodible nature of river sediments and the annual flood-pulse cycle of Himalayan rivers create an array of habitat conditions that encompass the life history requirements of diverse animal and plant communities. Annual flooding of the floodplain creates a mosaic of transitory and diverse microhabitats, thereby establishing high species diversity.

The dramatic increase in discharge during the monsoon season overspills riverbanks to inundate the adjacent floodplain. Annual flooding of rivers with floodplains results in a massive increase in fish production; more than ten times greater than the production of an equivalent river without a floodplain (Bernacsek 1984). The timing and duration of floods is critical, with early recession stranding deposited eggs and newly hatched fry, while prolonged flooding can cause high mortality from low oxygen levels and drastic changes in water chemistry (Pantulu 1986). Flooding also transports and deposits fertile alluvial soils onto the adjacent floodplain. This contribution of soil renews the conditions for productive riparian and floodplain plant communities. In the opposite direction, fine particulate detritus is entrained from the floodplain and

laterally transported to the river channel, thereby increasing the availability of carbon for primary production.

6.4 Riparian Vegetation Interactions

Riparian vegetation increases the stability of streambanks and increases hydraulic resistance. Periods of annual peak discharge can be viewed as a reset mechanism that confers pioneer characteristics to riparian vegetation. Plant succession tends to remain in early stages of development. Flood resistant trees and grasses become temporarily established until the next large flood uproots them, while simultaneously storing fertile sediments and providing optimal conditions for rapid regeneration.

The primary energy source for biotic production in rivers is organic inputs from outside the aquatic environment (Ryder and Pesendorfer 1989, Sedell *et al.* 1989). In large rivers, the majority of fine particulate organic carbon is supplied by upstream processing of fallen leaves and woody debris (Sedell *et al.* 1989).

On a local level, large woody debris inputs from riparian forests provide substrate for algal primary producers and bacteria and fungal consumers (Figure 14). Intricate networks of logs, branches, roots and small wood debris create a diverse array of cover and hydraulic gradients, thereby increasing microhabitat complexity and supporting the coexistence of multi-species fish communities (Sedell *et al.* 1984). The slow processing rate of wood in river environments maximizes their role in enhancing and stabilizing depositional features

Figure 14. Woody debris habitat in the Karnali River.

(Cummings *et al.* 1984). Eddy counter-currents below stream convergences, meanders, and instream islands trap woody debris and concentrate biotic diversity within the confines of the hydraulic refuge inside the eddy vortices. Species richness and fish biomass are related to the area of submerged wood, as well as the area of slack water of hydraulic refuge (Hortle and Lake 1983).

7. Environmental Threats To Aquatic Biodiversity

7.1 Habitat Degradation

Woody debris deposited on river shorelines outside national parks is quickly removed by local villagers for fuelwood consumption. The removal of woody debris decreases stream productivity and eliminates essential habitat for several fish species during all or part of their life history.

The mining of gravel and rock for road building in tributaries and along the mainstream bank alters the hydraulics and substrate composition of fish spawning habitats, thereby endangering fish populations and the aquatic wildlife that depends upon the fish.

Effluents from a paper mill and beer brewery in the Narayani River may be a source of water pollution that have contributed to declines in fisheries and aquatic wildlife. The brewery located above Sikraulighat utilizes a "spin green" biological treatment system but workers stated there is no testing of the effluent after it has gone through the system. No systematic monitoring of water quality has been conducted in the Karnali or Narayani rivers.

7.2 Direct Exploitation

Shrestra (1989) reported that dolphins in the Karnali River are exploited for their meat and oil. Oil is used in lamps, as an attractant for catching fish, and for medicinal purposes. One of the authors (Bishnu Bhandari) interviewed a Tharu man in the Karnali Basin who reported that local people sometimes kill dolphins that are caught accidentally in their fishing nets. They generally eat the meat and render oil from the fat. The oil is expensive and costs about NRs 400 (US$ 8) for a 250 ml bottle.

No evidence of dolphin exploitation was found during an intensive investigation of dolphins in the Karnali River conducted in 1990 (Smith 1993) and during census surveys conducted in 1993 (Smith *et al.* 1994). The authors did, however, interview one fisher in the Sapta Koshi River who proudly stated that he had killed five dolphins over a 15 year period using a strong seine net and gun. This hunting pressure may have contributed to reducing the number of dolphins in the Sapta Koshi River to the point where the population currently has no chance of long term survival (Smith *et al.* 1994). Small populations of dolphins isolated behind barrages will quickly become extinct with even limited hunting pressure.

Hunting of gharial and mugger crocodiles for skins, meat, and body parts thought to have medicinal value, and the collection of their eggs for food have contributed to population declines (Andrews and McEachern 1994). The current intensity of illegal poaching is unknown but similar to exploitation of dolphins, even low level poaching can have devastating effects on small fragmented populations.

Otters are still hunted in Nepal for their pelts, meat, and uterus of females, which is thought to have medicinal value (Foster-Turley *et al.* 1990). Fishers generally regard the animals as a nuisance because they steal their fish and destroy their nets. The effects of hunting on their population is unknown.

Freshwater turtles are exploited with long spear-like poles, hook and line, and by hand for their meat and body parts thought to have medicinal value. No information is available on levels of exploitation or which species are most affected in Nepal. All turtle species that have been recorded in the Karnali and Narayani rivers (see section 2.4) are utilized on a subsistence basis in the neighboring states of Uttar Pradesh and Bihar in India (Choudhury and Bhupathy 1993). Large scale commercial exploitation of turtles in India primarily focuses on flap- and softshell turtles (Choudhury and Bhupathy 1993).

Ducks are sometimes hunted during the end of the monsoon season. Hunters use a net approximately 35 to 40 feet long called a *gochhela jal*.

Judiciously managed riverine fisheries can contribute to the economic development and nutritional health of local people. The current absence of fisheries management and influx of nonlocal fishers using highly effective gillnets may lead to the collapse of riverine fisheries and the extirpation of aquatic wildlife that depends upon the fish. A more detailed discussion of fish exploitation is presented in section 5.3.

7.3 Effects of Dams

Girijapuri and Gandak Barrages

The Karnali and Narayani river basins are affected by barrages which are low gated dams used for irrigation and flood control. The Karnali River is contained behind the Girijapuri barrage (Figure 15) in Kailashpuri, India, located approximately 20 km south of the Nepal/India border, and the Narayani River is contained behind the Gandak Barrage, located at the Nepal/India border. These barrages have effectively isolated wildlife populations and left them particularly vulnerable to the impacts of human development, catastrophic environmental events, chance demographic changes, and inbreeding depression. Interference with fish migrations by stream barriers can lead to the disappearance or serious decline in the productivity of migratory fish species (Jhingran 1982, Goldsmith and Hildyard 1984, Scudder and Conelly 1985, Welcomme 1989). Many cyprinid and siluroid fishes undertake long upstream migrations away from feeding areas to spawning habitat, where well oxygenated waters and swift currents clean the eggs and there is a reduced threat of predation (Welcomme 1979).

