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Koshi Tappu Wetlands:
Nepal's Ramsar Site

Jay Prakash Sah

IUCN–The World Conservation Union

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IUCN - The World Conservation Union

Founded in 1948, IUCN - the World Conservation Union brings together States, government agencies and a diverse range of non-governmental organizations in a unique world partnership: some 880 members in all, spread across 133 countries.

As a Union, IUCN exists to serve its members - to represent their views on the world stage and to provide them with the concepts, strategies and technical support they need to achieve their goals. Through its six Commissions, IUCN draws together over 8000 expert volunteers in project teams and action groups. A central secretariat coordinates IUCN Program and leads initiatives on the conservation and sustainable use of the world's biological diversity and the management of habitats and natural resources, as well as providing a range of services. The union has helped many countries to prepare National Conservation Strategies, and demonstrates the application of its knowledge through the field projects it supervises. Operations are increasingly decentralized and are carried forward by an expanding network of regional and country offices, located principally in developing countries.

IUCN - The World Conservation Union seeks above all to work with its members to achieve development that is sustainable and that provides a lasting improvement in the quality of life for people all over the world.

IUCN in Nepal

IUCN has been active in Nepal since the country acquired state membership of the Union in 1973. IUCN's work in Nepal during the 1970's was primarily related to the protection of environmentally sensitive areas and wildlife conservation. The focus changed in the early 1980's, following His Majesty's Government's decision to initiate the preparation of a National Conservation Strategy (NCS) for Nepal. Between 1980 and 1982, IUCN assisted His Majesty's Government (HMG) in preparing a prospectus for National Conservation Strategy, which included a description of major environmental issues in Nepal and possible components to be included in the NCS. The prospectus was endorsed by HMG in 1983.

Preparation of the NCS began in 1985 under an agreement between HMG and IUCN with joint funding from the Canadian International Development Agency (CIDA), the Swiss Agency for Development and Cooperation (SDC), and the US Agency for International Development (USAID). In the following two years, the NCS, Nepal's first comprehensive environmental policy was developed through a process of extensive consultation with and participation of a wide range of people, from senior government officials to local villagers. Building on Success, the National Conservation Strategy for Nepal was endorsed by HMG in 1988.

Implementation of the NCS started in 1989 with technical assistance from IUCN and financial assistance from SDC. During 1991 – 1993, implementation of NCS began to gain momentum, as the NCS implementation project worked with various government and non-government agencies in the areas of environmental policy, law, education, planning, assessment, heritage and biodiversity conservation. These activities were expanded and consolidated over the next phase, 1994-1996, with ongoing funding from SDC, while the National Planning Commission (NPC) continued to play an important role as the government focal point in establishing much needed coordination with sectoral agencies. During the same period, IUCN also implemented a Heritage and Biodiversity Conservation Program funded by SDC, an NGO Environmental Management Program (NEMP), funded by USAID and a Street Theatre project funded by UNFPA. These programs supplemented the NCS Implementation Project.

IUCN Nepal started its wetlands program in 1992. The objectives of the wetland program are conservation and wise use of wetlands through community involvement and intersectoral collaboration.

The wetlands program regularly collaborates with relevant governmental, non-governmental and community-based organizations in the wise use of wetlands and their resources. The focus of the program is the bio-regional management of wetland habitats. Some of the key elements of the program include confidence building, collaboration, demonstration project, participatory exercises, and community based management plan. During its six years of activities in Nepal, the wetlands program has been able to bring together wetland scholars and informal Wetlands Group. Further, the wetlands program has developed a rapid reconnaissance methodology, prepared an inventory of Nepal's Tarai wetlands, established national wetland database and conducted demonstration projects, participatory action research and workshops.

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PREFACE

The Koshi Tappu Wildlife Reserve and adjoining wetlands are located on the floodplain of the snow-fed perennial river called Sapta Koshi, a tributary of the Ganges. The Reserve, which covers an area of 150 km^2, is the last refuge for Nepal's remaining population of wild water buffalo (*Bubalus bubalis*). Moreover, the reserve serves a crucial role in the maintenance and protection of the rich ecological and genetic diversity of the Koshi Tappu region. The reserve is Nepal's only Ramsar site, and supports about 50,000 waterfowl. The region is an important staging and nesting site for a large number of bird species.

The hydrological characteristics of the Koshi river and changes caused by the construction of a barrage on the river during the late 70s, play an important role in determining the ecological and physical characteristics of the region. Furthermore, the complex and varied interaction between the adjoining villages and the reserve is an important feature of this area, and merits critical study and understanding. The reserve is presently under severe threat by sedimentation from the river and encroachment by the local communities.

This publication, ***Koshi Tappu Wetlands: Nepal's Ramsar Site***, is a detailed study of the ecological and social features of the Koshi Tappu region, with particular emphasis on the wildlife reserve. The focus of the study is on people-park interaction and by examining the interaction between the reserve and the local communities, key issues in reserve management and conservation are identified. Mr. Sah's in-depth analysis of the issues presented in this study, provide the reader with an intimate and detailed view of a situation which has become all too familiar in many developing countries where the protection of natural resources is often in conflict with populations dependent on the use of these very resources. As emphasized in this study, the need for the implementation of a sustainable management regime with increased local participation is vital for the effective protection of these natural resources.

With the publication of this document, IUCN - The World Conservation Union hopes to contribute to a greater awareness and understanding of the importance of conservation and wise-use of wetland ecosystems.

Zakir Hussain
Gayatri Acharya
Seema Saeed

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CHAPTER 1

INTRODUCTION

Nepal, a land-locked mountainous country, lies between 26° 20' and 30° 10' N latitude and 80° 15' and 88° 10' E longitude. It covers an area of approximately 147,181 sq km and is bound by China to the north and by India to the east, south, and west. The altitude ranges from 60 m in the south to 8,848 m in the north. Consequently, the country has a wide range of climatic zones ranging from humid sub-tropical to alpine, within a short distance of 80-150 kilometers.

Nepal can be divided into three major ecological zones, namely the *terai* and *siwaliks*, the middle mountains, and the high Himalayas. Because of the unique topography of the country, several types of wetlands, which include water bodies and water saturated land, are scattered throughout the country in all the ecological zones.

1.1 Wetlands in Nepal

Wetlands cover about 7,435 sq km or approximately 5 per cent of the total area of the country (Table 1.1). In addition, it has been estimated that 80,000 ha of surface water area will be added as reservoirs if the hydro-electric power potential of the water resources of the three river systems, the Gandaki, the Bagmati and the Karnali, is exploited (Rajbansi, 1986).

Table 1.1 Distribution of wetlands in Nepal

Types of Wetlands	Estimated area (ha)	Percentage
Rivers	395,000	53.1
Lakes	5,000	0.7
Reservoirs	1,500	0.2
Marshy land	12,000	1.6
Village ponds	5,000	0.7
Paddy fields	325,000	43.7
Total	743,500	100.0

Source: Rajbhandari and Gurung, 1994

Wetlands possess a number of functional, economic and aesthetic values. They are rich in biodiversity which is reflected in the great variety of flora and fauna dependent for their survival on these wetlands. These include 172 species of fish, 190 species of birds, two endangered crocodile species and a number of reptiles and mammals. Similarly, 25 per cent of a total of 7,000 plant species found in the country are believed to be aquatic (Bhandari, 1993).

In Nepal, wetlands provide a number of services and goods for consumptive and non-consumptive uses. However, these are being destroyed by a number of factors, particularly anthropogenic activities which, in this country, are closely associated with the socio-economic conditions of the people. Although wetlands throughout the country are under pressure, the most threatened wetlands are

located in the lowlands, and in the valleys surrounded by the *siwaliks* and the middle mountains.

1.2 Wetlands of the *terai*

The lowlands, also called the *terai*, cover a narrow strip of land along the southern edge of the country. The region is characterized by various types of wetlands including a number of rivers and their floodplains, oxbow lakes, swamps, marshes, reservoirs, ponds and paddy fields. The floodplains of three major river systems, the Koshi, the Gandaki and the Karnali, together with other medium and small rivers, form a large portion of the wetlands in this region. The three major rivers originate in the high Himalayas and flow with significant discharge even during the dry season. The medium rivers, which originate in the middle mountains, are also perennial, but are commonly characterized by wide seasonal fluctuations in discharge.

In the *terai*, the rivers and their associated floodplains sustain the local communities who are dependent upon them for their livelihoods. These rivers serve a wide variety of functions including flood control, as sediment and nutrient retention reservoirs, and as food chain supports. They also provide a variety of products such as thatching material, fuelwood, fodder and timber, and are sites for livestock grazing, fisheries, recreation and the conservation of biological diversity. These areas provide feeding and breeding sites for various species of resident and migratory birds.

The hydrology of the area, which shapes the structure and function of an ecosystem, plays an important role in maintaining the integrity of the wetland. The floodplains are subject to periodic floods, the duration of which at a given elevation, called its hydroperiod, is important for the ecology. Periodic flooding of the land, especially during the monsoons, is a common feature in the Koshi Tappu region which lies on the floodplain of the Koshi river, in the lowlands of eastern Nepal.

The natural configuration of the land controls the depth, timing and duration of floods. Some areas, including the Koshi Tappu region, are strongly influenced by anthropogenic activities. In particular, the barrage constructed on the Koshi river for the purpose of flood control, irrigation and electricity generation, has had a profound impact on the ecology of the region.

The floodplains, oxbow lakes and other depressions, which retain water after the floodwater has receded, support a rich variety of wildlife including fish. The grasslands, which are subject to periodic flooding, offer excellent grazing sites for large populations of animals including domestic livestock.

The riverine forests on the floodplains are major sources of fuelwood, timber and other plant products. The utilization of these resources by local people, on a sustainable basis, has been a characteristic feature of the *terai* over centuries.

Recently, however, the commercial exploitation of the forests for revenue, coupled with a growing demand for agricultural lands to feed an increasing

population in the area, especially due to migration from the hills and the southern areas has led to a high rate of deforestation in the *terai*. The wetlands have also become more vulnerable especially from the conversion of lakes and marshes into cropland.

The Koshi Tappu region has not escaped this degradation. The dense riverine forests and the grasslands, where wildlife including large carnivores like the tiger and the leopard were once abundant, began to be cleared in the late 1950s with the construction of the barrage and embankments. The degradation of the habitat continued until the early 1970s through over-exploitation of the resources by the increasing population, compounded with the adverse impacts of the barrage. As a result, the large carnivores disappeared from the area and the population of wild water buffalo also declined abruptly. These events were occurring while a number of protected areas were being established all over the world in response to the growing feeling that the establishment of such reserves might arrest indiscriminate land use and allow evolutionary and ecological processes to function naturally (Schonewald-Cox, 1988). Since then, several protected areas have been established in Nepal as well.

1.3 History of Wetland Conservation in Nepal

There is no separate policy and legislation for the conservation of Nepal's wetlands. However, since many of Nepal's important wetlands are included within the protected area system, much of the conservation effort, in terms of establishment and management of protected areas, is relevant for wetland conservation as well. Although some areas in the country had been set aside as hunting reserves by the Rana regime (1846-1950), the concept of conservation first came into existence during the 1950s and the first wildlife law was promulgated in Nepal in 1957. Since then almost all five year development plans have stressed the need for conserving wildlife. The Aquatic Animals Protection Act 2017 (1961) was passed in 1961, in which the importance of wetlands and aquatic animals was emphasized. The Act prohibits the use of poison and explosive materials in water bodies and the destruction of dam, bridge or water system with the intent to catch or kill aquatic life. However, aquatic life may be captured from private water bodies as long as poisonous materials are not used.

Furthermore, a small rhino sanctuary was established in Chitwan in 1964 to protect the population of one-horned rhinos (*Rhinoceros unicornis*) with the help of a group consisting of soldiers and trained people, and known as *Gaida Gasti* (Rhino Patrol). Subsequently, in 1969, six Royal hunting reserves in the *terai* and one in the mountain area were gazetted under the Wildlife Protection Act 2015 (1969), but effective management could not be achieved because of the absence of adequate regulations, organization and staff (HMG, 1988a).

The modern era of conservation began in Nepal with the passage of the National Parks and Wildlife Conservation Act 2029 in 1973 and the beginning of a long-term project with the help of the Food and Agricultural Organization (FAO) and the United Nations Development Program (UNDP). The 1973 Act provided broad legislation for the establishment of national parks and reserves to protect areas and species. The Act also established a separate Department of National

Parks and Wildlife Conservation, previously contained as an office within the Department of Forest (HMG, 1973). Since 1973, the act has undergone through 4 amendments, one in each 1974, 1982, 1989 and 1994 (HMG, 1995).

Four types of protected areas have been described under section 2 of the NPWC Act of 1973, namely National Park, Strict Nature Reserve, Wildlife Reserve and Hunting Reserve. These types correspond approximately to the World Conservation Union (IUCN) protected area categories II, I, IV and VIII respectively, established by the Commission on National Parks and Protected Areas (CNPPA) of the IUCN-The World Conservation Union (Appendix 1.1). A subsequent amendment of the Act allowed the creation of a fifth type of protected area, namely Conservation Area, a category which corresponds approximately to IUCN protected area category V (IUCN, 1990a). However, the difference between protected forest as defined in the Forest Act 1993 and conservation area is not clear (BPP, 1995b). Nepal currently has 8 national parks, 4 wildlife reserves, 1 hunting reserve and 2 conservation areas (Table 1.2). Figure 1.1 shows the location of protected areas in relation to the physiographic zones of the country.

Table 1.2 The Protected Areas of Nepal

Name	Location	Area (sq km)	Date of Establishment
National Parks			
Royal Chitwan NP	Central terai	932	1973
Royal Bardia NP	Western terai	968	1988
Khaptad NP	Western middle hills	225	1984
Sagarmatha NP	Eastern Himalayas	1148	1976
Langtang NP	Central Himalayas	1710	1976
Rara NP	Western middle hills	106	1976
Shey Phoksundo NP	Western Himalayas	3555	1984
Makalu-Barun NP	Eastern Himalayas	1500	1992
Wildlife Reserves			
Koshi Tappu WR	Eastern terai	175	1976
Parsa WR	Central terai	499	1984
Shukla Phanta WR	Western terai	155	1973
Shivpuri WR	Central middle hills	144	1985
Hunting Reserve			
Dhorpatan HR	Western middle hills	1325	1987
Conservation Areas			
Annapurna CA	Western Himalayas	3400	1988
Makalu-Barun CA	Eastern Himalayas	830	1992

Source: CBS, 1992

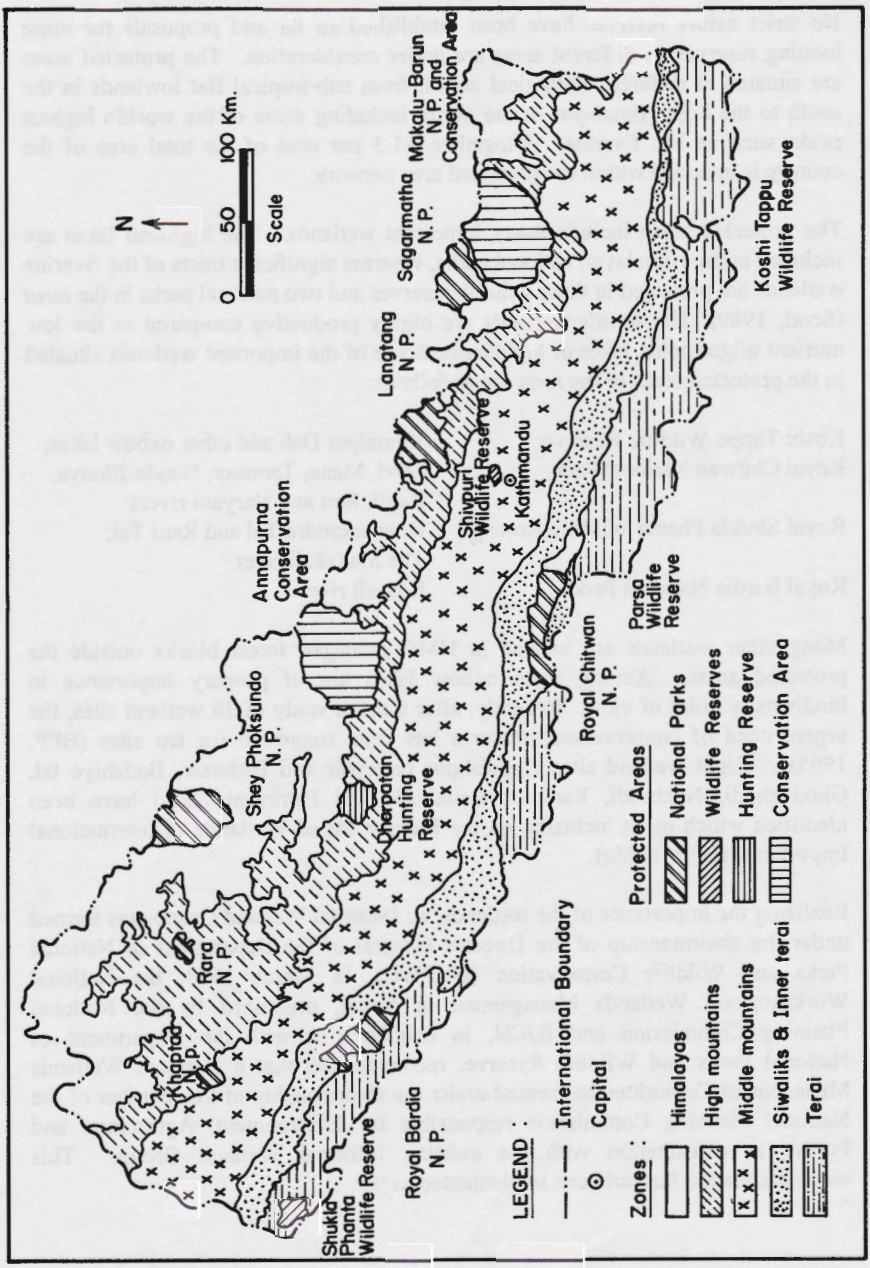


Figure 1.1 Protected areas of Nepal

The fourth amendment in the NPWC Act of 1973 has allowed to create buffer zone surrounding national parks and reserves in order to provide the use of forest products to local people. The Act defines buffer zones as "The peripheral area of the National Park or Reserve under Section 3A for providing facilities to local inhabitants to utilize forest products regularly".

No strict nature reserves have been established so far and proposals for more hunting reserves in different areas are under consideration. The protected areas are situated in different ecological zones, from sub-tropical flat lowlands in the south to the high Himalayas in the north, including some of the world's highest peaks such as Mt. Everest. Altogether, 11.3 per cent of the total area of the country is included within the protected area network.

The protected areas include many important wetlands. The highland lakes are included in the Himalayan national parks, whereas significant tracts of the riverine wetlands are protected in three wildlife reserves and two national parks in the *terai* (Scott, 1989). The *terai's* wetlands are highly productive compared to the low nutrient oligotrophic lakes of highlands. Some of the important wetlands situated in the protected areas of the *terai* are as follows:

Koshi Tappu Wildlife Reserve	:	Kamalpur Dah and other oxbow lakes,
Royal Chitwan National Park	:	Devi, Mana, Tammer, Nanda-Bhaiya, Rapti, Reu and Naryani rivers
Royal Shukla Phanta Wildlife Reserve:		Khayarkandra Tal and Rani Tal; The Mahakali river
Royal Bardia National Park	:	Karnali river

Many other wetlands are located in HMG managed forest blocks outside the protected areas. Among them oxbow lakes are of primary importance in biodiversity point of view. Recently, after a detail study of 36 wetland sites, the urgent need of conservation measures has been suggested for ten sites (BPP, 1995a). Eight wetland sites (Jagdishpur reservoir and Bishazar, Badahiya tal, Ghodaghodi, Nakhrodi, Rampur, Deukhuria and Patrayani lakes) have been identified which merit inclusion on the Ramsar list of Wetlands of International Importance (BPP, 1995a).

Realizing the importance of the wetlands, an Informal Wetland Group was formed under the chairmanship of the Director General of the Department of National Parks and Wildlife Conservation (DNPWC). In March 1993, the National Workshop on Wetlands Management in Nepal, organized by the National Planning Commission and IUCN, in collaboration with the Department of National Parks and Wildlife Reserve, recommended that a National Wetlands Management Committee be formed under the chairmanship of the member of the National Planning Commission responsible for Environment, Agriculture and Forest, in consultation with the existing Informal Wetland Group. This recommendation has not been implemented as yet.

1.4 Koshi Tappu

In the early 1970s, a need was felt to establish a wildlife reserve in Koshi Tappu to conserve the wild water buffalo *(Bubalus bubalis)* population. The wild water buffalo is one of 26 mammal species identified as protected wildlife species in Nepal under the section 10 of the National Parks and Wildlife Conservation Act, 1973 (Appendix 1.2). An area of about 170 sq. km. was gazetted as the Koshi Tappu Wildlife Reserve in 1976.

The establishment and management of the Koshi Tappu Wildlife Reserve, like most of the other protected areas in developing countries, aimed to set aside certain special places to protect them from the ravages of everyday use. Strong protective measures are advocated against anthropogenic activities within the area. Based on this principle, the National Parks and Wildlife Conservation Act, 1973 prohibits a number of activities including livestock grazing, cultivation, fishing, hunting and entry into the reserve except buffer zone without legal permission from the reserve authority. To enhance legal enforcement of the rules and regulations, the local people from the reserve area were relocated to other areas. Reserve staff, headed by a conservation officer and soldiers of the Royal Nepalese Army, are responsible for law enforcement.

Such protective measures, adapted for the management needs of the reserve, have helped to increase the population of wild water buffalo in recent years. However, the traditional practices and customary rights of the local people have been severely restricted by the regulations. The local people are allowed to use forest resources from only the buffer zone which has recently been created in some areas adjacent to the reserve. These communities, in the absence of alternatives, have subsequently violated the regulations by conducting illegal activities including livestock grazing, hunting, poaching and logging within the reserve.

People living at a subsistence level with few resources are then compelled to illegally collect essential products from the reserve. However, the main violators of the laws in the reserve are wealthier people who are usually socio-politically influential in the surrounding communities. Some of them are engaged in illegal hunting and logging. Furthermore, thousands of livestock are left to graze within the reserve by some livestock herders. The factors leading to differential resource use in general are varied and complex. The influences of inequalities in wealth and disparities in political power with regard to conservation issues should not be overlooked (Murdoch, 1980).

The exploitation of wetland resources, legally or illegally, has resulted in the degradation of wildlife habitats. Similarly, sedimentation and the subsequent rise in river bed levels has caused the loss of large tracts of forest and grassland. Livestock grazing inside the reserve has become crucial for the existence of the reserve. The presence of domestic livestock inside the reserve has not only created the danger of the spread of disease but has also threatened the genetic integrity of the wild buffalo. Diseases carried by livestock introduced by immigrants from the hills to the Chitwan valley, are thought to be the reason for the extinction of the population of wild water buffalo from the Royal Chitwan National Park.

As a result of these activities, there have been confrontations on several occasions between the reserve authorities and the local people. Moreover, the wild animals of the reserve have caused economic losses to local populations by damaging agricultural crops which has further aggravated the situation.

The wildlife reserve and the Koshi barrage comprise an important staging and nesting site for several bird species. Fourteen species present within the area are found nowhere else in Nepal while eighty seven species are winter visitors and trans-Himalayan migrants. Bird species like the swamp partridge *(Francolinus gularis)*, Bengal florican *(Honbaropsis benghalensis)*, white-tailed stonechat (*Saxicola leucura*) and striated marsh warbler (*Megalurus palustris*) have become either endangered or rare in the area.

Realizing the importance of the site, it was designated as a wetland of international importance and added to the Ramsar list on 17 December 1987 (IUCN, 1990b). The criteria for the inclusion of the site in the Ramsar list are as follows (Scott, 1989):

- The wetland regularly supports more than 20,000 waterfowl (Figure 1.2).
- The wetland is of special value for maintaining the genetic and ecological diversity of a region because of the peculiarities of its flora and fauna.

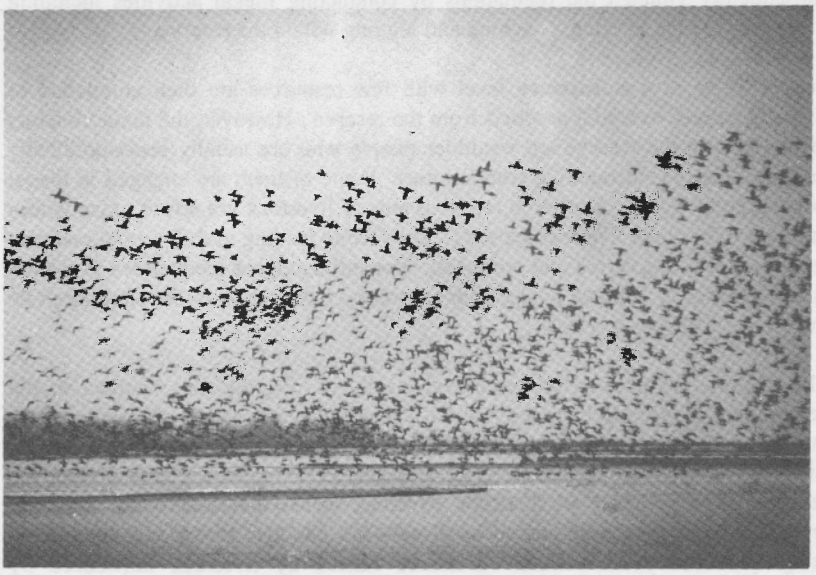


Figure 1.2 A flock of thousands of waterfowl: a criteria for establishing Koshi-Tappu as a Ramsar site (Photograph by Rajendra Suwal)

Despite this declaration, illegal activities such as trapping, hunting and poisoning of birds are common in the barrage area. This has led various researchers/scientists and institutions to advocate an extension of the protected area's boundaries (Wegge, 1976; Bauer, 1987; Heinen, 1993a, 1993b; Suwal, 1993, WMI/IUCN-Nepal, 1994; and BPP, 1995b). However, the area between the southern boundary of the reserve and the Koshi barrage has been leased to the Indian Government (Scott, 1989) and this presents a legal complication requiring inter-governmental cooperation.

A few published studies have examined the avifauna (Inskipp and Inskipp, 1985; Inskipp, 1989, Heinen, 1986; Heinen; 1987), the ecology of wild buffalo (Dahmer, 1978 and Heinen, 1993a), and conflicts between the local people and the reserve (Heinen, 1993b; Kherwar, 1996). However, in recent years, following the designation of the Koshi Tappu region as a Ramsar site, the need for a comprehensive document on the present status of the wetlands and their management has been realized. In response to this, a detailed study of the vegetation, wildlife, wetland resource utilization and the people's attitudes towards conservation has recently been done by Sah (1993a) and that of biodiversity by WMI/IUCN-Nepal (1994). The generation of such information will assist in the formulation of appropriate interventions for solving the management problems of the Koshi Tappu reserve, the only Ramsar site in the country. It is further hoped that this assessment will provide a framework for the development of a management plan for the wise and sustainable use of the resources of the area.

CHAPTER 2

MANAGEMENT OF THE RESERVE: PRESENT STATUS

Koshi Tappu Wildlife Reserve was gazetted in July 1976 to conserve the Nepalese population of the wild Asiatic water buffalo (*Bubalus bubalis*), the highly endangered wild progenitor of domestic water buffalo. The wildlife reserve is defined in the National Park and Wildlife Conservation Act, 1973 as `an area set aside for the conservation and management of mammals, birds, and other resources and their habitat'. This category of the reserve corresponds approximately to IUCN Protected Area category IV, namely `Managed Nature Reserve/Wildlife Sanctuary' (IUCN, 1990a).

2.1 Rules and regulations

Different sections of the National Parks and Wildlife Conservation Act, 1973 and subsequent amendments describe various aspects of the management practices to be undertaken for the management of national parks and wildlife reserves. The rules for National Parks were formulated exclusively for the Royal Chitwan National Park in 1974 and were later extended to include other national parks. Rules governing wildlife reserves were formulated in 1977 and were essentially similar to those established earlier for national parks. Rules and regulations related to wildlife reserves can be summarized as follows:

2.1.1 Entry procedures

Public entry was not permitted into a wildlife reserve until the passage of the second amendment of the NPWC Act 1973 in 1982 (HMG, 1982a), and the first amendment of the regulations for wildlife reserves in 1985 (HMG, 1985). The wildlife reserve regulations allow the public to enter the reserve and the following activities can be carried out with permission from the reserve authority:

- fishing by local residents under certain conditions specified by the reserve authority;
- entry of private vehicles on payment of a fee;
- the collection of specimens of all kinds (except protected species) for scientific purposes;
- the operation of private hotels, lodges or public transport inside the reserve with special permits.

People who enter the reserve have to pay an entrance fee, which is currently NRs 600 for foreign nationals and NRs 5 for Nepalese citizens. Children below the age of 5 are admitted free of charge, and those between the ages of 5 and 12 have to pay half price. Fees also have to be paid for fishing, camping, vehicles and for using access roads in the reserve for herding livestock. Any proposals made by DNPWC to increase fees are sent through the Ministry of Forests to the Cabinet. Table 2.1 shows the revenue earned from entrance fees and the number of visitors from 1985 to 1992.

Section 9 of the NPWC Act 1973 states that people enter reserves at their own risk and HMG is not financially responsible for injuries sustained within the reserve.

Table 2.1 Number of visitors and revenue earned (1984-1992)

Year	Number of Visitors		Revenue	
	Foreigners	Nepalese	Entrance fee	Elephant ride
1984/85	0	0	00	00
1985/86	6	0	300.00	1,050.00
1986/87	22	5	1,345.00	10,700.00
1987/88	51	8	3,100.00	11,950.00
1988/89	12	10	3,050.00	11,850.00
1989/90	1	0	250.00	00*
1990/91	33	31	8,405.00	00*
1991/92	61	52	20,335.00	00*

Source: Warden's Office, KTWR, 1993
1 US $ = NRs 49.50
* No revenue from elephant rides after 1989/90 because the elephants were moved to the Royal Chitwan National Park.

2.1.2 Prohibited activities

The NPWC Act 1973 and Wildlife Reserve regulations prohibit the following activities inside the reserve:

- clearing land for agricultural or residential use;
- grazing of livestock in the reserve or watering them in reserve rivers or water bodies;
- cutting and removing plant resources or setting these resources on fire;
- carrying weapons, explosives, or any item that could be used to kill or injure wildlife inside the reserves;
- hunting or harassing any wildlife or birds;
- destroying or disturbing bird nests or eggs;
- obstructing or diverting any river, stream or the source of water flowing in the reserve;
- bringing any poisonous material into the reserve or putting it into waters that flow through the reserve;
- mining or removing any minerals, stone, gravel or other such substances;
- playing music anywhere in the reserve apart from legally established lodges;
- destroying or removing any boundary, fence, signpost or notice of reserve.

These activities are prohibited in order to protect the wildlife and their habitat. The first amendment of wildlife regulations allows hunting or trapping of diseased or injured wildlife by the order of the prescribed wildlife authority. Rules published in 1979 allow Nepalese citizens to capture wild boar (*Sus scrofa*) with a special license (HMG, 1979).

Section 21 of the NPWC Act 1973 permits the use of weapons against any wild animal, protected or otherwise, in the process of attacking a person or a domestic animal. Since weapons are not allowed to be taken inside the reserve, this clause

is applicable only in areas outside the reserve. The subsequent amendment of the Act and regulations further clarify the situation under which people may kill wild animals in self-defense. Furthermore, it is stated in rules established in 1979 that wild boars that come into agricultural areas and cause damage can be captured or killed by land owners without a license. Apart from this, there are no provisions for compensating crop or life loss due to wild animals.

2.1.3 Administrative rights of a warden

Like many other national parks and wildlife reserves, Koshi Tappu Wildlife Reserve is surrounded by human settlements and several prohibited activities are often carried out illegally inside the reserve. The chief warden or the warden of the reserve is empowered through the Act and Wildlife Reserve regulations to hear and decide on cases of illegal activities. Furthermore, the wildlife officer or warden has the right to inspect and search, arrest without warrant, investigate and confiscate weapons and illegally obtained wildlife products.

To facilitate the enforcement of these rules, the warden may use informers whose information leads to the arrest of offenders. The rewards or penalties vary greatly based on the nature of the offense. Monetary rewards of up to NRs 50,000 can be provided to informers. In addition, fifty per cent of the cash value can be offered to those who provide information about persons in possession of illegal trophies. For illegal activities or hunting inside the reserve, penalties may include fines as high as NRs 100,000 and/or jail sentences of up to 15 years. For killing or wounding a wild buffalo, one of the protected wildlife, one can be punished with a fine up to NRs 75,000 and/or imprisonment for a period of up to 10 years. Table 2.2 shows the number of cases which were either taken to court or considered as serious offences in Koshi Tappu Wildlife Reserve while Table 2.3 lists revenue earned by the reserve from fines.

Acknowledging the dependence of the local people on resources available only inside the reserve, it is stated in section 16 of the NPWC Act 1973 that reserve authorities may allow for the removal of natural products on the payment of specified fee if these are considered important for the management of the area. Thatch grass cutting extends over a two week period during which people are allowed to cut thatch grass within the reserve for a fee of NRs 5 per person. Although provisions for such facility have been made for the Himalayan reserves under section 16 in order to provide grazing areas, fuelwood and timber to the local residents, the NPWC Act and regulations give a great deal of power to the warden and there are apparent changes in practices when wardens change.

Table 2.2 Number of cases of serious offences (1987-1993)

Cases	1987/88	1988/89	1989/90	1990/91	1991/92	1992/93
Logging	6	4	2	3	-	5
Hunting	3	2	-	-	3	1
Others	2	3	5	1	-	4

Source: Warden's Office, KTWR, 1993

Table 2.3 Revenue from penalties for illegal activities in NRs (1985-1992)

	Years						
	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92
July/Aug	0.00	20.00	2,750.00	10.00	60.00	40.00	1,920.00
Aug/Sept	2,560.00	2,350.00	2,904.00	65.00	650.00	2,020.00	75.00
Sept/Oct	4,851.00	101.00	867.00	0.00	1,320.00	1,080.00	610.00
Oct/Nov	3,100.00	1,000.00	1,208.00	480.00	3,530.00	765.00	0.00
Nov/Dec	2,650.00	1,100.00	3,940.00	5,680.00	1,310.00	450.00	215.00
Dec/Jan	25,600.00	400.00	12,465.00	1,450.00	0.00	0.00	3,622.00
Jan/Feb	3,275.00	1,300.00	5,276.00	3,550.00	200.00	1,820.00	93.00
Feb/March	17,550.00	7,200.00	1,360.00	430.00	785.00	970.00	4,031.00
Mar/April	4,850.00	16,875.00	11,850.00	23,012.00	515.00	0.00	9,240.00
April/May	12,650.00	6,162.00	16,564.00	1,840.00	280.00	0.00	40,135.00
May/June	11,400.00	500.00	710.00	190.00	20.00	0.00	8,375.00
June/July	1,900.00	2,560.00	335.00	160.00	260.00	420.00	190.00
Total	**90,386.00**	**39,568.00**	**60,229.00**	**36,867.00**	**8,930.00**	**7,565.00**	**68,506.00**

Source: Warden's Office, KTWR, 1993

1 US$ = 49.50 NRs

2.1.4 Buffer zone management

To address the problem of park-people conflicts, HMG has introduced a buffer zone concept through the 4th amendment in the Act 1993, and Buffer Zone Management Regulation 1996. The HMG of Nepal has been empowered to declare the surrounding areas of the parks and reserve as a buffer zone. However, for the declaration of a buffer zone, the factors such as; geographical situation of the reserve, area affected from the reserve, status of settlements and appropriateness from the point of management, have to be considered. In Koshi Tappu, Kushaha has been identified as the buffer zone so far.

According to the Act, the warden is responsible for managing the buffer zone in cooperation with local people, formed as user committees. In the buffer zone of the Koshi Tappu reserve, five user committees, namely, Parti tole, Sukumbashi tole, Jabdi tole, Khatar tole and Urman tole, covering 247 households, have so far been formed (HMG/UNDP, 1996a). Each of the committee has 11 members, including president, vice-president, secretary and treasurer. No woman is participating in any of these committees. It is not surprising because in the community, which is in the buffer zone, women are not educated, and are supposed to be involved in household activities only. The legislation, passed in 1996, has empowered the user groups to carry out community development activities, especially those that maintain a sustainable use of forest products without disturbing the wildlife habitat of the protected areas. These arrangements

have been made in order to solve the park-people conflicts on utilization and conservation of resources within the protected areas.

2.2 Institutional arrangements

The Department of National Parks and Wildlife Reserve is responsible for enforcing all wildlife laws within the parks and reserves and is administrated by the Ministry of Forestry. The head of each reserve is a 'warden' who is usually a gazetted third-class officer. Under the direct supervision of the warden there are many technical and administrative staff. Each reserve maintains an office at the reserve headquarters. The headquarters of the Koshi Tappu Wildlife Reserve are located near the village of Kushaha, 2.3 km north of Jamuwa bridge on the East-West highway, in Sunsari District. Figure 2.1 shows the map of the reserve. One ranger, most of the game scouts and all of the administrative staff are based at this office (Figure 2.2).

Two branch offices, one each to the east and the west of the reserve, are maintained for enforcing regulations. The office to the west of the reserve is located at Pathari in the village of Pipra Purba in Saptari district. It is headed by a ranger who supervises game scouts, responsible for the prevention of illegal activities. Another branch office, headed by the senior game scout is located to the east of the reserve in the village of Prakashpur, Sunsari district. Chief conservation officers and other technical staff from the Department of National Parks and Wildlife Reserve, located in Kathmandu, frequently visit the reserve under short-term deputation.

There are 61 staff positions at Koshi Tappu Wildlife Reserve, including 3 gazetted officers. But only one officer, is currently posted to the area. There are no veterinary staff and as a result, problems often arise when a wild animal is injured. Inadequate staff and equipment for field management are the chronic problems of the Department of National Parks and Wildlife Reserve as a whole (HMG, 1988a).

2.3 Physical facilities

There are separate buildings for office and staff quarters at the headquarters of the reserve. A building has been maintained as a guest house for visiting officials. In addition, a guest house built by J. T. Heinen, a wildlife biologist from the USA, is used by tourists and researchers. At the branch office, a single building is used as the office and as staff quarters. Electricity supply is available only at the head office and the Prakashpur branch office. Other facilities include a jeep, a motorbike, two boats and two bicycles. Two wireless sets, one each at the headquarters and the Pathari branch office, have been installed to communicate with the Department of National Parks and Wildlife Reserves and other national parks and reserves situated in different parts of the country. Eight elephants were earlier maintained for patrolling and wildlife viewing. However, due to damage caused by frequent visits by male wild elephants, the domesticated elephants were moved to the Royal Chitwan National Park. Boating facilities are also available for tourists.

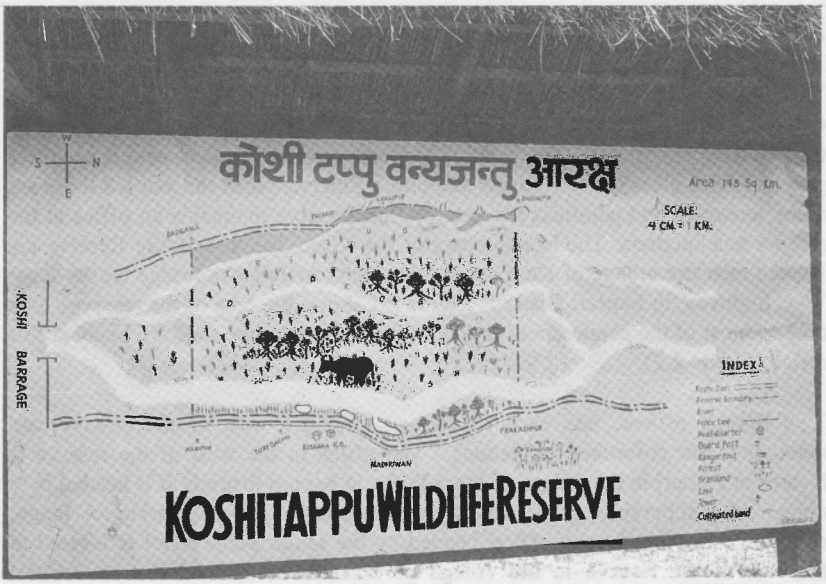


Figure 2.1 A map of the reserve at the reserve headquarters

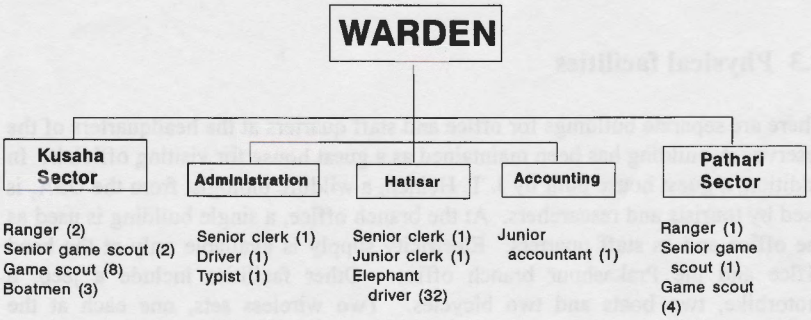


Figure 2.2. Organizational Chart of the Wildlife Reserve

Figure 2.2 Administrative structure

2.4 Management practices

There is hardly any management plan for the reserve except a plan for the recently created buffer zone. The management practices are confined to the protection of wild animals and the enforcement of regulations. Protection is carried out by the Warden's office and a battalion of the Royal Nepalese Army.

2.4.1 Role of reserve staff

Game scouts, working under the supervision of the warden and rangers, generally patrol inside the reserve. Occasionally, the patrolling team is led by rangers. The warden remains engaged in maintaining public relations, hearing and deciding on cases regarding illegal activities, and in administration. A limited budget for fuel and maintenance of the vehicle restricts the warden's movements.

During patrolling the game scouts may encounter an individual or group engaged in illegal activities, most commonly, livestock grazing, fuelwood collection, fodder collection, fishing, theft of the boundary fences and occasionally hunting or felling trees. Since the game scouts always enter the reserve without any arms, there is the possibility that they may be attacked by the offenders, especially when these are in groups and are engaged in hunting, logging and livestock grazing. Consequently, reserve staff very often do not dare to arrest them. Sometimes the offenders may try to influence the staff. As a result, livestock grazing and hunting, particularly by influential people, has become common practice inside the reserve.

Poorer people who may have no alternative source of fuelwood and fodder, often exploit the reserve's resources illegally and fish inside the reserve as well. However, when encountered by the reserve staff, they mostly run away or are ignored by the staff, although sometimes they may be persecuted. In general, offenders who are arrested, are those who cannot escape either by threatening or influencing the game scouts. Furthermore, even when they are brought to the office of the reserve and asked to pay the fines, local political leaders influence the authorities and hence, very few cases are usually filed in the office records (Table 2.2).