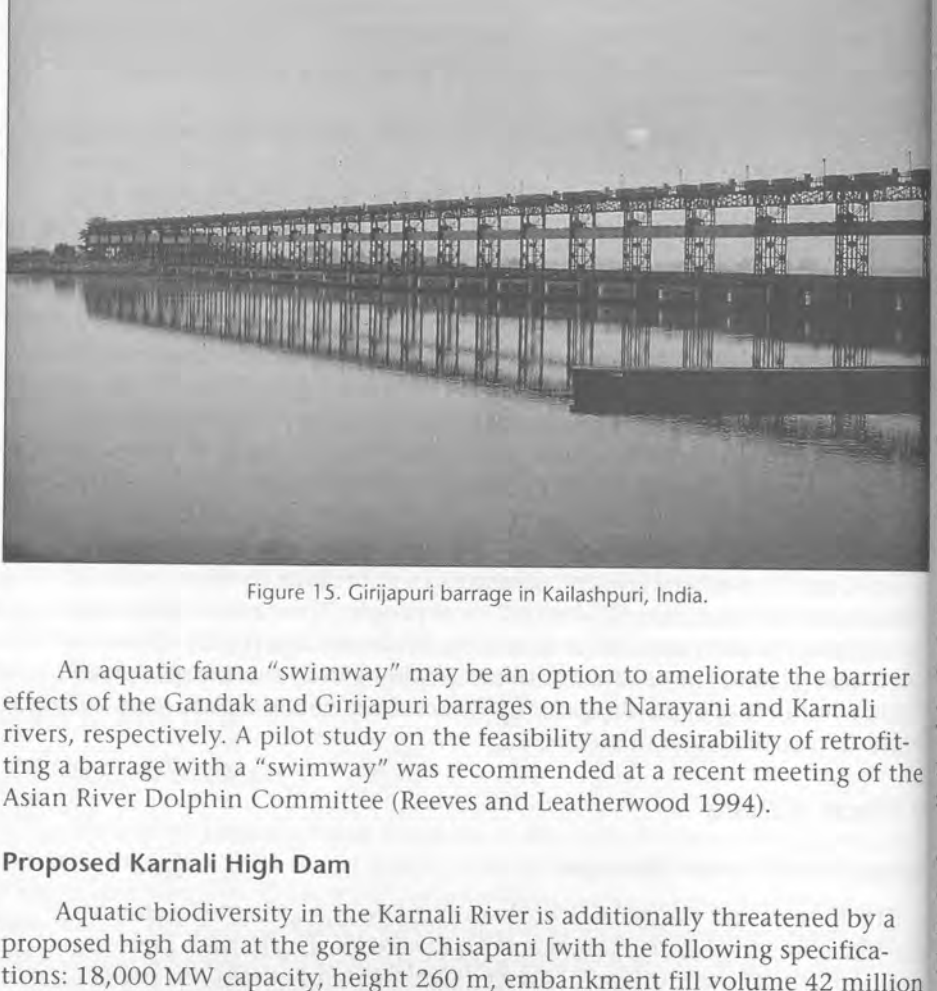


Figure 15. Girijapuri barrage in Kailashpuri, India.

An aquatic fauna "swimway" may be an option to ameliorate the barrier effects of the Gandak and Girijapuri barrages on the Narayani and Karnali rivers, respectively. A pilot study on the feasibility and desirability of retrofitting a barrage with a "swimway" was recommended at a recent meeting of the Asian River Dolphin Committee (Reeves and Leatherwood 1994).

Proposed Karnali High Dam

Aquatic biodiversity in the Karnali River is additionally threatened by a proposed high dam at the gorge in Chisapani [with the following specifications: 18,000 MW capacity, height 260 m, embankment fill volume 42 million cu/m, estimated cost US$ 5 to 6 billion (Warnock 1989)]. Activities related to geotechnical feasibility studies, bridge and road construction, and escalating human settlement have already had serious negative effects on the aquatic ecosystem near Chisapani (Smith 1993).

River channels below dams are as much a man-made and controlled ecosystem as the reservoir upstream (Bernacsek 1984). Downstream effects of dams buffer physical fluctuations such as seasonal discharge ranges, bed and suspended material transport, and temperature regimes and alter the structure of downstream biotic communities. The ecology of fishes inhabiting floodplain rivers shows them to be extremely sensitive to modifications in flood regime (Welcomme 1979).

The water quality of tailwaters below large dams is markedly altered. Sever

reductions in biodiversity have been attributed to altered thermal regime, especially in benthic macroinvertebrates (Ward and Stanford 1983). Variations in temperature, which is suppressed by dams, maximize species diversity by providing a large range of diurnal and seasonal thermal optima (Ward and Stanford 1979, Vannote *et al.* 1980). When temperature regimes shift from optimal ranges, fish populations are stressed, spawning may cease, excessive mortalities of developing eggs can occur, and growth of juveniles can be suppressed (Bell 1986). Modified temperature regimes below dams often do not provide sufficient information for critical life cycle events of macroinvertebrate and fish fauna (Holden 1979, Ward and Stanford 1979). Concentrations of dissolved gases in the water released below a dam may be substantially different from unregulated streams. Conditions can range from anoxic to supersaturated, depending upon release depth, retention time, reservoir stratification, basin morphology, and trophic status of the impounded waters (Hannan 1979). Alterations in the temperature regime can also alter gas equilibrium levels (Bell 1986). Gas supersaturation can cause lethal gas bubble disease in tailwater fish. The problem is most pronounced in waters released below high dams when air mixes with the falling water and dissolves under hydrostatic pressure. Spillway deflectors and other devices can be used to reduce gas supersaturation (Weitkamp and Katz 1980).

The interference with sediment transport and erosive effects of tailwaters released below dams have important impacts on the ecology of river basin environments (Taylor 1978). The discharge of clear water into an erodible channel and alterations in flow regime will inevitably cause stream channel and bed degradation (Leopold *et al.* 1964, Hammad 1973, Simmons 1979). These changes will drastically alter the complex channel morphology of the rivers that support high levels of aquatic biodiversity and productivity (see section 6.2)

Settling of suspended sediments and other sestonic particles in the lentic waters of reservoirs results in reduced turbidity of downstream discharges (Leopold *et al.* 1964). The gradual increase in turbidity during pre-monsoon months may be a crucial cue for gonadal maturation in stream fishes and provide cover from predators for newly emerged fry.

8. Sociological Perspective

8.1 Settlements

Chisapani is the largest settlement in the lower Karnali Basin and is the last major market center on the Karnali River before reaching the foothills of the Himalayas (Figure 2). Most of the 250 homes and shops in Chisapani were constructed during the last several years to support the construction of the Chisapani Bridge and geotechnical studies for the proposed high dam. There is a smaller market at the site of the proposed dam in Pitmari, a town of approxi-

mately 100 households, located two km upstream of Chisapani. Other major villages along the Geruwa Branch of the Karnali include Manaughat, Saijanaghat, Bajpur, and Kothiaghat. Two small markets are located downstream of the Nepal/India border in Bichhiya and Katarniyaghat.

Narayanghat is the largest settlement on the lower Narayani River. Across from the town is a pulp mill and paper factory in Gaidakot. A beer brewery is located dowstream in Rajahar. Devghat is a Hindu holy site and village located at the convergence of the Trisuli and Kali Gandaki rivers, located several km upstream of Narayanghat. Other major villages along the banks of the Narayani River include Argauli, and Sikraulighat. The town of Tribeni is located adjacent to the Gandak barrage.

8.2 Population and Political Divisions

The lower Karnali River is bordered by the Bardia and Kailali districts and the Narayani River by the Chitwan and Nawalparsi districts. These districts include a total of 35 Village Development Committee areas (VDCs) and one municipality. Ten VDCs in the Bardia District and one VDC in the Kailali District are located adjacent to the Karnali River. Nineteen VDCs in the Nawalparsi District and five VDCs and one municipality in the Chitwan District are located adjacent to the Narayani River. The total population and number of households in all these VDCs and one municipality are 327,991 and 56,366, respectively. The average size of each household is 5.8 persons. The populations of VDCs located adjacent to the rivers are 105,203 in Chitwan, 133,777 in Nawalparasi, 67,499 in Bardia, and 17,512 in Kailali (see Table 5 for details).

8.3 Ethnic Groups

Villagers inhabiting the Karnali and Narayani basins consist of indigenous Tharu, Bote, and Mushahar people, as well as recent migrants from the Himalaya. Migrants arrived after successful efforts to reduce the incidence of malaria in the 1950's and have settled, and deforested virtually all land above the floodplain, except areas incorporated within national parks and wildlife reserves.

The main ethnic groups living in the Bardiya and Kailali districts of the Karnali Basin are the Tharus and Sunahs, with the Tharus constituting the majority of inhabitants. Tharus in Bardia are subdivided into Dangoras (also called Dangali), Deshauris, and Rana Tharus. Sunahs are a distinct ethnic group that have settled along the banks of rivers and provide ferry services to local people. Previously, these people were considered to be low-caste "untouchables" but this is generally no longer the situation. Some Sunahs are nomadic and survive by fishing and gold mining (Figure 16).

The main ethnic groups living in the Chitwan and Nawalparasi districts of the Narayani Basin are Botes, Mushahars, Mallahs, and Tharus. Similar to the Karnali Basin, the Tharus constitute the majority of inhabitants, but are of a different type, calling themselves Rajput Tharus. Bote people are of two types: Pakhe Botes who depend upon land for their subsistence and may live away

from the river, and Khole Botes who live along the banks of rivers and use aquatic resources for their subsistence. Mushahar people generally control the ferry ghats in the Narayani River. Many settlements of these people were washed away by the floods of 1993.

8.4 Religion

Approximately 90% of the population living within the lower Karnali and Narayani basins consider themselves to be Hindus, with the remainder being Muslims and Christians. Major Hindu temples are located in Thakudwara, Devghat, and Tribeni. A large mosque is located in the town of Rajapur. Christianity is growing in popularity, particularly among Tharus and Sunahs in the Bardia District. One Sunah boy explained that he adopted the religion because "there is no need for priests, no need to observe festivals or worship gods, and there is no caste discrimination." He also said that new converts receive Rs. 1500 (US$ 30) to pursue self-employment activities. Three churches are located in Tikapur and members proselytize throughout the area.

8.5 Socio-Economic Conditions

The literacy rate is low among people living in the Karnali and Narayani river basins. During a sociological survey, one of the authors (Bishnu Bhandari), could find only one person in the Bote community that had completed a 9th grade education. Literacy rates in the Karnali basin are even lower than in the

Figure 16. Sunah women mining for gold along the banks of the Karnali River.

Narayani basin due to the remoteness of the area and lower stage of economic development.

Women in these areas generally stay at home to look after their children and do household chores. During times of food shortage they may go out for *nibek* or *baniari* to do manual labor on a landlord's field. Many Tharu women, and often children, have been employed as laborers for constructing the Mahendra Highway connecting Nepalgunj with Chisapani.

Most of the people living within the river basins own very little land, on average about one seventh of a hectare per household. Land holdings are tenuous because landforms within alluvial basins can change dramatically during flood conditions. As once fertile lands disappear, new lands are created. These new lands are generally appropriated by landlords with powerful political connections. Local farmers are often forced to rent land from these landlords in exchange for a share of the crop or they sometimes illegally cultivate government land. Fishing, gold mining, grass cutting, and fuelwood collecting are common ways for local farmers to supplement their meager incomes.

9. Sustainable Development

9.1 Definition

By definition, sustainable development must be compatible with preserving the natural systems that replenish and nourish the resources upon which human development depends. The impoverishment of subsistence farmers and fishers and declining populations of aquatic species indicate the need for alternative development strategies. Sustainable and ecologically appropriate development plans will include a variety of strategic initiative that capitalize on the diverse and dynamic nature of the river basin environment.

9.2 Aquaculture

Aquaculture methods for the successful cultivation of mahseer and sucker catfish have not been developed. The culture of mrigal carp is well known and details are given in Bardach *et al.* (1972). Traditional rearing methods might be adapted to cage aquaculture techniques that have the advantages of requiring little space, high productivity, low cost, and do not require sophisticated technical skills (McLarney and Parkin 1981). Mrigal brood fish could be collected from the catch of artisanal fishermen and kept in floating cages located in nearby irrigation canals or slow-flowing tributaries. During the breeding season, which coincides with the onset of the monsoon, pituitary extracts could be used to induce spawning. The broodfish would be put in a nursery cage lined with a fine mesh net to prevent egg loss and then removed after spawning. Alternatively, eggs and fry could be collected directly and placed in the cage. A disadvantage of collecting eggs and fry directly is that there is

currently no workable method of sorting them to species (Bardach *et al.* 1972) and cages might inadvertently be stocked with less desirable types. Fry would then be raised in the same cage and transferred to less densely stocked cages when they reach fingerling size. Fingerlings could be stocked directly into appropriate stream habitats or be grown out for consumption or stream stocking at a larger size. Funding for the culture of native fish species and stream stocking programs might come from developing a catch-and-release sportfishery and other carefully managed tourist activities. Local fishermen and farmers could be trained and financed to carry out these aquaculture activities and repayment for the loan be made in the form of fish for stream stocking.

9.3 Ecotourism

Conservation of wildlife in many developing countries has promoted economic development in the form of tourism. The tourist industry in Nepal is well established and currently the country's largest source of foreign exchange. Tourism in Royal Chitwan and Royal Bardia national parks and adjacent river basin areas has the potential to make substantial contributions towards conserving biodiversity and promoting local economic development. Although Royal Chitwan National Park currently receives over 15,000 visitors a year, the promised benefits of tourism have not materialized and few local jobs have been generated (Mishra and Jefferies 1991). A new road has recently made the access to Royal Bardia National Park much easier and will undoubtedly increase the small number of tourists that currently visit the park.

Judiciously managed ecotourism could provide local employment and an economic incentive for conserving aquatic biodiversity. River floatdowns are an eco-friendly way for tourists to experience exceptional riparian and aquatic landscapes while providing excellent opportunities for viewing aquatic and terrestrial animals (Figure 17). The survival of aquatic species may ultimately depend upon their ability to capture the imagination of people who have the economic resources to subsidize their preservation. River basin villages of indigenous migrant cultures contribute to the vitality of the river environment and provide a fascinating cultural context to the nature experience.

The involvement of local people in the development of ecotourism management plans will determine the social and environmental benefits derived from these activities. Ecotourism planning in river basins should be a collaborative effort of river ecologists, resource managers, tourist operators, and local people. Planning should also be consistent with the policies of HMG's (His Majesty's Government) Action Plan for Tourism (see HMG Environmental Protection Council 1993).

Research programs funded by ecotourism participants (modeled on organizations like Earthwatch and Oceanic Society Research Expeditions) could be developed as a means for accomplishing biodiversity conservation goals and providing income for local villagers. A catch-and-release sportfishery could assist fisheries research and be a sustainable activity which promotes the wise use of aquatic resources. The local interest generated by these programs could

Figure 17. A group of tourists/conservationists enjoying a floatdown of the Karnali River.

be used to spread public awareness of environmental issues.

9.4 Crocodile Ranching

Crocodile ranching can provide economic benefits to local people and contribute towards maintaining healthy crocodile populations. Crocodile ranches use eggs or juveniles collected from the wild to provide a rearing stock for marketable skins and meat. Additional income could also be gained from tourism. Because eggs and juveniles have high natural mortality rates, removing them from the wild has less impact on wild populations than exploitation of adult animals (Thorbjarnarson 1992). A certain fraction of captive-reared crocodiles are released back into the wild to be recruited into the breeding stock.

Since crocodile ranching maintains a direct connection between the availability of juveniles and eggs for rearing stock and wild crocodile populations, local people will have an economic incentive to conserve the animals and their environment. Ranching programs have generated income for local people and assisted conservation efforts in many countries with naturally occurring populations of crocodilians. Examples of countries that incorporate income generating ranching programs into an official crocodile management program are Zimbabwe, New Guinea, and Venezuela (King 1989, Ross *et al.* 1989).