2.4.2 The role of the army in management

In 1975, the Royal Nepal Army became generally responsible for law enforcement in all parks and reserves of the country. The management of the Koshi Tappu Wildlife Reserve also involves the protection of wild animals and their habitat with the help of a Royal Nepal Army company. The headquarters of the army post are located at the village of Kushaha. Five army sub-posts are located in the area, one each at the villages of Haripur and Madhuban, to the east of the reserve, and at the villages of Bairawa, Pathari and Kamalpur to the west of the reserve. The company is headed by a Captain, posted at the headquarters, where 100 to 150 soldiers are also posted. About 10 to 15 soldiers are posted at each sub-post. Training is conducted frequently at the reserve headquarters and an additional 50 to 75 soldiers remain present there.

The army is responsible for the protection of the wild buffalo and other wild animals, and for arresting people involved in illegal activities within the reserve. The presence of the army is advantageous for reducing poaching and illegal activity. However, the use of the army in protected area management is considered disadvantageous for the following reasons (Heinen and Kattel, 1992a):

- the chain of command is divided between two officers, namely, the warden and a protection unit commander, and this may sometimes create conflicts;
- the military protection unit currently absorbs up to 80 per cent of the DNPWC budget, which imposes monetary constraints on conservation efforts;
- the presence of a number of personnel in the area places an additional pressure on scarce resources such as fuelwood.

Furthermore, in Koshi Tappu, it has been observed that the soldiers posted on the east of the reserve usually do not patrol across the Koshi river although most of the illegal activities occur in the west of the reserve. Moreover, the soldiers have little understanding about their role in conservation (Heinen and Kattel, 1992a) since they are not given training in this aspect. In addition, Studsrod and Wegge (1995) have observed that the Army seems to keep a low profile these days to avoid conflicts with the increasingly more politically-aware local people. Thus, the present role of the army in the management of the reserve has to be reconsidered. Annapurna Conservation Area, where there is no army personnel, can be cited as an example of successful management without the presence of the army.

However, as long as the army is an integral part of the protected area management, there is need for close collaboration between the reserve authority and the army. This has become especially critical in recent years when increased interaction between local people and conservationists has been widely felt as needed. In Koshi Tappu joint initiatives between the army and the reserve authorities are occasionally taken to drive the livestock out of the reserve (Warden of the reserve, *pers. comm.*). However, this type of collaboration is needed for other activities as well. Special training regarding the role of the army in meeting the conservation needs of the reserve should be provided and steps should be taken by the army to use alternative means of energy in order to reduce the pressure on fuelwood resources of the reserve.

2.4.3 Park-people project

Recognizing the park-people conflicts on utilization and conservation of resources within the protected areas, a three year UNDP funded Park-People Project has been started since October 1994 (HMG/UNDP, 1996a). The aim of the project is to improve the socio-economic conditions of the people living in the adjoining VDCs and to enhance the people participation in managing the protected areas and their buffer zone. This is an addition to the effort of DNPWC to manage the national parks and reserves through revenue sharing. According to the 4th Amendment in NPWC Act 1973, thirty to fifty per cent of the total revenue, collected from the protected areas, can be used for community development activities in order to encourage local people's participation in the main stream of park management. However, owing to the large discrepancies in the amount of

revenue generated from different parks and reserves, the ministry reserves the right to fix the percentage of revenue earned from the respective protected area (HMG, 1995).

The project has aimed to enhance the local communities participation in managing the parks and their buffer zones (HMG/UNDP, 1996a). The emphasis is on the decentralization of resource management to the local people and the incorporation of traditional resource use and management systems. In addition, the project is planning to implement several programs to increase the conservation awareness among the people in the vicinity of protected areas.

Buffer Zone Development Program of the Park-People Project emphasizes community forestry, income generation activities, implementation of alternative energy and protection of river banks within the buffer zone. The Project realizes the importance of tourism in generating income around the protected areas, and thus, emphasizes the development of infrastructure for tourism promotion, formulation of codes of conduct for hotels and lodges and training of local people as guides, game scouts and hotel workers (HMG/UNDP, 1996a).

It is hoped that the project, after its completion, will be able to demonstrate an efficient way of managing protected areas through benefit sharing mechanism and people's participation. However, there are still a number of conflicts in the policy which need to be resolved. For example, the project, on one hand, aims to refine management plan with people's participation, while, on the other hand, it maintains the traditional concept of protection of resources by strengthening anti-poaching activities, controlling illegal grazing and tree removal activities (HMG/UNDP, 1996a). Similarly, it is becoming hard to coordinate between relatively low paid warden, who has authority to execute all the management regulations in the field, and the project field coordinator who has the added advantage of high salary and advanced logistic facilities. Thus, buffer zone management initiatives in the surrounding areas of all protected areas in the *terai*, including the Koshi Tappu reserve, are a challenge for wildlife managers who traditionally practice the implementation of conservation activities within the protected areas. This might be one reason that even after one and a half year of the project period, no community development activity has been done in the buffer zone of the Koshi Tappu region (HMG/UNDP, 1996a).

Despite considerable efforts made by reserve staff and soldiers, the management problems in the Koshi Tappu reserve remain acute for several reasons. Social, economic and demographic factors of adjoining communities impose many direct and indirect pressures on the reserve. Illegal activities such as firewood cutting, fodder collection, livestock grazing, fishing, hunting, and logging in the area are common. Similarly, wild mammals from the reserve frequently visit the croplands and local people suffer direct loss because of the damage to their crops by these animals. Although several programs for community development and conservation education have been planned by Park-People Project, the traditional practice of protecting resources and wildlife within the reserve and lack of detailed study before creating the buffer zone and executing the project are main obstacles in implementing sustainable management and conservation plan within the reserve.

CHAPTER 3

ECOLOGICAL PHYSIOGNOMY

The Koshi Tappu region mainly includes the Koshi Tappu Wildlife Reserve (KTWR). However, since most of the important wetlands lie outside the reserve, between the wildlife reserve and the Koshi barrage, and east of the eastern embankment, the information available concerning these areas is also discussed.

3.1 Physical conditions

3.1.1 Location

Koshi Tappu Wildlife Reserve extends between 26°33'- 26°45' N and 86°54'- 87°04' E on the floodplain of the Sapta Koshi river near the Nepalese-Indian border, in the *terai* of southeastern Nepal (Figure 3.1). It covers a total area of 150 km^2 and includes parts of Sunsari district of the Koshi zone, and Saptari and Udaypur districts of the Sagarmatha zone within the Eastern Development Region of the country.

The southern boundary of the reserve runs parallel to the Koshi Barrage, 6.5 km to the south. The barrage was constructed on the river between 1958 and 1962 by the Indian Government under an agreement with His Majesty's Government of Nepal for the purposes of flood control, irrigation and electricity generation. The area between the barrage and the southern boundary of the wildlife reserve is called '*dobhan*', meaning submerged, and is leased to the Indian Government.

The eastern and western boundaries of the reserve run along the 5-7 m high eastern and western earthen embankments respectively. Both embankments bound the river floodplain, thereby preventing water from flooding agricultural fields during the monsoons. The northern boundary runs through the floodplain from the eastern embankment near Prakashpur to the village of Tapeshwari north of the Trijuga river. On the floodplain, north of the wildlife reserve, are areas of sand and gravel, degraded grazing land, cultivated fields and human settlements.

3.1.2 Topography

The area is almost flat and roughly rectangular in shape with a length of about 16.3 km and width of 9.3 km. The elevation ranges from 75 to 100 m above mean sea level. It is drained by the Sapta Koshi river, a major tributary of the Ganges, and the Trijuga river which joins the Koshi in this area.

Because of the Koshi barrage, a large expanse of open water remains present throughout the year between the barrage and the reserve, while the most part of the reserve is subject to flooding during the monsoons. Borrow pits along the side of the embankments retain water for most of the year and support dense reed-beds. A seepage stream with a 100 m to 250 m wide strip of marshes on its fringes, is situated to the east of the eastern embankment. The reserve, which extends along the Sapta Koshi river, consists of extensive mud flats and marshes.

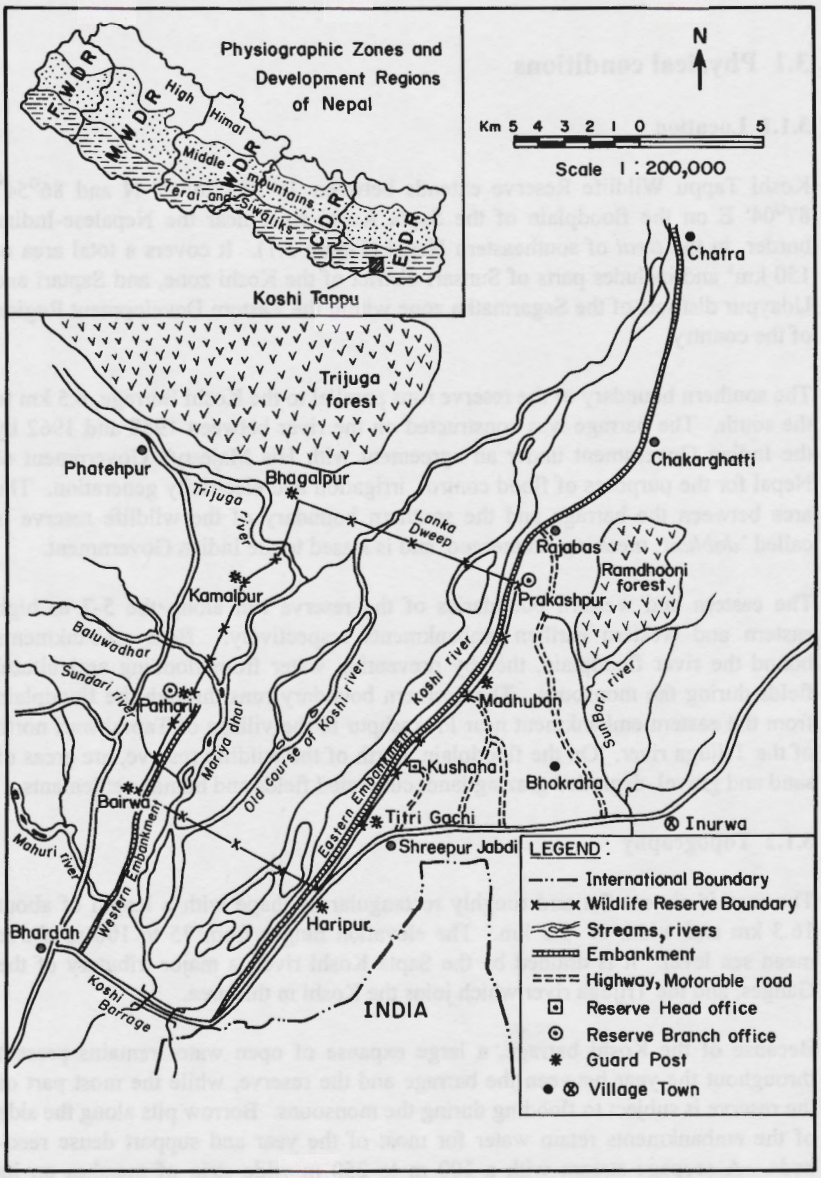


Figure 3.1 Location map of the Koshi Tappu region

3.1.3 Geology and soil

Geologically, the area lies in the northern part of the Gangetic plain. In the geologic past, after the formation of the Himalayas, the Indian plate was bent downward under the weight of the Himalayas, creating a major structural basin, which later filled with debris from the mountains to the north. These northern deposits, which have been often grouped into piedmont (foot slope) and low-lying alluvial deposits, are commonly referred to as the *terai*. The upper part of the piedmont is known as the *bhabhar* zone at 100-300 m above mean sea level (Bruijnzeel and Bremmer, 1989).

Koshi Tappu lies in a low-lying area and its alluvial deposits are mainly composed of thin fine sand, silt and clay which frequently alternate in different proportions (Ohta and Akiba, 1973). The nutrient content in the soil varies greatly, depending upon the time of sedimentation and the establishment of vegetation on it in subsequent years. During the course of a reconnaissance soil survey in Saptari district (Appendix 3.1), part of which is now included in Sunsari district, the following five different types of soil *viz.* sandy, sandy loam, loam, sandy clay loam and clay loam were described in the villages surrounding Koshi Tappu (Pradhan *et al.*, 1967).

i) Sandy soil: The color of the sandy soil varies from grey-brown to dark grey-brown. The soil is moderately alkaline with the average pH of 8.1. Its nutrient status is low with respect to all the major nutrients, *viz.* nitrogen, phosphorous, potassium and organic matter. This type of soil is most common in the villages of Madhuban, Kushaha, Kamalpur and Pipra Purba.

ii) Sandy loam: The color of the sandy-loam soil varies from dark grey-brown to light olive. Its pH varies from slightly acidic to moderately alkaline (5.2 to 7.75). The nutrient status is low with respect to nitrogen, and low to medium in phosphorous, potassium and organic matter. Based on the pH, two different sub-types of soil have been recognized:

a. Slightly to moderately acidic soil: Mostly found in the villages of Pipra Purba, Kamalpur and Odraha which are located west of the western embankment.

b. Slightly to moderately alkaline soil: Mostly found in the villages east of the eastern embankment, such as Madhuban, Kushaha and Shreepur.

iii) Loam: The color of loam found in this region varies from grey-brown to dark olive, and its pH ranges between 5.8 to 7.9. The fertility status of the soil, in general, varies from low in terms of phosphorous content, medium in potash, low to medium in nitrogen and low to high in organic matter. This type of soil is common in the villages of Haripur and Kushaha.

iv) Sandy clay loam to clay loam: This type of soil has been reported from the villages of Pipra Purba, Jagatpur and Badgama. The soil is dark grey-brown to olive in color. pH varies from slightly acidic to slightly alkaline (5.35 - 7.25). The soil is moderately to highly fertile. However, nutrient status is low in terms of phosphorous content, medium in potash, low to medium in nitrogen and medium to high in organic matter content.

3.1.4 Climate

Although the area lies north of the Tropic of Cancer, the Himalayas have sealed it off from the immediate influence of the air masses produced in Central Asia. Thus, it enjoys a tropical monsoonal climate similar to that found in the Indian sub-continent. The average annual rainfall ranges between 1,300 mm as recorded at Fatehpur, 1.5 km to the northwest of the reserve, and 2,051 mm at Chatra, four km to the northeast (Figure 3.2 and Appendix 3.2). Due to moisture laden winds from the Bay of Bengal, 80 - 85% of the total rainfall occurs during the monsoon period, from mid-June to late September. In winter, the area receives a small amount of rain brought by the southwesterly winds from the Arabian Sea. Humidity remains high all year round with the monthly average varying between 76% to 94% (Appendix 3.3).

In the pre-monsoon period, from March to mid-June, local convectional heating is an everyday phenomenon because of the large area of sand and water . As a result, strong winds blow daily during the afternoon. Fine, loose and light dust particles from the river bed, floodplain and adjacent barren fields are easily blown away by the turbulent air and become airborne, thereby reducing visibility. Hailstorms occur mostly during the hot months and cause great damage to standing crops in the nearby agricultural fields.

The average daily maximum temperature ranges from 23.5°C - 33.4°C, the minimum from 7.8°C - 25.3°C and the mean monthly temperature between 15.7°C and 29.2°C (Appendix 3.4). The temperature rises during the pre-monsoon period (February to May) and declines during the post-monsoon season (October to January), with the lowest temperatures recorded in January (Figure 3.3). The area is subject to a thermoxerochimenic bioclimate represented by hot (mean daily temperature greater than 15°C) and humid bioclimates with 5-6 dry months.

3.1.5 Wetland types

Numbers of definition for wetland (in Nepali, *simsar*, meaning low grade land under water not suitable for cultivation) are in use and are derived from two different concepts. The definition accepted by the Fish and Wildlife Service of United States (Cowardin *et al.*, 1979) is that a wetland is land where the water table is at, near or above the land surface long enough to promote the production of hydric soils or to support the growth of hydrophytes.

Hence, wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. A broader concept developed by the Ramsar Convention Bureau (1987) defines wetlands as:

> *'areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six meters.'*

Since Nepal is a land-locked country, the Informal Wetland Group in Nepal has defined wetlands within a country context, as follows:

> *'Wetlands represent landmasses saturated with water due to high water tables through either ground water, atmospheric precipitation or inundation. They may be natural or artificial, permanent or temporary, static or flowing, and freshwater or brackish'* (Bhandari, 1994).

These broad concepts of wetlands have posed difficulties in classifying and recognizing the true values of these areas. There are several classifications of wetlands developed by Odum *et al.*, (1974), Miller (1976) and Cowardin *et al.* (1979), among others. Scott (1989) classified 23 categories for describing Asian wetlands while Dugan (1990) recognized 30 categories of wetlands based on the range of wetland habitats which come under the mandate of the Ramsar Convention. This classification has been devised to recognize any wetland area, but requires information about an area at the micro-level to do so.

In view of the lack of information at such a level with regard to Nepal's wetlands, Bhandari (1993) classified the country's wetlands into seven categories, excluding rivers. WMI/IUCN-Nepal (1994) classified Nepal's wetlands in ten categories belonging to four major types, lacustrine, palustrine, riverine and rice-fields. According to this classificaiton, riverine wetlands consist of fast flowing rivers, slow flowing rivers, river flood plain and irrigation canal. Oxbow lakes, ponds and reservoirs are included in lacustrine habitats, and marshes and swamps in palustrine wetland types. Rice-field, the fourth type, includes both irrigated and rain-fed fields. A similar classification but with nine categories was done by BPP (1995a). Rice-fields, a kind of manmade wetlands, were not included in that classification. Here, however, a classification with eight categories of wetlands including rivers has been adopted. These categories comprise rivers, lakes, reservoirs, ponds, swamps, river floodplain, marshes and rice-fields. The following types of wetlands are found in the Koshi Tappu region (Scott, 1989):

1. Rivers and streams

The perennial Sapta Koshi river, which is a snow-fed river originating from the Himalayas and Tibet, represents the main wetland habitat in the region. It is a staging site for thousands of waterfowl as well as some other birds.

The Trijuga river, which originates in the Mahabharat region of the Udayapur district, enters the reserve from the northwest. It is called Mariya dhar in the southern part of the reserve. Two other rivers, the Mahuli and the Sundari, originating from the *siwaliks* of Saptari district, enter the reserve from the west near the villages of Pipra Purba and Badgama respectively. The total water surface area of the river and streams combined is approximately 1,425 ha at its low level. The Koshi river changes its course within the reserve between two embankments and thus, extensively modifies the ecosystem of the area.

2. Floodplain

The wildlife reserve is located on the floodplain of the Sapta Koshi river. The floodplain is a periodically flooded flat area between the river channel and the terrace or plateau delimiting the plain. The Koshi Tappu floodplain gradually dries up during the post-flooding period, although it remains saturated with water in certain places, while in other places it dries out to a loose sandy, semi-arid

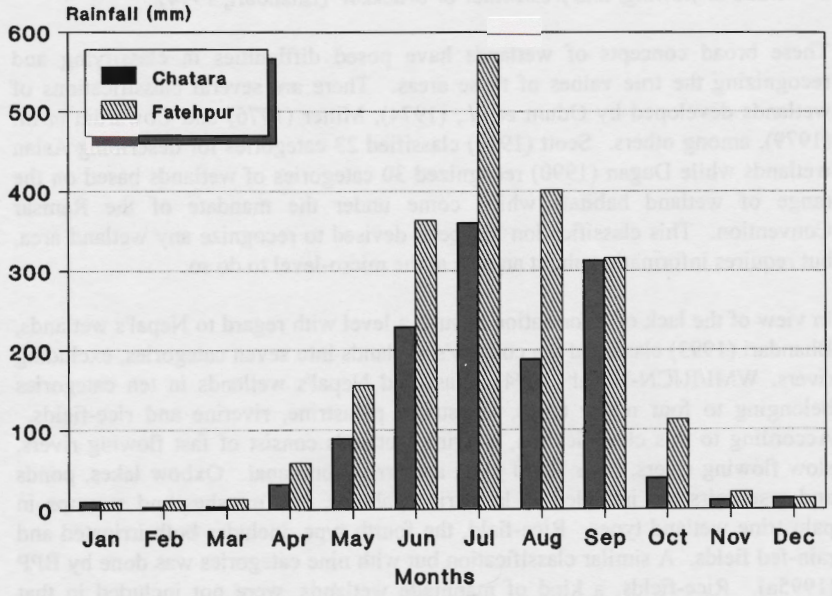


Figure 3.2 Monthly mean rainfall at Chatra and Fatehpur

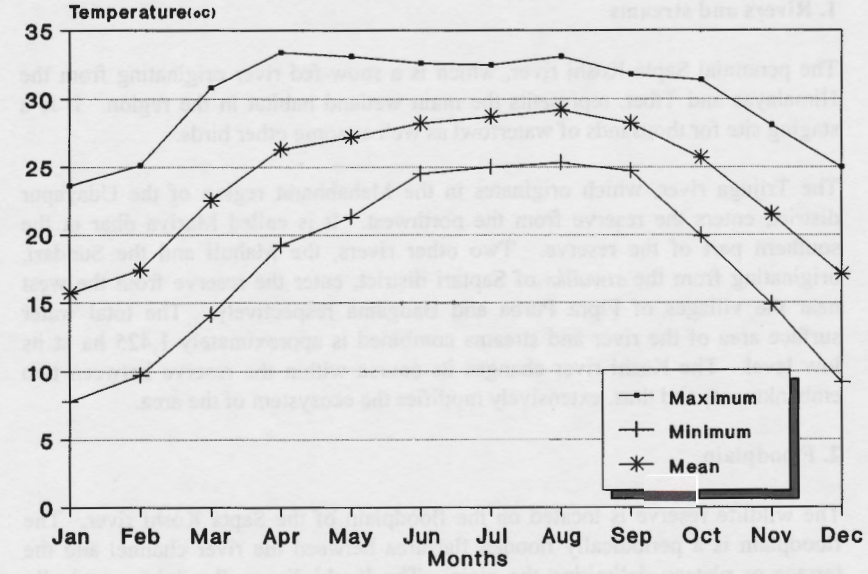


Figure 3.3 Monthly mean, maximum and minimum temperature at Chatra

condition. The floodplain is also characterized by grassy marshes, oxbow lakes, back swamp lakes and many other depressions which retain water throughout the year.

3. Oxbow lakes, riverine marshes

Oxbow lakes have been formed as a result of the meandering nature of the Koshi river. One such lake, known as `Kamal pokhari', meaning `lotus pond', and is located in the far west of the reserve near the village of Kamalpur. Three lakes are found in the eastern part of the reserve along the eastern embankment, near the village of Kushaha. An extensive marshy area lies on the fringes of these lakes. Some of oxbow lakes in the region have a short life-span as a result of regular siltation by the river.

4. Freshwater ponds and marshes

The borrow pits along the side of the eastern embankments retain water throughout the year. A stretch of 10 km long stream, with 100 - 250 m wide permanent freshwater marshes on its fringes, has been formed due to seepage from the Koshi river south of Prakashpur village (Figure 3.4). This stream flows towards the south between the eastern embankment and the abandoned railway track. Several human-made ponds of 0.5 to 2 ha are located along the embankment outside the reserve. The marshes support dense reed-beds. The seepage stream, marshes and ponds have become notable nesting sites for several bird species in the region.

5. Seasonally flooded grassland

About half of the area inside the wildlife reserve is grassland, dominated by combinations of *Cymbopogon, Imperata, Phragmites, Saccharum, Typha* and *Vetiveria* in different associations. It becomes flooded annually during the monsoons. Some portions of the grassland represent a savanna habitat (having been formed through the degradation of the forest) with tree remnants scattered throughout.

6. Swamp forest

On the floodplain of the Koshi river, forests are found in patches and consist mainly of *Dalbergia - Acacia* forest and mixed deciduous riverine forest, dominated by *Acacia catechu, Bombax ceiba* and *Dalbergia sissoo*. These forests are flooded annually during the monsoons and represent seasonally flooded forest, a type of freshwater swamp forest.

7. Reservoirs

A reservoir has been formed over a large area near the Koshi barrage. From the reservoir, water is drained into two canals, the eastern and the western canals, constructed for the purpose of irrigation. The water level in the reservoir fluctuates seasonally depending on the discharge in the river as well as in the canals. This open water area near the barrage is a major staging and nesting site in the region for several bird species, including waterfowl.

Figure 3.4 Marshes on the east of the eastern embankment

8. Rice-fields

In the vicinity of Koshi Tappu, most of the lowland paddy fields are bounded and well levelled. These fields generally remain under water during the monsoons and the post-monsoons although some may remain submerged at other times as well due to impoundment of irrigation water. These fields form large wetland areas which are important not only for birds but also offer an opportunity for paddy cum fish culture.

3.2 The Koshi river

The Koshi river, one of the major tributaries of the Ganges, is the third largest Himalayan river, originating from the Tibetan plateau and the snowy peaks in the central Himalayas. Its total catchment area is 60,400 sq km, of which 28,140 sq km (46.6 per cent) lies in Nepal, while the remainder is situated in Tibet. The Koshi river has a notorious reputation in the region for causing destruction through floods, especially in India. In the Koshi Tappu region, its behavior is the major factor which not only shapes the physical features of the region but also modifies the ecosystem of the area.

In Sanskrit, the Koshi river is called `Kaushik' and is commonly called Sapta Koshi (meaning seven rivers) because its catchment area is drained by seven major rivers, namely the Sun Koshi, Indrawati, Bhote Koshi, Tama Koshi, Dudh Koshi, Arun Koshi and the Tamur. However, the Indrawati, Bhote Koshi, Tama

Koshi and the Dudh Koshi join the Sun Koshi before they join the Arun Koshi and the Tamur at Triveni, about 10 km upstream of Chatra, to form the Sapta Koshi or Koshi. These last three are antecedent rivers as they came into existence before the rising of the Himalayas and drained an area from the Tibetan plateau to the Gangetic sea 70 million years ago (Bruijnzeel and Bremmer, 1989).

From Triveni, the Koshi flows for a length of about 10 km through a narrow gorge until it reaches the plains at Chatra where its normal width is about 0.9 km. From this point, the river flows through the Nepalese *terai*, including the Koshi Tappu Wildlife Reserve, for a distance of 42 km before it reaches the barrage which has been constructed near Bhimnagar. For this reason, afflux *bunds* of 42 and 14 km were constructed on the eastern and western banks of the river respectively in 1962. These bunds encompassed the floodplain, but prevented floodwater from entering the adjacent agricultural fields. From the barrage, the river flows along the Nepalese-Indian border for a few kilometers and then enters India. It eventually joins the Ganges, a few kilometers south of the Kursela railway bridge in Bihar, India. Discharge in the Koshi river was found to vary from 362 m^3/s in March to a maximum of 4,729 m^3/s in August with an annual average of 1,638 m^3/s (WECS, 1982).

3.2.1 Braiding of the Koshi river

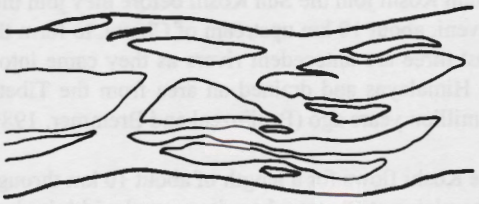
Braided rivers consist of two or more broad shallow channels divided by bars and islands, which are elevated areas that become submerged only during floods (Miall, 1977). A braided channel is characterized by i) channel segments, ii) nodes where segments branch or join, and iii) islands enclosed by segments (Gupta *et al.*, 1980) (Figure 3.5).

Several factors contribute to the formation of braided rivers, such as, coarse bed material, high bed load, highly fluctuating discharge, lack of vegetation and the sudden reduction in the slope of the river bed (Miall, 1977). Ever increasing meandering behavior of a river is also considered a major cause of braiding, such as the braiding of the Brahamputra river in Bangladesh (Kalam and Jabbar, 1991). However, in general, excessive silt load and consequent aggradation of the river bed are considered the primary causes of river braiding and the shifting tendency of its numerous channels. The increase in the intensity of braiding is usually determined by the degree of aggradation in the channel (Kumar and Mathur, 1986).

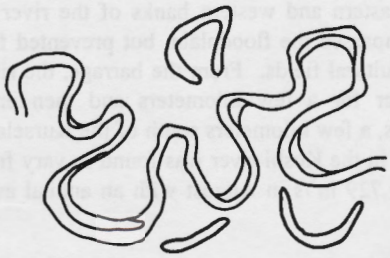
After leaving the *siwaliks*, many Himalayan rivers which are heavily laden with sediment during the monsoon, assume a braided pattern. The Koshi river starts to braid when it enters the plains near Chatra. The river has altered its course over the geological past and formed a semi-circular mega-alluvial cone from Chatra to near Kursela in India (Figure 3.6).

Sedimentation

The river looses about 76 percent of its initial sediment load along its course according to measurements taken at a gorge in Barah Chhetra (Godbole, 1986). By the time the river reaches Kursela in India, where the Koshi joins the Ganges, the sediment load decreases to 24% of that measured in the gorge (Appendix 3.5).



Braided river



Meandering river

Figure 3.5 **Two different patterns of a river**

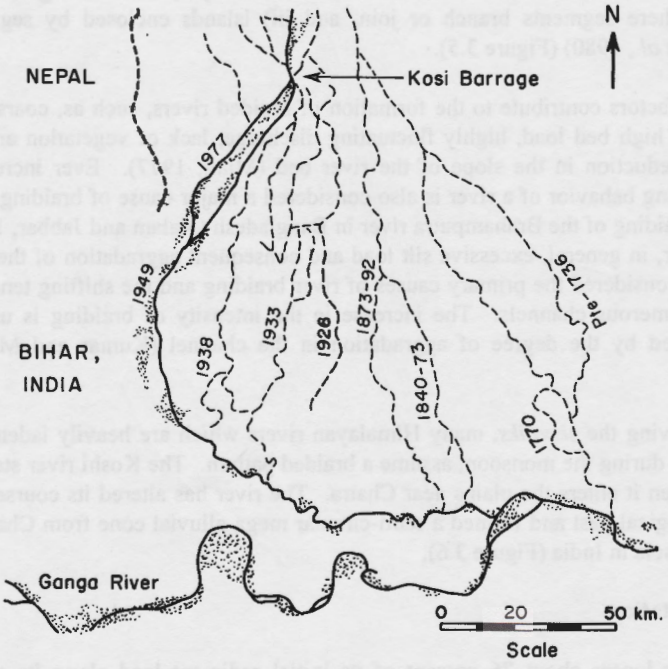


Figure 3.6 **Shifting of the Koshi river over its alluvial fan (1736-1977) (after Galay, 1987: Cited in Bruijnzeel and Bremmer, 1989)**

A sudden reduction in the slope of the river bed results in a marked reduction in the sediment transport capacity of the river. The Koshi river has a steep gradient of about 1.5 m/km in the gorge, upstream of Chatra (Sanyal, 1980). It drops at an average of 0.89 m/km between Chatra and the barrage. South of the barrage, the slope levels out considerably, and is only 0.04 m/km near Kursela in India (Figure 3.7 and Appendix 3.6). As a result, sediments are deposited by the river along its course. The average annual silt load of the river during 1948-78 was 94.9 million m^3, most of which was deposited below the barrage.

Asian rivers together supply up to 80 per cent of the world's total sediment transported to the seas (Holeman, 1968). The Himalayan rivers such as the Ganges, have a sediment load (11.3 t/ha/yr), much higher than non-Himalayan rivers like the Orinoco (0.9 - 2 t/ha/yr) or the Mekong (2.1 t/ha/yr) (Milliman and Meade, 1983). The Ganges is joined by numerous tributaries, both from the young mountain range to the north as well as from the old plateau in the south. Among them, the Sapta Koshi is particularly noteworthy for its unreliable behavior and because while it drains only 9 per cent of the entire Ganges basin (Bruijnzeel and Bremmer, 1989), it contributes 40 per cent of the total sediment load of the Ganges (Alford, 1988).

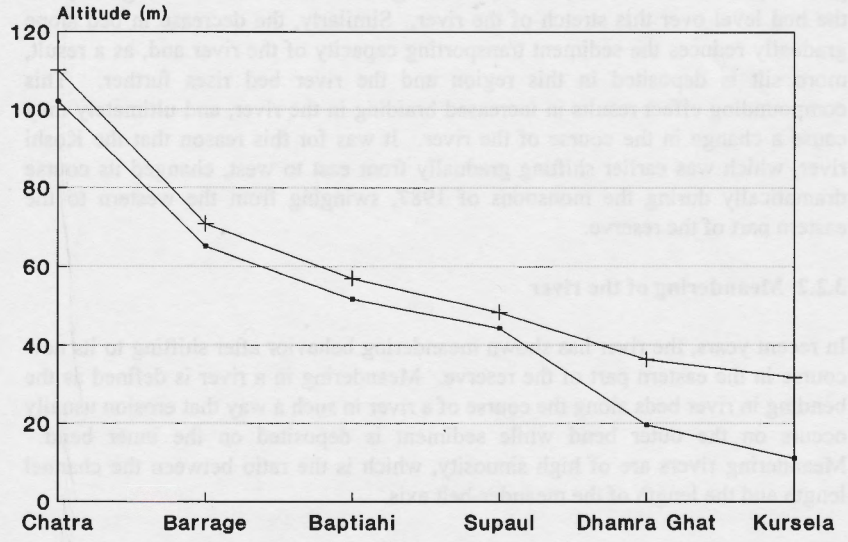


Figure 3.7 Slope profile of the Koshi river (Source : Godbole, 1986)

Impact of activity in the catchment area

Sediment concentrations and frequency of floods in the river are related to the characteristics of the catchment area. Increased severity of floods and soil erosion in major rivers, particularly during the monsoons, have occurred due to the loss of forest cover in the mountainous regions of the country (Eckholm, 1975; and

Tejwani, 1985). Furthermore, steep slope cultivation, mass wasting and glacial movements have also been responsible for the increased sediment concentrations and frequency of floods in rivers like the Koshi (Ives, 1986; Bruijnzeel and Bremmer, 1989).

Impact of the barrage on braiding of the river

Prior to the construction of the barrage in 1962, sediment in the Koshi river was mostly deposited downstream of the present barrage, whereas river bed degradation at a rate of about 165.66 mm per year occurred in the upstream area, including the Koshi Tappu Wildlife Reserve (Table 3.1). This resulted in greater braiding behavior of the river south of the barrage (in India) and was partially responsible for the gradual movement of the river 112 km westward over 250 years (Kumar and Mathur, 1986).

Immediately after the completion of the barrage, the river started to show less braiding characteristics south of the barrage, and a higher degree of braiding was observed in the upper portions of the river (Gupta *et al.*, 1980). Hence, it appears that the construction of the barrage has shifted the locus of maximum sedimentation from the downstream portion of the river to further upstream, causing a rise in the river bed (Sanyal, 1980) (Table 3.1).

The rate of the rise in the river bed is maximum near the barrage and decreases gradually towards the north, thereby resulting in a decrease in the average slope of the bed level over this stretch of the river. Similarly, the decrease in bed slope gradually reduces the sediment transporting capacity of the river and, as a result, more silt is deposited in this region and the river bed rises further. This compounding effect results in increased braiding in the river, and ultimately may cause a change in the course of the river. It was for this reason that the Koshi river, which was earlier shifting gradually from east to west, changed its course dramatically during the monsoons of 1987, swinging from the western to the eastern part of the reserve.

3.2.2 Meandering of the river

In recent years, the river has shown meandering behavior after shifting to its new course in the eastern part of the reserve. Meandering in a river is defined as the bending in river beds along the course of a river in such a way that erosion usually occurs on the outer bend while sediment is deposited on the inner bend. Meandering rivers are of high sinuosity, which is the ratio between the channel length and the length of the meander-belt axis.

Although braiding and meandering are two different forms of rivers, and differ in several characteristics (Miall, 1977) (Table 3.2), it has been observed that a given channel can change over a short distance from a braid to a meander and *vice versa* due to variations in locally independent factors (Leopold and Wolman, 1957).

In the Koshi Tappu region, the presence of the eastern embankment and the spurs perpendicular to it are factors which have caused the river to meander as they have made the eastern bank less erodible. Under these conditions, the development of a braiding pattern has been inhibited (Miall, 1977). Similarly, if

one bank is not erodible, it causes accelerated erosion by the river on the other bank (Burger *et al.*, 1991).

Table 3.1 The river bed variation in the Koshi river (1955-1974)

River section	Dist km	Bed Variation (mm/year)		Volume change in river bed (m^3)	
		1955-62	1963-74	1955-62	1963-74
Chatra-Jalpapur (Including Koshi Tappu)	27	-17.6	+123.4	-0.046	+28.304
Jalpapur-Bhimnagar (Barrage)	15	-165.6	+107.0	-16.058	+10.436
Bhimnagar-Dagmara (India)	26	-35.6	-8.3	-5.082	+1.181
Dagmara-Supaul (India)	34	-03.8	+18.6	-2.081	+10.228
Supaul-Mahesi (India)	40	+95.6	+63.5	+42.900	+20.949
Mahesi-Koparia (India)	25	NA	+120.3	NA	+15.730

Source: Sanyal, 1980

Table 3.2 Characteristics of braiding and meandering rivers

Characters	River types	
	Braiding	Meandering
Morphology	Two or more channels with bars and small islands	Single channel
Sinuosity	<1.3	>1.3
Load type	Bedload	Suspension, mixed load
Bedload percent	>11	<11
Width/depth ratio	>40	<40
Erosive behavior	Channel widening	Channel incision, meander widening
Depositional behavior	Channel aggradation, mid channel bar formation	Point-bar formation

Source: Miall, 1977

The observed change in the position of the river has had a marked effect on the vegetation dynamics, the movement of wildlife and the daily life of the local people. After 1987, the movement of the river towards the east has resulted in increased pressure on the earlier embankment. This pressure has become more pronounced at different places between Rajabas, north-west of the wildlife reserve, and Haripur, on the southern boundary of the reserve. Since the increase in sedimentation and the river bed rise is likely to continue in the future due to the deteriorating condition of the watershed, intensive research and careful monitoring of the behavior of the river are recommended.

3.3 Limnology

Several limnological studies have been done in the rivers and the lakes of Nepal (Hickel, 1973; Swarm 1980; Aizaki *et al.*, 1987; Lohamn *et al.*, 1988; Jones *et al*, 1989; Shrestha, 1990; McEachern, 1994). But the most comprehensive data on limnology in water bodies of Nepal are given in Jones *et al.* (1989). However, since their study was carried out in 1985, several changes in landuse in watershed area of water bodies have occurred. As a result, some discrepancies were found in recent limnological survey (McEachern, 1994).

In Koshi Tappu, water bodies comprise rivers and oxbow lakes. The bathymetric records have been maintained by the Indian Government to monitor flood and siltation in the Koshi barrage area. The records over 45 year period (Appendix 3.7) show a pattern of flow rate with peaks followed by diminished flow over a two to five year period and a 14 to 16 year flood cycle (Figure 3.8). From the data, a general increasing trend of flow rate is also evident. Changes in land use such as deforestation, and hence, water holding capacity and evapotranspiration within the watershed are mainly responsible for the observed trend (WMI/IUCN-Nepal, 1994).

The data on water chemistry of the Koshi river and the oxbow lakes in the Koshi Tappu region is limited to only few studies (Shrestha, 1990; Jones et al., 1989; McEachern, 1994; WMI/IUCN-Nepal, 1994). From these studies, it is found that alkalinity is surprisingly low in the Koshi river (Table 3.3). Jones *et al.* (1989) opined that sedimentary geology of the watershed, low in carbonates may be responsible for low alkalinity. They found Ca and Mg as two dominant cations constituting 60 and 25 per cent of total cations, respectively. It was different from the water chemistry in Indian part of the Koshi river, 15 km down the barrage, where calcium and sodium are major constituents of cations at 66 and 20 per cent, respectively (Sharma, 1996). Because of low alkalinity, the river systems in the Koshi Tappu region are very sensitive to changes that occur in their watershed (McEachern, 1994).

Furthermore, the river has much lower of nutrients than in the adjacent oxbow lakes. Almost all of the nitrogen and only 15 per cent of total phosphorous were in dissolved form (Table 3.3). In a study, WMI/IUCN-Nepal (1994) found the oxbow lakes of the Koshi Tappu floodplain in consistent with other tropical lakes. Although from a nutrient stimulating experiment, it was concluded that the lakes were nitrogen limited in spring season, the nitrogen to phosphorous ratio of 12:1 (Table 3.3) suggested that there might be occasions when phosphorus could be

limiting. The implications of nutrient limitation in an aquatic system become more relevant when that system receives agricultural runoffs from the fields where chemical fertilizers are used. When a lake with nitrogen limitation receives the inputs from nitrogen rich agricultural sources, subsequent algal bloom in the lakes can cause oxygen depletion resulting in sharp decline in fish population. At the same time, the application of phosphorous rich fertilizer will not have much affect. Since oxbow lakes in the Koshi Tappu region are more likely to be both nitrogen and phosphorous limited in different parts of the year (McEachern, 1994), the care has to be taken in the use of both kinds of fertilizers throughout the year so that biological diversity of the region is not adversely affected.

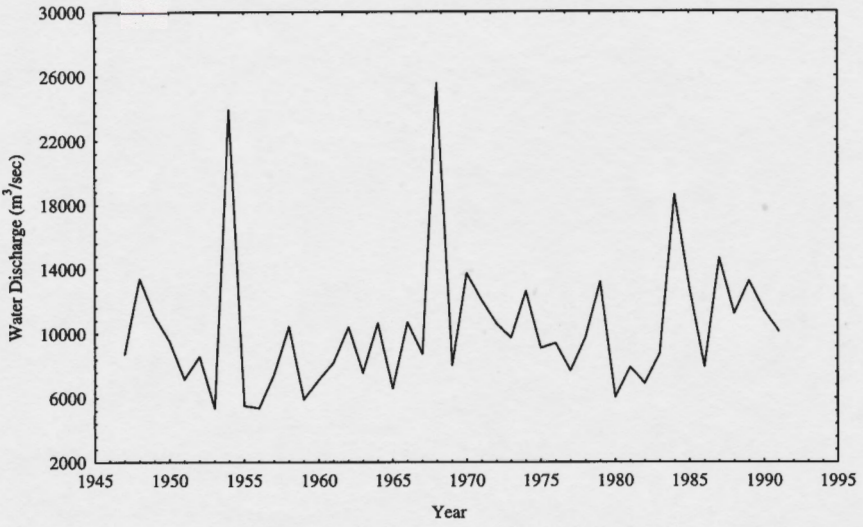


Figure 3.8 **Flood records for 45 years in the Koshi river**

Table 3.3 **Surface water characteristics of aquatic bodies in Koshi Tappu**

Water characteristics	Oxbow lake	The Koshi River
Temperature (°C)	25.0	21.6
Dissolved Oxygen (mg/L)	7.0	13.3
Conductivity (S/cm)	90.4	105.0
pH	8.0	-
Alkalinity (mg/L $CaCO_3$)	38.8	62.5
Total Nitrogen (mg/m3)	750.0	300.0
Dissolved Nitrogen (mg/m3)	-	290.0
Total Phosphorous (mg/m3)	59.0	164.0
Dissolved Phosphorous (mg/m3)	-	25.0
Chlorophyll a (mg/m3)	13.3	-

Source: WMI/IUCN-Nepal, 1994

CHAPTER 4

BIOLOGICAL RESOURCES

The Koshi Tappu region is rich in biological resources. The different kinds of wetlands in the area support a large number of plant and animal species, among which birds and fish are noteworthy. A considerable number of plant species present in Koshi Tappu are used for food, fuel, fodder, medicine and housing materials. Hundreds of people depend on fishing in the Koshi river and adjacent wetlands for their livelihoods. In addition, biodiversity in the area has potential genetic resources which could be used to improve the quality of domesticated species.