Mugger crocodiles have been successfully reared in captivity and have a

"classic" skin that could generate a net income of US$ 125-150 per 2-3 year old animal (Andrews and McEachern 1994). Classic skins are from those crocodile species that lack or have reduced bony plates on their belly (Brazaitis 1989).

Current regulations of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), of which both Nepal and India are members, classify mugger crocodiles as an Appendix I species, which prohibits international trade in the skins and other body parts. The convention, however, does allow producer nations to transfer populations of Appendix I crocodilians to Appendix II, which allows controlled international trade, upon presentation of credible scientific evidence that the populations can sustain commercial utilization (Thorbjarnarson *et al.* 1992).

10. Biodiversity Conservation

10.1 Ecological Value of Aquatic Species

The presence of dolphins and crocodiles in rivers may actually increase biological productivity and fish production. Productivity in aquatic ecosystems is largely determined by the availability of primary nutrients. Decreased stream velocity within eddy counter-currents trap nutrients and increase the availability of food for riverine biota. Counter-current systems also provide hydrologic refuges for dolphins and gharial to occupy while monitoring opportunities for capturing fish swimming in the mainstream current. When dolphins and gharial feed on these fish, they mobilize and redistribute nutrients, in the form of excrement, from the mainstream, where swift currents do not allow them to be fully utilized, to eddy counter-currents, where they become trapped within eddy boundaries and are locally used and subsequently recycled.

The foraging habits of the dolphins may also increase the productivity of eddy counter-current systems by disturbing bottom sediments. The dolphins release nutrients trapped beneath the streambed sediments, while rooting around with their long beaks for bottom fish and crustaceans. A somewhat similar contribution to aquatic productivity has been hypothesized for bottom foraging gray whales and walruses in the Bering Sea (Nelson and Johnson 1987).

The limited capacity of dolphins and gharial to prey on large fish may actually increase fish production in river basins. By reducing competition from sexually immature fish, the animals may unwittingly allow larger sexually mature fish to obtain sufficient food to maintain high levels of sperm and egg production. The remaining sexually immature fish may also benefit from reduced competition and attain sexual maturity at a faster rate.

The foraging strategies of dolphins and crocodiles may actually contribute to their own sustainability and increase fisheries production. In the Amazon River fish production fell where the numbers of crocodiles and freshwater dolphins declined (Fitkau 1973).

10.2 Religious and Cultural Value of Aquatic Species

The people of Nepal and India have a rich history of myths and legends concerning the environment where they live. These myths bridge the gap between the spiritual life and reverence for an increasingly threatened environment. The Ganges river dolphins are the subject of three myths told to the authors by local river people:

> *In the time of the ancients there was a benevolent king named Bhagirath. The King prayed to Lord Shiva for more than a thousand years to bring a great river to his people. When Shiva was satisfied with the King's devotion, he created a wondrous life-giving river from his long flowing hair. To spread the news that the river was coming, Shiva also made the dolphin susu and gave him the name Bhagirath, after the King who brought the river Bhagirathi (Ganges) to the people of Nepal and India. As the messenger king, the dolphin became husband to the river. This sacred bond between dolphin and river cannot be broken. Without a husband there can be no wife. Without the messenger king, who will carry the story of the river?*
>
> *– Hindu holyman at the temple in Thakudwara*

> *Long ago, two newly married daughter-in-laws went down to the river to take a bath. While bathing they noticed their senior brother-in-law coming down to the river for a drink of water. He was so distracted with his thirst that he did not notice the two girls. It was too late for them to cover themselves with their clothes. To prevent him from seeing their naked bodies, one sister-in-law ran into the forest and took the form of a porcupine, and the other sister-in-law dove into the river and became a dolphin. Dolphins are therefore believed to be the form of a woman and avoid being harmed by human beings.*
>
> *– Jangali Sunah*

> *There was once a king who went into the jungle to hunt wild animals. For the whole day he roamed around and found nothing to shoot. He started for home, upset, frustrated and empty-handed. He finally reached his palace at midnight and found the door locked tight. He called for his wife many times to open the door, but she was fast asleep, snoring loudly, and did not hear him. Already in a bad mood, the King lost his temper and cursed his wife to commit suicide by jumping into the river. The queen woke up just in time to hear the King's order. She immediately jumped into the river and drowned. Because of her faith in the Patibrata Dharma (where a wife worships her husband as a god), she took the form of a dolphin. To this day she can be seen coming out of the water to watch over her husband, hoping that he will relieve her of his curse.*
>
> *– Mukthar Mallah*

In much the same way as Royal Bengal tigers have come to symbolize healthy forest ecosystems in Nepal and India, Ganges susus and gharial crocodiles can be promoted flagship species of the ecological health and spiritual value of the river basin environment. As so-called "charismatic megafauna," dolphins and crocodiles can serve as a focal point for local conservation and development efforts.

Beyond the issue of preserving aquatic species to maintain biodiversity, these animals are part of everyday life on the river. A group of Tharu girls fishing in the shallows with haluka hoop nets run laughingly when a susu splashes them with its flukes while chasing after the same prey. A young boy sitting on the opposite bank exclaims in surprise as a huge soft-shell turtle crawls out of the water and spooks an enormous gharial to leap into the river.

Conservation of aquatic biodiversity is an issue that directly concerns the livelihood and quality of life of local people. Strategies to conserve aquatic biodiversity need to be addressed as part of an overall approach that links environmental priorities with economic and social development.

10.3 Perceptions of Local People on the Status of Aquatic Species

There is general agreement among local people that the number of aquatic animals has declined significantly in recent years. During a sociological survey conducted by one of the authors (Bishnu Bhandari) in 1995, this decline was attributed to: (1) downstream barrages, (2) periodic flash floods, (3) herbicides and pesticides flushed into the river, (4) landslides and soil erosion, (5) water pollution, (6) over-fishing by fish contractors, (7) deforestation, and (8) high human populations. One elderly man reported that until 15 years ago, the land bordering the river was completely covered with dense forest and aquatic animals could be seen in high abundance. Now more than 50% of the forest has completely disappeared and, although he occasionally sees aquatic wildlife and big fish, he is skeptical that they will remain for much longer. Another man reported that, although dolphins and turtles are rarely seen on the Nepal side of the Karnali River, they are abundant on the India side. He attributed the difference in abundance to the protection given to aquatic wildlife by the Indian Department of Forests and the Gharial Conservation Project in Katarniyaghat.

10.4 Aquatic Biodiversity Research

The richness of biodiversity in the Karnali and Narayani river basins reflects an array of complex and interconnected ecological processes that remain largely a mystery. Scientifically credible research can greatly facillitate the formulation of effective environmental planning strategies. The effects of human impacts can be determined and amelioration strategies developed with a more thorough knowledge of ecosystem processes.

Biodiversity conservation and sustainable development issues are being addressed in a proposed ecosystem-based research project sponsored by the IUCN Species Survival Commission (SSC). The project embraces the policies of

His Majesty's Government (HMG) of Nepal's Action Plan For Biodiversity Conservation (HMG's Environmental Protection Council 1993). A major component of this project is to develop a management plan for a proposed international aquatic biodiversity sanctuary in the Karnali River.

10.5 Legislative Protection

In Nepal, all wildlife species within national parks are protected from exploitation by the National Parks and Wildlife Protection Act, 2029 (1973). Ganges river dolphins and gharial crocodiles are listed in Schedule 1 of the act, which protects the species from exploitation throughout the country. Mugger crocodiles, otters, and turtles currently receive no legal protection outside of national parks and wildlife reserves in Nepal. Andrews and McEachern (1994) report that all hunting of crocodiles is prohibited in Nepal, but this protection appears to only apply to gharials. Otters were reported to be protected by the Aquatic Animals Protection Act (1961) in Foster-Turley and Santiapillai (1990) but they are not listed in the Nepal Gazette, which contains notifications of species protected by the act.