Most studies undertaken in Koshi Tappu have been made on birds (Inskipp and Inskipp, 1985; Heinen, 1986; Dolek, 1987; Mareby, 1987; Myers, 1988; Inskipp, 1989), fish (Shrestha, 1990) and the wild buffalo (*Bubalus bubalis*) (Dahmer, 1978; Kushwaha, 1986; Heinen, 1993a; Kherwar, 1996). Research on the floral composition and vegetation dynamics is limited (Sah, 1993a; Shrestha, 1994; WMI/IUCN-Nepal, 1994; Shrestha, 1996). An endeavor has been made in this chapter to summarize information available on the biological resources of Koshi Tappu. The ecology of the wild buffalo is presented in detail especially because of the establishment of the wildlife reserve to protect the last surviving population of this species in Nepal.

4.1 Vegetation distribution

Vegetation is the structural and functional backbone of a wetland ecosystem as it provides habitat, food and energy to its faunal and microbial communities. It is also a primary agent in bio-geochemical cycles and in succession. The vegetation in any wetland ecosystem is an assemblage of the populations of aquatic and wetland plant species. In Koshi Tappu, since most of the area, except a narrow elevated belt in the center, gets inundated annually during the monsoons, the vegetation is composed of aquatic and wetland vegetation. However, there are many plants present here which are not restricted to wetlands but can grow in non-wetland areas equally well.

Wetland plants can tolerate different degrees of wetness associated with the varied hydrophytic regimes found in wetlands, and which create a diverse set of environmental conditions. Nevertheless, plant composition gradually changes from a more typical wetland community to a transitional community caused by a decrease in soil wetness along a gradient between flooded and dry areas. The vegetation, together with the soils and hydrology of the area, serves as an important criterion for identifying and delineating the wetland (Tiner, 1991).

It has long been recognized that in wetlands, the hydrology of the area determines the distribution pattern of vegetation (Thibodeau, 1985). Recent studies have also shown that there are often distinct groupings of species associated with different degrees of flooding (Huenneke, 1982; Parsons and Ware, 1982 cited in Thibodeau, 1985). On a floodplain, many species react to the effect of flooding in various

ways and the selective survival of species to flooding determines the stratification of the species (Bedinger, 1978). This may result in the formation of a spatially complex mosaic where water depth and persistence of flood water determine the vegetation pattern (Whitehead *et al.*, 1990). However, the relationship between vegetation patterns and hydrological cycles is interactive and each has a direct influence on the other (Finlayson, 1989).

In Koshi Tappu, the vegetation consists of diverse physiognomic types. Submerged and floating leaved aquatics, tall reed stands, a seasonally flooded grassland/ savannah and structurally complex forest communities are found in various combinations of spatial arrangements. Altogether, 236 angiospermic plant species, most of which are wetland species, have been recorded from Koshi Tappu. Others have been found on the embankments and are typical mesophytes. All these plants belong to 65 families, of which the graminae family is represented by the highest number of species. The number of flowering plant species recorded from Koshi Tappu accounts for 13 and 4.7 percent of total flowering plants recorded for the *terai* and the country, respectively (WMI/IUCN-Nepal, 1994). A list of plants found in Koshi Tappu and their taxonomic families is provided in Appendix 4.1. Vegetation associations in Koshi Tappu are primarily determined by the degree of flooding coupled with the extent of human interference, such as logging, grazing, burning and grass-cutting. The importance of flood in shaping the vegetation pattern in Koshi Tappu is also evident from the spatial distribution of forest in linear patches. Since the degree of flooding and the nature of the river bed fluctuate regularly due to the braiding and meandering behavior of the Koshi river with a subsequent deposition of silt, the plants grow in different associations. Different patterns of burning, as well as grazing and grass cutting, further modify these associations.

The detailed floristic composition of the vegetation and its ecology have yet to be studied. However, the following types of vegetation associations have been classified on the basis of physiognomy and habitat.

4.1.1 Riverine forest

On the floodplain, forested wetlands are most common. Usually, forest communities are much more complex and more spatially heterogenous than submerged, floating and emergent vegetation (Verhoeven, 1992). In Koshi Tappu, the forests are mostly open and degraded, and form isolated patches of woodlands, dominated by one or more of the three species, *Acacia catechu, Bombax ceiba* and *Dalbergia sissoo*. Based on the Importance Value Index of the tree species in the forests of Koshi Tappu, the following associations of the riverine forest are described.

a. *Acacia catechu - Dalbergia sissoo* forest

Locally known as *Khair-Sissoo* forest, this is a typical riverine forest of the Nepalese *terai*, found mostly near the banks of rivers and on islands surrounded by segments of a braiding river. *Acacia catechu* and *Dalbergia sissoo* form the first seral stand of trees along the river course because they are able to withstand flooding. This forest type was found prominent in the northern and central part of Koshi Tappu (Figure 4.1), over an area of 400 ha (2.66 per cent of total area). It is

less than the area calculated from Dobremez's maps of ecosystem in which this forest was shown in 786 ha (BPP, 1995b). It is attributed to the changes which have occurred in Koshi Tappu since the map was prepared in early seventies. The forest is open, with crown cover ranging between 20-50 per cent. The Shannon's Species Diversity Index for trees was calculated about 1.127.

In this forest, the Importance Value Index (IVI), which is a summation of relative frequency, relative density and relative dominance of a species, was found quite high for *A. catechu* and *D. sissoo*, at 112.4 and 108.2 respectively, when compared to the values obtained for two other species, *Bombax ceiba* and *Trewia nudiflora* (Table 4.1). The latter two species were sparsely present at the eastern fringes of the forest. Dinerstein (1979) found *Bombax ceiba* and *Streblus aspera* mixed with *A. catechu* and *D. sissoo* in the Royal Karnali-Bardia Wildlife Reserve under similar environmental conditions. The presence of other species is associated with a change in soil type (Puri, 1960). The density of *A. catechu* (147 trees/ha) was found higher than that of *D. sissoo* (67 trees/ha), but due to the relatively high basal area of *D. sissoo*, their IVI values did not differ much. The average diameter at breast height (dbh) of *D. sissoo* and *A. catechu*, measured at 31.4 and 13.8 cm respectively, suggests that the forest is not fully matured and that the area remained continuously under disturbances by the river (WMI/IUCN-Nepal, 1994). The trees of *D. sissoo* and *A. catechu* formed two different canopy layers at about 15 m and 6 m respectively. The height of *A. catechu* increased gradually from west to east, towards the well drained area. Neither the understory layer nor the ground vegetation was found prominent during the dry season. *Phragmites* and *Saccharum* association grows poorly in this region and the open area is dominated by *Imperata cylindrica.*

Figure 4.1 ***Acacia catechu-Dalbergia sissoo*** **forest: a typical riverine vegetation type in the** ***terai***

Table 4.1 Importance Value Index (IVI) of tree species in the *Acacia catechu - Dalbergia sissoo* forest

Sp. No.	Plant species	R. F. %	R. D. %	R. Do. %	IVI
1.	*Acacia catechu* (L. f.) Willd	40.91	53.66	17.87	112.44
2.	*Bombax ceiba* L.	22.73	17.07	25.04	64.84
3.	*Dalbergia sissoo* L.	27.27	24.39	56.52	108.18
4.	*Trewia nudiflora* L.	9.09	4.88	0.97	14.54
Total		100.00	100.0	100.0	300.00

Source: Sah, 1993a

In Koshi Tappu, although both *Acacia catechu* and *Dalbergia sissoo* are found in different proportions, the forest is dominated by *D. sissoo* in the central-western and western parts of the reserve (Table 4.2). Similarly, in some relatively undisturbed places, *A. catechu* forms patches of pure stands (Figure 4.2). Thus, two different types of forest, *Dalbergia sissoo* forest and *Acacia catechu* forest, have been separately described by WMI/IUCN-Nepal (1994).

Table 4.2 Importance Value Index (IVI) of the tree species in *D. sissoo* dominated forest

Plant species	R. F. %	R. D. %	R. Do. %	IVI
Acacia catechu (L. f.) Willd	23.53	14.71	1.74	39.98
Bombax ceiba L.	17.65	8.82	7.12	33.59
Dalbergia sissoo L.	47.06	70.59	90.06	207.71
Trewia nudiflora L.	411.76	5.88	1.08	18.73
Total	100.00	100.00	100.00	300.00

Source: Sah, 1993a

b. *Dalbergia sissoo* forest:

In *Dalbergia sissoo* dominated forest, the crown cover ranged between 10 - 40 per cent and Shannon's Species Diversity Index was calculated as 0.907. The relatively low density of *A. catechu* was due to the fact that the species is selectively felled and that *D. sissoo* grows relatively faster in dry conditions. In this forest, ground vegetation consisted of *Arundinella* sp. *Cirsium wallichii,*

Clerodendron viscosum, Cynoglossum zeylanicum, Cyperus dichtomos, Diplozium esculentum, Eupatorium adenophorum, E. odoratum, Persicaria nepalensis, Solanum indicum and *Solanum xanthocarpum.*

Dalbergia sissoo was found dominant in the regenerated forest also. In this forest, trees were mostly of 5 to 8 m height and 6 to 12 cm dbh. With the changing soil condition of the area due to siltation and shifting of the river, the forest has regenerated in different parts of Koshi Tappu. Although regeneration is a continuous process, it has become prominent on the western side inside the reserve after 1987 when the Koshi changed its course from the west to the east. Regeneration of the forest has become rapid where the soil remains relatively moist in the post-flooding period and in areas free of intense fire and heavy grazing.

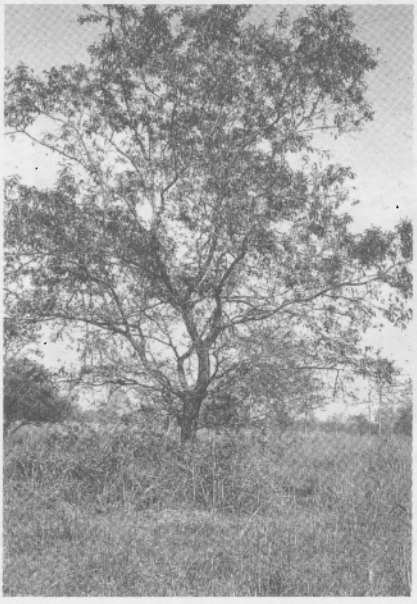


Figure 4.2 ***Acacia catechu*** **(Khair) : a dominant and valuable tree species in Koshi Tappu**

c. *Acacia catechu* forest:

The forest is dominated by *A. catechu* in the north western part of the reserve. The stratification of the canopy layer was found more prominent in this forest than in *D. sissoo* forest. Three canopy layers, each dominated by *A. catechu*, were present at 10-12, 5-10 and 3-5 m height In this forest ground vegetation consisted of *Cynoglossum zeylanicum, Cynodon dactylon, Deeringa amaranthoides, Eupatorium odoratum, Leucas indica, Persicaria barbatum, Solanum acculeatissimum, S. nigrum, S. tortum* and *Vernonia cinerea* (WMI/IUCN-Nepal, 1994).

d. Mixed deciduous riverine forest

The mixed deciduous riverine forest in Koshi Tappu is comparable to tropical deciduous riverine forests, as described by Stainton (1972) and is found to occur along the streams of the *bhabhar* - an 8 to 12 km wide zone situated to the south

of the *siwaliks* consisting of deposits of gravel and boulders in the fan area of the major and medium rivers - and in the *dun* valleys which are relatively flat areas surrounded by the *siwaliks*. In Koshi Tappu, this forest covered an area of 430.8 ha (2.87 per cent) in 1991 and is characterized by *Bombax ceiba* (simal) (Figure 4.3). It has a large buttressed trunk and scarlet flowers on leafless branches. Its light buoyant wood is used to make ferry boats.

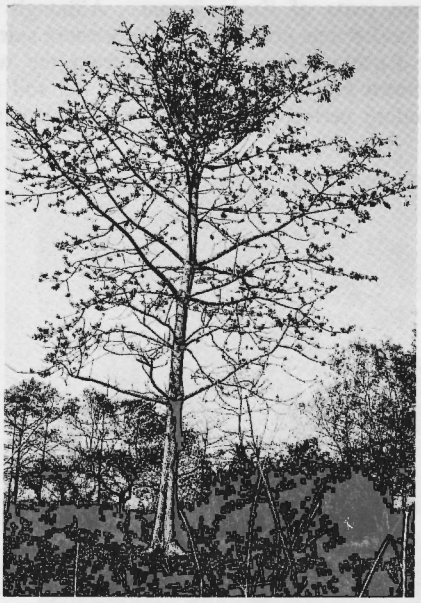


Figure 4.3 ***Bombax ceiba*** **(simal) in its flowering stage**

Bombax ceiba is usually associated with a number of other tree species (Stainton, 1972), but in Koshi Tappu, the species richness of this forest was relatively low (Table 4.3).

In this forest, the growth of *Artemisia vulgaris, Calotropis gigantica, Eupatorium adenophorum, Lantana indica* and *Solanum eriantum* as understory, and *Solena heterophylla, Boerhavia diffusa* and *Momordica charantia* as climbers, indicates the relatively dry conditions of the forest and also that it has been disturbed. Where the forest cover was broken, scrub vegetation consisting of *Adhatoda vesica, Clerodendron infortunatum, Colebrookea oppositifolia* and *Zizyphus mauritiana* was found.

Along the continuum, this association lies closer to a mixed deciduous hardwood forest. The Shannon's Species Diversity Index (1.505) and crown cover (30 - 60 per cent) were found relatively high. In general, the species richness increases with distance from the river bank and *Bombax ceiba* becomes less dominant. The forest is then designated as mixed deciduous forest.

The mixed deciduous forest at one time covered a large area in Koshi Tappu, but with the shift of the river to its present position, a major portion was destroyed, leaving only a narrow belt of 165 ha along the eastern embankment near the village of Prakashpur. Associated species include *Artocarpus lakoocha, Azadirachta indica, Eugenia jombolina, Ficus subincisa, Mallotus phillipensis, Salix* sp., and Trewia *nudiflora* among others.

Table 4.3 Importance Value Index (IVI) of tree species in mixed deciduous riverine forest

Plant species	R. F. %	R. D. %	R. Do. %	IVI
Acacia catechu (L. f.) Willd	8.33	13.64	8.09	30.06
Bombax ceiba L.	25.00	29.55	44.17	98.72
Dalbergia sissoo L.	29.17	25.00	29.44	83.61
Ficus subincisa Buch-Ham. ex Sm.	4.17	2.27	0.14	6.58
Garuga pinnata Roxb.	4.17	2.27	0.61	7.05
Trewia nudiflora L.	29.17	27.27	17.54	73.98
Total	100.00	100.00	100.00	300.00

Source: Sah, 1993a

4.1.2 Grassland/Savanna

In Koshi Tappu, 6,250 ha (41.6 per cent) of the total area was found covered by a grassland/savanna type of vegetation which is flooded annually during monsoons and is dominated by *Saccharum-Phragmites* association. The grassland is locally called *'phant'*. Major species present in different proportions include *Imperata cylindrica, Phragmites karka, Saccharum spontaneum, Typha aungustifolia* and *Vetiveria lawsonii*. The following types of vegetation associations are present:

a. Savanna

A large area in Koshi Tappu comprises this vegetation type where the ground is covered by *Saccharum-Phragmites* association, and trees of *Bombax ceiba* are sparsely scattered. Trees of other species like *Albizia chinensis, Dalbergia sissoo, Eugenia jambolina, Mallotus phillipensis*, and *Trewia nudiflora* are also present in low numbers. This type of vegetation is not characteristic of a zone with a tropical monsoon climate and has been formed due to the degradation of the forest.

b. *Saccharum - Phragmites* grassland

The grassland is dominated by *Saccharum* and *Phragmites*. This association of vegetation is most common in Koshi Tappu and found in diverse environments within the area, such as on the relatively stabilized floodplain, in the forest and in moist places. There are several other species which are found in this association of grassland (Table 4.4). The biomass production in this type of grassland ranges from 6.25 to 23.70 ton/ha (WMI/IUCN-Nepal, 1994).

In some dry area, *Cymbopogon* becomes co-dominant with *Saccharum* and *Phragmites*. In such condition, the number of associated species and the biomass production decreases significantly. The standing biomass was found 0.84 to 1.05 ton/ha only. Another major component of *Saccharum-Phragmites* grassland is

Imperata cylindrica, which forms pure stands where the area is open, dry and highly disturbed. This condition has been observed in Chitwan and Bardia also (Dinerstein, 1979). This species grows better than other tall grasses after a fire in Koshi Tappu, as it grows fast and flowers within a short period. Its seeds are well adapted for wind dispersal and rapid germination. As a result, very few associated species are found in *Imperata* stands. The biomass production ranges from 1.4 to 2.5 ton/ha (WMI/IUCN-Nepal).

c. *Saccharum - Tamarix*

On the floodplain, *Saccharum spontaneum* and *Tamarix dioica* grow first and become the dominant species where sand has been recently deposited. Later, other grasses, such as *Arundo donax, Erianthus ravennae* and *Phragmites karka* grow in various densities. These associations are better adapted to withstand flooding. However, low vegetation often disappears with monsoon flooding and re-emerges after the river level drops and the deposited silt is exposed.

Table 4.4 Plant species and their abundance in the *Saccharum-Phragmites* grassland of Koshi Tappu

Plant species	Family	Abundance
Imperata cylindrica L.	Graminae	***
Phragmites karka (Retz) Trin ex Steudes	Graminae	***
Saccharum spontaneum L.	Graminae	***
Alternanthera sessillis		**
Sida rhombifolia L.	Malvaceae	**
Tamarix dioica L.	Tamaricaceae	**
Vetiveria lawsonii (Hook f.) Blatter & Mccan	Graminae	**
Azeratum conyzoides L.	Compositae	*
Calapogonium mucunoides Desv.	Leguminosae	*
Cassia occidentalis L.	Leguminosae	*
Eclypta prostrata L.	Compositae	*
Hydrocotyl asiatica L.	Hydrocotylaceae	*
Lindernia pussila (Willd) Boldingh	Scrophulariaceae	*
Plantago major L.	Plantaginaceae	*
Tetrastigma serruatum	Vitaceae	*
Tylophora tenerrinea	Ascelpediaceae	*
Uraria logopoides (L.) Desv.	Leguminosae	*

Source: Sah, 1993a

* Less common, ** Common, *** Abundant

d. Swampy grassland

Swampy grasslands or reed swamps develop in swampy lowland areas, which are waterlogged for relatively longer periods during post flooding months, and are almost saturated during the rest of the year. In some areas reeds attain a height of 3-5 m. In Koshi Tappu, 1,652 ha (10.98 per cent) of the total area was represented by this kind of vegetation.

The presence of *Typha-Vetiveria* association serves as an indicator of swampy grassland in Koshi Tappu (Figure 4.4). Where frequent burning takes place, these species do not grow well. Other plants, which are present in this area, include *Calapogonium mucunoides, Crotolaria* sp., *Eclypta prostrata, Mollugo lotoides,*

Oxypetalum sp., *Persicaria barbata, Saccharum spontaneum, Scoparia dulcis, Sida rhombifolia, Spilanthes calva* and *Urena lobota,* among others. The presence of *Saccharum* in this community indicates that this type of grassland has originated from dry lands in water saturated areas (WMI/IUCN-Nepal, 1994).

The *Saccharum-Phragmites* association is most common in Koshi-Tappu. They grow as tussock-forming perennials and their growth is favored by the inundation of the area for a longer period during the post-monsoon season.

The physiognomy of the grassland in Koshi Tappu is comparable to that of Chitwan National Park, where riverine grasslands also remain inundated for considerable periods of time after the monsoons (Lehmkuhl, 1989), and favor tussock-forming perennials (Dinerstein, 1979). However, the larger portion of the total area in Koshi Tappu under this type of grassland and its changing boundaries might be attributable to the relatively longer period of inundation and the instability of the Koshi river. Natural grasslands and savanna usually occur where regular distribution of rainfall prevails throughout the year. The climatic condition of this region is clearly marked by a distinct rainy season and a prolonged dry period. Thus, the formation of these types of vegetation is attributable to frequent burning and intensive grazing (Wharton, 1968).

In Koshi Tappu, visibility in savanna/grassland habitat is dependent upon the seasons and the degree of human activities. During the monsoons, both visibility and movement remain restricted by tall grasses, the height of which may reach 3 to 4 m (Figure 4.5). People are allowed to extract the grasses during the last week of January. Thereafter, fire is applied intentionally by the local people to facilitate the growth of new grasses for the purpose of livestock grazing. This has resulted in the creation of the grassland habitat.

Figure 4.4 ***Typha aungustifolia*** **(pater): an indicator of swampy grassland in Koshi Tappu**

Figure 4.5 Tall grasses: a common feature on the floodplain

4.1.3 Aquatic/marshy vegetation

Marshes are wetlands where the land remains under water throughout the year with extensive growth of vegetation such as grasses and sedges. Marsh plants and their associated habitat provide important breeding and staging areas for a large number of resident and migratory birds.

About 179 ha (1.2 per cent) of the total area was found occupied by lakes and marshes. A 100 m to 250 m wide strip, consisting of the seepage stream and marshes at its fringes along the eastern embankment outside the reserve, was formed after the river shifted eastward. In addition to this, several fragmented water bodies and marshes are present inside the reserve along the Paleo-channel of the Koshi river. The vegetation in this kind of wetland is shaped by fluctuations in water level, degree of human interference and water quality. The vegetation of aquatic bodies/marshes consists of submerged, rooted floating, free floating and emergent plants forming intermingled mats.

In the aquatic bodies, submerged and floating plants are represented by a number of unrelated families, namely azollaceae, ceratophyllaceae, hydrocharitaceae, lemnaceae, menynthaceae, potamogenataceae, among others, whereas emergent vegetation consists mostly of members of cyperaceae and polygonaceae (Figure 4.6). These plants share common hydrophytic characteristics and are highly sensitive to seasonal fluctuations in the water level. A list of aquatic plants, categorized according to different forms, is given in Appendix 4.2.

Emergent vegetation, which generally occupies the water margin of the perennial water bodies, becomes submerged when there is a rise in water level during the wet season. In this condition, the shoots of the plants die out and slowly decompose into the water, thereby enriching it with organic matter. Information on the aquatic vegetation of Koshi Tappu is based upon a study of five water

bodies, three inside the reserve and two outside of it (Sah, 1993a). The qualitative abundance of each species based on its occurrence and coverage was recorded (Table 4.5). More extensive study of aquatic macrophytes in different wetland habitat in the Koshi Tappu region is given in WMI/IUCN-Nepal (1994) and Shrestha (1996).

Figure 4.6 ***Persicaria barbata*** **(Fam. Polygonaceae) grows luxuriantly on the fringes of marshes**

Oxbow lake near Kushaha *Machan* (Bird watching tower), hereafter written as Lake-KM, and Lake near Titri Gachhi (Lake-TG), are two undisturbed shallow lakes with stagnant water and are located inside the reserve along the eastern embankment. Lake-KM occupies about 2.5 ha and is near a bird-watching tower (*machan*) built on the embankment near the village of Kushaha. Lake-TG occupies about 2 ha near an area known as *Titri Gachhi.* Similarly, Marsh-KM and Marsh-TG, located near the Kushaha machan and Titri Gachhi, respectively, are the parts of marshy land outside the reserve, where human interference is high. These two marshes are connected with the seepage stream flowing from north to south east to the eastern embankment. The fifth lake, Kamalpur Dah, is an oxbow lake of about 8.5 ha in the western part of the reserve near the village of Kamalpur.

A study of the vegetation distribution in these water bodies showed that the number of species was high in the marshes situated closer to agricultural land outside the reserve. The species richness (No. of species m^{-1}) was highest (4.0) in Marsh-TG and lowest (1.1) in Lake-KM (Table 4.5). In each case, the number of species increased towards the fringes of the marshes. In another study, 45 species, more than three fourth of total wetland aquatic flowering plants in the Koshi Tappu, were reported from the marshes along the seepage stream (WMI/IUCN-Nepal, 1994). This was probably due to the relatively slow flowing and shallow depth of water, the favorable conditions for growth of smaller emergents as well as other aquatic plants except the sub-mergents, the number of which was relatively low in each marsh. Handoo and Kaul (1982), in a study of wetlands in India, also found a gradual increase in species richness with a decrease in water depth.

Table 4.5 Abundance of species and species richness in the oxbow lakes and marshes of Koshi-Tappu

Plant species	Lake-KM	Lake-TG	Marsh-KM	Marsh-TG	Kamalpur Dah
Free floating					
Azolla pinnata	-	-	+++	++	+
Eichornia crassipes	-	-	+++	+	+
Lemna minor	-	-	+++	+++	-
Lemna perpusilla	-	+	+++	+++	+
Pistia stratiotes	+	+	++	+++	++
Spirodela polyrrhiza	+	+	++	++	+
Wolffia globosa	-	+	++	++	+
Rooted floating					
Hydrocharis dubia	+	-	+	++	++
Hygrorhiza aristata	-	-	++	++	+
Ipomaea aquatica	-	-	-	++	-
Nelumbium nucifera	-	-	-	-	+++
Nymphoides cristatum	-	-	++	+++	+++
Nymphoides indicum	-	-	-	+	++
Persicaria hydropiper	++	++	+	++	+
Sub-mergents					
Ceratophyllum submersum	-	-	-	+	++
Hydrilla verticillata	+++	++	+++	+++	++
Potamogeton crispus	-	-	++	++	++
Ranaculus aquatalis	-	-	++	++	+
Emergents					
Cyperus sanuguin	-	-	+	-	-
Fimbristylis aestivalis	-	-	++	++	++
Paspalidium flavidum	-	-	++	++	-
Paspalidium geminatum	-	-	++	++	-
Paspalidium punctatum	-	-	+	++	-
Persicaria barbata	++	+	+	-	-
Phragmites karka	+	+	+	+	++
Polygonum glabrum	++	++	+	++	+
Rotola rotundifolia	-	-	+++	++	+++
Scirpus kysoor	-	-	++	++	+++
Setaria pallidefusca	-	-	-	+	-
Spiranthus sinensis	-	-	++	++	+++
Typha angustifolia	-	+	++	+	+++
Species richness	**1.1**	**1.3**	**3.6**	**4.0**	**2.9**

Source: Sah, 1993a

- absent, * less common, ** common, *** abundant

According to Miller (1973), the growth of emergents at greater depths requires extra energy for them to reach the surface and if excessive energy is expended in this effort, plants would become weak and susceptible to damage by other environmental factors. This may be the cause of low species richness in deep water. The extensive growth of *Eichornia crassipes* in deep water may be another factor which results in greater species richness at the fringes where its growth is less dense.

Lakes such as Lake-KM and Lake-TG inside the reserve, were similar in species composition, and the composition of marshes like Marsh-KM and Marsh-TG outside the reserve was also similar to each other as shown in Table 4.6. Kamalpur Dah, located in the western part of the reserve, had a species richness comparable to Marsh-KM and Marsh-TG. Altogether 28 species, the second highest in terms of wetland flora, were recorded in Kamalpur Dah by WMI/IUCN-Nepal (1994).

Table 4.6 Similarity index between marshes of Koshi Tappu

	Lake-KM	Lake-TG	Marsh-KM	Marsh-TG	Kamalpur Dah
Lake-KM		0.778	0.457	0.368	0.467
Lake-TG			0.541	0.450	0.563
Marsh-KM				0.877	0.816
Marsh-TG					0.846

Source: Sah, 1993a

While the inorganic and organic matter from adjoining agricultural land and villages are probably responsible for the enrichment of the marshes outside the reserve and for the vigorous growth of different species in those marshes, the reason for relatively low species richness in the lakes inside the reserve is attributed to the deposition of silt during floods in the Koshi river. Lake-KM and Lake-TG are situated on the floodplain of the Koshi river, and are annually flooded during the monsoon. This is even more evident in Kamalpur Dah, which is located inside the reserve but near the agricultural fields and has not been subject to regular flooding after 1987, and therefore, has a relatively high species richness (Figure 4.7).

A sedimentation rate greater than 30 mm/year is enough to bury and destroy most of the submerged community in the wetlands (van der Valk and Bliss, 1971). Data on sedimentation rates in these lakes are presently unavailable. However, if the annual river bed rise of 107 mm/yr (during the post-Barrage period, see table 2.1) is taken as an approximate sedimentation rate, it follows that this rate is 3-4 times higher than the danger level of 30 mm/year. At this rate, the destruction of the lakes is inevitable. However, if the sedimentation is checked, the seeds buried in the sediment usually have the potential to germinate (van der Valk *et al.*, 1983), and may be a source of increasing the species richness in these lakes.

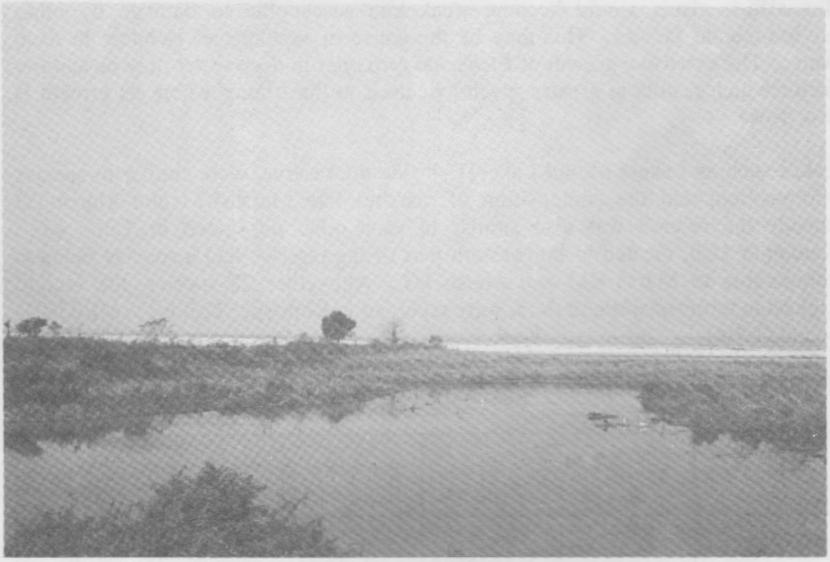


Figure 4.7 An oxbow lake rich in biodiversity

4.2 Wildlife diversity

Nepal lies at the junction of the Palaearctic and Indo-Malayan realms resulting in great faunal diversity. Koshi Tappu falls within the Peninsular Indian Division of the Indo-Malayan realm (Corbet and Hill, 1992). Most of the existing information on animal diversity is limited to vertebrates as there has been no effort so far to study the lower animals in the Koshi Tappu region. Even in the *terai*, butterflies are only the lower animals which have been studied in detail (BPP, 1995b). Apart from the listing of mammals and some fish species, detailed studies of vertebrates have been limited to birds and to one mammal species, the wild water buffalo (*Bubalus bubalis*).

4.2.1 Fish

The *terai* harbors the highest number of fish species among all the physiographic zones within the country. Altogether, 154 spp. (83%), which represent all the 11 orders of fish reported from Nepal, are found in the *terai* (BPP, 1995b). In the past, the Koshi river was famous in the region for its fish. However, in recent years, both the stock and the diversity of fish species have decreased due to over fishing and lack of proper management. This decrease has been reflected in the less frequent observations of merganser *(Mergus merganser)* and other predominantly fish-eating waterfowl species in the Koshi Tappu area (Suwal, 1993).

The river harbours a number of migratory fish. A study of the fish fauna found in the Koshi river was undertaken by Menon (1949) who reported 52 species of fish from the river in both Indian and Nepalese territory. Similarly, David (1959) gave an account of fish seed collection centers. Later, Menon (1962) added 69 more species to his previous list. Thereafter, a list of fish species found in the Nepalese

part of the Koshi river was prepared by Shrestha (1980) (cited in Shrestha, 1990) (Appendix 4.3). In a recent study, 83 species comprising 24 families were recorded from 13 different sites of the reserve and the surrounding area (WMI/IUCN-Nepal, 1994). The highest number of species was recorded from the Koshi Barrage area, which is outside the reserve, followed by upstream near Prakashpur. The most common species in the Koshi river were *Puntius conchonius, P. ticto* and *Barilius barna.* Similarly, *Badis badis, Chanda nama* and *Esomus danricus* were common in marshes and swamps (WMI/IUCN-Nepal, 1994).

In the study, it has been claimed that 8 new species, *Badis badis, Barillus tileo, Chela cachius, Danio rerio, Mystus cavasius, M. tengra, Sissor rhabdophorus* and *Somileptes gongota,* have been added in the existing list of fish for the Koshi Tappu region, and one species, *Colisa sota,* is the new record even for Nepal. It indicates that the area has not been studied well. Furthermore, only 5 species, which were recorded before, are mentioned missing in the survey (WMI/IUCN-Nepal, 1994). In comparison of such study with the list given in Shrestha (1990), more than 30 species were found not listed in the recent stud. It indicates that detailed studies are needed to assess the real status of the fish species and to determine whether any significant change in distribution has taken place.

4.2.2 Reptiles

A few individuals of the rare *gharial (Gavialis gangeticus)* were released in the Koshi river inside the reserve during 1982 and 1984 by the Captive Rearing Program, conducted in Chitwan National Park. Despite high mortality during the flood in 1987 (Bauer, 1987), a few of them are still present within the reserve area. This species is listed in CITES Appendix I as a species 'threatened with extinction', and in IUCN (1988) threatened categories as 'endangered'. Recently, an immature gharial measuring nearly 30 cm, was found dead by a dolphin survey team in March 1993 (Suwal, 1993). The equally rare freshwater crocodile *(Crocodylis palustris)* has also been reported from the Koshi river (Shrestha, 1994). Similarly, Monitor lizard (*Varanus bengalensis*), listed in CITES Appendix I as a threatened species, is found in the Koshi Tappu reserve near grasslands, marshes and ponds at the edge of forests (WMI/IUCN-Nepal, 1994). However, its status in the reserve is still unknown and needs detail study. Other reptiles recorded from the reserve include several species of turtles, lizards and snakes (Table 4.7).

4.2.3 Birds

In Nepal, a total of 834 species of birds have been recorded and this accounts for nearly one tenth of the world's known species. The species diversity of birds decreases with an increase in altitude. The *terai,* composed of flat lowlands below 300 m, has rich species diversity with more than 500 bird species of which 190 are wetland dependent species (Inskipp and Inskipp, 1985).

The Koshi Tappu area, including the reserve and the Barrage, is also rich in avifauna. A checklist, which includes 365 bird species (43.8 per cent of the records in the country), has been prepared for this area (Appendix 4.4). Almost all the species of waterfowl, waders, storks, ibises, egrets, gulls and terns found in Nepal, have been recorded from the site (Inskipp and Inskipp, 1985). Among them, a total of 13 species have been recorded only from this region, especially from the Koshi Barrage (Heinen, 1987). The status of the rare and new bird records are given in Appendix 4.5.

Table 4.7 Reptiles found in the Koshi Tappu area

Scientific name	Common name	Source
Amphaeslma skolata	Striped Keeback	WMI/IUCN-Nepal, 1994
Calotus versicolor	Garden lizard	" "
Chitra indica	Chitra turtle	Shrestha (1994)
Crocodilys palustris	Freshwater Crocodile	Scott (1989)
Gavialis gangeticus	Gharial	" "
Hardella thurgi	Brahminy terrapin	Shrestha (1994)
Kachuga kachuga	Rofed turtle	" "
Kachuga smithi	Smith's terrapin	" "
Kachuga tecta	Sail terrapin	" "
Testtuda elongata	Claw tailed tortoise	" "
Trionyx gangeticus	Ganges softshell	" "
Trionyx hurum	Peacock soft-shell turtle	" "
Trionyx leithi	Ganges soft-shell turtle	" "
Varanus bengalensis	Monitor lizard	WMI/IUCN-Nepal, 1994

Bird species in Koshi Tappu include 114 species of waterbirds, representing almost all the species known to occur in Nepal. Eight species of egrets and herons, two species of ibises, 20 species of ducks, 30 species of shorebirds as well as some stork species have all been recorded from the area (Scott, 1989). Among them, the lesser spotted eagle *(Aquila pomarina)*, tawny eagle *(Aquila rapax vindhiana)*, Eurasian kestrel *(Falco tinnunculus)*, swamp francolin *(Francolinus gularis)*, yellow-legged button quail *(Turnix tanki)*, watercock *(Gallicrex cinerea)*, orange-breasted green pigeon *(Treron bicincta)*, pompadour green pigeon *(Treron pompadora)*, black-breasted weaver *(Ploceus benghalensis)*, black-headed cuckoo-shrike *(Coracina melanoptera)*, white-tailed stonechat *(Saxicola leucura)* and striated marsh warbler *(Megalurus palustris)* are particularly noteworthy (IUCN, 1990b).

The area is important for both resident and migratory birds. The open water behind the Barrage is particularly important as a staging and wintering site for a variety of trans-Himalayan migrants, notably ducks and shorebirds, most of which are winter visitors or passage migrants (Scott, 1989). Among them, migratory waterfowl are notable and include the common pintail, the number of which exceeds 50,000. Migration of birds starts in late December, reaches a peak between mid-February and mid-March and then begins to decline until mid-May. The number of different species of migratory birds given in Scott (1989) is as follows:

Anas acuta	50,000	*Anas crecca*	2,000
Anas clypeata	500	*Anas falcata*	80
Anas penelope	600	*Anas platyrhynchos*	100
Anas querquedula	1,800	*Anas strepera*	200
Aythya baeri	20	*Aythya ferina*	100
Aythya fuligula	100	*Aythya nyroca*	150
Dendrocygna javanica	7,000	*Netta rufina*	50
Tadorna ferruginea	4,000		

Common shorebird species include the common sandpiper *(Actitis hypoleucos)*, little stint *(Calidris minuta)*, Temminck's stint (*C. temminickii*), kentish plover *(Charadrius alexandrinus)*, common snipe *(Gallinago gallinago)*, Eurasian curlew

(Numenius arquata), ruff (*Philomachus pugnax*), Eurasian golden plover *(Pluvialis dominica)*, common greenshank (*Tringa nebularia)*, and green sandpiper *(Tringa ochropus)*. Other regular migrants include bar-headed goose *(Anser indicus)*, grey heron (*Ardea cinerea)*, Eurasian coot (*Fulica atra)*, little comorant *(Phalacrocorax niger)*, great crested grebe (*Podiceps cristatus)* and purple swamp hen *(Porphyrio porphyrio)*.

Other noteworthy species, which have been recorded in small numbers, include black stork (*Ciconia nigra)*, black-necked stork (*Ephippiorhynchus asiaticus*), greater adjutant stork (*Leptoptilos dubius)*, lesser adjutant (*L. javanicus)*, painted stork *(Mycteria leucocephala)*, spoonbill (*Platalia leucorodia)*, Indian skimmer (*Rynchops albicollis)*, comb duck (*Sarkidiornis melanotos)* and oriental white ibis *(Threskiornis melanocephalus*) (Scott, 1989).

Some bird species such as cinnamon bittern (*Ixobrychus cinnamomeus)*, Chinese little bittern (*I. sinensis*), cotton pygmy goose (*Nettapus coromandelianus)*, watercock *(Gallicrex cinerea)*, pheasant-tailed jacana (*Hydrophasianus chirurgus)* and little tern (*Sterna albifrons)* are summer visitors. Some bird species such as greylag goose *(Anser anser)*, darter *(Anhinga melanogaster)*, swamp partridge (*Francolinus gularis)*, Bengal florican (*Houbaropsis bengalensis)*, Eurasian tree sparrow (*Passer montanus)* and little cormorant *(Phalacrocorax niger)* have become either endangered, scarce or uncommon in the area (Heinen, 1987). Some of them need to be included in the protected list of the country (Heinen and Yonzon, 1994). A few individuals of swamp partridge were sighted near the village of Kushaha village along the eastern embankment. During a study by Dodman and Guinan (1991), a total of 17 individuals of swamp partridge were recorded. The total area of its habitat was estimated at approximately 2 square kilometers, with a density of 9 birds/sq km (Suwal, 1993).

Six of the 11 bird species which are believed extinct from Nepal within this century once occurred in the terai (BPP, 1995b). Similarly, one of the world's most threatened species of the Bustard family, the Bengal florican (*Eupodotis bengalensis*) has not been sighted in recent surveys. The number of Bengal florican has declined at Chitwan as well, probably as a result of annual cutting and burning of grasses (Inskipp and Inskipp, 1985), which is also common in Koshi Tappu. Two breeding species, the changeable hawk eagle (*Spizaetus cirrhatus)* and the dusky eagle owl *(Bubo coromandus)*, have not been recorded since 1976 (Inskipp, 1989).

The reservoir and marshes near the Barrage and wetlands along the eastern embankment form the most important habitat to support large numbers of bird species, followed by forests, savanna and grassland inside the reserve (Figure 4.8).

Since reliable records have not been consistently maintained over long periods, the impact of the multiple uses of the Barrage on resident and migratory birds is poorly understood (Heinen, 1987). Any physiographic change in the region has significant impacts on the distribution of the bird species. The waterfowl have benefited from the construction of the Koshi Barrage through the development of a large expanse of water and extensive marshlands. However, the increased frequency of flooding has negatively affected a large number of breeding species, notably the herons and storks. Migratory species residing here as winter visitors might have been least affected (Bauer, 1987).

Taking into account the conservation value of the area, it would seem appropriate to develop a database with the information on status, altitudinal limits, breeding and migration of birds, and conduct continuous monitoring in order to assess the

dynamics of the avian diversity with respect to the multiple use of the Barrage, instability of the Koshi river and the human activity in the wetlands both inside and outside the reserve.

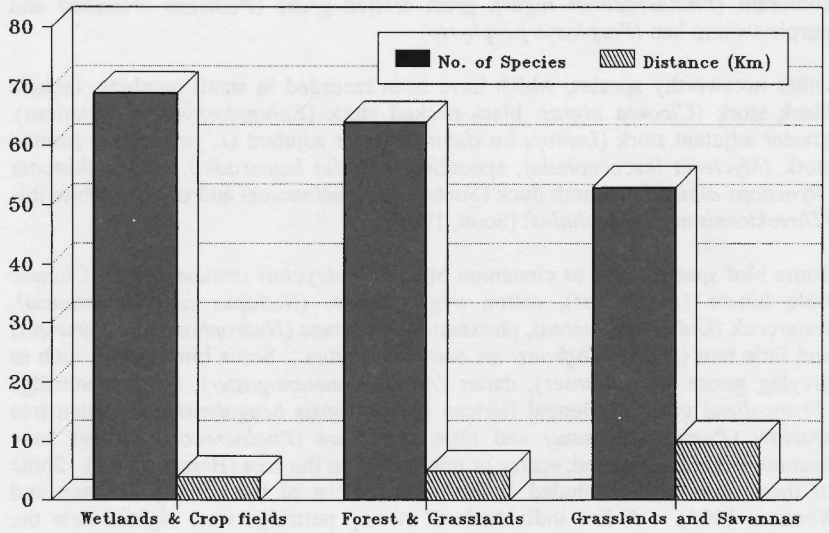


Figure 4.8 Number of bird species in different habitats

4.2.4 Mammals

Ninety one species of mammals belonging to 12 orders are found in the *terai* and *siwaliks*, while in Koshi Tappu 23 species have been recorded (BPP, 1995b). In the past, the Koshi Tappu area was covered with dense riverine forest and tall grasses where large carnivores, such as the Bengal tiger (*Panthera tigris)* and leopard *(Panthera pardus)* were abundant. Although the number of wild water buffalo has increased in the last few decades (Heinen, 1993b, Suwal, 1993), the number of total wildlife species in Koshi Tappu has diminished greatly due to development activities, human encroachment and flooding (Bauer, 1987, Heinen 1995).

In comparison with other protected areas of the *terai*, Koshi Tappu shows considerable impoverishment in its fauna (Bauer, 1987; Heinen, 1995). The last tiger in the area was reported more than 18 years ago and leopards have also recently become extinct. The intensity of agriculture before the declaration of the wildlife reserve and loss of the forest have been attributed to the total loss of these carnivores in Koshi Tappu. However, the area contains Nepal's last surviving population of wild water buffalo *(Bubalus bubalis)* which is believed to be the ancestor of the domestic buffalo and is also called the Wild Asiatic buffalo. It is thought, however, that the entire population in Koshi Tappu may have been hybridized with domestic water buffalo.

Among other mammals, the wild boar (*Sus scrofa)* is common. Large mammals like *gaur (Bos gaurus)* and *nilgai* (*Boselaphus tragocamelus)*, which are considered as vulnerable species (BPP, 1995b), are rarely seen. Spotted deer (*Cercus axis)*, hog deer *(Cercus perchance)* and all three Nepalese otter species (*Lutea lutea*, *Lutrogale perspicillata* and *Aonyx cinerea*) are still found in small numbers. Small carnivores, including the fishing cat *(Felis viverrina)*, jungle cat

(*F. chaus*), Indian fox *(Vulpes vulpes)* and the jackal (*Canis aureus),* are also found in Koshi Tappu. Other mammals include the rufous-tailed hare (*Lepus ruficaudatus)*, rhesus macaque (*Macaca mullata*) and several species of bats. A small population of the Gangetic dolphin (*Platanista gangetica)* are found in the river (Smith, 1994). Besides, five Asiatic elephants visit the Koshi Tappu reserve from India during the summers. The status of mammals in the Koshi Tappu region, studied by WMI/IUCN-Nepal (1994) is given in Table 4.8.

Table 4.8: Status of mammals in the Koshi Tappu Wildlife Reserve

Mammal species	Common name	IUCN	CITES	Local
Axis axis	Spotted deer			R
Axis porcinus	Hog deer			R
Bubalus bubalis	Wild water buffalo	E	III	C
Canis aureus	Jackal			C
Felis chaus	Jungle cat			R
Herpestes auropunetatus	Small Indian Mongoose			C
Lepus ruficaudatus	Rufous-tailed Hare			O
Lutra perspicillata	Smooth coated otter	K		O
Platanista gangetica	Gangetic dolphin	V	I	R
Pteropus giganteus	Indian flying fox			C
Sus scrofa	Wild boar			O
Vulpes bengalensis	Indian fox	K		O

Source: WMI/IUCN-Nepal, 1994

E = Endangered; V = Vulnerable; K = Insufficiently known, I = Appendix I; III = Appendix III; R = Rare; O = Occasional; C = Common.

The populations of the mammals have decreased in recent decades. Although all the protected areas have undergone some degree of faunal collapse (Heinen, 1995), in comparison to other protected areas, Koshi Tappu has lost most of its carnivores (86%) and ungulates (58%) over the last 40 years (Bauer, 1987; Heinen, 1995)(Table 4.9; Figure 4.9). In addition to its smaller size and isolated location between densely populated settlements as some of the probable reasons (Figure 4.10), various dam related factors have also played some part in this decline (Bauer, 1987). It has been noticed that the monsoonal floods have had a major impact on large mammal species.

Table 4.9: Faunal collapse of carnivores and ungulates in the protected areas of Nepalese terai

Protected Area	Number of Carnivores			Number of Ungulates		
	F	C	Faunal collapse (%)	F	C	Faunal collapse (%)
Koshi Tappu WR	7	1	86	12	5	58
Parsa WR	8	7	12	15	11	27
Royal Bardia NP	8	6	25	15	12	20
Royal Chitwan NP	8	7	12	15	10	33
Royal Shukla Phanta WR	7	6	14	13	8	39

Source: Heinen, 1995

F = Former; C= Current.

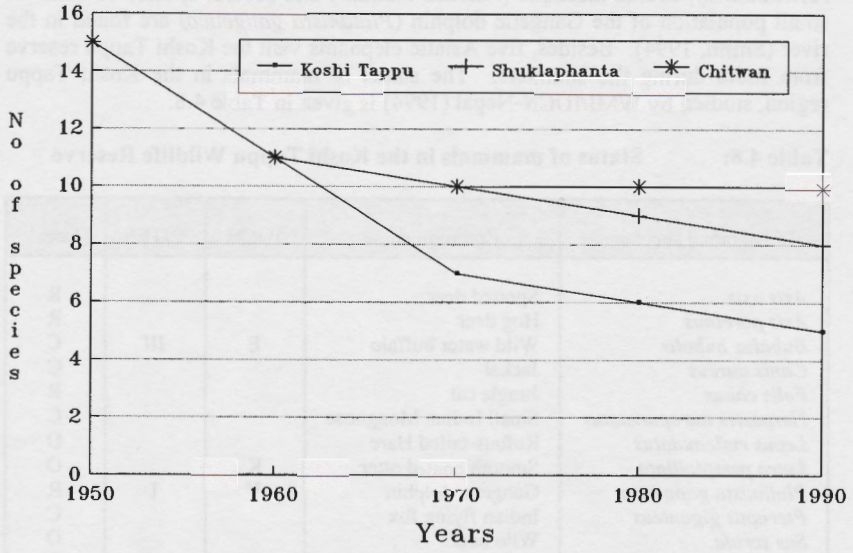


Figure 4.9 **Loss of ungulate species in the protected areas of the *terai* during the past 40 year (Source : Bauer, 1987)**

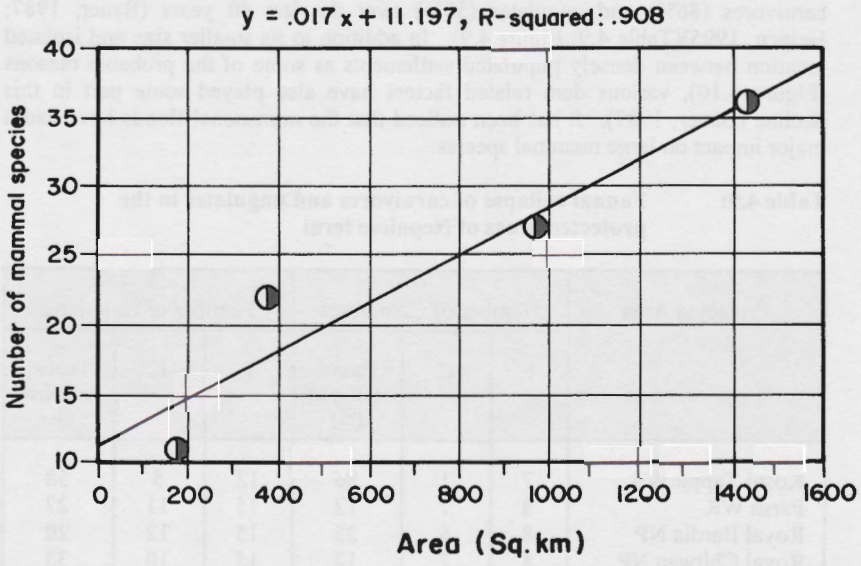


Figure 4.10 **Species-Area relationship of mammal species within the protected areas of the *terai* (Source: Bauer, 1987)**

4.3 Ecology of the wild water buffalo

The wild water buffalo (*Bubalus bubalis)*, a critically endangered ungulate, is the wild progenitor of domestic water buffalo which is widely used as a dairy and drought animal in Asia, parts of North Africa and Europe (Cockrill, 1974). It is called *Arna* in Nepal where the species is one of 26 mammal species, listed for protection under the National Park and Wildlife Conservation Act 1973. Research on the ecology and behavior of the wild buffalo in Nepal has been undertaken by Gupta and Mishra (1972), Dahmer (1978), Kushwaha (1986), Bauer (1987), Heinen (1993a), Suwal (1993) and Kherwar (1996).

Habitat

Once the wild water buffalo was found throughout the lowlands of South Asia but it is now considered endangered throughout its range. In Nepal, it was recorded in the 1960s in what is now the Royal Chitwan National Park in the central lowland, The population in this region became extinct probably as a result of diseases carried by domestic cattle and buffalo (Seidensticker, 1976). At present, a small population is confined within the Koshi Tappu Wildlife Reserve where there is no immigration or emigration of wild buffalo. However, domestic buffalo do enter the reserve and may join the wild herds.

The wild water buffalo prefers swampy floodplain with tall elephant grass and scrubby woodland forest in the vicinity. However, within its home range, the animal shows seasonal variation in habitat utilization (Dahmer, 1978). One of the factors affecting the preference of the habitat by wild buffalo is sunlight intensity since during the winter, open short grasslands are preferred by most of the wild buffaloes, whereas the forests and agricultural fields provide shelter during the monsoons.

Figure 4.11 [redacted]
(Photograph by Rajendra Suwal)

Morphology and behavior

The wild water buffalo resembles the domestic buffalo in all respects except in body size and shape of the horns. It has a heavier built body with a large head bearing a pair of horns curving toward the center of its head (Figure 4.11). The body color is exclusively black although in some cases it changes with age (Mishra, 1982). The animal has no known breeding season, although in Nepal it is believed to be in spring. The gestation period is about 12 months and females give birth to one calf at a time.

Heinen (1993a) conducted a detailed study on the population structure and growth, causes of mortality, habitat use, home range, seasonal movements, and social behavior. According to the study, the water buffalo is a highly social animal, and females remain in the groups in which they were born. Young males also remain mostly in groups, whereas adults live either as resident bulls in mixed herds comprised of females and their dependent offspring, or as bachelors, either singly or in herds. Adult bulls, living in bachelor herds, drive out sub-adult males from the mixed herds (Dahmer, 1978).

The study also suggests that the tendency for males to live in groups diminishes with age. Heinen emphasized that this general social structure is common to many large ungulates, but is in contrast to the closely related tamaro *(B. mindorensis)*, a smaller species which tends to be a solitary forest dweller (Kuehn, 1986). In Koshi Tappu several domestic buffalo may join wild herds to form combined herds of hundreds of buffaloes.

Population dynamics

Based on estimates made by 13 different authors in different years, Bauer (1987) concluded that the population increased from 25 in the early 1960s to about 90 in 1987. On the other hand, he stated that the continuous degradation of the quality of the habitat in Koshi Tappu after the construction of the Barrage in 1963 was one of the main reasons for the depletion in the number of large mammals.

Heinen (1993a) noted that it was not possible to establish changes in populations because of the lack of reliable censuses prior to 1976 as is evident from Table 4.10. The reason for this was noted by Dahmer (1978) as the difficulty experienced by observers in reliably distinguishing between wild water buffalo and domestic back crosses. Thus, it is difficult to determine the trend of the wild buffalo population in this area.

It seems likely that due to the destruction of the habitat, the population had been decreasing until the population was provided protection after the area was officially established as a wildlife reserve. The presence of a remnant population of this endangered bovid was the main reason for the declaration of the area as a wildlife reserve, based on the recommendations of a number of wildlife experts (Gupta and Mishra, 1972).

Heinen (1993a) estimated the population of wild buffalo to be 91 and 93 in 1987 and 1988 respectively, and based on Dahmer's estimate in 1976, he calculated the instantaneous population growth rate (r) for the periods of 1976-87, 1976-88 and 1987-88 (Table 4.11). The decline in population growth between 1976 and 1988 was due to a decrease in fecundity and high mortality during severe floods in 1987. Since there has been no immigration or emigration of individuals and the species is highly polygamous, the reason for the decrease in fecundity is attributed to inbreeding. Moreover, the increased number of domestic livestock in the

reserve might also have resulted in density dependent factors, responsible for the decrease in fecundity.

Table 4.10 Population estimates of wild water buffalo at Koshi Tappu

Year	Estimated Population	Authority
1945	100	Lohani (in Blower, 1971)
1966	15-20	Daniel and Grubh (1966)
1966	20-30	Spillet and Tamang (1966)
1966	100	Willan (in Daniel and Grush, 1966)
1968	60	Lohani (in Blower, 1971)
1969	30-40	Caughley (in Blower, 1971)
1971	40	Blower (1971)
1971	21	Pellinck (1971)
1972	40-45	Gupta and Mishra (1972)
1974	100	Upreti (1974)
1975	40-60	Poppleton (1975)
1976	63	Dahmer (1978)
1986	106	Kushwaha (1986)
1987	91	Heinen (1993a)
1988	93	Heinen (1993a)
1993	158	Suwal (1993)

Source: after Mishra, 1982

Table 4.11 The population growth rate (r) of wild water buffalo in Koshi Tappu Wildlife Reserve since 1976

To (Year)	From (Year)		
	1976 (n = 63)[1]	1987 (n = 91)[2]	1988 (n = 93)[2]
1987 (n = 91)	0.0334		
1988 (n = 93)	0.0325	0.0217	
1993 (n = 158)[3]	0.0501	0.0920	0.1060

Sources: 1. Dahmer (1978), 2. Heinen (1993a), 3. Suwal (1993)

$r = \ln(n_1/n_2)/t$ (Heinen, 1993a); n = Population of wild buffalo,

Contrary to Heinen's conclusion, the estimated population of wild buffalo as 158 in 1993 by Suwal (1993) shows a growth rate of 10.6 per cent between 1988 and 1993. This figure confirms the problem of distinguishing between wild buffalo and domestic back crosses, and indicates the magnitude of the threat to the genetic integrity of the wild population.

Threat to wild buffalo population

In Koshi Tappu, monsoon floods are one of the main causes of mortality of the wild buffalo, especially calves and adult females (Sharma, 1996). Although the mortality rate in recent floods was about 10 per cent, a flood might sometimes prove disastrous as is evident from Dahmer's (1978) mortality estimation of 40 per cent caused by the monsoonal flood in 1968 (Bauer, 1987). Similarly, the mortality was 12 per cent of the total population in 1987 floods when 8 one year old calves and 3 adult females died (Heinen, 1993a).

In the absence of any refuge from floods inside the reserve, large mammals go to the adjoining agricultural fields during the annual floods. The adult wild buffalos spend much of their time during the rainy season outside the reserve. At the same time, mixed herds remain stranded inside the reserve until a flood is underway, and this often results in high calf mortality (Heinen, 1993a). The condition is worsened because of the unpredictable behavior of the river and a sudden rise of flood level is common. The flooding problem is expected to increase with time due to increasing sedimentation and rising river bed in the area after the construction of the Koshi Barrage (Sah, 1993b). Consequently, severe floods in successive years can decrease the population to a level from which it may be virtually impossible to recover or to maintain an effective breeding population. Other causes of mortality like old age and injuries from intraspecific fights have also been encountered but are very infrequent (Heinen, 1993a). A wild buffalo was found dead from unknown causes in March, 1993 near Haripur Post (Suwal, 1993). Another female wild buffalo with a span of horn 203 cm was found dead on Nov 20, 1994 (Sharma, 1996).

Because of degradation of habitat and the competition for food with domestic buffalo inside the reserve, wild buffalo raid the agricultural fields and graze on agricultural crops very frequently. When they are unable to receive compensation for their damaged crops, the villagers may sometimes kill the animals.

In addition, the presence of domestic buffalo in the mixed herds poses the danger of diseases which may increase mortality. A sub-adult wild buffalo was found dead in Koshi Tappu during March, 1976, probably because of the disease *hemorrhagic septicemia* which is the most common epizootics in the domestic animals in the *terai* (Mishra, 1982). Thus, the present population of wild buffalo is not considered viable under the prevailing conditions of the wildlife reserve because of the concomitant effects of herd structure, a low population size, flood-induced mortality of calves, frequency of contact with domestic animals, and the physical nature of the reserve which does not include the entire home range for the buffalo herd (Heinen, 1993a).

4.4 Threats to biological diversity

From the above discussion, it is apparent that the Koshi Tappu region is rich in flora and fauna. Its floral diversity in different types of wetlands support a high number of animal species, of which birds and fish are noteworthy. The biological resources of this region offer a wide range of benefits to the local community, and are also of national and international importance because they have the potential to contribute significantly to global biodiversity. However, the present trend of the indiscriminate exploitation of these resources, and the sedimentation and shifting of the course of the river have posed a number of threats. Relatively lower floral diversity in the oxbow lakes which are subject to sedimentation, is an example of the damage possible.

With the loss of the vegetation cover and habitat degradation, a number of plant and animal species have either become locally extinct or threatened in this area. Large carnivores have disappeared and the population of wild water buffalo is not considered viable. The extent of the problem is difficult to assess due to the lack of sufficient baseline data. Therefore, regular monitoring of the status of these valuable resources in the region is desirable in order to develop strategies for their management.

CHAPTER 5

LAND USE CHANGE

Knowledge of land use and land cover is important in the planning and management of wetlands so as to overcome the problems of uncontrolled development, destruction of important wetlands, the loss of wildlife habitat and many other causes of deterioration environmental quality (Anderson *et al.*, 1976). Information on existing land use patterns and changes in land use over time is one of the primary pre-requisites for effective management of an area. An attempt has been made to identify existing land use patterns and changes which have occurred over the last three decades, followed by a discussion of the successional pattern on the floodplain in Koshi Tappu.

5.1 Land use pattern

Concepts concerning land cover and land use are closely related and in many cases have been used interchangeably (Anderson *et al.*, 1976). However, land cover refers to `the vegetational and artificial constructions covering the land surface' (Clawson and Stewart, 1965) or simply `the type of feature on the surface of the earth' (Lillesand and Kiefer, 1987). Land use, on the other hand, refers to `human activities on land which are directly related to a specific piece of land' (Clawson and Stewart, 1965; Lillesand and Kiefer, 1987).

Several different techniques are used to obtain information about land use/land cover. Among them, the use of aerial photographs and satellite imagery has become common in recent years. However, as remote sensing image-forming devices do not directly record human activities on the ground, several keys of interpretation, such as pattern, tone, texture, and site association are used to derive information about land use activities from basic information about land cover. However, some activities such as fuelwood collection and hunting, among others, can not be easily related to the type of land cover, and supplemental information is needed to describe such land use activities. Similarly, multiple uses of an area pose another problem. Some areas may be used for fuelwood collection, grazing, logging and hunting simultaneously and hence, supplemental data is required in order to have more detailed land use information.

The present discussion on the land use/land cover in Koshi Tappu is based on land use maps of 1959, 1978 and 1991, prepared from topographic maps (Sheet no. 72 J/14 and 72 N/2, HMG, Nepal), a Land Utilization Map (LRMP, 1984), an aerial photograph of 1990-91 at a scale of 1:50,000 and Landsat TM Imagery of December 12, 1991, supplemented by a field survey in February 1993 and information available from other secondary sources. The United States Geological Survey (USGS) system of classification (Anderson *et al.*, 1976), has been adopted in a slightly modified form. The classification here is mostly limited to level I, and in some cases to level II of this system, and provides a general view of the land use in the area. Further study may help describe the specific land use activity and land cover in this area at level III and IV of this system. Altogether, eight major classes of the land use/land cover were recognized in Koshi Tappu (Figure 5.1).

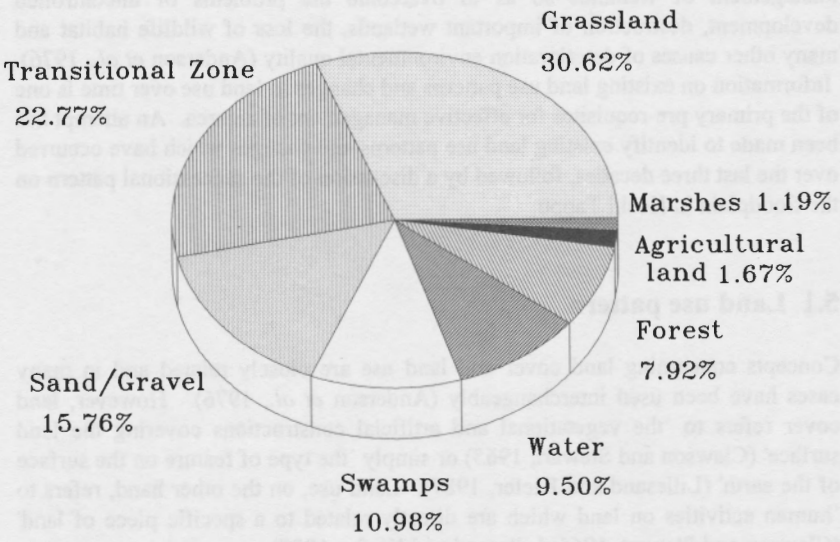


Figure 5.1 **Land use pattern in the Koshi Tappu Wildlife Reserve (1991)**

1. Agricultural land

Despite the ban on any kind of cultivation within the reserve and the efforts of the reserve staff to evacuate the reserve area, about 80-100 households continue to reside inside the reserve along the western embankment near the villages of Badgama and Pipra Purba, where they cultivate more than 100 ha of land (Figure 5.2). Paddy, wheat, millet, oilseeds and potato are the main crops. This activity is in conflict with the existing legal arrangements of the wildlife reserve.

Cultivation is also practised in some parts of the area between the southern boundary of the reserve and the Bhardah-Barrage link road (Figure 5.3). The area was marshy land before the shifting of the river. It is legally under the Koshi Project.

2. Grassland/Savanna

The largest area in Koshi Tappu is occupied by grasslands and savanna which was found 4,600 ha (30.6 percent) of the reserve, located mainly in the western part of the reserve and west of the Koshi river. Most of the grasslands/savanna are flooded during the monsoons, but remain inundated for a relatively shorter period. As a result, the soil becomes comparatively dry during the winter and dry summer. This part of the reserve is subject to intensive grazing and frequent burning. During the dry season, people cut thatch grasses and burn the vegetation.

3. Swamps

In contrast to the relatively dry grassland/savanna, wet grasslands were classified as `swamps' since these areas remain saturated with water long after the monsoons are over. This area can be easily recognized by the presence of grassland vegetation dominated by a *Typha-Vetiveria* association. The Koshi Tappu wet grasslands were found on an area of 1,652 ha of land (11 percent of the total area) and are subject to moderate grazing and burning.

During the grass cutting season this area is visited by relatively few people due to the swampy conditions and the presence of a high proportion of less preferable grass species.

4. Forests

The next important vegetated land cover/land use category includes different types of forests, which covered about 20 per cent of the reserve area 30 years ago, but have now been reduced to a mere eight per cent of the total area. These occur in patches and are more degraded than before.

Within the wildlife reserve, three types of forests were recognized, namely *Acacia catechu-Dalbergia sissoo* forest (400 ha or 2.66 per cent), mixed deciduous riverine forest (430.8 ha or 2.87 per cent) and *Dalbergia* dominated forest. All these forest areas are flooded during the monsoons except for a narrow belt of elevated area in the middle of the reserve. Similarly, all other forests are subject to intensive grazing and frequent burning except for patches of dense forests near the village of Prakashpur and the west bank of the river in the middle of the reserve. The forest in the southern part of the reserve is frequently subjected to illegal logging and hunting.

5. Rivers and streams

These include the Sapta Koshi river, the Trijuga river and many other locally derived tributaries. At present, the main course of the Sapta Koshi river is located in the eastern part of the reserve, whereas the old channel of the Koshi (Figure 5.4) and the Trijuga river still flow through the western part of the reserve.

Since the Koshi river flows at minimum water level during December to February, the water area of 1,426.5 ha (8 per cent) as depicted in the land use map of the wildlife reserve, represents a minimum water area which increases significantly after March, first due to the melting of snow in the Himalayas, and later due to the monsoon rains throughout its catchment area. As a result, a much larger area is under water during the monsoon floods. This situation may be compared to the floodplain of the Lower Mekong in Indochina where the Great Lake in Cambodia changes in area from 250,000 ha in the dry season to 1,100,000 ha when flooded (Finlayson and Moser, 1991).

Despite the ban on fishing inside the reserve, this activity continues illegally mostly in the Trijuga river and the old channel of the Koshi river. Near the northern and southern boundary of the reserve, fishing is common in the main channel of the Koshi river also.

Figure 5.2 **Settlements and cultivation inside the reserve: a source of conflict between reserve staff and local people**

Figure 5.3 **Cultivation in the swampy areas, north of the Bhardah-Barrage linkage road**

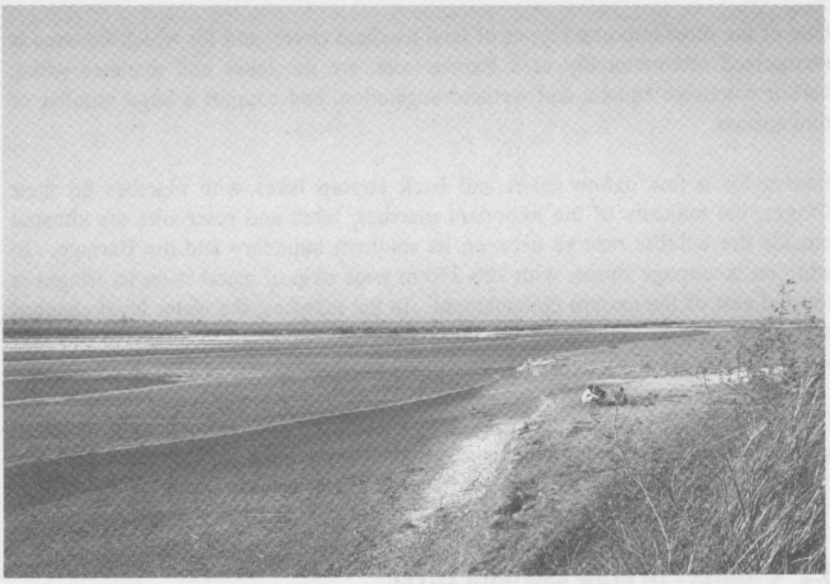


Figure 5.4 Old course of the Koshi river

6. Sand and gravel

Since the wildlife reserve is located on the alluvial floodplain, which receives alluvial deposits from the river in the form of sand and silt, a large area in Koshi Tappu is covered by sand and gravel. These depositions were found in an area of about 2,300 ha (15.4 per cent) during the dry season, which reduces in size when most of it gets submerged with the rise in water level of the river and streams.

As such these areas are of no permanent use to the people, although livestock herders may stay adjacent to the northern and southern boundary of the reserve with their herds of livestock at night during the dry season. They sometimes build temporary huts in these areas, especially when reserve staff and soldiers increase the frequency of patrolling within the reserve. On these occasions, they take their livestock inside the reserve for grazing as and when the opportunity arises.

7. Transitional zone

Once the land becomes barren due to deposition of sand, pioneer species from the surrounding community invade the area and grow to represent early stages of succession. This may not reflect any particular type of community, particularly when the area remains open to human interference.
Vegetation such as grassland may become severely degraded and look like virtually barren land due to intensive grazing and frequent burning. This type of land in Koshi Tappu was found in almost one fourth of the area (22.8 per cent) and was categorized as `transitional zone'. This area is more vulnerable to human disturbance and needs special consideration for management.

8. Lakes and marshes

One of the most important types of land use/land cover, and for which the area is recognized internationally as a Ramsar site, are the lakes and marshes which harbor extensive aquatic and wetland vegetation, and support a large number of bird species.

Except for a few oxbow lakes and back swamp lakes with marshes on their fringes, the majority of the important marshes, lakes and reservoirs are situated outside the wildlife reserve between its southern boundary and the Barrage. In addition, a seepage stream with 100-250 m wide strip of marshes on its fringes is located east of the eastern embankment. In the marshes, the water level changes seasonally, and in the dry season, these areas are subjected to intensive grazing, while fishing and snail collecting are carried out throughout the year.

Despite its location inside the reserve near the Kamalpur post, fishing, grazing, snail collection and other human disturbances are high in Kamalpur Dah, an oxbow lake, because it is the only source of stagnant water in this area.

5.2 Changes in land use/land cover

The land use/land cover changes continuously in an ecosystem due to natural processes and human interference. Since a floodplain is a depositional feature of a river valley, sediment is temporarily stored on the floodplain and remains in an equilibrium condition over a period of years, the net inflow of sediments equalling the net out flow (Leopold *et al.*, 1964). However, the landscape features within a floodplain are dynamic and ever-changing as the river braids and meanders through it (Lambou, 1989).

Human civilizations have evolved in river valleys and associated floodplains. Even today, the most dense populations in the world live on the floodplains of large rivers like the Ganges, Brahamputra, Indus, Mekong and the Nile. In these areas, additional lands are continually being brought under cultivation to feed growing populations. Much of the industrial expansion taking place throughout the world has been focused on floodplains. Dams, constructed to provide power for domestic needs and development of such industries, often disrupt floodplain agriculture and reduce the area of floodplain pasture (Scudder, 1989).

In Nepal, data regarding the loss of wetland areas and associated vegetation is scarce and the information on the deforestation rate is unreliable. Blandon (1990) reported an annual deforestation rate of 4.3 per cent in Nepal between 1981 to 1986. However, in the Forest Resources Master Plan Project (HMG, 1988c), the deforestation rate was estimated at only 0.4 per cent annually, between 1964 to 1986. Some areas have been converted to agricultural land while the majority of the land has been converted to open scrubby vegetation through overgrazing. The problem in the southern part of Nepal is severe where the deforestation rate was 1.4 per cent between 1964 to 1979 and increased to 3.4 per cent for the period 1979 to 1986, in comparison with 0.4 per cent for the whole country during the same period (HMG, 1988c; FRSC, 1994). The deforestation rate was high because the area received migrants from the south as well as from the mountains

during the last 30 years, after the eradication of malaria in the *terai* in the 1950s (Gurung, 1984). About 104,000 ha of the *terai* forest was cleared between 1950s to 1985 by the Ministry of Forests and Soil Conservation under a government settlement program (HMG/ADB/FINNIDA, 1988). Despite such a high rate of deforestation in the *terai*, the Government still considers it as an overflow region for surplus population of the midhills of Nepal.

Land cover on the floodplain is subject to seasonal change as the area between the river channel and the raised land floods periodically. The duration of such floods in any area, and the kind of dissolved and particulate constituents carried by the flows, determine the nature of the plant community in that area. Similarly, the presence of a large tract of flowing water disrupts the accessibility to some area by a portion of the population living in surrounding communities, thereby affecting land use activities. Thus, any change in the flooding regime brings vast changes in the land cover and land use of that area. In Koshi Tappu, the land uses are changing continuously due to human interference, the shifting course of the Koshi river and the subsequent deposition of sediment.

5.2.1 Change between 1959 to 1978

In 1959, 57 per cent of the area currently under the Koshi Tappu Wildlife Reserve was vegetated i.e., covered with forests or grasses. Grassland and forest covered 37.5 and 19.5 per cent of the total area respectively (Figure 5.5). Forests were mostly dense and of diverse associations. *Acacia-Dalbergia* forest and mixed deciduous riverine forest covered 720.6 ha and 2236.6 ha of land respectively.

Patches of agricultural land, associated with settlements such as the villages of Baghjhora, Petmari, Nagrutola, Champapur-Balchhawa, Jalpapur, Ramuawan, Shobhanpur and Haldibari, were scattered throughout the region. A stretch of land west of the Koshi river, which flowed through the western part of the present reserve area at that time, was also cultivated (Figure 5.6). Similarly, settlements like Garurh tola, Mainha, Jorbandha, Baluwa and Sukhipur villages and their agricultural lands occupied large areas between the present Barrage and the reserve boundary.

The entire area of the present reserve was used by the people for fuelwood and fodder collection, livestock grazing and hunting without any restriction. Large portions of the present reserve area were easily accessible only to the people living east of the Koshi river. Fishing and driftwood collection from the river were common and were undertaken mostly by people living either inside the present reserve area or west of the river.

Over the next two decades, between 1959 and 1978, the construction of the Barrage and embankments, and later, the declaration of the wildlife reserve, had a profound impact on land cover and land use. Exploitation of resources continued indiscriminately after the construction of the Barrage until the establishment of the reserve. About 3.2 per cent of the forest area was lost annually with a total loss of 58 per cent during this period. The grassland also decreased by 39 per cent (Appendix 5.1) although 14.5 per cent of the total area (Figure 5.7), which had been classified as swamps in 1978 (LRMP, 1984) (Figure 5.8), was covered with grasses as verified from aerial photos of 1978. Thus, there was little overall

change in grass cover. However, a total 1,118.3 ha (38.2 per cent) of forest changed to grasslands and 2,298.7 ha (40.8 per cent) of grasslands changed to either agricultural land or barren area, including sand and water, of which 55 per cent was covered by sand (Table 5.1).

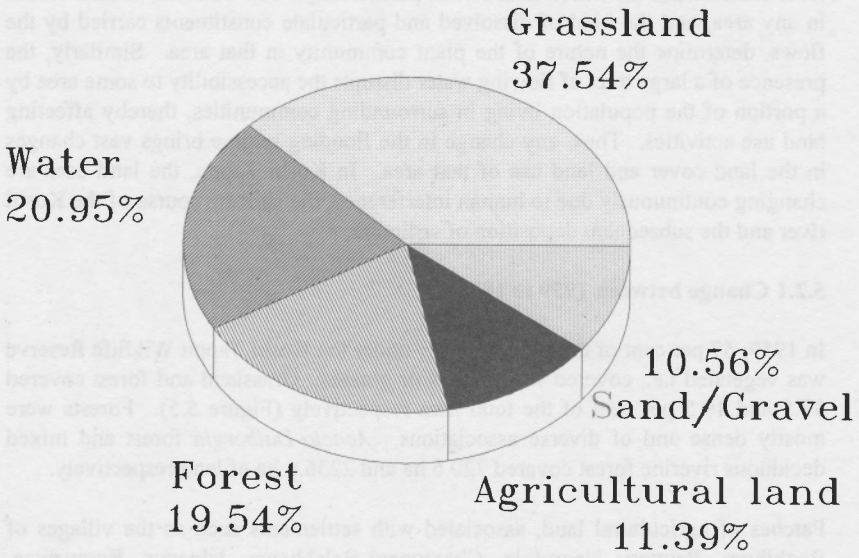


Figure 5.5 **Land use pattern (1959)**

Table 5.1 **Land-use change (1959-1978)**

Change from	Change to						
	Agri. land	Forest	Grasslands	Water	Sand/ Gravel	Swamps	Total
Agri. land	*475.5	21.6	251.2	492.6	359.4	113.1	1,713.3
Forest	486.2	*670.2	1,118.3	35.2	114.8	507.6	2,932.3
Grasslands	361.9	388.6	*1,570.9	671.2	1,265.6	1,376.7	5,635.0
Water	0.2	54.9	243.8	*1,088.1	1,714.0	44.6	3,145.6
Sand/Gravel	2.3	92.2	242.7	339.3	*771.2	139.1	1,586.8
Total	1,326.2	1,227.6	3,427.0	2,626.4	4,224.9	2,181.1	15,013.1

* = These are not the changes.

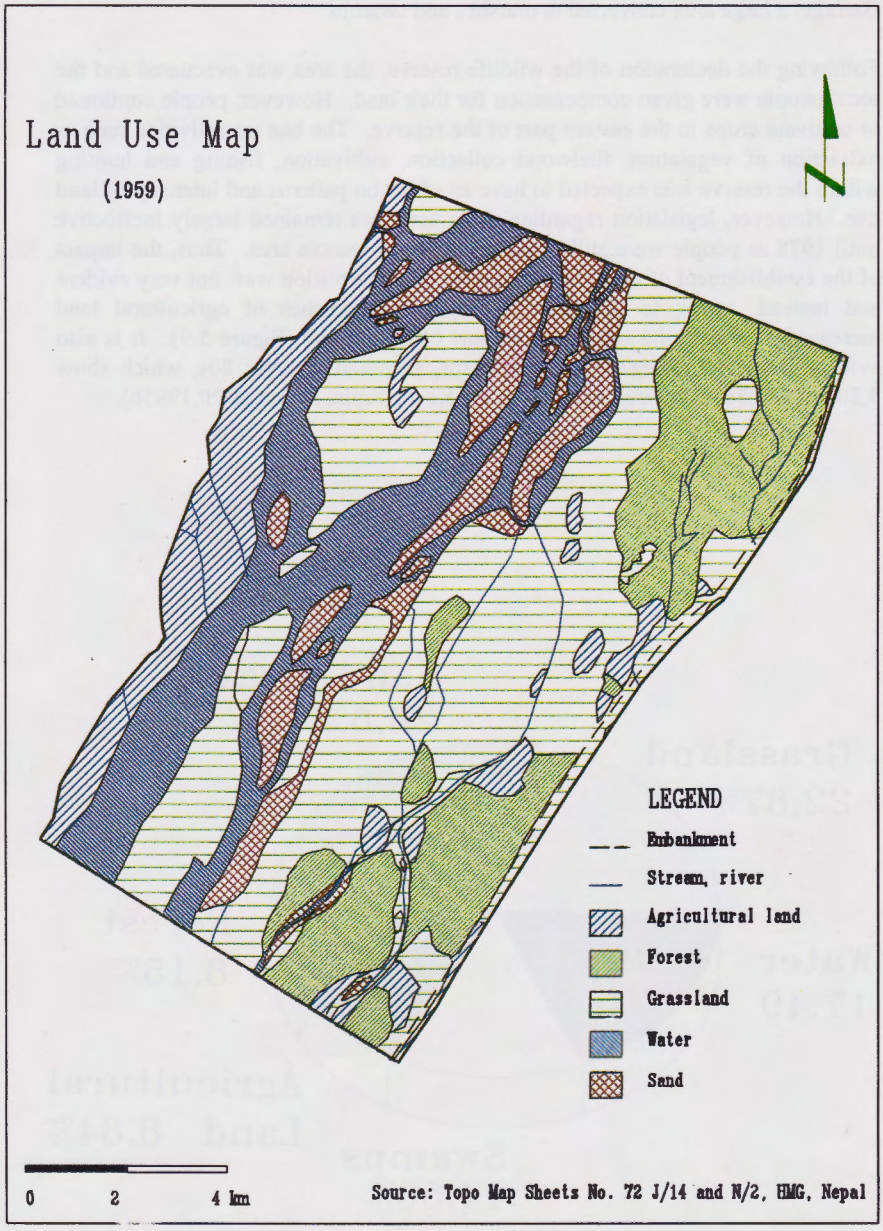


Figure 5.6 Land use map (1959)

The total area of sand/gravel increased from 1,586 ha in 1959 to 4,235 ha in 1978. The reason for such a large area to be covered by sand was again most probably the increased rate of sedimentation after the construction of the Barrage after which the river became more braided (Gupta *et al.*, 1980). The main channel of the river shifted westward, whereas several secondary channels developed in the middle portion of the reserve area. Between the boundary of the reserve and the Barrage, a large area converted to marshes and swamps.

Following the declaration of the wildlife reserve, the area was evacuated and the local people were given compensation for their land. However, people continued to cultivate crops in the eastern part of the reserve. The ban on activities such as extraction of vegetation, fuelwood collection, cultivation, fishing and hunting within the reserve was expected to have an effect on patterns and intensity of land use. However, legislation regarding these activities remained largely ineffective until 1978 as people were still residing inside the reserve area. Thus, the impact of the establishment of the reserve in terms of conservation was not very evident and instead, owing to the growing population, patches of agricultural land increased in size in the south-eastern part of the reserve (Figure 5.9). It is also evident from Dobremez's ecological maps, prepared in early 80s, which show 3,204 ha (21.36%) agricultural land in the Koshi Tappu region (BPP,1995b).