The Department of National Parks and Wildlife Conservation (DNPWC) of Nepal is charged with protecting aquatic wildlife in Nepal. In spite of legal protection, the DNPWC has found it difficult to protect free ranging and vulnerable riverine wildlife (Sharma 1994).

The following recommendations were made in a workshop on human resources development and fisheries research in Nepal on 1-3 April 1992, organized by the Fisheries Development Division/HMG Nepal:

(1) Appropriate technical authorities should be identified for effective enforcement of existing regulations.
(2) The conservation of aquatic fauna should include the provision of fish ladders/ lifting devices or hatchery establishments.
(3) Exploitation of river resources should be conducted such that aquatic animals are not adversely affected.
(4) The revised Aquatic Animals Protection Act should be implemented by the: (a) Natural Water Leasing Authority, (b) License issuing authority (fishing), and (c) Pollution Controlling Authority (not currently in existence; establishment recommended).

All wildlife species within national parks in India are protected by the Indian Wildlife Protection Act (IWPA) of 1972. Ganges river dolphins, Asian small-clawed otters, gharial and mugger crocodiles and several species of turtles are listed in Schedule I, which gives them legal protection throughout the country. Most other aquatic wildlife species are listed in Schedule II-IV, which confers various levels of lesser protection.

In India, enforcement of the IWPA and administration of national parks and sanctuaries is the responsibility of the state government. The state of Uttar Pradesh has responsibility for protecting wildlife within the portion of the

Karnali River located in India and for managing the Katarniyaghat Gharial Sanctuary.

10.6 A Proposed International Aquatic Biodiversity Conservation Zone

The biodiversity conservation policy of HMG of Nepal is to ensure that adequate representation of major ecosystems is included in the protected area system and to preserve endemic and endangered species and their habitat (HMG's Environmental Protection Council 1993). It is the premise of the authors that the fragile and unique riverine environments located below the Siwalik foothills are not adequately represented in the protected area system and that, without prompt action, the prospects for continued survival of aquatic wildlife species is poor.

The authors, IUCN/SSC Cetacean Specialist Group, and the Asian River Dolphin Committee have proposed that the stretch of the Karnali River from Golaghat, Nepal to Katarniyaghat, India be designated as an international zone for the conservation of aquatic biodiversity (see Reeves and Leatherwood 1994 and Reeves and Leatherwood 1995).

In Nepal, the protection given to wildlife within Royal Bardia National Park could be extended to the proposed conservation zone. India has a provision for the designation of aquatic conservation areas in the Wildlife Protection Act of 1972 and the area already receives nominal protection as a gharial sanctuary. Mechanisms for binational cooperation in this regard can be found in the Corbett National Peace Park Action Plan for transboundary parks, 1986, and the Convention Concerning the Protection of World Cultural and Natural Heritage, Paris 1972. Both Nepal and India are parties to the action plan and convention.

A conservation zone approach could be taken similar to the Makalu-Barun Conservation Zone and Annapurna Conservation Area. The idea would be to allow traditional uses of the river by local people in exchange for assistance in protecting the resource base. For example, local artisanal fishers could be allowed to fish and their rights protected from outside contractors in exchange for using only environmentally sound fishing techniques (e.g., throw-nets, hoop-nets, and hook and line) and not removing woody debris from streambank habitat. Inclusion within an aquatic biodiversity sanctuary would lend legitimacy and provide a management infrastructure for fisheries rehabilitation and aquaculture programs. Local participation should be a key element in the management and decision-making process, incorporating elected representatives from established village political structures. Trust-building strategies should include options that achieve both conservation and human development goals (see Hough 1988).

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Table 1. Classification of aquatic mammals and listing of protected status.*

TAXONOMIC CLASSIFICATION	PROTECTED STATUS			
	IUCN	*CITES*	*NEPAL NPWPA*	*INDIA IWPA*
CLASS MAMMALIA				
Order Cetacea				
Suborder Odontoceti				
Superfamily Platanistoidea				
Family Platanistidae				
Platanista gangetica Ganges river dolphin, susu	V	1	I	I
Order Carnivora				
Family Mustelidae				
Subfamily Lutrinae				
Lutra perspicillata Asian smooth otter	K/SLCC	2	NL	II
Lutra lutra Eurasian otter	V/SLCC	1	NL	II
Aonyx cinerea Asian small-clawed otter	K/SLCC	2	NL	I

* Protected status abbreviations are as follows:
IUCN: Red Data Book Categories E = Endangered, V = Vulnerable, R = Rare, I = Indeterminate, K = Insufficiently Known.
Otter Action Plan Country Classification: SLCC = Species of Local Conservation Concern.
CITES: Appendix I = Endangered species that may not be traded internationally;
Appendix 2 = Species not at present endangered but which might become so if trade is not regulated.
Nepal: NPWPA = National Parks and Wildlife Protection Act, 2029 (1973);
Schedule I = Rare and endangered species which are protected throughout the country;
NL = Not listed.
India: IWPA = Indian Wildlife Protection Act of 1972;
Schedule I = same definition as NPWPA;
Schedules II - IV protect wildlife from indiscriminate hunting and confers various other measures of protection. The authors have been unable to find an exact definition of these schedules; one is not included in the act.

Table 2. Classification of aquatic reptiles and listing of protected status. *

TAXONOMIC CLASSIFICATION	PROTECTED STATUS			
	IUCN	*CITES*	*NEPAL NPWPA*	*INDIA IWPA*
Class Reptilia				
Order Crocodylia				
Family Crocodylidae				
Subfamily Gavialinae				
Gavialis gangeticus Gharial	E, SDE, NWPR = Highest	1	I	I
Subfamily Crocodylinae				
Crocodylus palustris Mugger	V, SDE NWPR = High	1	NL	I
Order Chelonia				
Sub-order Cryptodia				
Family Trionychidae				
Aspideretes gangeticus Indian softshell turtle	NL	1	NL	I (IV)**
Aspideretes hurum Indian peacock softshell turtle	NL	1	NL	I(IV)
Chitra indica Narrow-headed softshell turtle	NL, APR3	NL	NL	IV(I)
Lissemys punctata andersoni Indian flapshell turtle	NL	1	NL	I(IV)
Family Emydidae **Sub-family Batagurinae**				
Hardella thurjii Crowned river turtle	NL, APR3	NL	NL	I
Geoclemys hamiltonii Spotted pond turtle	I(E)**, APR3	1	NL	I(IV)
Kachuga dhongoka Three-striped roof turtle	NL, APR3	NL	NL	NL
Kachuga kachuga Red-crowned roof turtle	I(E), APR1	NL	NL	I?(I)
Kachuga smithii pallidipes Brown roofed turtle	NL	NL	NL	NL
Kachuga tecta Indian roofed turtle	I	NL	NL	I(IV)
Kachuga tentoria flaviventer Indian tent turtle	NL	NL	NL	NL

* See Table 1 and below for protected status abbreviations.

IUCN: SDE = Wildlife population status: Severely Depleted/Endangered; NL = Not listed.
APR = Action Plan Rating; 1 = known threatened species in need of specific conservation;
3 = species for which specific conservation projects and status surveys are required;
NWPR = Need for wild population recovery (see Table 1 for IUCN categories)

** Number or letter in () indicates change recommended in Choudhury and Bhupathy 1993 or Stubbs 1991, for Indian Wildlife Protection Act and IUCN Red Data Book status ratings, respectively.

Table 3. List of bird species observed during aquatic wildlife surveys of the Karnali and Narayani rivers in February-March 1993/94 and December 1994

Note: Letter(s) in () denote the rivers(s) where the species was seen
K = Karnali River and N = Narayani River

GREBES (PODICIPEDIDAE)
Little Grebe, *Podieps ruficollis* (K)
Great Creasted Grebe, *Podiceps cristatus* (K)

CORMORANTS AND DARTERS (PHALACROCORACIDAE)
Little Cormorant, *Phalacrocorax niger* (K, N)
Large Cormorant, *Phalacrocorax carbo* (K, N)
Indian Shag, *Phalacrocorax fuscicollis* (N)
Darter, *Anhinga rufa* (K, N)

HERONS AND BITTERNS (ARDEIDAE)
Little Egret, *Egretta garzetta* (K, N)
Intermediate Egret, *Egretta intermedia* (K, N)
Large Egret, *Egretta alba* (K, N)
Cattle Egret, *Bubulcus ibis* (K, N)
Gray Heron, *Ardea cinerea* (K, N)
Purple Heron, *Ardea purpurea* (K)
Little Green Heron, *Butorides striatus* (K, N)
Pond Heron, *Ardeola grayii* (N)
Yellow Bittern, *Ixobrychus sinensis* (N)
Eurasian Bittern, *Botaurus stelleris* (N)

STORKS (CICONIIDAE)
White-necked Stork, *Ciconia episcopus* (K, N)
Painted Stork, *Ibis leucocephalus* (K)
Lesser Adjustant Stork, *Leptoptilos javanicus* (N)
Black-necked Stork, *Ephippiorhychus asiaticus* (K)
Black Stork, *Ciconia nigra* (K)
Open-billed Stork, *Anastomus oscitans* (K)

IBISES AND SPOONBILLS (THRESKIORNITHIDAE)
Black Ibis, *Pseudibis papillosa* (K, N)
Eurasian Spoonbill, *Platalea leucorodia* (K)

GEESE AND DUCKS (ANATIDAE)
Merganser, *Mergus merganser* (K, N)
Ruddy Shelduck, *Tadorna ferruginea* (K, N)
Red Crested Pochard, *Netta rufina* (K)
Common Pochard, *Aythya ferina* (N)

Greylag Goose, *Anser anser* (K)
Bar-headed Goose, *Anser indicus* (N)
Common Teal, *Anas crecca* (K, N)
Cotton Teal, *Nettapus coromandelianus* (K)
Lesser Whistling Teal, *Dendrocygna javanica* (K)
Northern Shoveler, *Anas clypeata* (N)
Northern Pintail, *Anas acuta* (N)
Spotbill, *Anas poecilorhyncha* (K)

KITES, HAWKS, EAGLES AND VULTURES (ACCIPITRIDAE)
Osprey, *Pandion haliaetus* (K, N)
Long-legged Buteo, *Buteo hemilasius* (N)
Himalayan Grey-headed Fishing Eagle, *Ichthyophaga nana* (K,N)

RAILS, CRAKES AND GALLINULES (RALLIDAE)
Purple Gallinule, *Porphyrio porphyrio* (K)
Coot, *Fulica atra* (K, N)

WADERS (CHARADRIIDAE)
Temminck's Stint, *Calidris temminckii* (K, N)
Little Stint, *Calidris minutas* (N)
Spurwing Lapwing, *Vanellus spinosus* (K, N)
Red-wattled Lapwing, *Vanellus indicus* (N)
Greenshank, *Tringa nebularia* (K, N)
Great Thicknee, *Esacus recurvirostris* (K)
Common Redshank, *Tringa totanus* (K)
Little Ring Plover, *Charadrius dubius* (K, N)
Common Sandpiper, *Tringa hypoleucos* (K, N)
Spotted Redshank, *Tringa erythropus* (K)

COURSERS AND PRATINCOLES (GLAREOLIDAE)
Small Pratincole, *Glareola lactea* (K, N)

GULLS AND TERNS (LARIDAE)
Black Headed Gull, *Larus ridibundus* (K, N)
Great Black-headed Gull, *Larus ichthyaetus* (N)
Brown Headed Gull, *Larus grunnicephalus* (N)
Indian River Tern, *Sterna aurantia* (K)
Black-bellied Tern, *Sterna acuticauda* (K)

KINGFISHERS (ALCEDINIDAE)
White-breasted Kingfisher, *Halcyon smyrnensis* (K, N)
Eurasian Kingfisher, *Alcedo atthis* (K, N)
Small Pied Kingfisher, *Ceryle rudis* (K, N)

Large Pied Kingfisher, *Ceryle lugubris* (N)
Stork-billed Kingfisher, *Pelargopsis capensis* (N)

LARKS (ALAUDIDAE)
Sand Lark, *Calandrella raytal* (N)

THRUSHES, CHATS AND ALLIES (TURDIDAE)
Plumbeous Redstart, *Rhyacornis fuliginosus* (K)
White-capped River Chat, *Chaimarrornis leucocephalus* (N)
Hodgson's Bush Chat, *Saxicola insignis* (N)
Jerdon's Bush Chat, *Saxicola jerdoni* (N)

NUTHATCHES (SITTIDAE)
Wall Creeper, *Tihodroma muraria* (N)

PIPITS AND WAGTAILS (MOTACILLADAE)
Grey Wagtail, *Motacilla caspica* (K, N)
Pied Wagtail, *Motacilla alba* (K, N)
Yellow-headed Wagtail, *Motacilla citreola* (K)
Large Pied Wagtail, *Motacilla maderspatensis* (K)

SWALLOWS AND MARTINS (HIRUNDINIDAE)
Sand Martin, *Riparia paludicola* (K, N)

Table 4. List of fish species recorded in the Karnali and Narayani rivers.*

TAXONOMIC STATUS	LOCAL NAME(S)[A]	RIVER	SOURCE(S)[B]
ORDER CLUPIFORMES			
FAMILY CLUPEIDAE			
Gudusia chapra (Ham)	Suiya, Darahai, Fulia	K , N	1,3,5,7,8,11
Gudusia godanahiai	Suiya, Darahai, Fulia	K , N	7,11
FAMILY NOTOPTERIDAE			
Notopterus notopterus (Pallas)	Golhai, Darahai,Fulia	K , N	1,3,4,5,7,8,11
Notopterus chitala	Mohi, Patara	K , N	1,3,5,8
ORDER CYPRINIFORMES			
FAMILY CYPRINIDAE			
Accrossocheilus hexagonolepis (McCl)	Katle	K , N	3,4,8,11
Aspidoparia jaya (Ham)	Mara	K , N	1,3,4,9
Aspidoparia morar (Ham)	Harda, Bhegna Karangi, Karhawa	K , N	1,2,3,4,5,8,9,11
Amblypharyngodon mola (Ham)	Piruwa	K , N	1,3,4,7,8,11
Barilius barila (Ham)	Chahale	K , N	1,3,4,8
Barilius barna (Ham)	Faketa, Poti,	K , N	1,3,4,5,8,9,11
Barilius bendelisis (Ham)	Faketa, Gudari, Jhojho	K , N	1,2,3,4,5,8,10,11
Barilius bola (Ham)	Bola	K , N	1,3,4,8,11
Barilius jalkapoorei (Shrestra)	Jalkapoor	K , N	5,9,11
Barilius shacra (Ham)	Fageta, Jhilke	K , N	1,3,4,10,11
Barilius tileo (Ham)	Tikahinia	K , N	1,3,4,5,8,11
Barilius vagra (Ham)	Tilkhina	K , N	1,2,3,4,8,11
Catla catla (Ham)	Bhakur, Catlogi	K , N	1,3,6,8,11
Chagunius chagunio (Ham)	Patherchatti, Gorahi, Kubre	K , N	1,2,3,4,5,8,11
Cirrhinus mrigala (Ham)	Rewa, Naini	K , N	1,3,8,9,11
Cirrhinus reba (Ham)	Rewa	K , N	1,3,4,5,8,9,11
Crossoheilus latius (Ham)	Kachara, Lohari	K , N	1,2,3,4,8,9,10,11
Chela cachius (Ham)	—	K , N	1,3,4
Chela laubuca (Ham)	Deduwa	K , N	1,2,3,4,8
Danio aequipinnatus (McCl)	—	N	4,8,11
Danio dangila (Ham)	Dedhawa	K , N	1,3,4,11
Danio devario (Ham)	Chitharipothi	K , N	1,3,4,8,11
Danio rerio (Ham)	Zebra	K , N	1,3,4,8
Esomus danricus (Ham)	Darai, Dhedawa	K , N	1,3,4,5,8,11
Garra annandalei (Hora)	Buduna	K , N	2,4,5,8,9,10,11
Garra gotyla (Gray)	Mathal, Thumree	K , N	1,2,3,4,5,8,11
Garra lamta (Ham)	—	K , N	1,3
Labeo angra (Ham)	Thed, Thunde, Kalanch	K , N	4,5,8,11
Labeo bata (Ham)	Thaind	N	4