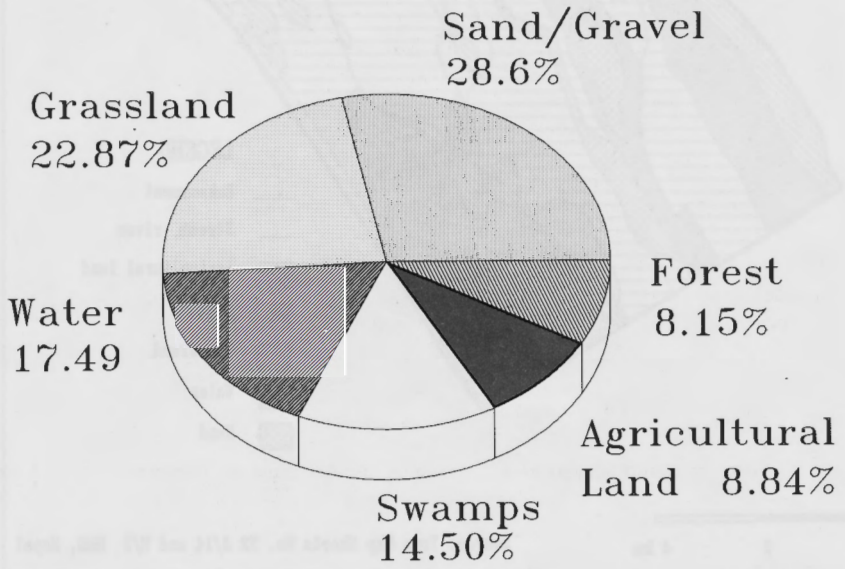


Figure 5.7 **Land-use pattern (1978)**
Source: Land utilization map, HMG (1984b)

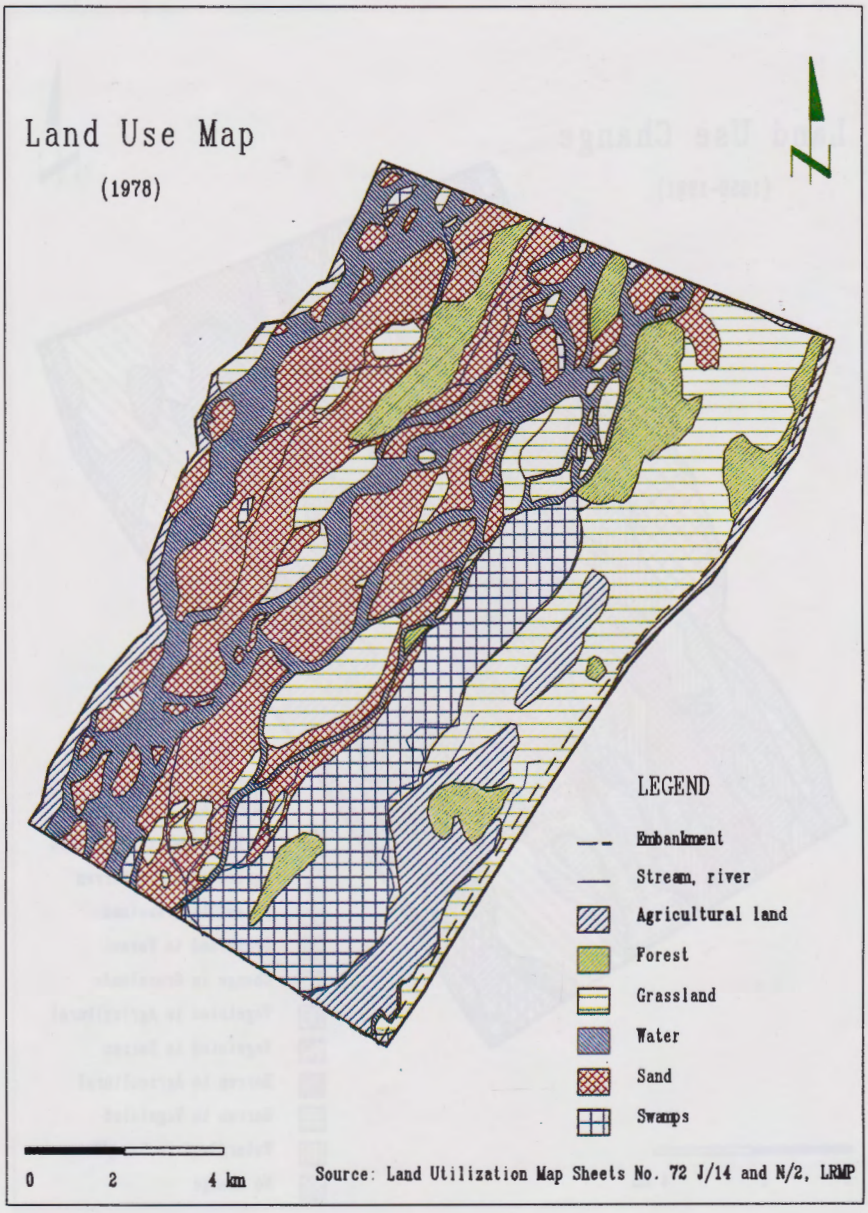


Figure 5.8 **Land use map (1978)**

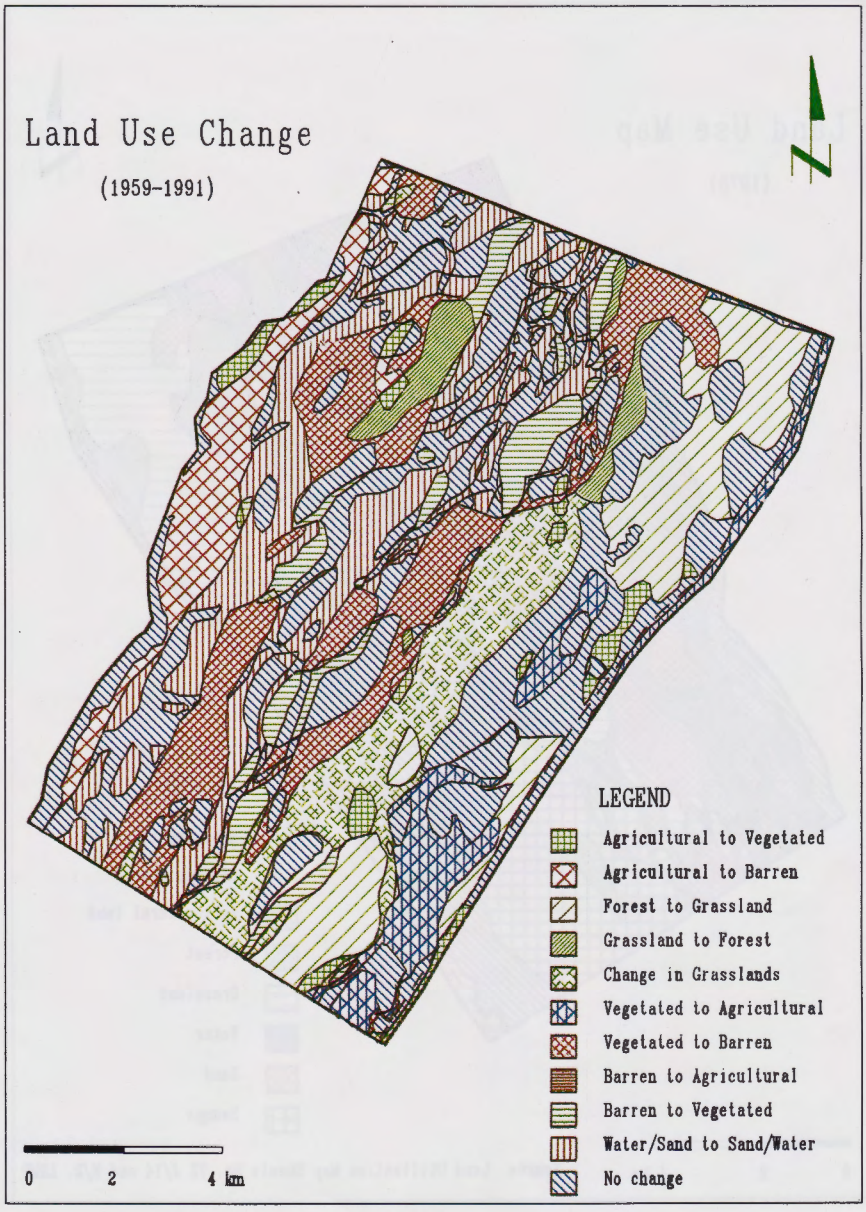


Figure 5.9 **Land use change (1959-1978)**

5.2.2 Change between 1978 to 1991

Over the next 13 years, between 1978 and 1991, there was an unexpected change in land cover/land use within the region. The Koshi river changed its course from the western part of the reserve to the eastern side, near the eastern embankment (Figure 5.10). As a result, a tract of forest in the northeastern sector of the reserve disappeared (Figure 5.11). A major loss of grassland habitat occurred, in which 1,130 ha (20 per cent) of grassland were replaced by water and sand (Table 5.2).

With the declaration of the wildlife reserve in 1976, 12,000 people were forced to move out from the reserve area in 1979, abandon their agricultural land and settle elsewhere. This land within the reserve was expected to be occupied by regenerating vegetation in subsequent years, but 857.7 ha of this area converted to water and sand area due to changes in the course of the river (Table 5.2).

A pronounced effect of the shifting of the river was felt outside the reserve, where a seepage stream, with a 100 to 250 m wide strip of marsh, developed on the land east of the eastern embankment. Although the newly-created stream and marsh constituted a source of water for the surrounding communities, the adjacent agricultural land subsequently became more swampy and caused changes in cropping patterns. Furthermore, despite the declaration of the area as a wildlife reserve, the forests and grasslands were still used by the people for various purposes. Thus, a large area of the forest changed to grassland (Figure 5.12).

Human interference was not of the same intensity throughout the reserve. As a result, vegetation regenerated well in some regions, especially, in the western part of the reserve, from where the river shifted to the east. In this western part, forest has regenerated on 280 ha, and about 2,230 ha of land, which was previously either under water or covered by sand, became covered by different stages of grassland succession. In most parts of the floodplain, which were covered by sand, the vegetation was found to be in an early stage of succession. This area of early succession was found to cover 2,715 ha, and was classified as a transitional zone (Sah, 1993a).

Furthermore, the people in the west started cultivation on the land between the reserve and the Bhardah-Barrage link road as the area became relatively dry after the shifting of the river course. In contrast to this, the eastern part of that region, where the people were earlier cultivating land, became either submerged or covered by sand or changed to marshes and swamps. However, in the dry season, parts of this area are still used for livestock grazing.

5.2.3 Change between 1959 to 1991

A comparison of the land use/land cover between 1959 and 1991 shows that there was significant loss of vegetated area (Figure 5.13). About 60 per cent of the forest was lost during that period (Appendix 5.1). Even what the forests were present in 1991, only 24 per cent of that was the representation of the original forest (Table 5.3). On the other hand, the area covered with sand and gravel increased by 45 per cent.

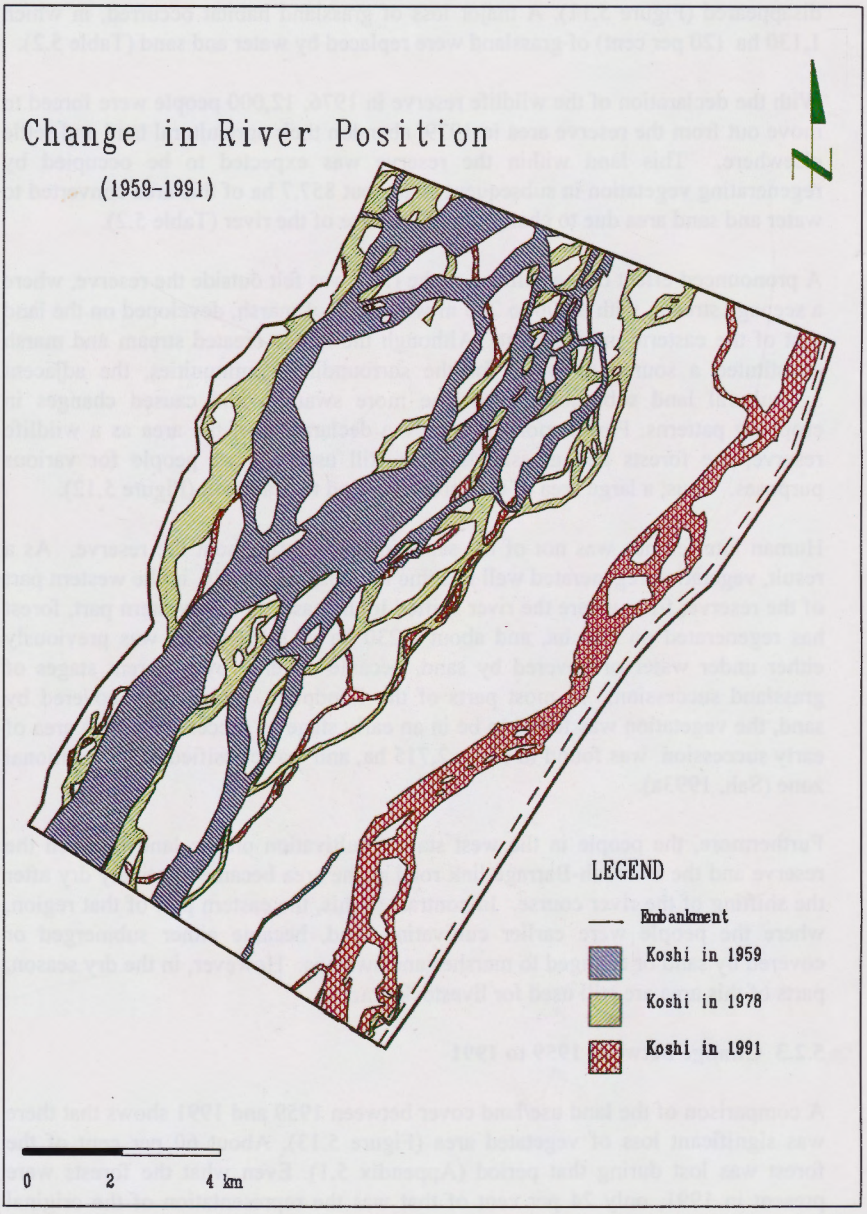


Figure 5.10 **Change in position of the Koshi river within the reserve (1959-1991)**

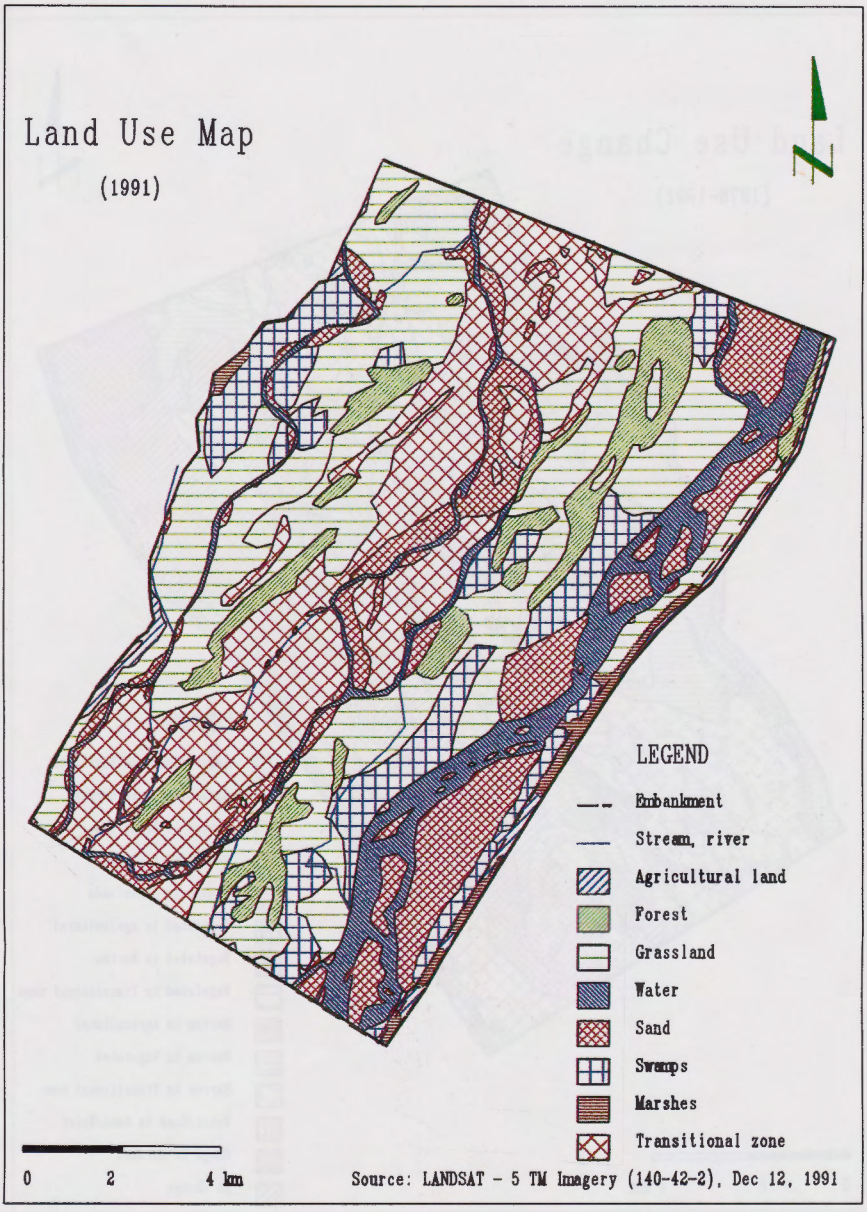


Figure 5.11 **Land use map (1991)**

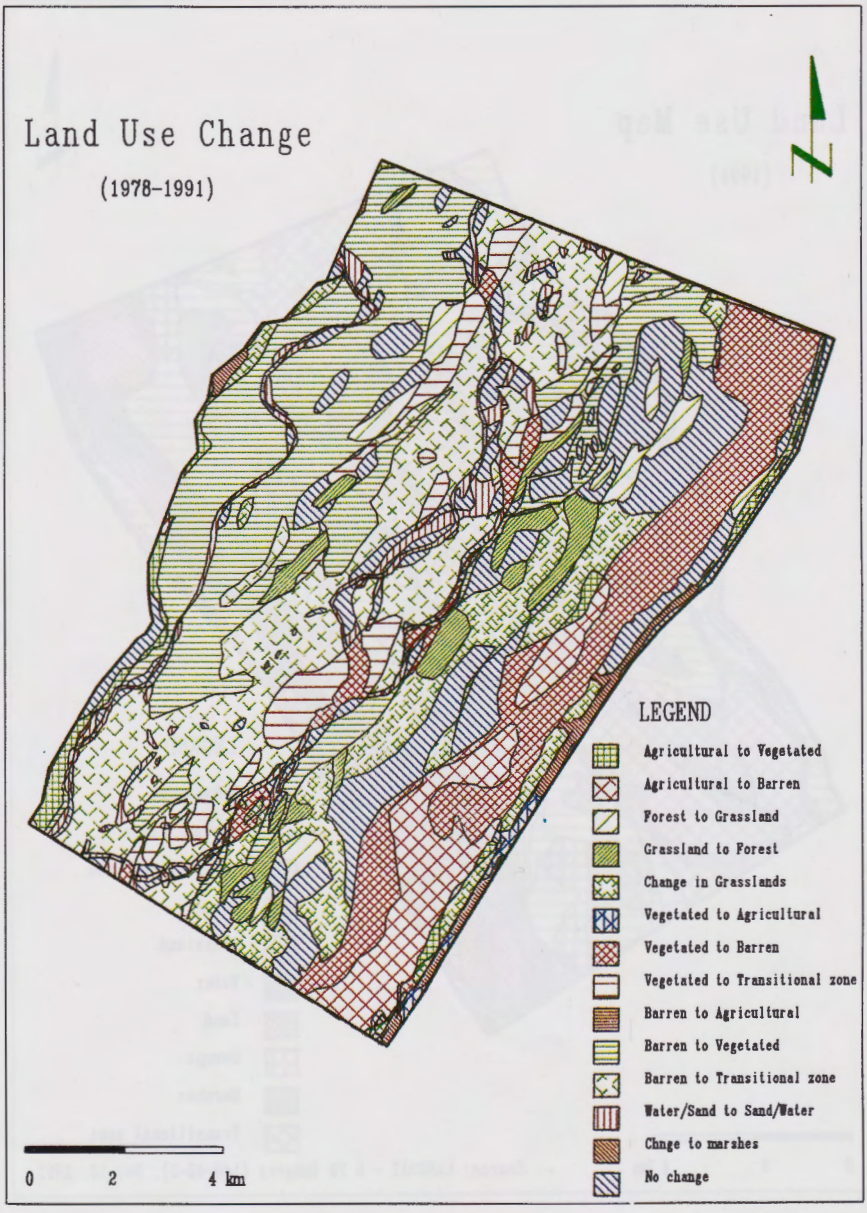


Figure 5.12 Land use change (1978 to 1991)

Table 5.2 Landuse change (ha) in Koshi Tappu from 1978 to 1991 (* = These are not the changes).

Change from	Change To								
	Agricultural land	Forest	Grassland	Water	Sand/ Gravel	Swamps	Marshes	Transitional zone	Total
Agricultural land	*161.6	27.4	183.8	308.2	549.6	74.2	21.4	-	1,164.4
Forest	0.0	*342.4	370.9	83.9	197.0	30.9	2.4	200.0	885.1
Grasslands	77.8	114.3	*946.3	544.7	668.6	461.9	150.1	468.9	2,486.2
Water	6.0	46.4	975.3	*100.4	296.1	231.2	1.4	969.6	2,525.9
Sand/Gravel	3.1	235.7	1,353.8	188.3	*444.7	253.7	0.0	1,745.5	3,780.1
Swamps	1.8	419.4	768.6	200.1	145.0	*600.3	4.1	36.2	1,575.3
Total	88.7	843.2	3,652.3	1,425.6	1,856.2	1,051.8	179.4	3,420.3	12,417.0

Table 5.3 Landuse change (ha) in Koshi Tappu from 1959 to 1991 (* = These are not the changes).

Change from	Change To								
	Agricultural land	Forest	Grassland	Water	Sand/ Gravel	Swamps	Marshes	Transitional zone	Total
Agricultural land	*106.5	37.1	679.8	243.6	206.0	353.7	50.5	36.0	1,606.8
Forest	21.5	*246.8	675.3	606.9	884.7	447.7	4.9	44.6	2,685.6
Grasslands	119.5	738.2	*1956.2	383.7	550.1	666.2	124.1	1,096.9	3,678.7
Water	0.9	145.0	974.6	*106.6	356.4	157.7	0.0	1,404.4	3,039.0
Sand/gravel	1.8	18.5	312.8	84.6	*303.7	26.7	0.0	838.7	1,283.0
Total	143.8	938.9	2,642.5	1,318.9	1,997.2	1,652.1	179.4	3,420.5	12,293.1

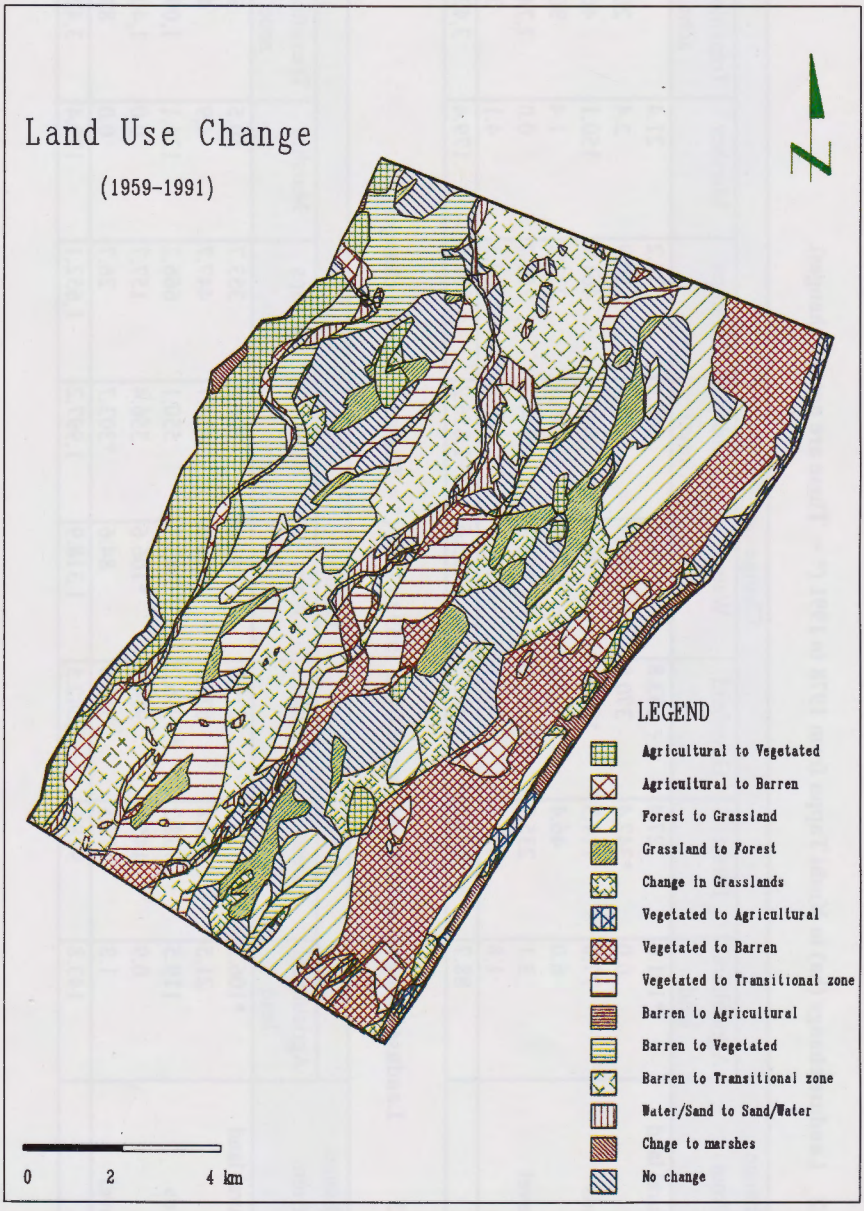


Figure 5.13 Land use change (1959 to 1991)

An overlay of all three land use maps, 1959, 1978 and 1991 (Figure 5.14), reveals that 2,114 ha of land, which was covered by either forest or grassland in 1959, became denuded before 1978, and remained non-vegetated area until 1991 (designated as Vegzone 1). This occurred because of its conversion to water or sand covered area during the previous two decades.

Vegetation, which either regenerated before 1978 (Vegzone 2) or remained present throughout that period up to 1978 (Vegzone 3), disappeared after 1978, mainly due to the shifting of the river to its present position. In contrast to this, a large non-vegetated area in the western part of the reserve was covered by grassland and some linear patches of the forests, mostly dominated by *Dalbergia sissoo* (Vegzone 4). This regeneration, especially in the moist lowlands, indicates that despite grazing pressure, species such as *Saccharum spontaneum, Phragmites karka, Imperata cylindrica* and *Vetiveria lawsonii* colonize fast enough to cover the area. From this, it is also opined that the regular burning and moderate grazing pressure forced the succession to be arrested in the form of grassland, otherwise the whole area might have become covered by forest.

Regeneration in relatively dry areas was not only slow but remained under higher pressure from grazing and frequent burning. The vegetation did not grow well in these areas, which have been designated as 'transitional zones' (Vegzone 9). If human activities were to decrease, this area has the potential to develop into forest. However, some of the grasslands and forests of 1978 in the central part of the reserve changed to transitional zones (designated as Vegzone 7 and 8), which indicates that human pressure is prominent in these areas.

Lastly, Vegzone 10 refers to the recently-formed marshes which are under enormous pressure due to human disturbance. These areas need more care from a wetland management point of view because they serve not only as the staging and wintering sites for many rare bird species but several species of macrophytes can grow here, thereby increasing the biodiversity within the area. Vegzone 11 refers to the area which remained as non-vegetated area, i.e. covered by water and/or sand, throughout this period of analysis.

5.3 Successional trend

Once the vegetation is cleared due to human activities and sand deposits on the floodplain of the river, the area is colonized by several ecological species, among which *Tamarix dioica* and *Saccharum spontaneum* are important (Figure 5.15). In Koshi Tappu, it has been noted that *Tamarix dioica* colonizes prior to *Saccharum spontaneum*, contrary to the observation made by Dinerstein (1979) who, in his study on vegetation patterns in Bardia of western Nepal, reported that *Saccharum* colonized first and served as a receptacle for the seeds of *Tamarix*. *Saccharum spontaneum* as a first colonizer was reported by Lehmkuhl (1989) in Chitwan also. He, however, found there *Narenga porphorycoma* in stead of *Tamarix dioica* competing with *S. spontaneum*. It seems that due to its gymnospermic physiognomy and xerophytic character, *Tamarix* can grow well in the sandy soil of Koshi Tappu.

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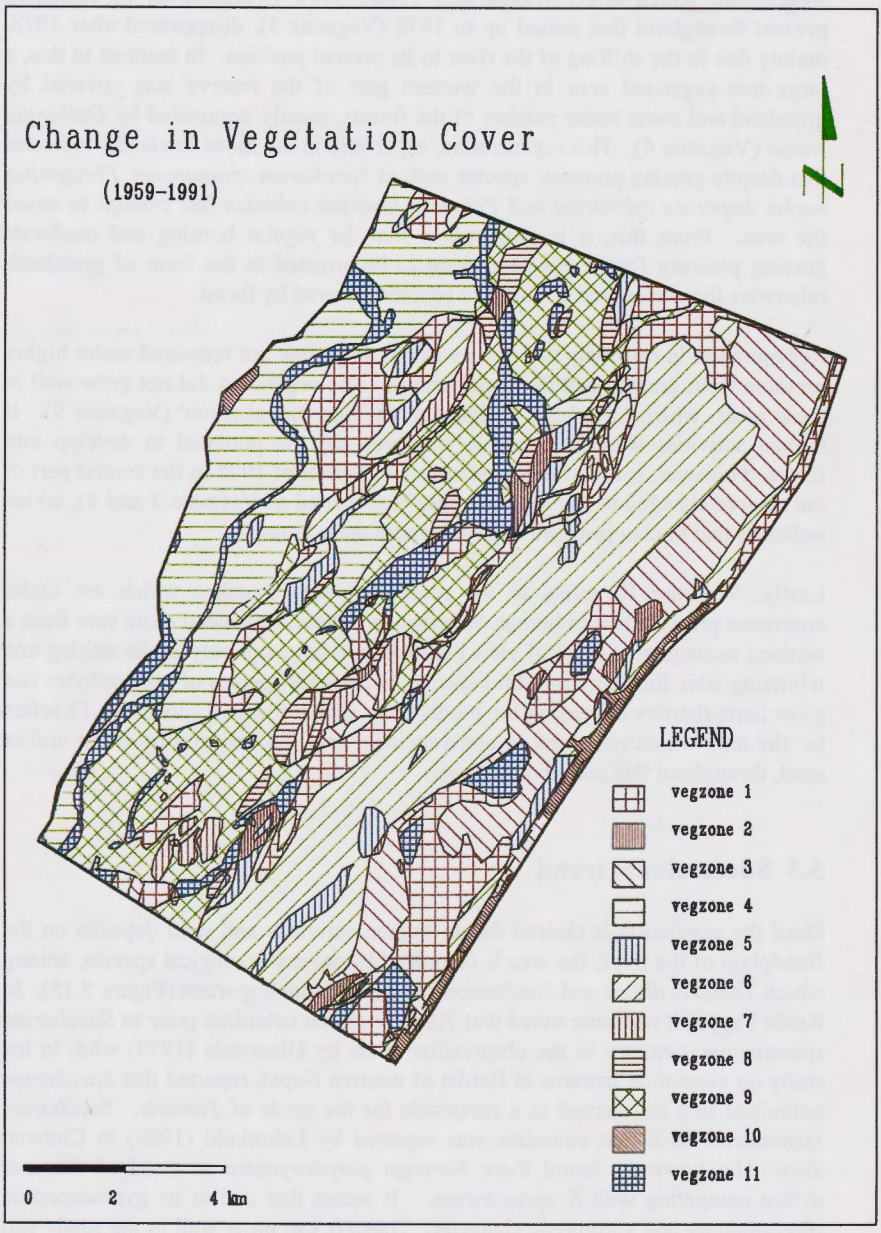


Figure 5.14 Change in vegetation cover (1959 to 1991)

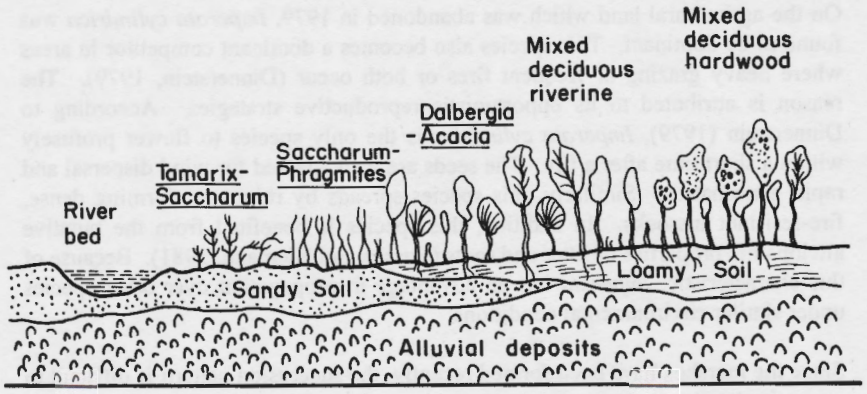


Figure 5.15 Successional zonation of the vegetation on the floodplain

It is also evident that in later stages of succession when the soil becomes more stable, *Tamarix* does not grow taller and it gives way to other species. However, both *Tamarix* and *Saccharum* were found growing together in some areas. Another important feature here is that *Saccharum* shows prostrate branches in the early stages of succession, probably in order to develop an extensive root system to stabilize the sandy soil. The ability to flower just after the monsoon and to produce numerous light seeds, adapted to wind and water dispersal, favor the *Saccharum* sp. as a primary colonizer (Dinnerstein, 1975).

Once the growth of *Tamarix* and *Saccharum* becomes dense, it acts as a receptacle for the seeds of *Phragmites* and other grass species like *Arundo donax* and *Erianthus ravennae*. Phragmites karka remains dominant in relatively undisturbed area (Lehmkuhl, 1989). Further stages of succession are determined by the period of inundation, drainage condition, frequency of fire and grazing intensity.

When there is relatively less human disturbance and a shorter period of inundation, the soil becomes more stabilized and tree species establish themselves. The diversity of the tree layer increases with the increase in soil stability. On more stable soil, mixed deciduous forest consisting of species like *Bombax ceiba, Eugenia jambolina* and *Trewia nudiflora*, among others, can be found. Finally, after 100 to 200 years the climax community is formed by sal (*Shorea robusta*) forest (Carson *et al.*, 1986). This is more or less similar to conditions in northern India as described by Champion and Seth (1968). In Koshi Tappu, however, the sal forest is absent. It suggests the occurrence of frequent fluvial and anthropogenic disturbances in the past.

When forests are degraded due to logging, overgrazing and frequent burning, they develop into a savanna/grassland type of vegetation dominated by *Saccharum*

spontaneum and *Imperata cylindrica*. In addition, fluvial action also remains an important disturbance arresting the succession in the form of grasslands (Seidensticker, 1976). That is why, grasslands in this type of climate are generally classified as disturbance disclimax (Dabadghao and Shankarnarayan, 1973). In some areas in Koshi Tappu, where there is neither heavy grazing nor frequent burning, seedlings of *Dalbergia sissoo* and *Acacia catechu* can be found.

On the agricultural land which was abandoned in 1979, *Imperata cylindrica* was found to be dominant. This species also becomes a dominant competitor in areas where heavy grazing or frequent fires or both occur (Dinnerstein, 1979). The reason is attributed to its opportunistic reproductive strategies. According to Dinnerstein (1979), *Imperata cylindrica* is the only species to flower profusely within a short time after a fire. The seeds are well adapted for wind dispersal and rapid germination. Similarly, this species spreads by rhizomes, forming dense, fire-resistant tussocks. In addition, this species is benefited from the putative allelopathic properties of litter and roots (Eussen and Niemann, 1981). Because of this characteristic, *Imperata* has an advantage in propagation over other species under similar environmental conditions.

Since the marshes have been formed recently, the succession pattern is difficult to assess in detail. However, in some swamps, which formerly used to be marshes but are relatively dry at present because of the shifting of the river, swampy vegetation dominated by *Typha angustifolia, Phragmites karka* and *Vetiveria lawsonii* has been noted. Dominance of *Phramites karka* was reported on marshy sites in Chitwan also (Lehmkuhl, 1989). Similarly, water hyacinth *Eichornia crassipes* has colonized most part of the marshes east of the reserve, which are exposed to human activities (Figure 5.16).

Figure 5.16 ***Eichornia crassipes*** **(water hyacinth) choking the water bodies**

Water hyacinth causes the accumulation of organic matter, siltation and high rates of evapotranspiration which may together result in the disappearance of a water body (Brij Gopal, 1987). Based upon previous discussions of the vegetation, a model of plant succession on the floodplain of the Koshi is proposed (Figure 5.17).

The successional trend on the floodplains of Koshi Tappu indicates that the vegetation structure and distribution have also been changing due to human induced disturbances such as burning and livestock grazing. Since the extent of such activities and any other type of vegetation use is primarily determined by the socio-economic conditions of the surrounding communities, the results of a recent household survey will be discussed in later chapters to obtain a clear understanding of the socio-economic factors causing vegetation change, and thus, land cover and land use changes in the reserve.

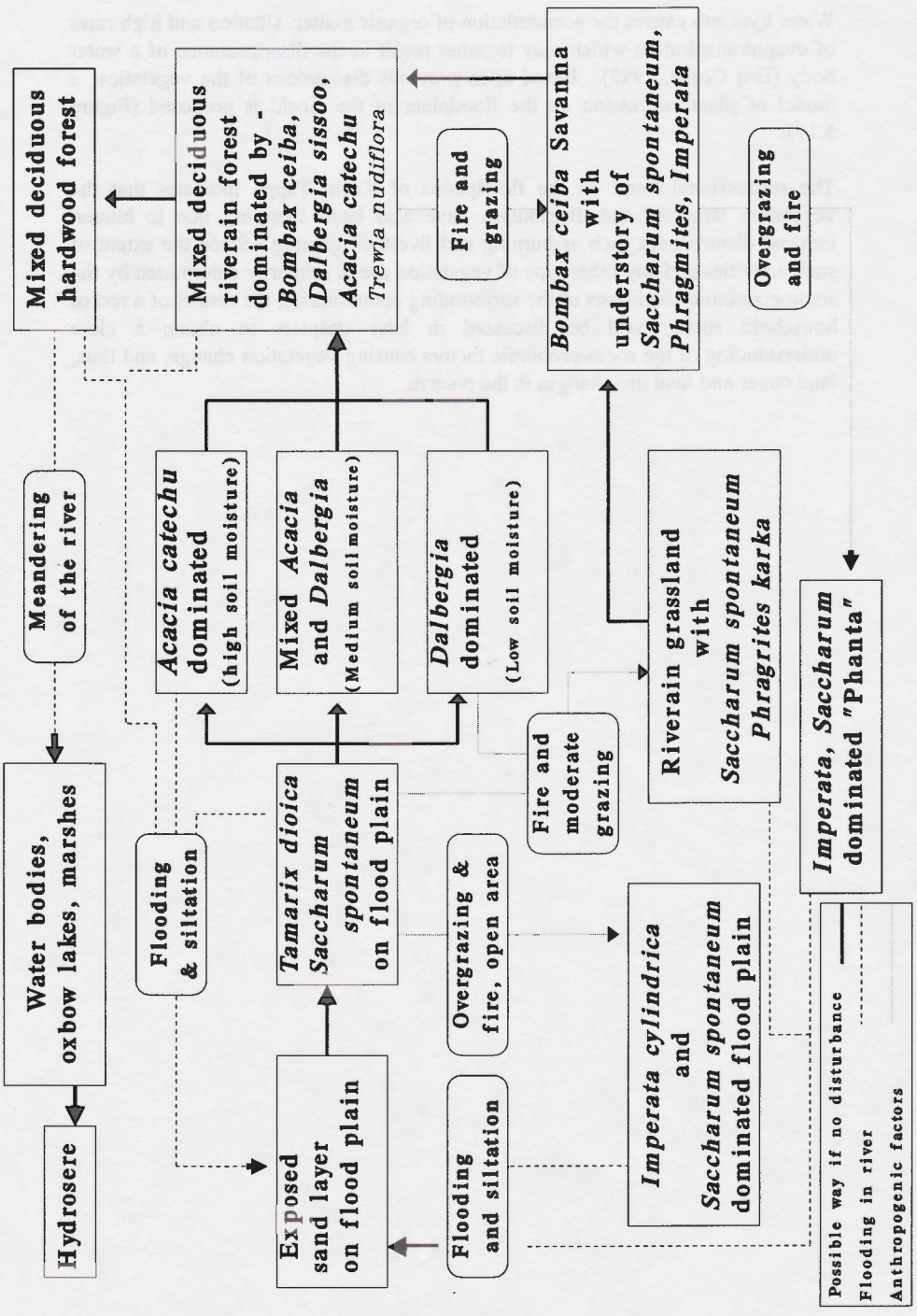


Figure 5.17 **Possible pathways of successional changes on the floodplain**

CHAPTER 6

HUMAN SETTLEMENTS

The national parks and wildlife reserves in Nepal, as in other developing countries, are surrounded by human settlements. The settlements in close proximity to these protected areas, especially in the *terai*, are densely populated and mainly dependent on agriculture. They interact with the reserve in multifarious ways which are usually influenced by the socio-economic conditions of the people as well as the local and national political environments. In recent years, it has been realized that the ecosystem cannot be considered in isolation and neither can areas be set aside exclusively for conservation purposes without taking into account social, economic and political considerations (Whitehead *et al.*, 1990).

Koshi Tappu Wildlife Reserve is surrounded by densely populated villages both to the east and the west and there are more than 500 households in the north, living on the floodplain of the Koshi river. These villagers have been using the resources of Koshi Tappu to meet their daily needs ever since they settled in the region. Following the declaration of the area as a reserve, they have no legal access to these resources. However, interactions between the local people and the reserve continue to exist in different forms. Examining the socio-economic characteristics of these communities provides information regarding these interactions and shows the dependence of local people on the wetland resources. Furthermore, an understanding of people's attitudes towards the reserve would also assist in the management of the wildlife reserve. Based on a recent survey (Sah, 1993a; WMI/IUCN-Nepal, 1994), the socio-demographic characteristics and the educational status of the surrounding communities are described below.

6.1 Location of villages

Koshi Tappu Wildlife Reserve lies on the floodplain, bounded to the east and west by the eastern and western earthen embankments respectively. Several villages belonging to the 12 Village Development Committees (VDC) are located to the east and west of these two embankments. Prior to the establishment of the present multi-party political system in the country, these VDCs were known as the Village *Panchayats*.

To the east of the reserve, Haripur, Shreepur-Jabdi, Kushaha, Madhuban and Prakashpur VDCs are situated from south to north along the eastern embankment in Sunsari district (Figure 6.1). Similarly, to the west, in Saptari district, Bairawa, Badgama, Jagatpur, Pipra-Purba, Kamalpur and Odraha are located adjacent to the reserve, and in Udaypur district, the village of Tapeshwari shares a boundary with the reserve. To the north, wards 4 and 5 of the Prakashpur VDC are located near the reserve on the floodplain and are called Lanka Dweep. Table 6.1 shows the villages and their wards which are located adjacent to the wildlife reserve.

The boundaries of the districts and the Village Development Committees have changed frequently in the past. To some extent these changes may have distorted the demographic data from the villages.

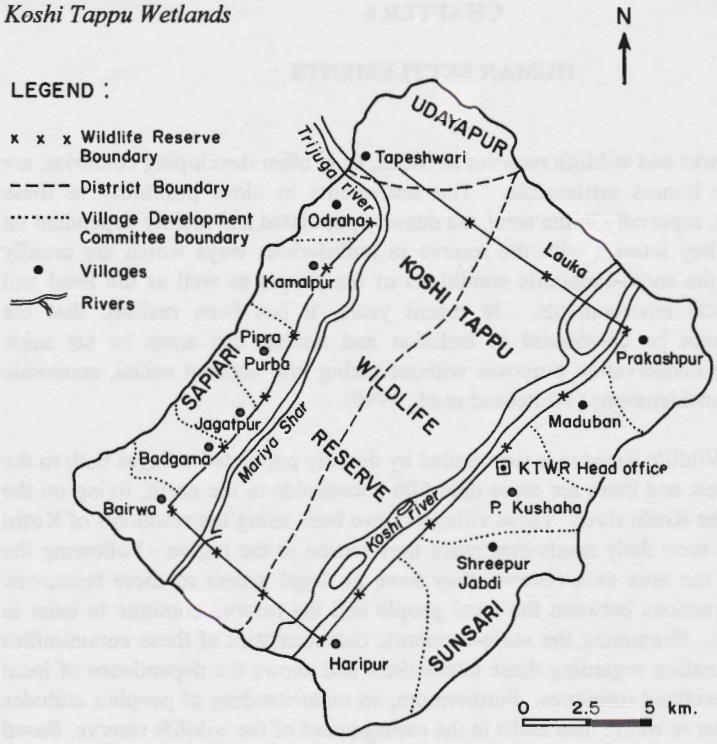


Figure 6.1 **Location of different villages around Koshi Tappu**

Table 6.1 **Wards of villages near the boundary**

District	Village	Wards near the boundary
Sunsari	Haripur	2, 4, 7, 8, 9
	Shreepur Jabdi	6, 8, 9
	Paschim Kushaha	4, 9
	Madhuban	1, 7, 9
	Prakashpur	4, 5, 6, 7, 9
Saptari	Bairawa	3, 4, 5, 6, 7, 8
	Badgama	7, 8
	Jagatpur	1, 3, 4
	Pipra Purba	2, 3, 4, 5, 6, 9
	Kamalpur	1, 2, 3, 4, 5
	Odraha	1, 2, 3
Udaypur	Tapeshwari	2, 3, 4

Source : Sah, 1993a

6.2 Socio-demographic structure

Demographic characteristics such as population, age structure, gender ratio, household size and migration are closely related with economic activities of communities, thereby affecting the perception and attitude of these communities towards nature conservation and the wildlife reserve. These parameters have been analyzed in the following sections.

6.2.1 Population

The *terai* of Nepal is a densely populated region where 47 per cent of the population live on only 17 per cent of the total area of the country. Of the 75 districts of the country, twenty districts, including Sunsari and Saptari, are included in this region which includes the inner *terai* as well.

In 1991, the population density of Sunsari and Saptari districts was found to be 370 and 341 per square kilometer respectively, comparison with 125 and 253 per square kilometer for the country and the *terai* respectively. Thus, these districts are among the most densely populated districts of Nepal. In the villages surrounding the reserve, the total population was 68,019 in 1991 (CBS, 1992b) (Table 6.2). About 55.7 per cent of the population resided in the east, 39.9 per cent in the west and 4.4 per cent in two wards within the village of Prakashpur in the north.

An overview of the population and its growth in surrounding villages shows that the population growth in those villages between 1971 and 1991 was 2.8 per cent, slightly higher than the national average (2.4 per cent) for the same period. It also varied in different parts of the two districts of Sunsari and Saptari, which had population growth rates of 2.9 and 2.7 respectively. Although the data on population in 1981 for those villages were ambiguous because of the readjusted boundary of the VDCs (then known as Village *Panchayats*), available data shows that growth was much higher in the 1970s than in the 1980s, especially in the three villages of Haripur, Shreepur and Kushaha in Sunsari district, where most of the migrants from other areas of the country settled.

Two types of factors, endogenous and exogenous, influence the population growth of an area. Endogenous factors include the age structure, social settings, culture, education, health awareness, medical facility, and exogenous factors remain mostly concerned with migration.

Marriage at an early age and a larger number of women of child-bearing age are two factors responsible for a high fertility rate. Twelve districts in Nepal which have the lowest age of women at marriage, 13.7 to 15.5 years, are located in the *terai* region. Saptari was the fifth lowest with an average age of 14.3 years for women at marriage (CBS, 1987). In the Sunsari district, the average age at marriage was 17.4 years which may be due to a relatively higher proportion of hill migrants in that district because the tendency to give education to woman is more common among them than in the *terai* community. The villages around the Reserve might show a similar trend.

Table 6.2 Population in different villages around Koshi Tappu

District	Village	HH No.	Male	%	Female	%	Total
Sunsari	Haripur	1,238	3,509	53.4	3,061	46.6	6,570
	Shreepur-Jabdi	1,527	4906	51.0	4,711	49.0	9,617
	P. Kushaha	1,413	4,168	52.6	3,756	47.4	7,924
	Madhuban	1,016	2,828	50.7	2,751	49.3	5,579
	Prakashpur	1,990	5,638	50.4	5,555	49.6	11,193
	Sub-total	**7,184**	**21,049**	**51.5**	**19,834**	**48.5**	**40,883**
Saptari	Bairawa	5,91	1,564	50.9	1,507	49.1	3,071
	Badgama	5,54	1,670	50.6	1,633	49.4	3,303
	Jagatpur	6,65	1,849	50.2	1,831	49.8	3,680
	Pipra Purba	5,10	1,363	49.6	1,386	50.4	2,749
	Kamalpur	6,73	1,788	49.3	1,840	50.7	3,628
	Odraha	6,59	1,726	49.2	1,784	50.8	3,510
	Sub-total	**3,652**	**9,960**	**49.9**	**9,981**	**50.1**	**19941**
Udaypur	Tapeshwari	1,321	3,526	49.0	3,669	51.0	7,195
	Sub-total	**1,321**	**3,526**	**49.0**	**3,669**	**51.0**	**7,195**
	TOTAL	**12,157**	**34,535**	**50.8**	**33,484**	**49.2**	**68,019**

Source: CBS, 1992b

The age at marriage is closely related with the level of education and occupation. In general, the higher the level of educational achievement the more delayed the marriage (CBS, 1987). Similarly, if women are engaged in non-agricultural activities outside the home, marriage is also delayed. Thus, to reduce population growth rates, it is necessary to improve educational standards and to find employment opportunities for women in the non-agricultural sector.

The social setting includes a relatively high population growth amongst groups which do not have a strong willingness to adapt to a means of family planning due to inadequate education and awareness, and traditional beliefs that more children safeguard against the effects of high child mortality. Among all these groups,

Muslims are regarded as being the most reluctant to practice family planning within the region.

Increasing medical facilities in the district hospital and the establishment of two health posts in these villages have augmented population growth, by decreasing the death rate. Furthermore, the huge influx of people from the hills to the *terai* due to availability of land, the eradication of malaria and increasing accessibility to other regions of the country, has accelerated population growth rates in the *terai* (CBS, 1987). Among the regions of the *terai*, the eastern region recorded the highest number of immigrants over the last two decades because the land in the eastern *terai* is comparatively more fertile than that of the central and western *terai*. The villages adjacent to the Koshi Tappu region have also received immigrants from the north. In addition, migration from India and other parts of the *terai* too have added to population growth in this region.

6.2.2 Gender ratio

The gender composition is the most basic of all demographic characteristics and influences population growth, occupational structure, migration and economic activities. In the villages around Koshi Tappu, the percentage of females varied from 46.6 per cent in Haripur to 51.0 per cent in Tapeshwari with an average of 49.2 per cent for the total population (Table 6.2).

During the survey in 1993, females constituted only 8.1 per cent of respondents. The low proportion of females responding to the questionnaire was a consequence of cultural restrictions. In the *terai* community, women are not accustomed to talk freely with strangers. A different response rate was received from communities which had migrated from the hills. Seventy-three per cent of the female respondents were from hill migrants living mostly in the villages of Prakashpur and Madhuban of Sunsari district.

6.2.3 Ethnic composition

A sample survey of 160 households in these villages showed that 91.3 per cent of the population was Hindu, 5.6 per cent were Muslims and 3.1 per cent were Buddhists (Table 6.3). This differs slightly from the religious composition of the population in the country where Hindus constitute 90 per cent of the population, Buddhists 5.3 per cent, Muslims 2.7 per cent and others 2.0 per cent. The higher percentage of Muslims in the Koshi Tappu region is due to the fact that 96.5 per cent of all Muslims in the country reside in the *terai* (CBS, 1987).

Among the Hindus, there is a diverse culture and a stratified hierarchy of castes, which is ranked in descending order, namely Brahman, Kshetry, Vaishya, and Shudra. Hindus who have migrated from the mountains and those residing in the *terai* have similar caste systems but differ somewhat in terms of culture, education and economic status. The way of life of the *terai* people is more similar to that of northern India than that of the Nepal hill people or hill migrants (Bista, 1972).

Among the *terai* people, the Yadav caste and other occupational castes such as Dhanuk, Kewat, Hajam, Badahi and Lohar, and tribal castes like Tharus, Jhangar and Bantar also practice the Hindu religion. Except for Yadav, who are large in number and play a significant role in Koshi Tappu, the above mentioned occupational castes and others such as Teli, Haluwai, Sudi and Kalwar are grouped together as Vaishya. People belonging to the tribal castes of Tharu, Jhangar and Bantar of the region are regarded as the indigenous people of the northern *terai* where the forest was dense until early this century and they lived in harmony with nature.

The Tharus are probably amongst the oldest groups to inhabit the *terai*. They are scattered throughout the *terai* from east to west. About 12 per cent reside in Sunsari district (CBS, 1987). Although their culture and language have been greatly influenced by others, they still speak their own language, which is distinct from the regional language, Maithili, and the national language, Nepali. With appropriate planning, their traditional culture could be preserved as a cultural heritage and their indigenous knowledge of natural resources may be helpful in developing strategies for the effective management of the wildlife reserve.

Table 6.3 Population by different religious/caste groups near Koshi Tappu

Caste group	No. of HH	Percent
Brahman/Rajput	7	4.4
Yadav	34	21.3
Vaishya	33	20.6
Shudra	28	17.5
Tribal (Tharu, Jhangar, Bantar)	26	16.3
Bahun/Giri/Newar	14	8.7
Sikarmi, Damai, Kami etc.	4	2.5
Gurung/Limbu etc. (Buddhists)	5	3.1
Muslims	9	5.6
Total	160	100.0

Source: Field Survey, 1993

6.2.4 Age structure

The age structure of a population is important in demographic analysis to estimate fertility and mortality levels as well as the economically active human resource potential. The result of the survey showed that about one third (34.2 per cent) of the population was below 12 years of age (Table 6.4). The percentage of children per household varied greatly among different religions and castes (Table 6.5) which also determine the social status of the people.

Table 6.4 Proportion of population in different age groups by district

Age group (years)	District		Average of total
	Sunsari	Saptari	
Below 7	14.2	16.8	15.4
7 - 12	18.7	19.0	18.8
13 - 60	63.3	59.8	61.7
Above 60	3.8	4.4	4.1
Total	100.0	100.0	100.0

Source: Field Survey, 1993

Table 6.5 Proportion of population in different age groups by caste or religion

Group	f'	Age class (years)			
		0 - 6	7 - 12	13 - 60	Above 60
Rajput/Brahman	4.4	3.2	20.6	76.1	0.0
Yadav	21.3	17.4	17.1	60.8	4.7
Vaishya	20.6	14.7	14.5	66.3	4.5
Shudra	17.5	16.0	26.0	53.4	4.5
Tribal	16.3	12.5	21.8	63.6	2.0
Bahun/Newar	8.8	9.2	15.6	70.8	4.5
Gurung/Limbu	5.6	18.1	17.0	63.8	1.2
Muslims	5.6	23.0	26.6	46.6	3.8
Average		15.4	18.8	61.7	4.1

Source : Field Survey, 1993

f' = Proportion of total population

Amongst all the groups, Muslims had the highest percentage of children (49.6 per cent) per household followed by Shudra (42.07 per cent). In the higher castes among Hindus of the *terai* community and hill migrants, these figures were as low as 23.8 per cent and 24.8 per cent respectively.

The higher percentage of children in households from Saptari district is attributed to the relatively higher number of households from the Shudra caste who have a relatively high proportion of children per household (Table 6.5). The population below 6 years old was smaller than that of children from 7 to 12 years of age, suggesting that the birth rate has decreased in recent years in the area.

The majority of the population (61.7 per cent) was between 13 and 60 years of age, and constituted the labor force of the community. The proportion of older people was relatively higher in the villages of Saptari district because the settlements in that area are comparatively older due to the fertile land and the presence of the north-south road from Kanchanpur to Fatehpur since the beginning of this century, which gives better access to medical and economic facilities. Furthermore, the first irrigation project of the country, the Chandra canal, was constructed in this area in 1924. The presence of a higher number of older people in old settlements was also found in the western *terai* (Thapa and Weber, 1986). Another reason may be due to emigration of relatively younger people from the western *terai* to the east of the Koshi during the 1960s when the Koshi had the tendency to shift westward.

Children below 13 years old and people above 60 years of age are considered dependants while the economically active group constitutes those aged between 13 and 60 years. Dependants constituted 38.28 per cent of the total population and the dependency ratio was found to be 1:0.62. The ratio was somewhat higher in Saptari (1:0.67) than in Sunsari (1:0.58) because of the higher percentage of children amongst the Shudra.

In any survey, the respondents age structure is important in determining its relation with the awareness and attitude of the people. In the present study, the interview for the household survey was conducted with the economically active head of the household and so, 98 per cent of the respondents were in this group of which 61 per cent were between 30 and 50 years of age (Figure 6.2).

6.2.5 Household size

The survey result showed that the average household size in the area was 7.2 (Table 6.6). Most of the households had 5 to 8 members, and 44.5 per cent of the total households were larger than the average size of 7 members. This survey showed a larger household size than the value recorded in population census, in which it was found to be 6.2. The reason for this may have been the tendency of married males to report separate households in Government surveys, to show relatively low land-holdings.

The tendency to have larger households was found to be more prevalent in those families which had a higher social status by caste and landholding size. Muslims were exceptions to this and their large household size reflected their adherence to traditional values of living in combined families. Similarly, the tendency to have large households was stronger in the *terai* community than in those communities which had migrated from the hills. Households where members were engaged in both agriculture and business activities were also larger.

Household size has a large impact on the socio-economic status of the people in the community. Large sized households, with large landholding, are usually considered strong and more able to influence decisions made at the community level.

Table 6.6 Proportion of households of different sizes

Religious/Caste groups	f	f'	Household size			Average size
			< 6	6 - 8	> 8	
Rajput/Brahman	7	4.4	0.0	57.1	42.9	8.3
Yadav	34	21.3	26.5	44.1	29.4	7.2
Vaishya	33	20.6	21.2	36.4	42.4	7.5
Shudra	28	17.5	35.7	46.4	17.9	6.4
Tribal	26	16.3	34.6	23.1	42.3	7.5
Bahun/Newar	14	8.8	7.1	78.6	14.3	7.4
Gurung/Limbu	9	5.6	44.4	44.4	11.1	5.7
Muslims	9	5.6	0.0	66.7	33.3	8.0
Average			25.0	44.4	30.6	7.2

Source : Field Survey, 1993

f = frequency of households; f' = Proportion of total population

6.2.6 Occupational structure

The major occupation of the people in the villages is agriculture. About 92 per cent of the households were found to be engaged in agricultural related activities (Table 6.7). Similarly, 132 households were dependent on fishing and they usually undertake this activity in the woodlands of the study area (Huyghenian, 1993b). A small number of households are involved in small business and trade to supply daily consumer items. Very few households were found to be engaged in private and government services. Some of the lower castes are involved in small cottage industries like manufacturing of mats, earthen pots and in tailoring. These industries help in reducing dependency on agriculture and assist in supplementing the household economy.

Table 6.7 Occupational distribution

Occupation	No. of HH	Percent
Agriculture	118	73.7
Agriculture/Business	6	3.8
Agriculture/Service	12	7.5
Business	1	0.6
Fishing	4	2.5
Private Service/Wage labor	15	9.4
Cottage industry	4	2.5
Total	160	100

Source : Field Survey, 1993

6.2.7 Migration

After the eradication of malaria from the *terai* in the 1950s, a large number of people migrated from the hills to the *terai*, resulting in significant effects on the population distribution and land-use in this region (Gurung, 1984). During the late 1950s, attracted by the job opportunities created by the construction of the Barrage, a number of people came to this region from other parts of the country and most settled down permanently.

The migration of populations from one village to another and the shifting of settlements in response to the unstable behavior of the Koshi river were common in the past. The effect was more prominent in India as the river gradually shifted 110 km west from its original position of 250 years ago. In Nepal, people from the villages of Chhapki, Sauryahi and others located on the western bank of the river, had to migrate to other regions because of the westward shift of the river.

Over fifty per cent of the households in the Koshi-Tappu region were found to have immigrated either from India, or from one village to another village within the same district or from another district of Nepal. Of the total immigrants, the highest proportion comprised of those who had migrated from other districts of the *terai* (Table 6.8) and includes migration between the west and the east of the Koshi river. About 11.2 per cent of the total immigrants were found to have immigrated from one village to another village within the same district.

Table 6.8 Place of origin of migrants

Immigrated from	Number of household	Proportion of household (%)	Proportion of immigrated household (%)
Present Reserve area	22	13.8	27.2
Village of same district	9	5.6	11.2
Other district (*terai*)	27	16.9	13.3
Other district (hills)	20	12.5	24.7
India	3	1.9	3.7
Total	81	50.7	80.1

Source: Field Survey, 1993

Migrants from the hills, who settled in northern villages such as Madhuban and Prakashpur in Sunsari district, and in Odraha and Kamalpur in Saptari district comprised 24.7 per cent of the total migrants. The number of total immigrants in Sunsari was relatively higher than in Saptari because access to resources in the region was easier in the east than in the west, prior to the shifting of the river to its present position.

Sixty three percent of the total immigration occurred between 1963 and 1980, i.e., after the construction of the Barrage, when the Koshi river was gradually shifting towards the west and was more braided due to the Barrage. After the declaration of the wildlife reserve in 1976, about 12,000 people were forced to move out from the reserve and to settle elsewhere. Figure 6.2 shows the number of immigrants in different periods during the last 50 years.

Compared to immigrants, the number of emigrants was found to be very low among the surveyed households. Very few people from this region have emigrated permanently to other places in search of a better livelihood. However, many people travel to other parts of the country and to India, to work as seasonal laborers.

Migration, either from outside or from one village to another village within the region, not only influences demographic change but also acts as one of the determining factors in building an attitude towards nature conservation. With increased migration to an area, pressure increases on the resources present in the area and the new migrants have little concern with conservation of these resources.

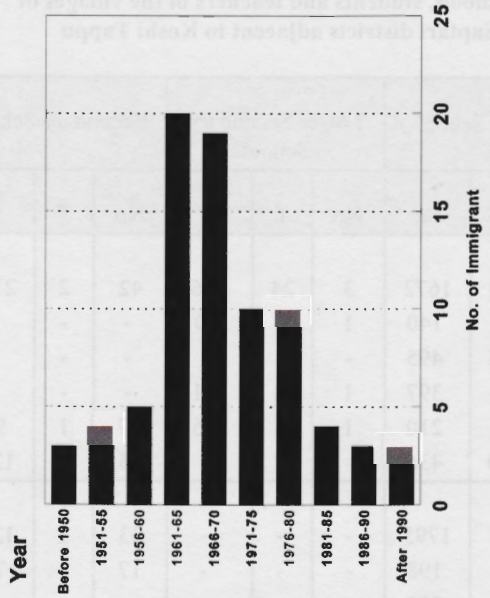


Figure 6.2 Number of immigrants in different years

6.3 Educational attainment

The literacy rate in the villages adjacent to the wildlife reserve was found 42.4 per cent. A literate person is defined as one who has the ability to both read and write in at least one language. The education of the people influences the social and economic activities in the community as well as their own awareness and attitude.

The educational level of the head of the household strongly affects the decisions in the household activity, whereas the educational level of all the household members influences the way such decisions are taken. Similarly, child education reflects the socio-economic status of the household. Hence, education is discussed here under the following sections: respondent's educational level, household's educational level and children's education.

6.3.1 Educational institutes

Eighteen primary schools, three lower secondary schools and four secondary schools were found located in the villages of Sunsari and Saptari districts adjacent to the wildlife reserve (Table 6.9). The infrastructure for most of the schools was found to be inadequate. The total number of teachers and students in all the schools was 179 and 7,613 respectively. The number of teachers and students was found 271 and 10,237 respectively, when Tapeshwari VDC of Udaypur district was also included (WMI/IUCN-Nepal, 1994).

Table 6.9 Number of schools, students and teachers in the villages of Sunsari and Saptari districts adjacent to Koshi Tappu

Villages	Primary School			Lower Secondary School			Secondary School		
	No	T	St.	No	T	St	No	T	St
Sunsari District	8	33	1672	3	24	886	42	2	2126
Haripur	1	3	140	1	5	70	-	-	-
Shreepur-Jabdi	3	15	495	-	-	-	-	-	-
Kushaha	1	6	397	1	11	521	-	-	-
Madhuban	1	5	210	1	8	295	17	1	901
Prakashpur	2	10	430	-	-	-	25	1	1275
Saptari District	10	41	1795	-	-	-	33	2	1234
Bairawa	1	5	198	-	-	-	17	1	784
Badgama	1	4	225	-	-	-	-	-	-
Jagatpur	3	12	385	-	-	-	-	-	-
Pipra-Purba	2	7	376	-	-	-	-	-	-
Kamalpur	2	8	401	-	-	-	-	-	-
Odraha	1	5	210	-	-	-	16	1	450
Total	18	80	3467	3	24	886	75	4	3360

Source: Field Study, 1993

T = No. of Teachers; St = No. of Students

6.3.2 Respondent's educational level

Fifty per cent of the respondents were found to be illiterate and only 1.2 per cent had studied beyond secondary school (Table 6.10). A high degree of inequality was observed in the level of education of respondents in both the districts as the Respondent's Education Level Index was about 2.5 times higher in Sunsari district than in Saptari. This was because of the higher percentage of lower castes in the surveyed population of villages in Saptari district.

The education of the respondents shows a strong relation with the social status of the people, and hence with land holding size. Similarly, it shows a significant negative correlation with age which indicates that the new generation is more educated. Since education is considered one of the determining factors of increased awareness of the need for conservation, this trend may reflect a changing attitude towards conservation of the reserve.

Table 6.10 Index of the respondent's education level

Education level	Wt	Proportion of Respondents				
		District		Gender		Total
		Sunsari	Saptari	Male	Female	
Illiterate	0.0	44.3	56.9	47.6	76.9	50.0
Able to read & write	0.2	17.0	29.2	23.1	15.4	22.5
Primary	0.5	9.1	6.9	8.8	0.0	8.1
Lower secondary	0.7	10.2	2.8	6.8	7.7	6.9
Higher secondary	1.0	17.0	4.2	12.2	0.0	11.3
Intermediate	1.2	1.1	0.0	0.7	0.0	0.6
Graduate	1.4	1.1	0.0	0.7	0.0	0.6
Total		100.0	100.0	100.0	100.0	100.0
Education Level Index		.349	.145	.277	.085	.259

Source: Field Survey, 1993

6.3.3 Educational level of household members

More than fifty-seven percent of all household members were found to be illiterate (Table 6.11). The Education Level Index of 0.310 and 0.198 in Sunsari and Saptari districts respectively, shows distinct inequality between the two areas. Greater inequality prevails in the educational level of household members of different gender and castes.

The educational level among females is much lower than that attained by males. Even at the country level, the proportion of male attendance at primary, lower secondary, secondary and graduate level in rural areas exceeded the proportion of females by 2.46, 5.10, 7.40 and 11.66 times respectively, in 1981 (CBS, 1987). Hindus of higher castes have the highest Education Level Index (0.561) as compared to others (Table 6.12).

Table 6.11 Index of educational level of households members

Education level	Weight	Proportion of Household members				
		District		Gender		Total
		Sunsari	Saptari	Male	Female	
Illiterate	0.0	43.1	55.9	30.4	70.1	57.2
Able to read and write	0.2	20.7	24.0	25.4	18.4	18.8
Primary	0.5	14.3	8.4	16.4	6.2	9.9
Lower secondary	0.7	10.8	4.9	12.4	3.3	6.9
Higher secondary	1.0	7.7	4.7	10.1	2.0	5.4
Intermediate	1.2	2.2	1.2	3.1	0.2	1.5
Graduate	1.4	1.3	0.9	1.3	0.0	0.3
Total		100.0	100.0	100.0	100.0	100.0
Education Level Index		.310	.198	.376	.112	.212

Source: Field Survey, 1993

Table 6.12 Education level index for social/religious groups

Education level	Wt.	Proportion of population (6 yr age and above) (%)							
		R/B	Y	V	S	Tr	B/N	G/L	M
Illiterate	0	7.1	40.7	45.7	74.1	62.5	25.7	42.9	67.3
Able to read & write	0.2	28.6	24.0	20.5	17.7	19.6	23.7	30.9	25.5
Primary	0.5	26.8	13.2	12.8	5.4	8.3	17.2	14.3	1.8
L. secondary	0.7	12.5	10.3	8.6	1.4	5.4	18.3	9.5	3.6
H. secondary	1.0	12.5	8.8	7.6	1.4	3.6	10.8	2.4	1.8
Intermediate	1.2	8.9	1.5	2.9	0	0	3.2	0	0
Graduate	1.4	3.6	1.5	1.9	0	0.6	1.1	0	0
Total		100	100	100	100	100	100	100	100
Education Level Index		.561	.313	.303	.086	.163	.423	.224	.107

Source: Field Survey, 1993

R/B = Rajput/Brahman, Y = Yadav, V = Vaishya, S = Shudra, Tr = Tribal, B/N = Bahun/Newar, G/L = Gurung/Limbu & others, and M = Muslims

Variations in the respondent's education and household members' education reveals that the decision of the head of the household to educate household members is affected not only by their own education but by social customs, fluctuations in economic status and the availability of resources and educational institutions. The educational level of the household members in the villages of Madhuban and Prakashpur is relatively higher may be because these villages have better educational facilities as well as a higher population of hill-migrants who have a stronger tendency to educate children and women, in comparison with the *terai* community.

6.3.4 Child education

In the rural areas, children are usually enrolled in school after the age of six, which is the minimum age for admission to schools in Nepal (CBS, 1987). Most villages in the region have only primary schools. All children are supposed to receive primary education, provided free since 1975. However, many poor children may never be enrolled in schools (Figure 6.3). The frequency of enrolment of children of this age in schools reflects the attitudes of the heads of households towards education and the extent of the availability of schools, as well as economic conditions.

Nearly 65 per cent of the households were found to have children of primary school going age with an average of 1.36 children per household, which represents 19.4 per cent of the household members. This figure was slightly higher in Saptari district (20.3 per cent) than in Sunsari (18.8 per cent). Muslims had the highest proportion of children of primary school going age, whereas the lowest proportion was found among the Vaishya community.

Seventy-five percent of the total number of children of primary school-going age were found to be enrolled in schools. Since, the enrolment of children reflects the socio-economic status of the people, the highest enrolment (100 per cent) was naturally found among the higher caste Hindus (Table 6.13) while the proportion was lowest among the Shudra.

Tribal castes, who had earlier been reluctant to receive education, have realized that in many cases they had been cheated by immigrants and had lost their land due to their inability to read. Thus, there is a growing tendency among them to educate their children.

The enrolment of female children in some groups was found to be far below the country's average of 50 per cent. It ranged between 12.5 per cent among Muslims to 100 per cent among higher caste Hindus (CBS, 1987). About 61.8 per cent of the female children of Yadav, who constitute one fifth of the population and occupy a high socio-economic status, were enrolled in school.

Despite free primary education, enrolment in schools is not satisfactory. The drop-out rate of enrolled children is also high. The survey of 10 primary schools in 1993 showed that the drop-out rate in primary school varied from 55 per cent to 86 per cent. This trend is similar to that found in the whole country as indicated in the results of a

country-wide study which showed that 75 per cent of students enrolled in grade I dropped out and the remaining 25 per cent only reached grade VI (CBS, 1987).

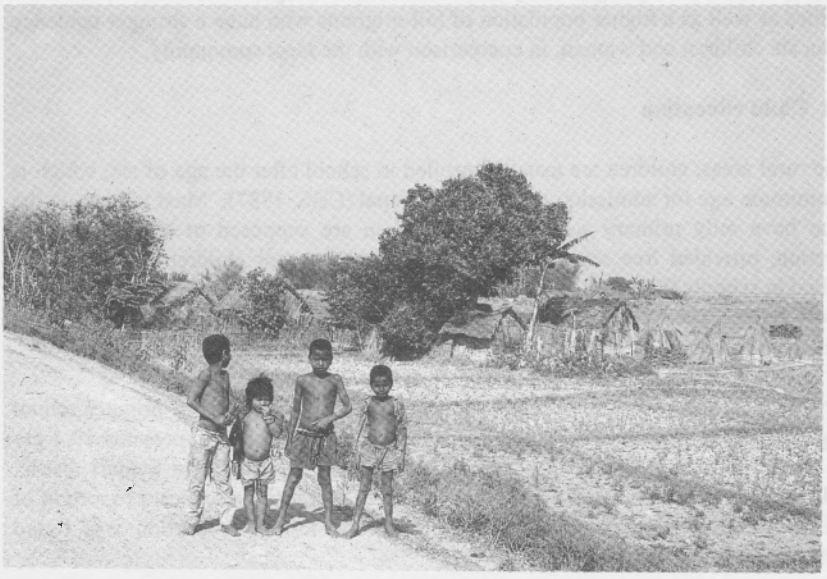


Figure 6.3 Poor rural children who may never be enrolled in a school.

Table 6.13 Primary school enrolment

Religious/Caste Group	Children (%)		
	Total between 7-12 yrs age	Enrolled in primary school	Female children enrolled
Rajput/Brahman	20.6	100.0	100.0
Yadav	17.1	84.5	61.8
Vaishya	14.5	77.4	70.0
Shudra	26.0	43.5	12.5
Tribal	21.8	36.5	26.5
Bahun/Newar	15.6	100.0	100.0
Gurung/Limbu	16.9	57.1	33.3
Muslims	26.6	69.0	20.2

Source: Field Survey, 1993

Children are often unable to attend school regularly because of their involvement in livestock grazing and other household activities. Later, when they can no longer cope with school and household commitments, they drop out. Female children drop out of school more often because of early marriage in the rural areas.

The reasons for the poor enrolment of children and the higher number of drop-outs from school are related to social, economic and political parameters. The major causes are the distant locations of schools, unawareness amongst parents of the need for education, lack of money, demand for child labor, discrimination between different castes and the lack of job opportunities for educated people.

Primary schools are located not more than half an hour walk from any ward of the villages. However, the distant location of secondary schools results in poor school attendance beyond primary level. Of the eleven Village Development Committees (VDCs), seven have no secondary schools and some students have to walk two hours to reach school. In the east of the reserve, two adjoining VDCs, Prakashpur and Madhuban, have a secondary school in each, whereas three other villages Kushaha, Shreepur and Haripur, do not have any secondary schools despite their favorable location near the highway.

One reason for the existence of secondary schools in Prakashpur and Madhuban is the dominance of migrants from the hills in the former two villages, who are usually more aware of education than the *terai* community. However, it was also found in Haripur that under the previous political system, high ranking families had a strong socio-political influence in the community and tried to inhibit the establishment of schools in the village so that the education of villagers would not dilute their influence. Thus, the improvement of socio-political awareness could also help in improving educational levels in these communities.

CHAPTER 7

ECONOMIC ACTIVITIES

The wetlands of the Koshi Tappu region support a significant range of economic activities in the surrounding communities where, like the country as a whole, the economy is dominated by agriculture. The area lies in the *terai*, `the granary of Nepal', and the agricultural sector concentrates mostly on food production. However, owing to the interdependency between livestock production and crop farming in the rural economy of the *terai*, livestock rearing forms an integral part of economic activities. In the absence of any infrastructure for industrial development in the region, non-farm activities, apart from labor export, are also supported mainly by the wetland resources. Capture fishery in the main channel of the Koshi river and associated wetlands is a major occupation of some households.

7.1 Agricultural activities

Koshi Tappu Wildlife Reserve is surrounded by agricultural land and settlements to the east and west. People farm on the floodplain of the Koshi river to the north and the south of the reserve. Agricultural land is the most fundamental resource of household production in an area where the agricultural sector provides employment to about 94 per cent of economically active population. Within the agricultural sector, crop production, fruit tree plantation and fishery are practiced. In the vicinity of Koshi Tappu, like in other parts of the *terai*, crop production, particularly food grains, dominate the agricultural activities. The *terai*, as a whole, is called `the granary of the country' and consists of 63 per cent of the cropland and contributes 60.3 per cent of the total crop production of the country (Table 7.1) (Bista, 1989).

Table 7.1 The distribution of crop land and crop production in different ecological zones of the country

Ecological Zones	Area[1] (%)	Population[2] (%)	Crop land[3] (%)	Crop Production[3] (%)
Mountains	23	7.82	5	5.3
Hills	60	45.56	32	33.1
terai	17	46.62	63	60.3

Source: 1. Sharma, 1984; 2. HMG, 1992a; 3. Bista, 1989

7.1.1 Land quality

The agricultural fields, which are locally called *khet*, are mostly paddy fields which represent a type of wetland. Owing to the topography, soil characteristics and accessibility to irrigation, the land differs in quality along a gradient, and any particular parcel of land may be suitable for one crop species, but unsuitable for another. Thus, it is difficult to categorize agricultural land into different classes based on land quality.

Land may be irrigated or non-irrigated. In the vicinity of the reserve, more than 50 per cent of the land is irrigated. Sub-branches of the Chandra irrigation canal irrigate the land in the west of the reserve, while in the east, newly created marshes and a branch of the Chatra irrigation canal are the main sources of water for irrigation.

In another classification, constructed for the purpose of tax, land in Nepal was classified into four categories, namely *awal, doyam, sim* and *chaur* in 1934 (Regmi, 1977: cited in Thapa and Weber, 1990). Land productivity differs between these categories and land evaluation also depends on this classification. The quality of land decreases from *awal* to *chaur* respectively.

Results of the household survey showed that 35.16 per cent of total agricultural land in these villages belonged to the *awal* class, and most of the land was of *doyam* type (Table 7.2). Some land was of the *sim* type. *Chaur* usually do not belong to the individuals, but are public land as in other parts of the *terai.*

Table 7.2 Land distribution in two districts according to land quality

Land Quality	Wt	Sunsari		Saptari		Total	
		Land (Bigha)	f'	Land (Bigha)	f'	Land (Bigha)	f'
Awal	1.0	78.2	29.4	69.9	45.0	148.1	35.1
Doyam	0.8	164.0	61.6	81.5	52.5	245.5	58.3
Sim	0.6	24.0	9.0	3.8	2.5	27.8	6.6
Total		266.2	100.0	155.2	100.0	421.4	100.0
Land Quality Index		0.840		0.885		0.867	

Source: Field Survey, 1993
1 Bigha = 0.68 Ha
f' = Proportion of the total land

7.1.2 Land ownership and tenancy structure

Land resources play an important role in the production system of the households, and land ownership is a prerequisite to 'vertical mobility' in terms of asset acquisition and income generation. Agricultural land in the villages east and west of the reserve, belongs to the local people, whereas the areas between the reserve and the Barrage-Bhardah link road, constitute a portion of land which has been given to the Koshi Project. The agricultural land on the floodplain, north of the reserve, is public land. The total land under all VDCs around Koshi Tappu is 19,968 ha in which private and government owned lands are 15,455 ha and 2,785 ha, respectively (WMI/IUCN-Nepal, 1994). Similarly, among all the VDCs, Prakashpur has the maximum land (4,353 ha). The minimum land (%%2 ha) is in the Badgama VDC.

In addition, people claim about 465 ha land inside the reserve where they cannot practice cultivation because the land has been acquired by the reserve and any kind of cultivation inside the reserve is not permitted. This disputed dual ownership is one of the sources of conflict between the reserve authorities and local people (Sah, 1993a; WMI/IUCN-Nepal, 1994).

Different land operating systems like owner operated, and rental and share-cropping are found in the villages. Results of the household survey showed that 75.6 per cent of total land was owner operated, and a minor proportion was rented out. In the area, only 73.1 per cent had their own land, most of which were owners as well as tenants, farming on their own land as well as on share-cropping or rented land. The lands are rented in/out on an oral basis to avoid *mohiyani hak* a kind of legal conflict between land owncer and tenants. Land rent ranged between NRs 9,000 to 22,000 per ha (WMI/IUCN-Nepal, 1994). The tenure status was found to be different within the district (Table 7.3). Similarly, it was found to decrease over time. In the whole *terai*, the number of tenants and the land under tenancy decreased significantly from 25 per cent in 1961 to 8 per cent in 1981 (Bista, 1989).

Table 7.3 Land distribution according to land ownership

Land Tenure	Sunsari		Saptari		Total	
	Land (Bigha)	f'	Land (Bigha)	f'	Land (Bigha)	f'
Owner Operated	207.7	78.0	110.6	71.3	318.3	75.5
Share-crop in	1.0	0.4	7.4	4.8	8.4	2.0
Share-Crop out	0.0	0.0	8.8	5.7	8.8	2.1
Rented in	50.0	18.8	13.0	8.3	63.0	15.0
Rented out	7.5	2.8	0.5	0.3	8.0	1.9
Inside Reserve	0.0	0.0	14.9	9.6	14.9	3.5
Total	266.2	100.0	155.2	100.0	421.4	100.0

Source: Field Survey, 1993
1 Bigha = 0.68 ha
f' = Proportion of the total land

The area of land utilized on rental basis is higher in Sunsari compared to the land in Saptari. It is due to the fact that in Sunsari some wealthy families have large land-holding but do not themselves practice farming. This feature is common in most of the *terai* (Thapa and Weber, 1990), but such families are not always resident. Some families, who received *birta* and *jagir* in the *terai* during the Rana regime (1846-1951) as rewards for their services, still hold land in the *terai*. This land is generally cultivated by tenants. In the vicinity of Koshi Tappu, 7.3 per cent of the land belongs to this category. This absentee landlord system is an obstruction to proper land use and agricultural development. The Rajput and the Brahman communities usually do not practice farming through share-cropping and some Rajput, Brahman and Yadav families have rented out their land.

Share-cropping and rented land have created some employment opportunities for small farmers. Results of a research conducted in Nepal found no significant difference in the efficiency between tenant-operated and owner-operated farms (APROSC, 1985; cited in Bista, 1989). However, it is believed that tenancy prevents efficient use. Thus, it is regarded as a major constraint on increasing the overall productivity of the land in Nepal (Karki, 1988). As a result, all the land reform programmes in the country have, in the past, aimed at decreasing land under tenancy. In contrast, the modern view favors tenancy, especially share-cropping. Bista (1989) noted that some regions, especially in the *terai*, where there has been a substantial decrease in holdings under tenancy, have not shown increased productivity. Furthermore, a decline in tenancy has not brought equality in the distribution of holdings as the concentration of land holding has increased over time.

7.1.3 Landholding size

The agricultural system in the country in general and in the *terai* in particular, has been characterized by a great disparity in land distribution for many centuries. The disparity was at a peak during the Rana regime (1846-1951) when most of the land used to be owned by relatives of Ranas, government officers and *zamindars* (landlords). Later, with the implementation of a number of Acts, such as the Tenancy Right Security Act 1951, the Land Reform Act 1957, the Birta Abolition Act 1959 and the Land Reorganization Act 1962, *Birta, Jagir, Ramam* and *Zamindari* systems of land ownership were abolished.

Furthermore, the Land Reform Program was launched in 1964 with the aim of imposing ceilings on the size of land holdings, redistribution of land, adjustment of tenancy conditions and regulation of rents. The success of this program is still uncertain. The average holdings of large landowners has decreased from 114 ha to 39 ha after ceilings were implemented. On the other hand, not only is the number of landless on the increase in recent years (Pant, 1987), but the number of small holders with holdings of less than 0.5 ha have increased from 29 per cent in 1961 to 51 per cent in 1981 (Bista, 1989).

In the villages around Koshi Tappu in Saptari and Sunsari districts, this disparity in land holding exists to some extent. The average land holding size was 2.62 Bigha (1.7 ha) per household. Of the total households, 26.9 per cent did not own land, however, 15 per cent of them were tenants since they received some land on share-cropping or rental basis. Thus, 11.9 per cent were landless, of which 41.2 per cent and 57.9 per cent were in Sunsari and Saptari districts, respectively. This is less than the percentage of landless in the whole of the *terai* (23 per cent), but is quite high when compared to the hill area where landless people make up only one per cent of the population.

Since the land tenure status differs, the relative value of owner operated land, rented or shared out land and rented or shared in land is expressed as the ratio 1:0.75:0.25. This is because the tenant, i.e., household which practices farming on share-cropping or rented in land, is entitled to only one-fourth of that land, whereas the land owner owns three-fourths of the same land. Land holdings can be computed in terms of landholding size units (LHSU) to measure the average land holding per household and to incorporate the differences in land tenure.

In the villages around Koshi Tappu, the average landholding size unit (LHSU) was found to be 2.44 Bigha (1.66 ha) per household. The households of Sunsari had a relatively larger holding (2.81 Bigha) than those of Saptari (1.98 Bigha). Similarly, Rajput/Brahmans had the highest average landholding of 4.95 Bigha (3.37 ha), whereas Shudras had only 0.7 Bigha (0.47 ha) per household (Table 7.4).

Table 7.4 Average landholding and proportion of total land by caste or religious group

Group	Household		Average landholding (Bigha)	Proportion of total land
	f	f'		
Rajput/Brahman	7	4.4	4.95	8.9
Yadavas	34	21.3	3.84	33.4
Vaishyas	33	20.6	2.93	24.7
Shudras	28	17.5	0.69	4.9
Traditional	26	16.3	2.07	13.8
Bahun/Newar	14	8.8	2.67	9.5
Gurung/Limbu	9	5.6	0.77	1.8
Muslims	9	5.6	1.30	3.0
Total	160	100.0		100.0

Source: Field Survey, 1993
1 Bigha = 0.68 Ha
f = Frequency
f' = Proportion of the total number of households

For practical purposes the households were divided into five categories, namely, marginal, small, small-medium, medium and large, based on landholding size unit. It was found that 30.6 per cent of the households were either landless or owned land below one Bigha (0.68 ha). Their average landholding was 0.41 Bigha (0.28 ha) (Table 7.5). Although the proportion of large landholders was low (10 per cent), they owned 34.1 per cent of the total land with an average land holding of 8.34 Bigha (5.56 ha). By comparison, 50 per cent of small land holders owned only 15.5 per cent of the total land.

The minimum landholding given by the Government to new settlers, who have mostly migrated from the hills to different parts of the *terai*, is 4 Bigha (2.72 ha). If this figure is regarded as the minimum requirement for a household to fulfill its subsistence requirements, 83.1 per cent of the total households in the Koshi Tappu area were found to have landholdings below this level. Households with landholding greater than 2.72 ha, had an average landholding of 4.67 ha, which cannot be considered large enough to be redistributed among the small holders. Furthermore, uniform distribution of the toal 15,455 ha private land among all 12,157 households will result only 1.91 Bigha (1.27 ha) per household in all the VDCs around the reserve. It suggests that any policy of allocating 4 Bigha (2.72

ha) land to a family should be revized in context to regions and density of population around the Koshi Tappu area otherwise that will simply result a shift of concentrated land ownership from one group to another.

Despite intensive programmes focussed on land reform in the country since 1964, the concentration of land holding has been found to have increased over the same period (Bista, 1989). The reason for the decrease in average land holding of large land holders, and the increase in the number of small land holders over generations, is due to the tradition of dividing inherited land among male offspring.

Table 7.5 Average landholding and proportion of total land in different classes by landholding size

Landholding size class	Landholding size (Bigha)	Household		Average landholding (Bigha)	Proportion of total land
		f	f'		
Marginal	0 - 1	49	30.6	0.40	5.1
Small	1 - 2	46	28.8	1.54	18.1
Small-medium	2 - 3	22	13.8	2.67	15.0
Medium	3 - 5	27	16.9	4.01	27.7
Large	> 5	16	10.0	8.34	34.1
Total		160	100.0		100.0

Source: Field Survey, 1993
1 Bigha = 0.68 ha
f = Frequency
f' = Proportion of the total Households

The limited land resources and few off-farm opportunities for employment, indicate that the situation will deteriorate further in the future, since a reduction of holding size has a direct effect on the well being of farmers (Karki, 1988).