Labeo boga (Ham)	Thilke	K , N	2,4,6,7,8,10,11
Labeo calbasu (Ham)	Kalanch, Basarahili	K , N	1,2,3,4,6,7,8,9,10,11
Labeo dero (Ham)	Gurdi, Rohu, Kathalegi	K , N	1,2,3,4,5,6,7,8,9,10,11
Labeo dyocheilus (McCl)	Gardi, Kalanch	K , N	1,2,3,4,6,7,8,9,10,11
Labeo gonius (Ham)	Kursa	K , N	1,3,4,5,8,11
Labeo pangusia (Ham)	Termassa, Kalancha	K , N	2,3,6,7,8,9,10,11
Labeo rohita (Ham)	Rohu	K , N	1,3,5,8,11
Osteobrama cotio (Ham)	Chanawro, Gurda	K , N	1,3,4,5,7,11
Oxygaster argentea (Day)	Namsehara	K	8
Oxygaster bacaila (Ham)[c]	Chelwa	K , N	1,3,4,5,8,9,11
Oxygaster gora (Ham)	—	K , N	1,3,6,7,8
Oxygaster phulo (Ham)	—	K	8
Puntius apogon (Val)	Sidhara, Patharachatti	N	4,8
Puntius chilinoides (McCl)	Sidhara	K , N	8,11
Puntius chola (Ham)	Sidhara, Sidre, Pothi	K , N	1,3,4,5,7,8,11
Puntius conchonius (Ham)	Sidre, Sidhara	K , N	1,3,4,5,6,8,11
Puntius gelius (Ham)	—	K , N	1,3,4
Puntius guganio (Ham)	—	N	1,3,4
Puntius sarana (Ham)	Kande, Bada, Pothi, Sidhara	K , N	1,3,4,5,8,11
Puntius sophore (Ham)	Pothi, Sidhara, Chandapothi	K , N	1,2,3,4,5,8,10,11
Puntius ticto (Ham)	Sidhara, Poti, Potina, Darahi	K , N	1,3,4,5,8,9,11
Rasbora daniconius (Ham)	Dedhawa	K , N	1,2,3,4,5,7,8
Schizothoraichthys annandalei (Reg)[d]	Thude, Asala	K , N	1,3,4,9,10
Schizothoraichthys progastus (McCl)	Chuchhe, Asala	K , N	3,4,8,11
Schizothorax plagiostomus (Heck)	Asala	K , N	2,3,5,8,11
Schizothorax richardsoni (Gray)	Asala, Soal	N	1,3,4,8,11
Semiplotos semiplotus (McCl)	Padhani, Chepti	K , N	1,3,4,8,11
Tor putitora (Ham)	Chawar, Sahar, Mahseer	K , N	1,2,3,4,5,6,7,8,9,10,11
Tor tor (Ham)	Sahar	K , N	1,2,3,4,5,6,7,8,10,11
FAMILY PSILORHYNCHIDAE			
Psilorhynchus balitora (Ham)	—	K , N	1,3,4,8
Psilorhynchus sucatio (Ham)	Pathachatti	K , N	1,3,4,8
FAMILY HOMALOPTERIDAE			
Balitora brucei (Gray)	Titae, Patherchatti	K , N	1,3,4,8
FAMILY COBITIDAE			
Acanthophthalmus pangia (Ham)	—	N	4
Botia almorhae (Day)	Baghe	K , N	1,2,3,5,6,7,8,10,11
Botia lohachata (Chaud)	Getu, Baghe	K , N	1,3,4,8,11
Botia dayi (Hora)	Getu	K , N	1,3
Lepidocephalichthys guntea (Chand)[e]	Lata, Goira	K , N	1,2,3,4,5,7,8,11
Noemacheilus beavani (Gunth)	Gadela, Pate Goira, Kanelani	K , N	1,2,3,4,8
Noemacheilus botia (Ham)	Gadela	K , N	1,3,4,8,10,11
Noemacheilus corica (Ham)	Kholumachha	K , N	1,3,8,4,5

Noemacheilus devdevi (Hora)	—	N	4
Noemacheilus rupicola (McCl)	Gadela	K , N	2,4,8,10,11
Noemacheilus rupecola var inglishi (Hora)	Kholumachha	K , N	1,3,10
Noemacheilus savona (Ham)	—	K , N	1,3,4
Noemacheilus scaturigina (McCl)	—	N	1,3,4
Somileptus gongota (Ham)	Latani, Goira	K , N	1,3,5,8
ORDER SILURIFORMES			
FAMILY BAGRIDAE			
Mystus aor (Ham)[f]	Kanti	N	4,8,11
Mystus bleekeri (Day)	Tengra, Katena	K , N	1,3,4,5,11
Mystus cavasius (Ham)	Tengra, Junge, Palawa, Katena	K , N	1,3,4,5,8,11
Mystus seenghala (Sykes)[g]	Kanti, Sujnha	K , N	4,5,8,11
Mystus tengara (Ham)	Tengri	K , N	4,5,6,10
Mystus vittatus (Bloch)	Tengra	K , N	1,3,4,8,11
Rita rita (Ham)	Rita, Belunda	K , N	1,3,4,7,8,11
FAMILY SILURIDAE			
Ompok bimaculatus (Bloch)	Voktam, Chottari Pabata, Lalmuha, chachara	K , N	1,3,4,5,7,8,11
Ompock pabda (Ham)	—	N	4
Wallago attu (Schn) Ghoptari, Ghugunes	Buhari, Padani	K , N	1,3,4,5,6,8,7,11
FAMILY SCHILBEIDAE			
Ailia coila (Ham)	Sutara, Patanga	K , N	1,3,4,8,11
Clupisoma garua (Ham)	Baikha	K , N	1,2,3,4,6,7,8,9,11
Eutropichthys vacha (Ham)	Baikha, Bachwa	K , N	1,3,4,8,11
Pseudeutropius atherinoides (Bloch)	Jalkapoor, Patasi	K , N	1,3,4,5,8,11
Pseudetropius mirius	Baikha, Jalakpoor	K	3,10
Silonia silondia (Ham)	—	K	1,3
FAMILY SACCOBRANCHIDAE			
Heteropneustes fossilis (Bloch)	Singhi	K , N	1,3,5,8,11
Family Claridae			
Clarias batrachus (Lin)	Mungri, Mangur	K , N	1,3,5,8,11
FAMILY AMBLYCIPITIDAE			
Amblyceps mangois (Ham)	Bindhar, Pichhi	K , N	1,3,4,5,8,11
FAMILY SISORIDAE			
Bagarius yarrelli (Sykes)	—	N	4
Bagarius bagarius (Ham)	Gonch, Thend, Gochara, Baghai	K , N	1,2,3,5,7,8,9,10,11
Erethistes pussilus (Miller and Tros)	—	K , N	1,3,4,8
Erethistoides montana (Hora)	—	N	4