7.1.4 Cropping systems

Cropping systems refer to the cropping patterns used on farms and their interactions with farm resources. Cropping patterns depend upon the physical and socio-economic environment of the area, and are highly environment specific (Corangal, 1977; cited in Timsina and Suvedi, 1986). The overall cropping pattern in Nepal is dominated by paddy which is produced wherever possible, even on the steep high hills. However, paddy and wheat are the predominant food crops of the *terai*, while maize and millet are favored in the hills. These four crops together account for about 90 per cent of the cropland in the country (Sapkota, 1986).

In the villages around Koshi Tappu, cereal crops such as paddy and wheat are cultivated, while maize is mostly cultivated on upland areas in northern villages like Odraha in the west, and Prakashpur and Madhuban in the east (Table 7.6).

Non-cereal crops such as legumes, oil seeds, potato, jute and vegetables are also cultivated by most of the households but in low proportions. Vegetables are cultivated intensively on the floodplain to the north of the reserve which is very fertile for some of them. For example, people of Lanka Dweep grow vegetable Pointed Gourd (*parwar*) which is usully sold in local *bazars* and is transported to Kathmandu as well (WMI/IUCN-Nepal, 1994).

The cropping pattern in the area consists mostly of either sequential and/or mixed cropping. Sequential cropping or the cropping cycle depends upon the quality of land, irrigation facilities, ability of the farm holders to invest in inputs, credit facilities and extension services. However, in general, the cropping cycle in this area is paddy-wheat-fallow, paddy-oilseeds-fallow, paddy-wheat-jute and paddy-fallow-wheat.

Paddy is generally planted in late June to mid-August and harvested in December when wheat and oilseeds are sown in irrigated and non-irrigated land respectively. In the lowlands, a local variety of rice called *bhadaiya,* which has a short life cycle, or jute is usually planted in late May and harvested in late August. Such fields are then used to cultivate either paddy, wheat, potato or vegetables.

7.1.5 Cropping intensity and crop diversification

It has been widely recognized that the limited land resources have to be utilized more intensively to fulfill the increasing demands for food from the growing population. Multiple cropping, the growing of more than one crop a year on a piece of land, offers opportunities for subsistence farmers to increase farm productivity (Beets, 1982; Pendleton, 1982; cited in Timsina and Suvedi, 1986).

The Cropping Intensity Index (CII), also called the Multiple Cropping Index, has been used to analyze the intensity of land use for farming. It is defined as the ratio of the total area under different crops to the total arable land.

The result of the survey in the vicinity of Koshi Tappu showed that households of the Shreepur-Jabdi village of Sunsari district were using their land most intensively, followed by the village of Kamalpur of Saptari district (Table 7.6). The irrigation facilities from branches of the Chatra canal and the Chandra canal, respectively, were the reasons for the high intensity index. Similarly, cropping intensity decreased as the land holding size increased, i.e., both were negatively correlated with each other (Table 7.7). The reason for this is the traditionally higher input intensity on the smaller farms. Consequently, there is higher productivity on smaller farms.

The intensive use of land is always associated with the use of modern technology, improved seeds, pesticides and chemical fertilizers. Around the Koshi Tappu reserve, most commonly used chemical fertilizers are Urea and Potash, and among pesticides, BHC, Metaacid, Dythene M 45 are common (WMI/IUCN-Nepal, 1994). However, data on the extent of the use of such agricultural inputs are lacking. It has, however, been observed that their use is gaining momentum through a Small Farmer Development Programme, launched in at least two villages in the area, Madhuban and Odraha. While the use of fertilizers has some short-term positive impacts on agricultural production, they might have a negative

impact on the marshes in the east of the reserve also, which receive agricultural runoffs and are important habitat for several species of birds. Signs of eutrophication have already become visual in such wetlands. However, it is most unlikely that all agricultural runoffs from 7 VDCs directly go to the Koshi Tappu reserve, as mentioned by WMI/IUCN-Nepal (1994), because the reserve is bounded by embankments along the whole eastern and the most of its western boundaries.

During the last thirty years, the use of improved varieties of cultivars has been promoted through different agricultural programs in the country. Such varieties have been found to be more susceptible to disease. To avoid excessive use of pesticides, crop diversification has become a component of integrated pest management. Crop diversification not only helps farmers in terms of providing an income to meet their daily needs but also helps to break the life cycle of pathogens, which in turn helps to reduce crop damage by diseases. The importance of diversified cropping is recognized to some extent by the communities around Koshi Tappu. Households in the east of the reserve have more diversified cropping than those in the west.

7.1.6 Crop productivity

In Nepal, the agricultural sector is characterized by an inadequate knowledge of modern technology and ineffective extension services, lack of external inputs and institutional credits for the farmers. As a result, crop productivity is low. Despite efforts to adopt modern methods of crop production in the last three decades, productivity per unit of land has decreased in the country by 0.5 per cent, and in the *terai* by 0.3 per cent annually during the period 1967 to 1982 (Sapkota, 1986). Whatever increase in production has been experienced, it is due to an increase in cropland. Productivity has increased in the eastern *terai* by 0.1 per cent in the same period.

In the villages near Koshi Tappu the trend of productivity differs locally. People in the east have experienced an increase in crop productivity over the last few years, whereas in the western portions people have noticed a decreasing trend. In the survey, the crop productivity for all the major crops except millet was still found to be higher in the western villages than that in the eastern ones (Table 7.8).

This trend becomes further evident when productivity is analyzed by land holding size. It was found that productivity decreased with an increase in land holding size (Table 7.9). In another district of the *terai*, no significant negative relation between landholding size and crop productivity was found (Tiwari, 1990). It was found instead that in an area where farm sizes are small, off-farm activities are limited, and traditional agriculture dominates, the inverse relationship was true (Tiwari 1990). Other factors which influence crop productivity are soil characteristics, extent of labor input, quality of seeds, use of fertilizer, irrigation facilities, etc.

Compared to crop productivity of other parts of the *terai*, the productivity of this region is low, indicating that there may be potential to improve productivity. However, a more detailed study is required in order to understand the complex nature of cropping systems and to improve the economic conditions of the people.

Table 7.6 Cropping area and cropping intensity index by village

Village	Total area (Kattha)	Crop area (%)									Cropping Intensity Index
		Paddy	wheat	Maize	Millet	Potato	Pulses/ Oil seed	Jute	Vegetable	Total	
Sunsari	5325	97.2	18.8	4.4	0.5	2.5	31.5	8.5	1.7	164.4	1.64
Haripur	1100	100.0	20.1	0.2	0.0	1.6	28.6	8.6	0.8	159.9	1.60
Shreepur	1458	98.9	25.6	1.4	0.2	2.7	36.4	12.0	1.0	178.0	1.78
Kushaha	1463	99.9	19.1	0.5	0.9	2.7	34.3	7.9	2.9	168.1	1.68
Madhuban	1026	89.2	10.2	7.2	0.7	3.0	28.8	5.7	1.8	146.5	1.46
Prakashpur	278	92.8	7.9	47.8	0.4	1.8	4.3	2.5	1.8	159.4	1.59
Saptari	3102	90.0	29.6	1.0	1.6	2.2	29.0	8.4	1.2	163.0	1.63
Bairwa	485	97.1	31.1	0.4	1.9	2.3	26.8	7.6	1.2	168.5	1.68
Badgama	884	79.9	40.8	0.0	0.2	2.4	21.3	14.1	1.4	160.1	1.60
Jagatpur	372	92.7	25.3	0.0	2.4	2.2	19.1	0.0	0.8	142.5	1.42
Pipra purba	497	90.5	23.1	2.0	4.0	2.2	28.2	11.1	1.8	163.0	1.63
Kamalpur	617	96.1	25.8	0.0	0.8	1.9	45.4	6.3	0.8	177.1	1.77
Odraha	247	91.9	15.8	8.1	2.0	1.6	36.4	2.0	0.4	158.3	1.58

Source: Field Survey, 1993
20 kattha = 0.68 ha

Table 7.7 Cropping area and cropping intensity index by land holding

Landholding Size	Total area (Kattha)	Crop area (%)									Cropping Intensity Index
		Paddy	wheat	Maize	Millet	Potato	Pulses/ Oil seed	Jute	Vegetable	Total	
Marginal	441	95.5	24.3	23.1	3.2	4.3	24.7	2.7	5.4	183.2	1.83
Small	1586	97.6	24.3	6.7	0.7	2.3	33.0	4.9	1.6	171.0	1.71
Small-medium	1216	93.6	21.1	1.2	1.9	2.8	29.6	11.3	2.6	164.2	1.64
Medium	2268	96.4	25.3	0.7	0.5	2.6	37.7	7.3	1.2	171.7	1.72
Large	2916	91.7	20.4	1.0	0.5	1.8	24.2	10.9	0.6	151.1	1.51

Source: Field Survey, 1993
20 kattha = 0.68 ha

Table 7.8 Cropping Intensity Index and crop productivity by districts

District	CII	Productivity of the crop (Quintal/ha)					
		Paddy	Wheat	Maize	Millet	Potato	Jute
Sunsari	1.64	15.85	12.75	16.62	11.83	82.14	12.69
Saptari	1.63	21.21	12.67	10.80	12.65	84.26	13.52
Nepal		24.07	14.10	16.25	11.66	87.57	11.41

Source: Field Survey, 1993
CII = Cropping Intensity Index

Table 7.9 Cropping Intensity Index and crop productivity by landholding size

Landholding	Cropping Intensity Index	Productivity of the crop (Quintal/ha)					
		Paddy	Wheat	Maize	Millet	Potato	Jute
Marginal	1.83	21.01	15.25	13.97	12.67	91.35	12.75
Small	1.71	17.85	13.48	13.07	11.70	83.07	12.29
Small-medium	1.64	17.60	12.92	12.44	10.59	87.58	12.61
Medium	1.72	17.16	12.37	13.33	12.94	80.54	13.47
Large	1.51	16.55	11.86	12.79	10.29	75.16	13.53
Average	1.68	18.03	13.18	13.12	11.64	83.54	12.93

Source: Field Survey, 1993

7.2 Livestock rearing

Livestock production is an integral part of the local subsistence economy in rural areas of the country. Farmers, especially in the *terai*, need livestock to plough their fields and to pull bullock-carts which are the only means of carrying loads on rural dirt roads (Figure 7.1), to provide dairy products for household needs, to produce manure for fertilizer and as security, since animals can be sold in times of need. Crop by-products can be utilized to feed the animals. The interdependence of crop farming and livestock raising is an important feature of the Nepalese rural economy, particularly in the *terai*.

In the villages around Koshi Tappu, 96.87 per cent of households who practice farming also raise livestock. Households which do not have farmland raise livestock as their main means of livelihood. The area around Koshi Tappu is relatively important in terms of livestock rearing because one fifth of the population, belonging to the Yadav caste, are traditional cow-herders (Majupuria, 1991).

7.2.1 Livestock species

Cattle were raised by 87.5 per cent of households representing all religions and Hindu castes from all the villages. Male cattle or oxen are used to plough fields

and to pull bullock-carts, and are maintained only by farm holders, whereas cows are kept by most people for milk, manure and as a stock. The cow is the national animal and is worshiped by Hindus, hence it is never used for beef.

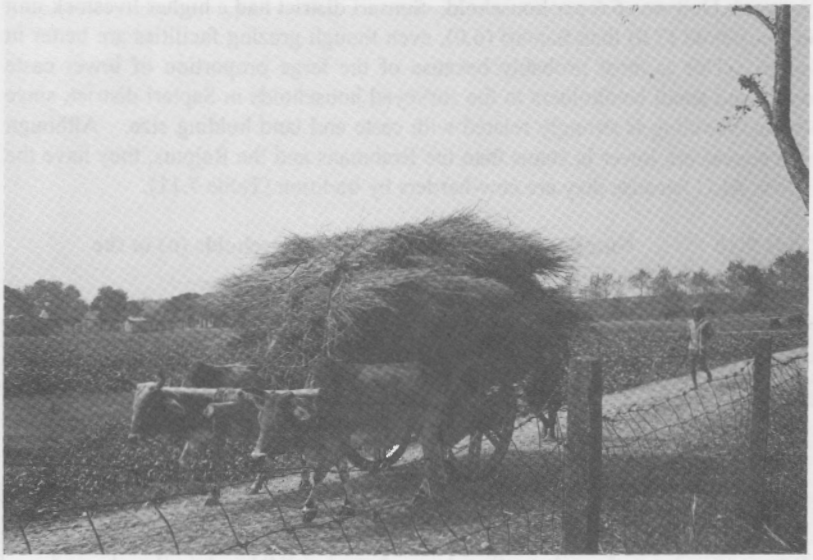


Figure 7.1 **Thatching grass from the reserve being transported by bullock-cart**

Buffaloes and goats were raised by 63 per cent of households. Buffalo are higher cash earning animals and are mostly raised by large landholders and wealthier households. Male buffalo are sometimes used for draft power, but mostly as a source of meat by the migrants from the hills, whereas people of the *terai* community use them as a means of earnings only. The female buffalo is preferred by people in all villages from both communities.

Pigs and poultry are raised by a relatively low proportion of households due to socio-religious reasons. Most Hindus in the area consider chickens and pigs as untouchable. Chickens are raised only by Muslims while people of the *'dom'* Hindu caste may keep pigs. Instead of poultry, pigeons are raised for meat by many Hindu households in the villages of Saptari district.

7.2.2 Livestock herd size

In Nepal, the total number of livestock is estimated at 16.5 million, among which more than 7 million are cattle (CBS, 1994). Religious beliefs, which forbid the slaughter of cattle, and the legal ban on the export of cattle are the main causes of the growing unproductive population of livestock. However, livestock size per household has decreased over the last twenty years, although a tremendous increase in the number of farm families within that period has lead to an absolute increase in livestock number (Gurung, 1987). Table 7.10 shows the number of livestock owned by surveyed households in the villages around Koshi Tappu.

Average livestock unit

The average number of livestock is best expressed in terms of Average Livestock Unit (ALSU). The total Livestock Unit in the country is 7.1 million or 2.75 units per household (Gurung, 1987). In the villages near Koshi Tappu, the Average Livestock Unit was 6.6 per household. Sunsari district had a higher livestock unit per household (7.0) than Saptari (6.0), even though grazing facilities are better in Saptari. This is most probably because of the large proportion of lower caste people and small landholders in the surveyed households in Saptari district, since livestock holding is strongly related with caste and land holding size. Although the Yadavas are lower in status than the Brahmans and the Rajputs, they have the highest ALU because they are cow-herders by tradition (Table 7.11).

Table 7.10 Number of livestock owned by households (n) in the adjoining villages of Koshi Tappu

Livestock	Sunsari (n=88)	Saptari (n=72)	Total (n=160)	Mean (n=160)	Min.	Max
Cattle	459	341	800	5.00	0	40
Buffalo	204	133	337	2.11	0	25
Goats	218	145	363	2.27	0	10
Pigs	5	0	5	0.03	0	3
Chickens	304	28	332	2.08	0	60

Source: Field Survey, 1993

Table 7.11 Distribution of livestock units by caste or religious group

Group	f	Livestock Unit		LISI*
		Average	f_l	
Rajput/Brahman	4.4	7.9	5.3	0.713
Yadavas	21.3	12.4	40.1	0.743
Vaishyas	20.6	7.2	22.5	0.722
Shudras	17.5	2.9	7.7	0.610
Traditional	16.3	4.6	11.4	0.645
Bahun/Newar	8.8	6.3	8.4	0.675
Gurung/Limbu	5.6	2.5	2.2	0.628
Muslims	5.6	2.9	2.4	0.547
Total	100.0		100.0	

Source: Field Survey, 1993

f = Proportion of total households

f_l = Proportion of total livestock

LISI = Livestock size Index

* = Chickens and ducks are not included

Relationship between landholding and livestock herd size

In an agricultural society, wealth is often held in the form of land and livestock (Tulachan, 1985). The number of livestock raised per household showed significant positive correlation with landholding size ($r = 0.7222$; P-value<0.01).

Dhungel (1987), in his study in a village of the *terai*, did not find a distinct correlation between the size of the operational land holding and animal herds, but noticed a pattern in relation to the number of cows and buffalos. The number of cows was found to increase with an increase in size of holdings up to a certain limit, beyond which it starts to decrease, whereas the number of male cattle and buffaloes increases with land holding (Dhungel, 1987). This was attributed to the fact that cows are raised mainly for their manure and beyond a certain limit it becomes more profitable to use chemical fertilizers than to increase the number of cows.

In the Koshi Tappu area, this trend is not evident, most probably because wealthier people are mostly Yadavs who prefer to increase their livestock herd size as far as possible. As a result, the livestock distribution among the households of this area was not uniform but tended to be skewed. The top 10 per cent of the farmers had 26.5 per cent of the total livestock. However, the average livestock unit per unit of farmland was higher among households who have marginal or small landholding (Table 7.12). This reveals that the food requirement of livestock of these farmers has to be fulfilled by sources other than farmland and thus, their dependence on the reserve and nearby wetland vegetation is relatively higher.

Table 7.12 Distribution of livestock unit by landholding size

Landholding size class	f'	Livestock Unit		ALUF*	LISI*
		Average	$f_{l'}$		
Marginal	30.6	2.6	12.1	5.09	0.600
Small	28.8	5.6	24.5	3.34	0.680
Small-Medium	13.8	6.6	13.8	2.40	0.720
Medium	16.9	9.0	23.1	2.18	0.725
Large	10.0	17.4	26.5	1.19	0.760
Total	100.0		100.0		

Source: Field Survey, 1993

f' = Proportion of total households

$f_{l'}$ = Proportion of total livestock

ALUF = Average livestock unit per Bigha of farmland

LISI = Livestock size Index

* = Chickens and ducks are not included

Average Livestock Size Index (ALSI) is used as an indicator of the relative proportion of large-sized livestock to small-sized livestock in a herd. The value of ALSI shows that higher Hindu castes and large landholders prefer to have larger

livestock compared to small landholders of lower caste Hindus and others, who have mostly small-sized livestock. Larger livestock need more initial investment as well as more fodder resources. Regarding large livestock, the number of cattle is higher than buffalo among all and in all sizes of farm holders. Farmers usually keep at least one pair of cattle for farming whereas buffaloes, which need more investment than cattle, are not raised by smaller landholders.

7.2.3 Livestock feeding and grazing

Before the establishment of the wildlife reserve people of this region used to feed their livestock by allowing them to graze freely in the grassland found in what is today the Koshi Tappu reserve. This practice still continues depending on the enforcement of reserve rules and regulations, attitudes of reserve staff, socio-political environment, availability of grass outside the reserve, seasons, climates and agricultural production.

People also graze their livestock outside the reserve. Grazing is always supplemented by stall feeding. The factors related with grazing inside the reserve are discussed in the next chapter. In the following sub-sections, stall feeding, reasons for not practicing stall feeding and grazing outside the reserve are discussed.

a. Livestock grazing

Grazing is considered to be the cheapest way of feeding livestock. Farmers take their livestock to graze at different sites during different seasons. In a typical village of the *terai*, livestock graze on public land and road sides between June and September, on the bounds of the fields during September to December, and in harvested fields from December to June. The trend is different in the villages near Koshi Tappu, where, in addition to these places, about 95 per cent of the households take their livestock to graze either in the grassland or forest of the reserve or in the marshes along the eastern embankment (Figure 7.2).

A 200 to 300 m wide strip of marshes and swampy grassland along the eastern embankment is the main grazing site for livestock from the villages of Madhuban, Kushaha, Shreepur and Haripur. The density of livestock grazing in that area was found to peak in the late afternoon, reaching 6 to 10 livestock units per hectare. The total number of livestock units grazing in that area was estimated at 3,200 animals per day. These figures reflect that the area is not only a grazing site for livestock from adjoining villages but also for those from other villages. From all these villages, 12 - 20 per cent of the households graze their livestock in the swampland inside the reserve, by traversing the eastern embankment when they get an opportunity.

Intensive grazing in the marshes is destroying the habitat of several important bird species and may cause the elimination of vegetation from the marshes within a few years if the grazing pressure is maintained throughout the year at the present level.

Fortunately, the livestock grazing cycle differs for different animals in different seasons. Cattle graze for the whole day, whereas buffalo are taken to graze either

for the whole day or only in the afternoon. Male cattle and calves usually are not grazed with cows in all seasons because male cattle remain busy mostly either ploughing or pulling carts, and very young calves stay in shelters to escape the heat in summer. Some farmers practice a 'zero grazing system' during some parts of the year, particularly during the rainy season, when the animals are stall fed.

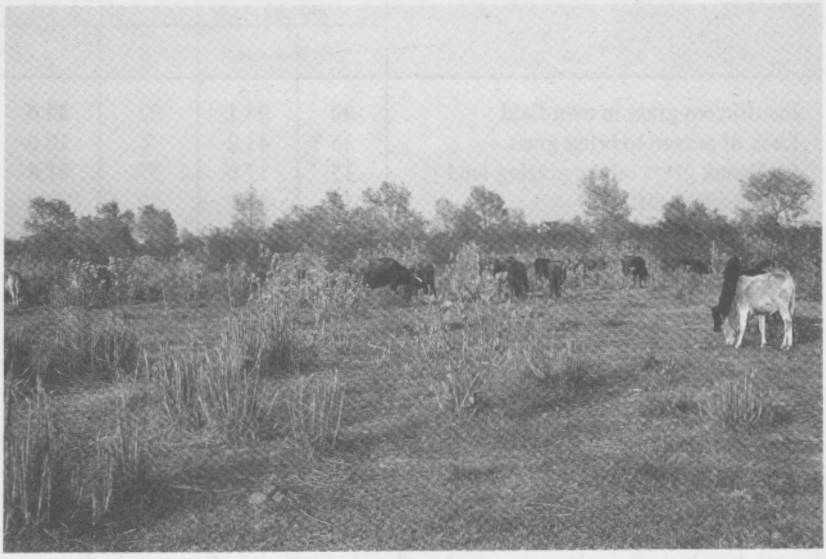


Figure 7.2 Livestock grazing in the marshes along the eastern embankment

Reasons for grazing

The result of a sample survey shows that the availability of inadequate grasses in farmer's fields, and the perception that grazing makes livestock healthy are the main reasons for taking livestock for grazing. The fodder required by the livestock owned by each household is generally greater than the fodder supplying capacity of their farmlands. The practice of agroforestry and the plantation of fodder trees on their farmland is almost non-existent. In fact, grazing is the only way of feeding livestock at a minimum cost (Banerjee, 1982).

Table 7.13 shows that households in Saptari district regard the grassland in the reserve as grazing land. They are allowed to take their livestock to the river which is about one kilometre inside the reserve and take this opportunity to graze their livestock within the reserve area while moving their herds to the river.

b. Stall Feeding

Farmers feed their stall-fed livestock on dried food, notably, the by-products from their crops (Figure 7.3). Of these, straw from rice or wheat is the most important. It is stored in stacks on nearby fields after threshing. At the time of feeding, it is

cut into small pieces and given to the animals, usually mixed with green fodder, oil cakes or bran of the grains. The availability of these food stuffs depends on the production of the crop.

Table 7.13 Reasons given for livestock grazing

Reasons for grazing	Sunsari n'= 85		Saptari n'=70	
	f	f'	f	f'
Insufficient grass in own field	80	94.1	62	88.6
Lack of person to bring grass	35	41.2	7	10.0
Sufficient grass on the grazing land	15	17.6	57	81.4
Stall feeding difficult	11	12.9	49	70.0
Water problem for stall feeding	1	1.2	44	62.8
Grazing makes livestock healthy	78	91.8	58	82.9

Source: Field survey, 1993

n' = No. of households having livestock

f = frequency

f' = Proportion of households having livestock

In the villages near Koshi Tappu, 42 per cent of the households were found practicing stall feeding, but the proportion of stall fed livestock was quite low (Table 7.14). Only 3.6 per cent and 12.2 per cent of the total number of cattle and buffalo respectively were stall-fed in all seasons. Most households stall feed their livestock only in the rainy season when they have plenty of grasses in their own fields and kitchen gardens. Furthermore, since farmers are busy in their paddy fields, they do not have enough time to take their livestock for grazing over long distances during this season.

Table 7.14 Number of livestock and seasons of stall feeding

Seasons	Buffalo			Cattle		
	Number	f'	f_1'	Number	f'	f_1'
Rainy	140	58.8	17.5	41	77.4	12.2
All	98	41.2	12.2	12	22.6	3.6
Total	238	100.0		53	100.0	

Source: Field Survey, 1993

f' = Proportion of livestock species in stall feeding

f_1'= Proportion of total livestock species

In the field survey, some households reported that they were practicing stall feeding in all seasons for all animals, but none of them was found to be cultivating fodder grass. Since, most of them have more than 15 livestock, it is unlikely that such a large herd of livestock could be supported on agricultural residue alone.

The composition of feed given to livestock at stall feeding varies for different animals in different seasons. It consists mostly of green fodder and dried crop residues in different combinations.

Green fodder is made available partly from sources such as fodder trees on their own farmland, public land near the embankments and road sides, and the reserve area, especially during the dry summer and winter. In the wet summer, some farmers, especially in the east of the reserve, plant forage crop such as *janera (Sorghum bicolor)*. These are sown at the end of May or the beginning of June, and are harvested in August. Most of the fields surrounding their homesteads are used for this purpose so that the farmers may collect fodder as they need it over the busy summer.

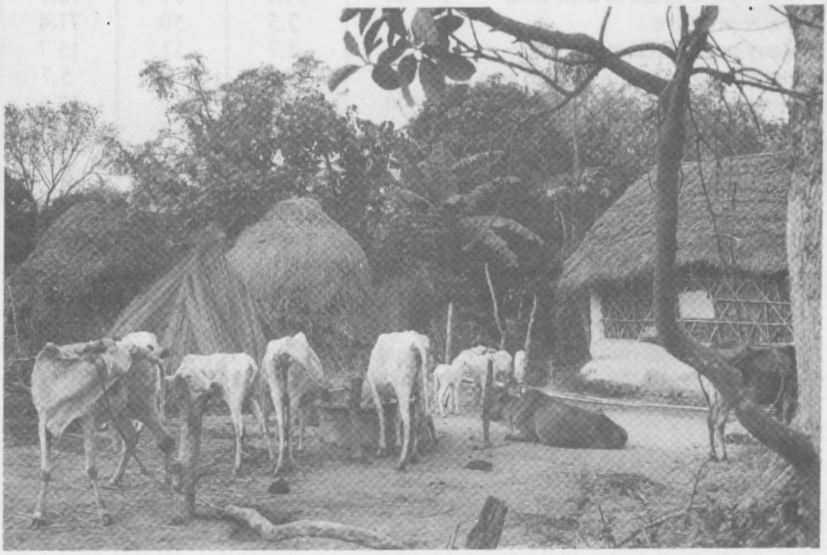


Figure 7.3 Agricultural residue is used to stall feed livestock during the rainy season

Crop residues, which were found to provide 32 percent of the total fodder in the whole country, includes mostly straw, oil cakes, cereal grain and crop by-products, and legume products.

Among the reasons given for stall feeding, the strongest were the restrictions placed on access to the reserve. In the survey, only one percent of the people recognized that over-grazing destroys vegetation. This indicates that people are not aware of the impact of grazing. They do not want to cultivate forage crops in their fields which they consider too small to even grow cereal crops to feed themselves. Thus, they do not practice stall feeding on a large scale.

7.2.4 Problems in livestock rearing

The population of the country has almost doubled over the last three decades. To feed the growing population, more land has been brought under crop cultivation. Since crop farming and animal husbandry are interdependent in rural communities, the increase in the number of farm holders has resulted in an increase in the number of livestock in the country. There has been a corresponding decline in the area of forest and pasture land. As a result, the shortage of animal feed has become the largest constraint in livestock production. Table 7.15 shows the major problems in livestock rearing in the villages around Koshi Tappu.

Table 7.15 Problems of livestock production

Types of problems	Sunsari n'= 85		Saptari n'=70	
	f	f'	f	f'
Vegetation decreasing	81	95.3	22	31.4
Insufficient grass in own field	80	94.1	51	72.9
Water problem	3	3.5	50	71.4
Many unproductive livestock	4	4.7	11	15.7
Livestock not healthy in the area	73	85.9	4	5.7
Unavailability of workers	40	47.11	12	17.1
Unavailability of Vet. Doctor	85	0.0	67	95.7
Unavailability of Market for milk	0	0.0	1	1.4
Not free to take to India to sell	9	10.6	6	8.6

Source: Field Survey, 1993

n' = No. of households with livestock

f = frequency of households

f' = Percentage of households with livestock

It is believed that ruminants get only 54 per cent of their total feed requirements (Joshi, 1990). In the high hills and mountains, where the Government's Pasture Development Programme has been launched, 50 per cent of surplus fodder has been produced (Giri, 1990). The problem of insufficient fodder is however, severe in the middle hills and the *terai* where more than 80 per cent of livestock are raised (Rajbhandari, 1990) and a pasture development program is lacking for this area, as is the distribution of fodder seeds (Gurung, 1987).

Despite the considerable number of livestock per household in the area, no farmer is cultivating fodder grass in their fields apart from *Sorghum bicolor* in the rainy season on relatively small areas. They rely on the vegetation either inside the reserve or outside on public land. However, public grazing land outside the reserve has become limited to road sides, canal banks and the abandoned railway tract because farmers have illegally converted most of the public land, called *aailaini*, to farmland. The Land Act of 1968 clearly states that individuals who encroach upon prohibited public land will be punished. The Land Revenue Act of 1979 states that illegal registration of public land will be cancelled, if discovered. However, in both of these Acts, it is not clear who is responsible and who should appeal in case of any violation of the law (Dhungel, 1987).

Some land use changes to grow more food crops have reduced grazing land area. Field boundaries, which were used for livestock grazing, have been thinned and trimmed so that they serve merely as demarcations between the plots and barriers for the paddy water and can no longer sustain grazing. Similarly, uncultivated fields, which could support grazing for at least four months every winter, are used for wheat cultivation. All this has increased people's dependence on the practice of livestock grazing in the reserve as well as in the marshes along the embankments. However, in the east of the reserve, the marshy land, apart from a 20 to 50 m wide strip between the railway track and the embankment, belongs mostly to private owners and grazing here may be stopped any time.

The next important problem is the non-availability of a veterinary doctor, as a result of which farmers have lost their livestock to diseases. After 1987, when the river changed its course, the land to the east of the embankment became swampy and a large expanse of marshes was created. The health of the livestock which

graze in these marshes has deteriorated continuously over the years because of attacks by the liver fluke *(Fasciola hepatica)* which is transmitted mainly through snails *(Viviparis* sp.) found in these marshes. Fascioliasis, which is caused by this liver fluke, directly or indirectly affects the health negatively and hence the economic value of the ruminant livestock. The symptoms include reduced body weight, growth rate, milk yield, fertility and draught power. At the national level, the costs of drugs, laboratories and research on this disease have been high. It has been estimated that liver fluke infestation causes losses of 80 - 200 million NRs per annum (Thakur, 1990).

Water holes like ponds and rivers are essential for livestock where the animals are bathed. While water in the newly formed marshes is used for various purposes in the east of the reserve, water scarcity is a serious problem in the west. Except for the people in the village of Kamalpur, where an oxbow lake is located near the boundary, the people from the other villages in the west have to rely on the river located inside the reserve as a source of water for their livestock.

7.3 Non-farm activities

7.3.1 Fishing

Fish farming is one of the most important economic activities in the *terai.* However, it is not popular among the communities around Koshi Tappu due to the relative abundance of fish in the Koshi river and associated wetlands. This activity remains mostly limited to capture fisheries, practiced mainly by traditional fishermen.

In the villages near the wildlife reserve, a detailed survey of fishing households was conducted by Heinen (1993b). Fishing was found to be the major occupation of about 132 households, with 191 fishermen belonging to the fishermen caste, called *mallah* (Table 7.16). About 90 per cent of these households were landless, compared with 26.9 per cent of the households in the region as a whole, and even the landholdings of those fishermen with land were very small in comparison to others in the area. These households had a total population of 728 people, of which the female members were mainly responsible for selling the fish in local markets.

Table 7.16 Fishing households around Koshi Tappu

Characters	Sunsari	Saptari	Total
Number of households	92	41	132
Total household members	135	56	191
Number of Fishermen	532	96	728
Number of households with land	4	10	14
Number of households with livestock	11	7	11
Number of households with land and livestock	2	7	9
Number of households dependent on fishing	85	30	115

Source: Heinen, 1993b

Despite the ban on fishing inside the reserve, it is commonly practiced in the Trijuga river and Kamalpur Dah in the west, and in the Koshi river near the village of Haripur, located near the south-east corner of the wildlife reserve. Outside the reserve, fishing is most common in the area near the Barrage as well

in the seepage stream and marshes on the east of the reserve (Figure 7.4).

Some parts of the privately owned seepage stream and marshes are leased by local fishermen at the rate of 2,500 NR/year/acre (Suwal, 1993). One fisherman can catch 2-4 kg of fish per day which is sold in the local market. The most common method of fishing in Koshi Tappu region is by using nets and baskets. A detailed account of fishing methods in the Koshi Tappu region is found in WMI/IUCN-Nepal (1994).

Cast nets, locally called *Guttijal ar Chantijal,* are most commonly used for catching fish in the rivers and oxbow lakes. Based on the mesh size, there are three types of such nets, such as: i) Adhakharijal (mesh size 1 cm x 1 cm), ii) Jangarijal (3.8 cm x 3.8 cm, and iii) Sakhajal (8 cm x 8 cm). Furthermore, the gill net, locally known as *mahajaal*, is also used near the Koshi Barrage. It is placed in the river overnight and the fish are collected the following morning. Four types of gill net are commonly used. Those are as follows:

	length	breadth	meshsize
i) Madorjal	12 m	1.0-1.5 m	1.2 cm x 1.2 cm
ii) Patajal	16 m	1.5-2.0 m	3.8 cm x 3.8 cm
iii) Mahajal	25 m	6.0-8.0 m	3.8 cm x 3.8 cm
iv) Tiyari	varies	vaires	
a) Pachauna	""	""	7.5 cm x 7.5 cm
b) Satauna	""	""	12.5cm x 12.5 cm

In addition, Dragnets, also called *tunnijal*,which is 10 to 12 m long and 1.5 to 2 m wide with small mesh size, are used at a time starting from different corners and dragging the nets slowly towards the centre. Near the Koshi Barrage, a kind of Scoopnet, called *chatijal*, with long handle and triangular in shape is mostly used.

In the marshes, where the water is not so deep, *chhanki* or *chauki jal*, which is prepared with the help of two long bamboo flanks and a square nylon net, is commonly used. In the seepage stream, where the current of water is low, several types of baskets are placed to collect fish.

Other fishing devises, used in the Koshi Tappu region are rod and line (*banshi*), *sohat*, *chanch* and d*hasa*. A *bansi* has a simple rod and a line with one hook or many hooks, each attached at the tip of nylon threads which remain tided with a column of nylone rope. This devise is very common and is used all year around. A *sohat*, which is approximately 3-5 m long and is made up of bamboo with nine spikes, each with a pointed and curved hook at the tip, is used to kill big fishes after rainy season when volume of water decreases. *Chanch*, a 10-12 long and 1 m wide screeen type trap, is made up of the stem of Kans (*Saccharum spontaneum*). It is commonly used in the side channels of main rivers, where it is set across at night vertically with the help of poles, and in the morning, it is pushed from both ends to encircle the trapped fishes at the center. *Dhasa* is also made up of stem of Kans (*S. spontaneum*), and is used at the point where water falls from the higher level.

Other methods are poisoning, spearing and hand picking. The use of poison for fishing was obseved in wetlands in other parts of the country also (*Pers. observation*; BPP, 1995b). Fishes living in shallow marshes or mud burrows are simply cought by hands.

Figure 7.4 **Restrictions on fishing within the reserve have increased pressure on the wetlands along the eastern embankment**

According to local fishermen, the stock of fish in the Koshi river has decreased over the years. Over population of fisherman, use of harmful fishing mehtods like bombing and poisoning, use of small mesh sized nets and traps, obstruction in up and down migration of fishes biy the Koshi Barrage, siltation and diseases are the main reasons of the depletion of fish populatio (WMI/IUCN-Nepal, 1994). As a result, the fishermen can no longer depend solely on fishing for their livelihood and many are gradually changing their occupation. Some of them have started livestock rearing.

7.3.2 Cottage industries

Very few people in this area are engaged in cottage industries. There are 26 rice mills in the villages around Koshi Tappu. The traditional Hindu castes are engaged in mat weaving from reeds and cattails. However, people are not allowed to collect them from the reserve area except for a 15 day period during the last week of January. They either cut the reeds and cattails from the reserve illegally for the remaining part of the year or depend on the swamps around Kamalpur Dah and marshes on the east of the reserve. The mats are sold in the local market. In addition, some households are engaged in tailoring and in making earthen pots and furniture

There was no government sponsored programme in the area to promote this type of cottage industry before Park-people project, which has recently been lauched in the protected areas of the *terai* under the concept of buffer zone management and is planning to encourage the local people to be engaged in different cottage industries in order to improve their economic conditions. Before before initiating any programme, an extensive study is necessary to explore the current status of cottage industries, their contribution to the household income and their development potential.

7.3.3 Employment in public/private sector

Only 2.7 per cent of the economically active population were found employed, of which 1.35 per cent were in government and 1.35 per cent in the private enterprises. Most of the employees of government institutions that are present in this region do not come from the local villages. Even in the office of the wildlife reserve, 60 per cent are employed from outside the region. Similarly, it was found that in a primary school in the village of Odraha, not a single teacher comes from the village itself. A sample survey also showed that most people with educational levels of secondary school or above are unemployed. This situation further discourages the local people to educate their children.

7.4 Household income

The main sources of income in this area are farming and livestock production. The proportion of non-farm generated income is high among the smaller landholders. Figure 7.5 below shows the distribution of the population in different income groups.

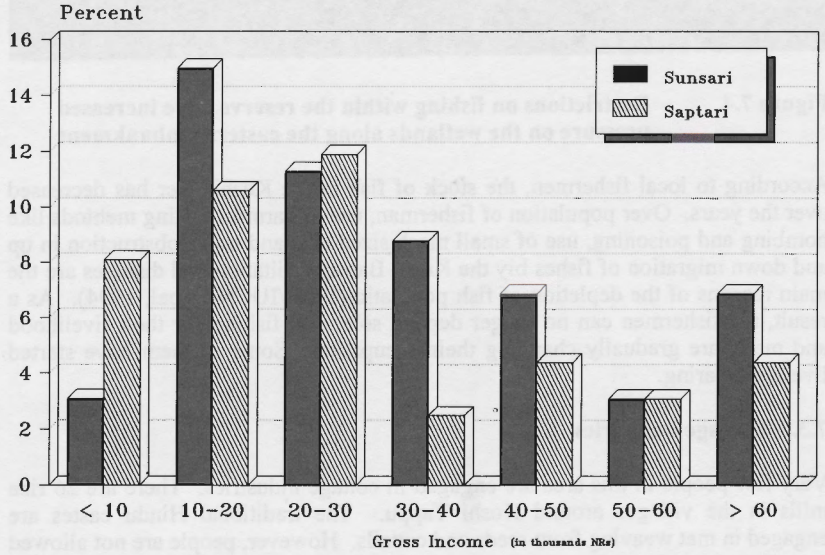


Figure 7.5 Proportion of households in different income groups

7.4.1 Farm income

While farming is the main economic activity in the area, most of the farmers consider their agricultural production low and unsatisfactory. In the survey, people were reluctant to talk about their income from agriculture and complained that they did not have much crop production because of the damage caused to their crops by the wild water buffalo.

The average annual gross income from agriculture was estimated at about 20,686 NRs per household, but this was not evenly distributed amongst the households. The farm incomes of large landholders were about 16 times more than those of marginal landholders. An analysis of east-west differences showed that household income per annum is higher in the villages of Sunsari district owing to the large landholding of the households (Table 7.17).

As the average landholding size increases according to the status of Hindus, it is more likely that the Rajput and the Brahman households would have higher incomes from agriculture than others. The households with lowest incomes belong to the Shudra caste, two third of whom are either landless or have marginal landholding (Table 7.18). Thapa and Weber (1990) opined that the farm income of large landholders in villages of the middle hills is also higher because they hold better quality land. However, in this area, the land quality index does not differ much among the different sized landholders.

Despite the variation in income, very few households (18.6 per cent) were found to sell their surplus crop products for cash, and most of them had crop-production below subsistence level. Hence, about two-thirds of the households were in debt, having borrowed money from neighbors, relatives and government enterprises.

7.4.2 Income from livestock

Livestock may be regarded as a savings account and their products as interest earned on that account. The income from livestock varies greatly according to the livestock size unit per household. The top 10 per cent of the families surveyed, mostly belonging to the Yadavas, received 47 per cent of the total income from livestock. Despite their relatively larger landholding, among the Hindus the Rajput and the Brahman households had lower incomes from livestock than the Yadavs, while the Shudra Hindus and the Muslim households received the least income from livestock.

Livestock contributes 20 per cent of the total income of these households whereas the national average of earnings from livestock is 23 - 30 per cent of household income (Shah, 1980). This indicates that the livestock in this area are relatively less productive. All the households encountered in the survey were found to be rearing only local breeds of livestock which are not as productive as hybrids. It seems that the government's livestock breed improvement program has not been successful in this area.

According to key informants, Jersey cows were distributed in other parts of these districts but they did not survive long. It is believed that the *terai* is not suitable for them (Gurung, 1987). Yazman and Oli (1990) have pointed out that livestock with greater than 25 per cent exotic breeding may not survive in production systems based on low quality feed and scavenging. Scarcity of fodder and fascioliasis might be other factors responsible for the lower productivity of the livestock. However, detailed studies may highlight specific issues and help develop strategies to improve livestock production together with the wise use of the wetlands.