Gagata cenia (Ham)	Tikthi, Gogta	K , N	1,3,4,5,8
Gagata sexualis	—	N	4
Glyptothorax cavia (Ham)	Capree, Vendro	K , N	1,3,4,8
Glyptothorax conirostris (Steind)	—	K	1,3
Glyptothorax horai (Shaw & Sheb)	Kotel, Kathel	K , N	1,2,3,4,6,7,8
Glyptothorax pectinopterus (McCl)	Karasingha Capree, Dupmacha	K , N	1,3,4,8,11
Glyptothorax ribeiroi	—	K , N	1,3
Glyptothorax telchitta (Ham)	Kotel	K , N	1,2,3,4,11
Glyptothorax trilineatus	Kavre	K , N	3,4,8
Hara hara	—	K , N	1,3,4
Laguvia ribeiroi	—	N	4
Nangra nangra (Ham)	—	N	4
Nangra viridescens (Ham)	—	N	4
Pseudecheneis sulcatus (McCl)	Kabre, Marcha	K	4,8,9
Sisor rhabdophorus (Ham)	—	N	4,11
ORDER ANTHERINIFORMES			
FAMILY BELONIDAE			
Xenentodon cancila (Ham)	Cuhchhe bam, Kauwar, Dangawa, Sui	K , N	1,3,4,5,8,11
ORDER CHANNIFORMES			
FAMILY CHANNIDAE			
Channa gachua (Ham)	Hilae, Charangi, Chenga	K , N	3,5,8,10,11
Channa marulius (Ham)	Sauri, Bhaura	K , N	4,5,6,8
Channa orientalis (Schn)	Charangi	K , N	1,3,4,8
Channa punctatus (Bloch)	Hilae, Charangi, Bhote, Gauri	K , N	1,3,4,5,8,11
Channa striatus (Bloch)	Charangi, Sauri	K , N	4,5,8,11
ORDER SYNBRANCHIFORMES			
FAMILY AMPHIPNOIDAe			
Amphipnous cuchia[h]	Bam	K , N	1,3,4,5,8,11
ORDER PERCIFORMES			
FAMILY CENTROPOMIDAE[i]			
Chanda baculis (Ham)	—	N	1,3,4,8
Chanda nama (Ham)	Nata channa	K , N	1,2,3,4,5,8,9,11
Chanda ranga (Ham)	Bhitte, Chanari	K , N	1,3,4,8,10,11
FAMILY NANDIDAE			
Badis Badis (Ham)	Khesalei, Khesaki	K , N	1,3,4,5
Nandus nandus (Ham)	Dhala, Dewan	K , N	1,3,4,5,8,11
FAMILY MUGILIDAE			
Sicamugil cascasia (Ham)	Rewa	K , N	1,3,4
Rhinomugil corsula (Ham)	—	K , N	1,3

FAMILY GOBIIDAE			
Glossogobius giuris (Ham)	Bulla	K , N	1,3,4,5,8,11
FAMILY ANADANTIDAEJ			
Anabas testudineus (Bloch)	Kabai, Kerkhi	K , N	1,3,8,11
Colisa fasciata (Bloch & Schn)	Katara, Khesara	K , N	1,3,4,8,11
Colisa lalia (Ham)	—	K , N	1,3
ORDER ANGUILLIFORMES			
FAMILY ANGUILLIDAE			
Anguilla bengalensis (Gray)	Rajbam	K , N	2,4,5,6,7,8,11
ORDER MASTACEMBELIFORMES			
FAMILY MASTICEMBELIDAE			
Macrognathus aral (Bloch & Schn)	—	N	4
Macrognathus aculeatus (Bloch)	Gainchi, Bamali	K , N	1,3,5,8,11
Mastacembelus armatus (Lacep)	Chusi Bam	K , N	1,3,4,5,6,7,8,9,11
Mastacembelus pancalus (Ham)	Kathgainchi	K , N	1,3,4,11
ORDER TETRAODONTIFORMES			
FAMILY TETRADONTIDAE			
Tetraodon cutcutia (Ham)	Phokcha	N	4,8

* K = Karnali (Solta to Kothiaghat) and N = Narayani (Devghat to Tribenighat)

a = Local names taken from HPC 1992 and Shrestra 1994.
b = Sources coded as follows: 1 = Menon 1962; 2 = J. Shrestha 1981; 3 = Rajbanshi 1982; 4 = Edds 1986; 5 = Jha and T.K. Shrestha 1986; 6 = New Era 1987; 7 = H.P.C. 1989; 8 = T.K. Shrestha 1990; 9 = Smith 1993; 10 = H.P.C. 1992; 11 = J. Shrestha 1994.
c = *Salmostoma bacaila* (Ham) in Edds 1986.
d = *Schizopyge progastus* (McCl) in Edds 1986.
e = *Lepidocephalus guntea* (Ham) in Edds 1986.
f = *Aorichthys aor* (Ham) in Edds 1986.
g = *Aorichthys seenghala* (Sykes) in Edds 1986.
h = *Monopterus cuchia* (Ham) in Edds 1986.
i = Family Chandidae in Edds 1986.
j = Family Belontidae in Edds 1986.

Table 5. Population of VDC areas bordering the Karnali and Narayani rivers.*

VDC AREAS	DISTRICT	NO. OF HOUSEHOLDS	TOTAL PERSONS
Bharatpur Municipality	Chitwan	10,918	54,670
Dibyanagar	Chitwan	1,259	7,074
Gunjanagar	Chitwan	2,025	11,076
Manalpur	Chitwan	2,580	12,969
Meghauli	Chitwan	2,027	12,281
Saradanagar	Chitwan	1,334	7,133
Argauli	Nawalparasi	1,297	8,820
Amarapuri	Nawalparasi	967	5,451
Dawanne Devi	Nawalparasi	2,058	10,833
Dibyapuri	Nawalparasi	887	4,968
Dumkibas	Nawalparasi	1,236	6,948
Gaidakot	Nawalparasi	2,347	12,874
Kawaswoti	Nawalparasi	1,169	6,551
Kolhuwa	Nawalparasi	1,025	6,292
Kundiya	Nawalparasi	1,252	7,564
Kumarwarti	nawalparasi	698	4,155
Mukundapur	Nawalparasi	1,406	7,631
Narayani	Nawalparasi	1,188	7,234
Narsahi	Nawalparasi	768	4,639
Pakalihawa	Nawalparasi	1,153	7,891
Parsauni	Nawalparasi	832	4,709
Pithauli	Nawalparasi	1,084	5,957
Pragatinagar	Nawalparasi	1,640	9,591
Rajahar	Nawalparasi	1,387	7,839
Tribenisusta	Nawalparasi	1,477	7,830
Dhodhari	Bardia	1,810	10,568
Gola	Bardia	694	5,340
Khairi Chandanpur	Bardia	656	5,303
Manau	Bardia	833	5,741
Manpur Tapara	Bardia	842	7,387
Pasupatinagar	Bardia	613	4,766
Patabhar	Bardia	1,241	10,488
Sivapur	Bardia	725	5,639
Suryapatawa	Bardia	826	6,709
Thakurdwara	Bardia	718	5,558
Baliya	Kailali	3,294	17,512

** Source: Central Bureau of Statstics. 1994. Population of Nepal by Districts and Village Development Committees/Municipalities. His Majesty's Government, National Planning Commission Secretariat, Kathmandu, Nepal.*