7.4.3 Non-farm income

Besides farming and livestock production, the other major sources of income of the households are wage labor, business, the institutional employment, cottage industries and fishing. In this area, the most common way to earn a living is to work as a wage laborer. This includes the labor force working in agriculture as well. It was difficult to estimate the real non-farm income from wage laborers. However, young members of about 13 per cent of the households, belonging mostly to marginal and small landholders of lower castes, were found going to the states of Punjab and Assam in India to work, and earn 8,000 to 15,000 NRs. per person over 4-6 months each year. Based on this, it was estimated that 16.51 per cent of the total non-farm income or 43.98 per cent of the income from wage labor was due to labor export. This explains why non-farm activities contribute 60.7

Table 7.17 Household gross income (NRs) from different sources by district and land holding

Sources	District		Landholding size				
	Sunsari	Saptari	Marginal	Small	Small-medium	Mediu	Large
Cereal Crops							
Paddy	15,269	14,162	2,749	9,566	16,236	23,859	49,202
Wheat	2,160	2,489	487	1,491	2,484	2,069	7,016
Maize	441	79	260	478	118	98	281
Millet	55	147	47	68	234	80	168
Sub-total	17,925	16,877	3,543	11,603	19,072	26,106	56,667
Non-cereal crops							
Potato	1,375	802	326	818	1,424	2,025	2,445
Oilseeds	717	491	102	403	668	1,257	1,644
Jute	1,011	716	41	259	1,255	1,268	4,047
Vegetables	305	151	140	170	360	359	335
Sub-total	3,408	2,160	609	1,650	3,707	4,909	8,471
Fruit selling	506	242	86	176	491	774	1,119
Total farm income	21,839	19,279	4,238	13,429	23,270	31,789	66,257
Livestock							
Milk products	1,466	1,512	449	987	1,950	2,629	3,538
Livestock selling	2,297	2,707	972	1,967	2,295	3,000	7,963
Sub-total	3,763	4,219	1,421	2,954	4,245	5,629	11,501
Non-farm sources							
Fishing	102	667	1,000	174	0	0	0
Business	1,551	3,931	1,684	413	3,545	3,815	8,563
Cott. Industry	159	403	286	457	0	0	500
Service	4,602	806	735	913	8,864	5,370	2,813
Wage labor	4,795	3,139	4,857	5,728	3,682	1,630	1,344
Remittance & others	977	139	204	543	591	889	625
Sub-total	12,186	9,085	8,766	8,228	16,682	11,704	13,845
Total Gross Income	37,788	32,583	14,425	24,611	44,197	49,122	91,603

source: Field Survey, 1993
1 $ = 49 NRs

Table 7.18 Household gross income (NRs) from different sources by social/religious groups

Sources	Caste/Religious groups							
	Rajput/ Brahman	Yadav	Vaishya	Shudra	Tribal	Bahun/ Newar	Gurung/ Limbu	Muslim
Cereal Crops								
Paddy	26,240	23,616	19,490	4,532	11,553	16,410	3,134	5,372
Wheat	3,700	3,499	3,593	793	1,928	1,734	420	600
Maize	0	0	85	164	148	1,373	1,179	378
Millet	0	82	100	146	91	154	27	53
Sub-total	29,940	27,197	23,268	5,635	13,720	19,671	4,760	6,403
Non-cereals								
Potato	2,478	1,424	1,530	382	750	2,030	213	213
Oilseeds	1,277	1,129	658	107	600	610	20	233
Jute	1,433	1,348	1,838	118	231	907	67	156
Vegetables	496	248	261	88	367	197	107	158
Sub-total	5,684	4,148	4,287	695	1,948	3,744	407	760
Fruit selling	571	556	406	71	300	986	44	178
Total farm income	36,195	31,902	27,960	6,402	15,968	24,401	5,211	7,341
Livestock								
Milk product	857	3,911	1,939	143	846	171	333	389
Livestock selling	943	5,624	2,782	472	2,096	1,279	1,722	700
Sub-total	1,800	9,535	4,721	615	2,942	1,450	2,055	1,089
Non-farm								
Fishing	0	118	0	1,714	0	0	556	0
Business	2,000	1,324	6,364	1,429	1,827	1,786	444	3,778
Cot. Industry	0	0	879	0	0	0	1,556	0
Services	6,429	1,853	4,970	714	1,769	7,857	1,667	0
Wage Labor	0	1,706	3,970	5,179	6,558	3,785	5,000	5,055
Remittance & others	857	676	955	125	385	857	0	1,111
Sub-total	9,286	5,677	17,138	9,161	10,539	14,285	9,223	9,944
Total Gross Income	47,281	47,114	49,819	16,178	29,449	40,136	16,489	18,374

source: Field Survey, 1993.
1 $ = 49 NRs

per cent of the total income in those households which are either landless or have marginal landholding.

The Vaishyas, who are traditionally business people, have the highest incomes from business and are usually engaged in the business of household commodities. Very few of the households (2.7 per cent), which had better education and had the opportunity to get jobs in government or non-government enterprises, were receiving income from employment in the public sector. Public sector contribution in total household income ranged from 3.07 to 19.6 per cent. The income from cottage industries was mainly available to the households of the occupational castes, such as the Damai and the Kumhale, and its contribution to total household income was very low.

All the incomes expressed above are gross incomes. Since people have to reinvest part of this income in various activities, especially farming, livestock production, and cottage industries, they utilize only part of it for household consumption and to fulfill other necessities. In order to formulate strategies to improve the economic conditions of the people, detailed cost-benefit analysis of certain activities, such as farming, livestock production and some alternative economic activities, are necessary.

As a whole, the economic condition of the people in these villages cannot be considered satisfactory. The major economic activities are wetland resource based and, as a result, they exploit wetland resources such as vegetation and fish, from both inside and outside the reserve. Thus, the availability of resources inside the reserve and access to these resources plays an important role in their economy, and subsequently influences their attitude towards the wildlife reserve.

CHAPTER 8

UTILIZATION AND CONSERVATION OF WETLAND RESOURCES

Most people in the vicinity of Koshi Tappu live at subsistence level. Their main source of income is farming which is usually supplemented by the use of wetland resources. Since the declaration of a part of Koshi Tappu as wildlife reserve in 1976, a number of conflicts have arisen between the local people and the reserve authorities over the utilization of these resources. This, in turn, has affected the wetlands as well as the local economy and is reflected in people's attitudes towards conservation of the wetlands.

Households that benefit from the presence of the wetlands are more likely to be positive towards conservation than those which do not (Infield, 1988). It is believed that the use of natural resources by people would have a corresponding influence on their perception and attitude towards the conservation of these resources.

8.1 Use of wetland vegetation

People living in nearby villages depend on the reserve's vegetation for energy, fodder, livestock grazing, building materials and other products (Appendix 8.1). Table 8.1 shows the proportion of households using the vegetation inside the reserve for different purposes.

Table 8.1 Number of households in two districts using vegetation inside the reserve for different purposes

District	Types of Resource use					VRUI
	Fuel	Fodder	Grazing	Building materials	Other products	
Sunsari n=88	31 (35.2)	58 (65.9)	50 (56.8)	64 (72.7)	13 (14.8)	0.4908
Saptari n=72	63 (87.5)	68 (94.4)	66 (91.7)	71 (98.6)	45 (62.5)	0.8694

Source: Field Survey, 1993

VRUI = Vegetation Resource Utilization Index

Figures in parentheses represents the percentage

The higher value of Vegetation Resource Utilization Index indicates that more people in the west (Saptari district) use vegetation inside the reserve than those in the east (Sunsari district) because the reserve area is more easily accessible to them. This has resulted in a relatively greater amount of vegetation being utilized per household in the west (Table 8.2).

The marginal landholders and small landholders constitute the majority of the communities who use vegetation for different purposes (Table 8.3). Since they have no alternatives, they enter the reserve to extract vegetation for different

purposes with the knowledge that they risk being penalized for undertaking illegal activities.

Table 8.2 Utilization of vegetation resources by households in different districts

Land holding size	f'	Fuel		Fodder		Thatch grass	
		t/HH	%	t/HH	%	L/HH*	%
Sunsari	55.0	0.7	29.6	5.0	40.9	64.8	47.5
Saptari	45.0	2.1	70.4	6.0	59.1	87.5	52.3

Source: Field Survey, 1993

f' = Fraction of total population; * load per Household

Table 8.3 Number of households using vegetation inside the reserve for different purposes by landholding size

Land holding size	Types of Resource use					VRUI
	Fuel	Fodder	Grazing	Building materials	Other products	
Marginal	42	38	35	44	29	0.7672
n=49	(85.7)	(77.5)	(71.4)	(89.8)	(59.7)	
Small	27	34	27	38	18	0.6274
n=46	(58.7)	(73.9)	(58.7)	(82.6)	(39.8)	
Small-med.	9	17	16	20	5	0.6180
n=22	(40.9)	(77.3)	(77.2)	(90.9)	(22.7)	
Medium	11	21	19	20	5	0.5630
n=27	(40.7)	(77.8)	(70.4)	(74.1)	(18.5)	
Large	5	14	12	13	1	0.5625
n=16	(31.3)	(87.5)	(75.0)	(81.2)	(6.3)	

Source: Field Survey, 1993

VRUI = Vegetation Resource Utilization Index

Figures in parentheses represents percentage of households

The amount of vegetation extracted per household by the marginal and small landholders is not usually as high as that used by the large landholders (Table 8.4). However, the marginal and small landholders use greater amounts of vegetation for fuelwood in comparison to the wealthier people. The extraction of vegetation for fodder is higher among large landholders who raise large herds of livestock. The use of vegetation for thatch grass is more or less the same for all the groups because it is equally essential to all members of the local communities.

Table 8.4 Utilization of vegetation resources by households with different landholding size

Land holding size	f'	Fuel		Fodder		Thatch grass*	
		t/HH	%	t/HH	%	L/HH	%
Marginal	30.6	2.36	52.44	4.9	24.82	74.5	30.39
Small	28.8	1.15	23.96	5.2	27.86	71.6	27.42
Small-medium	13.8	0.93	8.86	5.3	13.60	82.7	15.15
Medium	16.8	0.92	11.30	6.1	18.97	70.1	15.76
Large	10.0	0.47	3.44	7.9	14.74	84.7	11.28

Source: Field Survey, 1993

f' = Percentage of total population

* = Load per household

8.1.1 Vegetation as a source of energy

From the above discussions, it is apparent that the dependence of the people on vegetation varies according to the use it is put to.

In the villages adjacent to the Koshi Tappu, fuelwood, crop residues, animal dung, kerosene and electricity provide the sources of energy for cooking and lighting. Kerosene is used by virtually all households for lighting purposes. Electricity is limited to the villages of Prakashpur and Madhuban. For cooking, villagers use fuelwood, crop residues and animal dung in different proportions.

The traditional source of fuelwood in this area has been the riverine forest, but with a depletion of the forest area by 3.2 per cent per annum over the last twenty years since 1959, fuelwood has become scarce. Fuelwood collection was prohibited after the declaration of the area as a wildlife reserve. In recent years, there has been a severe fuelwood shortage throughout the region. Indeed, the Himalayan region as a whole, of which Nepal is a part, was categorized by FAO in 1980 as an `acute scarcity zone' for fuelwood (Eckholm *et al.*, 1984), where the over-cutting of wood has been one of the major causes of forest degradation (HMG, 1988c) with 90 per cent of the forest resources being extracted in the form of fuelwood (Rajbhandari, 1990).

Because of the fuelwood shortage, people in this region use mostly `*dhadhi*', animal dung and crop residues mixed in different proportion during different seasons. *Dhadhi* comprises dry weeds, dry minor woody products and climbers. Despite the legal ban on the extraction of any kind of wood, `*dhadhi*' is used by most of the households. Woody products of the forest constitute a low proportion of the total extracted fuelwood because of the risk of being penalized. Several studies have shown that in a wood scarce area, people tend to use more agricultural residues (Eckholm *et al.*, 1984; IDS, 1987) and *dhadhi* (mostly weed stalks), also called *jhikhra* (Sharma, 1991) rather than the fuelwood. In fact, the

ratio of fuelwood to other resources may be 1:1 (Mahat *et al.*, 1987). Sometimes permission for `*dhadhi*' collection is given by the local authority. However, for the greater part, people enter the reserve illegally.

a. Fuelwood consumption and supply

Although no study has been undertaken on fuelwood requirements in the area, the average value of 354 kg/capita/per year for the *terai* (Shah *et al.*, 1991) has been adopted for this area. From this, the fuelwood requirement per household has been calculated as 2.4 mt/year. Extraction of fuelwood/*dhadhi* from Koshi Tappu was found to be 1.4 mt/household/year. Thus, on an average, each household has to meet a deficit of 44 per cent from other sources. At the national level, fuelwood constitutes 78.84 per cent of the total household energy consumption (CBS, 1991).

The use of fuelwood/*dhadhi* is not the same for all the households. People in the west of the reserve use more fuelwood/*dhadhi* (70.4 per cent) in comparison to those in the east (29.6 per cent) because the area is easily accessible to them. It was also found that poor people extracted 95 per cent of their needs from the vegetation in the reserve. The proportional deficit was higher in wealthier households. As there is no other alternative source of fuelwood, it is likely that most of the households use animal dung and crop residue to meet their deficit.

b. Conflicts in using fuelwood

Use of the ordinary mud stove

Despite its scarcity, all the households use fuelwood for cooking on ordinary '*chulo*' (mud stove) which have 15 per cent fuel efficiency (Sharma, 1991). Only 2.4 per cent of the households were found to be using improved ovens, and 18.8 per cent of these occasionally used kerosene (Table 8.5). The use of kerosene for cooking is limited because it is relatively expensive. An improved stove, which could save up to 50 per cent of fuel wood compared to the conventional *chulo*, is used at a household's own initiative and there is no program or project in the area for the promotion of its use.

Table 8.5 Number of households using different types of cooking devices

District	Types of Oven		
	Ordinary Chulo	Improved Chulo	Kerosene stove
Sunsari (n=88)	88 (100.0)	2 (2.27)	25 (28.41)
Saptari (n=72)	72 (100.0)	2 (2.78)	5 (6.94)

Source: Field Survey, 1993

Figures in parenthesis represent per cent of total population.

Restrictions on the collection of driftwood

Conflicts arise not only because of the ban on the extraction of fuelwood/*dhadhi* from the reserve but also because people have been denied the right to collect driftwood within the reserve area. The Koshi river carries a large amount of driftwood from upstream, mostly during the monsoon, which used to be collected by the people in that region prior to the establishment of the wildlife reserve. Since the prohibition of this activity inside the reserve, the driftwood either travels further downstream, where people living near the Nepalese-Indian border collect it or it gets deposited on the floodplain (Figure 8.1), where it decomposes over time.

Data on the total amount of driftwood is lacking. Just after the major flood in 1987, Heinen (1993b) estimated the quantity of partially collected driftwood at 1,000 tones at a total value of about $4700. In the same year, local people were given permission by the warden to collect driftwood from the reserve area for a few weeks following the monsoon floods. This was only a temporary arrangement to compensate for the loss of people's property in the flood and the practice has never been repeated. Only recently, the regulation has been passed that drift wood can be collected and used by the people within the buffer zone (HMG, 1996).

Figure 8.1 Driftwood on the floodplain

Utilization of fuelwood by Government officials

It is noteworthy that while people are denied access to these resources, reserve staff and the soldiers posted to protect the area from poaching and other illegal

activities, use fuelwood resources from the reserve regularly. The number of soldiers at all the posts varies between 240 to 300. Based on the average per capita requirement of fuelwood in the *terai*, they would normally consume 110 tones of fuelwood per annum. Moreover, if the amounts observed collected in February 1993 were an indication of levels amassed throughout the year, the total consumption would exceed actual requirements.

At the national level, in addition to the pressure on natural resources, military protection unit consumes up to 70 per cent of the budget of the Department of National Parks and Wildlife Conservation (DNPWC). Thus, the role of the army in protected area management needs to be reviewed (Lucas and Bajimaya, 1987; Sharma, 1991 and Heinen and Kattel, 1992a). However, it may be noted that a positive impact of the army's presence in the surrounding community is reflected by the absence of robberies in the area, which were previously frequent.

c. Impact of fuelwood shortage

Because of fuelwood shortage, the local villagers use agricultural residues and animal dung. These cannot be considered sound alternatives since their use as fuel reduces the utilization of organic manure in the fields, resulting in a decline in agricultural productivity, which is already at subsistence level (Sah, 1993a; WMI/IUCN-Nepal, 1994). The loss of crop productivity due to burning of dung could be about 10% per tone of deficit of fuelwood (Sherchan, 1989). The fuelwood problem is one of the major reasons for the negative attitude of the locals towards the wildlife reserve.

The smoke from low quality wood used in making *dhadhi*, especially that emitted from burning *Ipomoea* sp., is carcinogenic and the use of inefficient cooking stoves increases the magnitude of the effect.

8.1.2 Livestock grazing inside the reserve

Livestock rearing is an integral part of the local economy. Since all areas around the reserve are over-grazed, there are no alternative pastures that are readily accessible. The only available grazing area lies within the reserve. Since livestock grazing within the reserve is banned, livestock have been caught by the reserve staff on several occasions, and the owners are penalized. Livestock grazing inside the reserve not only causes wildlife habitat degradation but is also one of the major causes of increasing tension between local people and the reserve staff.

a. Types of grazing

Livestock grazing is practiced inside the reserve throughout the year by most of the livestock holders. Several factors such as seasons, floods, livestock herd size, enforcement of law and order by reserve authorities, socio-political stability etc. affect the grazing intensity and cycle within the reserve. Three types of grazing are identified, namely, permanent, regular and occasional grazing.

Permanent grazing

A number of livestock are left inside the reserve permanently (Figure 8.2) by the large livestock owners who mostly belong to the Yadav caste. About 50 households own over 10,000 to 12,000 large livestock (cattle and buffalo) between them. Each household has no less than 100 animals and some have more than 500 animals. They are mostly from different villages of Sunsari and Saptari districts (Table 8.6), which may be located several kilometers from the reserve. Some of their relatives from India also have cattle inside the reserve. Usually, livestock owners appoint herders to look after the cattle and buffaloes. A team of herders may take responsibility of livestock from different owners. In addition to monthly wages, herders are entitled to a portion of the milk while the calves remain the property of the owners.

The number of cattle inside the reserve was estimated at 7,000 in 1988 (Heinen, 1993b). Following the democracy movement in 1990, these numbers grew as public and political pressure resulted in a breakdown of law enforcement, particularly with regard to public use of reserve land. Although the number, estimated by authorities and researchers vary, it ranges between 7,000 and 15,000 (Heinen, 1993a; Sah, 1993a; Suwal, 1993; WMI/IUCN-Nepal, 1994; Kherwar, 1996). Besides the abundance of grass inside the reserve, another motive for the livestock owners to keep their buffalo within the reserve is that they prefer to cross-breed them with the wild population. Hybrids fetch a high price in the market, especially in India. A second year hybrid of wild and domestic buffalo may be valued at up to 20,000 Indian Rupees, i.e., 50 - 80 per cent more than an ordinary buffalo.

Figure 8.2 **Wildlife reserve or grazing land? Domestic animals graze freely inside the reserve**

Table 8.6 Households with large livestock herd size (More than 100 livestock units)

Villages	No. of HH	No. of Livestock
Sunsari		
Bhokraha	1	200- 250
Haripur	3	450- 550
Joginia	1	200- 250
Madhuban	1	100- 125
Narsingha-Tappu	1	250- 300
Shreepur-Jabdi	6	1000-1200
Saptari		
Badgama	2	400- 500
Bairwa	1	125- 150
Dhanpuri	2	1200-1500
Kanchanpur	1	100- 125
Lohjara	1	125- 150
India	1	400- 450
Total	21	4500-5500

Source: Field survey, 1993

Regular grazing

Households take their livestock inside the reserve at least five days a week all year round, except during the rainy season. Regular livestock grazing is practiced by most of the households of the adjoining villages in the west and by a few of the villages in Sunsari.

Based on livestock holding per household and the proportion of households taking their livestock inside the reserve (Table 8.7), the total number of livestock grazing regularly was estimated at 15,000 to 17,000 from villages in the west and 3,200 from those in the east and north. During the rainy season, only some of the households take their livestock inside the reserve because of floods in the river and because grass is available in their own fields.

Occasional grazing

The strictness of the reserve staff and soldiers, and the frequency of their patrols to any parts of the region determines to some extent the pattern of grazing. About 26.1% of households practices occasional grazing on the eastern side, where grazing land inside the reserve is limited to the area between the Koshi river and the eastern embankment. The frequency of patrols by reserve staff and soldiers in this area is high because the headquarters are located in the vicinity.

Table 8.7 Households taking their livestock regularly inside the reserve during different seasons

District	Livestock Unit per Household	Seasons		
		Summer	Rainy	Winter
Sunsari (n = 88)	7.0	9 (10.2)	-	12 (13.6)
Saptari (n = 72)	6.0	66 (91.7)	57 (79.2)	66 (91.7)

Source: Field Survey, 1993

b. Conflicts from livestock grazing

Livestock grazing is one of the major issues generating conflicts between local people and the management of the reserve. Soldiers spend much of their time impounding illegally grazing livestock and presenting the owners for prosecution. However, the efforts made by guard posts to keep their command areas free of livestock varies considerably. Whatever may be the reason, but Sharma (1996) opined that authorities are protecting the domestic cattle and assisting the herdsmen. One reason might be their sympathy towards people who have no alternatives. The view of soldiers in Koshi Tappu concerning grazing is similar to that expressed by soldiers in Chitwan National Park and quoted by Sharma (1991):

> *"The problem lies in policy, and the policy makers expect us to implement an impossible task. If they do not become a little sympathetic to their problem how can we see a cow starve to death."*

The presence of a large livestock herd permanently inside Koshi Tappu wildlife reserve has resulted in the following conflicts:

Penalty discriminations

Livestock inside the park are occasionally impounded by reserve staff and fines are imposed on owners (Figure 8.3). One problem is that there is no fixed charge or fine for any particular activity. In Chitwan National Park, penalty rates for illegal livestock grazing and collecting of firewood in the park are NRs 25 per head and NRs 60 per person respectively (Sharma, 1991), but in Koshi Tappu, it depends solely on the staff's discretion. Usually, larger landholders have to pay more, even up to 500 NRs per livestock. As a result, they try to compensate their loss by exploiting more resources from the reserve. It may be the reason why WMI/IUCN-Nepal (1994) recognized unjust penalty as one of major conflict in the use of resources in Koshi Tappu.

Figure 8.3 **Domestic animals are occasionally captured by reserve personnel**

Effect on the livelihood of poor households

The level of strictness on livestock grazing affects the economy of the people, both poor and rich. The presence of such a large number of livestock inside the reserve has provided employment not only to those people who are employed to look after the herd of livestock, but also to about 500 people who collect dry dung from inside the reserve as a means of livelihood over a period of eight months (Figure 8.4). In 1993, each of these collectors was able to earn 8 to 12 NRs per day by selling this dung in the nearby Indian market. Since 75 per cent of the economically active members of each household were engaged in this practice, the average earning per household per annum was estimated at 6,000 to 7,000 NRs and was equivalent to a total earning of 1.4 million NRs per annum.

Access to water resources inside the reserve

The Mariya river in the western part of the reserve is the only source of water for livestock in the west. Hence, although the use of water resources inside the reserve is legally prohibited, people take their livestock to the river, making use of the opportunity to graze them on the land between the reserve boundary and the river. Recently, it has been recognized as a problem around all the parks and reserves. In response, a regulation has been passed that domesticated animals can be taken to the water resources in the buffer zone (HMG, 1996). But, in the Koshi Tappu reserve, it is most unlikely that Mariya dhar will be the part of buffer zone

within the present framework, and thus, the problem seems to be continued in future.

Competition for food and shelter

Due to the presence of a large number of livestock, wild animals have to compete with them for food and shelter. This is probably one of the reasons why the wild animals go to agricultural fields to graze and to look for shelter. Wild buffalo and wild boar are frequent visitors to the cultivated fields. The situation becomes critical in the dry season when grass becomes scarce and the grassland is subjected to frequent burning. As a result, wild animals such as hog deer and wild boar lose suitable areas for shelter.

Figure 8.4 **Collecting animal dung within the reserve is an occupation of more than 500 people**

Threats to the genetic integrity of wild buffalo

Because of crossbreeding between domestic and wild buffalo, the genetic integrity of the latter is threatened. However, Heinen (1993b) believes that this is not a serious threat because adult males of domestic buffalo are observed very infrequently in the reserve, as reported by Gable (1987). Hence, Heinen assures that it is unlikely that a domestic male could monopolize a wild mixed herd in competition with a wild male.

However, these assumptions lack conclusive data from any detailed study. Even though it is unlikely for a domestic male to breed with a wild female, offspring from a female domestic buffalo crossed with a male wild buffalo may be mistaken

as members of the wild population. Subsequent generations, despite breeding exclusively with wild buffaloes will carry some genes from domestic buffalo, although the effect may be diluted. Thus, there is always a great danger to the genetic integrity of the wild species. Therefore, a detailed study is needed to confirm the severity of the problem.

Danger of disease

The presence of domestic livestock always poses a danger of disease to the wild population. Seidensticker (1976) has suggested that disease was the major cause of extirpation of the wild water buffalo from the Royal Chitwan National Park.

In the Koshi Tappu region, Gable (1987) found about 62% of the domestic livestock inside the reserve in poor condition, from which he concluded that the probability of an epidemic and transmission of disease to the wild herbivores is increased. However, detailed information on this subject in Koshi Tappu is lacking, which reflects the need for studies to formulate appropriate measures to avert the extinction of the last wild buffalo population in the country.

Effects on birds

Since the reserve is an important staging and nesting site for several species of ground nesting birds, the livestock can trample their nests, eggs and chicks. Birds which are most affected include the Bengal florican *(Houbaropsis benghalensis)*, blue peafowl *(Pavo cristatus)*, various waterfowl and all the birds belonging to the family Phasianidae (Suwal, 1993).

Burning

Burning is a well-established practice in grassland management (Ovington, 1984), and is always associated with livestock grazing. In Koshi Tappu, it is practiced by the local people against the desire of the reserve staff and soldiers. Burning is carried out by livestock grazers to remove accumulated, non palatable grass and to stimulate the growth of succulent and nutritious new grass.

Vegetation loss

The amount of vegetation grazed per livestock depends on age, sex, type of livestock, weight, season, pasture condition and plant species. As the age and sex of the animals have not been recorded, values from the standard herd structure in the country have been considered to calculate the livestock unit which, along with the normal average weight of the livestock, has been used to estimate the amount of vegetation loss inside the reserve.

Normally, a buffalo consumes 23 - 35 kg of grass per day, when it is allowed to graze freely on healthy grassland (Banerjee, 1982). The total consumption of vegetation by grazing was estimated by calculating livestock units in terms of adult cattle and their daily food requirement, estimated at 500 to 700 tones/day. However, this value may vary greatly depending on the factors noted above.

At the time of grazing, vegetation is lost through trampling as well. In Koshi

Tappu, clear passages through the tall dense grass can often be seen. The loss in grass cover due to walking and trampling was determined by subtracting the passage area from the total ground area. The loss was estimated as 18 to 29% of total ground cover by walking and trampling during grazing.

Changes in composition

Grazing mostly does not cause total loss of vegetation from the area but plant composition and coverage are altered. Succession can be arrested at different stages depending on the degree of grazing. An area which has the potential to develop into forest might instead be changed into grassland, and productive grassland may in turn become barren. Due to overgrazing, *Imperata cylindrica* takes advantage, replacing other more palatable grass species.

The effect of burning on vegetation has been widely studied (Duffey, 1974). In this area, it has been noticed that small bare patches of ground between tussocks of *Saccharum* and *Phragmites* association support the growth of new grasses.

8.1.3 Fodder collection

In addition to livestock grazing inside the reserve, people also collect fodder grass. There is virtually no restriction on fodder collection in the west and the north of the reserve, where more than 90 per cent of the households collect fodder. Each household collects one to three bundles per day. In the east, the amount depends on the opportunities people have to enter the reserve because of the patrolling by soldiers and staff.

The most common plants, harvested for the fodder, are *Commelina paluda, Cynodon dactylon, Cyperus* sp., *Echinochloa colona, E. crusgallii, Ficus* sp., *Grewia disperma, Imperata cylindrica, Mimosa pudica,* young leaves of *Phragmites karka, Setaria pallidofusa, Saccharum spontaneum* and *Tamarix dioica.*

Although the result of the survey showed that 65 per cent of households of the villages in Sunsari district collected grasses from the reserve, most of them collected them from the east-facing slope of the embankment while many of them, apart from villagers of 4 and 5 wards of village Prakashpur, can enter the reserve only 1 to 3 days per week on average. Thus, very few households from these villages regularly collect fodder grasses from the reserve. It is noteworthy that most of those who do regularly collect fodder from within the reserve are from the village of Madhuban, where an army post is also located. In one survey (Suwal, 1993), 100 out of 200 people surveyed were found to be from this village. They enter the reserve between 8 am to 10 am (Suwal, 1993) and the majority of them are women and children (Figure 8.5).

8.1.4 Thatching grass

The houses in the villages of the *terai* are constructed with bamboo and mud for the walls and thatched grasses for the roof (Figure 8.6). Thatching grass, locally called *'khar'*, is nowadays, in many parts of the *terai*, found only within the

protected areas. People living in the vicinity of these areas naturally have the desire to use these resources for the maintenance of their huts.

Figure 8.5 Women involved in fodder collection

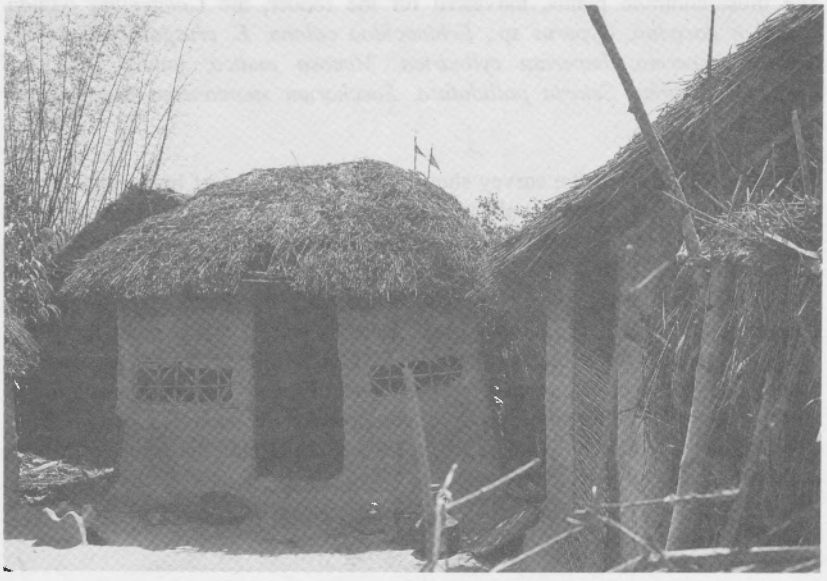


Figure 8.6 A typical thatched-roof of a poor rural household

In recent years, it has been realized that strict regulations to stop the use of resources and promote the effort to conserve them in protected area surrounded by a dense human population, is not possible (Hough, 1988). Thus, protected areas need to provide some economic benefits to the local people (Mishra, 1982; Lehmkuhl *et al.*, 1988). In Nepal, local people are given such benefits in the form of permits issued with a nominal charge to cut thatch grass for a period of two weeks, during the last week of January and the first week of February each year.

In Koshi Tappu Wildlife Reserve, local people are allowed to harvest thatching and cane grasses to be used as construction materials for a period of two weeks each year. Each person is required to pay NRs 5.00 for a permit which is valid for the entire grass-cutting season. They may carry out as much grass as they can on their backs. A total of 11,912 permits were issued in 1993. Figure 8.7 shows the number of permits issued each year since 1985.

The decrease in the number of permits being issued in recent years is probably due to the fact that damage to fencing wire facilitates entry into the reserve without permits. Furthermore, many people during the field survey in February, 1993 complained that since they cut grass for their own use, there should be no entrance fee. The decrease in stock and quality of grass, in addition to the effects of livestock grazing and trampling, further indicated that there is excessive pressure by people on thatching grasses.

The grass *Imperata cylindrica* is most favored for thatching. In Koshi Tappu, good stands of *I. cylindrica* are found on old agricultural lands. A tract of this land changed to a water and sand-covered area in 1987, when the main course of the river shifted to the eastern part of the reserve. Moreover, in the course of time, plant succession has led to these grassland areas being dominated by tall grasses such as *Saccharum* sp. and *Phragmites karka* which are less suitable for thatching, and are less desirable than *I. cylindrica.*

People make several trips a day at the beginning of the season since grasses located near the boundary are cut first. Usually, the number of individuals entering the reserve is highest at the start of the season and then declines. Lehmkuhl *et al.* (1988) described the case in Royal Chitwan National Park where the number of permit holders entering the reserve during the grass cutting season of 1986 peaked on the second day, then dropped sharply to remain fairly steady over the next six days, and thereafter fell to about 3 - 5 per cent of the maximum number.

Heinen (1993b) found that in 1987, the number of permit holders entering the Koshi Tappu reserve decreased with the progress of the grass cutting season. He found that the average number of days that individuals visited the reserve to collect grass was 11 and the average number of loads collected was 3.2 per day. Based on the price in nearby markets, he estimated the total value of thatching grass removed from the reserve during the 1987 grass cutting season, ranged between 3.7 and 5 million NRs ($165,000 to 220,000). However, the price is low in the markets around the boundary of the reserve and so, collecting thatching grass to sell locally is not always profitable. Thatching grass prices in Birpur, India, 10 km to the south, are almost 2-3 times higher than those in Nepal. Thus,

people who want to sell thatching grass, prefer to sell it in India. In Nepal, market prices for thatching grass approximately double a few weeks after the grass cutting season.

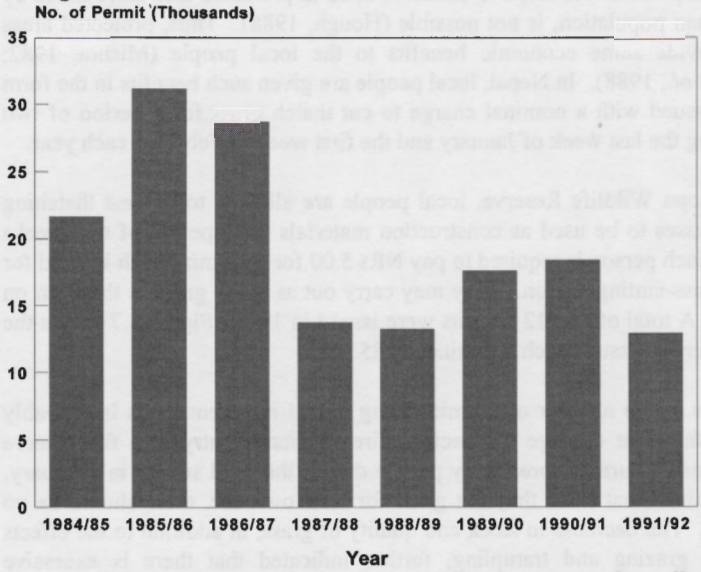


Figure 8.7 **Number of permits issued by the reserve for collection of thatching grass**

Impact of thatch grass cutting

In the vicinity of Koshi Tappu, about 90 per cent of the people collect thatching grass solely for their own use (Heinen, 1993b) in comparison to about 98 per cent in Chitwan National Park (Lehmkuhl *et al.*, 1988). The proximity of the Indian border and the higher prices attained in the markets there most probably account for the difference in the numbers of people who collect thatching grass.

During the survey in 1993, people stated that they would purchase grass from the market or from neighboring villages were it no longer available in the reserve. However, it is virtually impossible to purchase thatching grass outside the reserve area and it seems unlikely that they would be able to buy it from the market. They would have to substitute grass with other plant products, probably straw, which is itself a scarce resource used in livestock feed. Other substitutes, such as tiles and concrete, are expensive and most people cannot afford them.

This indicates that the use of thatching grass from the reserve is indispensable for the local people. In fact, the availability of thatching grass has been found to be the main reason for the acceptance of protected areas by people in the Koshi Tappu region and in Chitwan National Park (Heinen, 1993b; Mishra, 1982; Lehmkuhl *et al.*, 1988).

Granting permission for grass-cutting benefits the local people and helps to gain support for the reserve, but may have some negative impacts as well. During the grass cutting period, young trees are cut to make poles and vines are cut to tie the bundles of grass. Similarly, theft of fuelwood in this season is common. In fact, it

is due to the theft of fuelwood that the grass cutting period has been shortened from 20 days to 15 days and is now planned to be limited to 10 days in order to minimize such theft (Lehmkuhl *et al.*, 1988).

In addition, many large mammals are killed or injured during this period when they find their habitat disturbed and try to flee from the reserve (Sah, 1993a; Sharma, 1996) (Figure 8.8). According to key informants, in the 1993 grass cutting season alone, eight deer were killed, although official records do not confirm this. Similarly, two spotted deer (*Axis axis*) were found dead in 1995 grass cutting season (Sharma, 1996). The strategy of providing benefits to the local people, in terms of granting permission for cutting grass over 15 days, needs to be reviewed. Decreasing the number of days may be one possible way to minimize adverse effects although this may not be very effective since very few people enter the reserve during the last few days of the grass cutting period.

8.1.5 Logging

Logging, legally or illegally, is the common practice through out the *terai* forest. It is because of high timber value of sal (*Shorea robusta*), sissoo (*Dalbergia sissoo*), khair (*Acacia catechu*) and other species. Most of the logging is done illegally. According to one estimate from Bara district forest alone, $ 100,000.00 of revenues are lost every year by the illegal felling of trees and smuggling of the timber (IUCN, 1995)

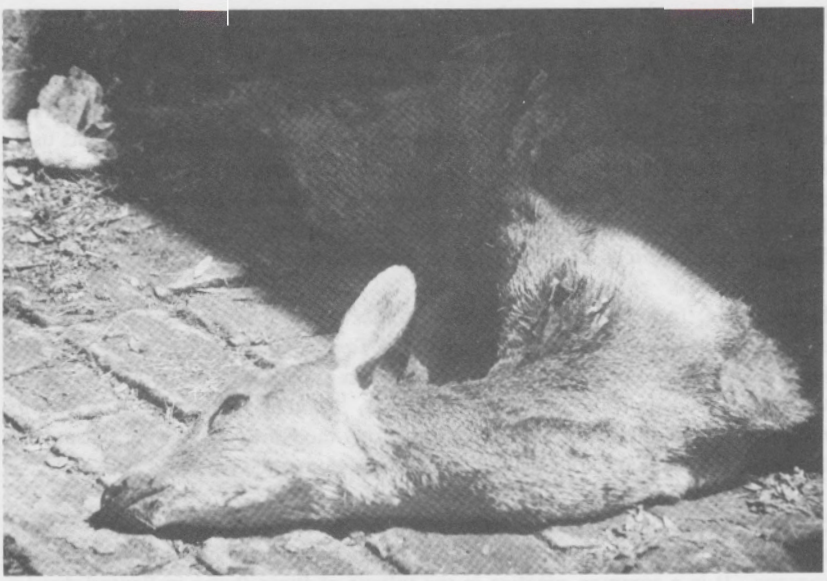


Figure 8.8 **A hog deer injured by villagers during the grass-cutting season (Photograph by Rajendra Suwal)**

The disappearance of the forest in Saptari district in the early decades of this century and the construction of a north-south road from Kanchanpur to Phatehpur led to an increase in human disturbances in Koshi Tappu. During the period of Barrage construction a number of trees were felled to meet the needs of construction work. Since the Barrage and the highway improved transportation facilities, logging operations continued in this region up until the formal establishment of the wildlife reserve. Thereafter, although there was no forest in other parts of Koshi Tappu, except the reserve, logging activities were gradually reduced in response to the ban on the extraction of the wood from the reserve. In recent years, however, logging is practiced illegally but is limited to the southern part of the reserve.

The southern boundary of the reserve is obscure and open. People can easily enter the reserve and trees, mostly of *Acacia catechu* and *Bombax ceiba*, can be cut. *A. catechu*, due to its high commercial value, is more vulnearable. These trees are then loaded on a boat and are carried up to the Barrage, from where they are easily transported to other areas and are smuggled mostly to India. Sometimes, logs are carried to India by boat, especially when the gate of the Barrage remains open. Boats are used to smuggle logs even from the Chatra-Baraha Chhetra and forests.

Logging has negative impact on the environment of the Koshi Tappu region. For example, removing of simal (*Bombax ceiba*) tree, which is the nesting site of Lesser Adjutant Stork (*Leptotilos japanicus*) has affected the number of this bird (Pokharel, 1996). Logging within the Koshi Tappu region not only leads to the destruction of wildlife habitat but it also makes land more vulnerable to river bank erosion, which is already a major problem due to the shifting behavior of the Koshi river.

8.1.6 Minor products

The most extensively used minor vegetation resource is *Dryopteris chochleata*, a fern extracted as a leafy vegetable. It is harvested on a commercial scale from the western part of the reserve and is even supplied to Kathmandu. Other plants used as green vegetables are *Alternanthera sessilis, Diplazium esculantum, Eclipta prostrata, Euphorbia hirta, Leucas cephalotus, L. indica, Lippia nodiflora*, and *Vernonia cineria* (Appendix 8.1). Other wild varieties of vegetables, namely *Solena heterophylla* and *Momordica charantia* are also collected.

Furthermore, fruits of wild plants like *Anthocephalus cadamba, Pithecolobium dulce, Solanum spp., Syzygium cumini, Tamarindus indica* and *Zizyphus mauritiana* are also edible. The fruits of *Bombax* are collected to obtain the cotton which is used in pillows and mattresses. Similarly, berries of *Zizyphus mauritiana*, and mushrooms are collected during the winter and spring season and are harvested for household use rather than for commercial purposes.

Some people belonging mostly to the traditional castes, have adopted mat weaving as an occupation to support their income during the spring and dry summer seasons. It is a common practice in the village of Pipra Purba in Saptari district where *Typha angustifolia* is harvested from swampy areas near Kamalpur Dah, from the marshes to the east of the eastern embankment, and from the swamps and marshes between the southern boundary of the reserve and the Barrage. Stem of

Cyperus distans and leaves of *Saccharum spontaneum* are also used in mat weaving. In addition, twigs of *Tamarix dioica* and inflorescence of *Phragmites karka* are collected for making brooms. Very few people harvest *Vetiveria lowsonii* which is used to make screens.

Aquatic plants from oxbow lakes and marshes are also used by the local people on different occasions. Leaves of *Nelumbo nucifera*, found mostly in Kamalpur Dah and some other oxbow lakes, are harvested to make plates for dishes in festivals and for worshiping gods. Similarly, jalkumbhi (*Pistia stratioides*) are used as bio-fertilizer in rice and potato fields.

8.2 Fishing

Fishermen are mostly landless and fishing is often the only source of income for them. Because fishing activities are prohibited inside the reserve, more pressure is exerted on water bodies and marshes outside the reserve, towards the east, where intensive fishing is carried out. In addition, some people fish illegally in the main stream of the Koshi river near Haripur village along the southern boundary of the reserve. They fish in groups of 10-12 people with cast nets and mesh nets and may sometimes also use gill nets which occasionally kill dolphins and turtles (Suwal, 1993).

The situation is different in the west in Jagatpur, Badgama and Pipra Purba villages where they have no option other than to fish inside the reserve illegally. They mainly fish in the Trijuga river in the northern part of the reserve and in Mariya Dhar in the southern part. In addition, many people can be seen fishing and collecting snails in the Kamalpur Dah although an army post is located nearby. However, fishing inside the reserve sometimes results in confrontations between fishermen and the reserve staff. Annual permits are issued to local fishermen of certain ethnic groups for fishing in the Rapti, Narayani and Reu rivers in the Chitwan National Park (Sharma, 1991), but such initiatives have not been taken in Koshi Tappu.

The vegetation in these wetlands, marshes and oxbow lakes in the east and the west respectively, are removed by the fishermen to facilitate mass fishing. The removal of vegetation not only eliminates some plant species but also disturbs natural succession. Similarly, fishing activities during the spawning period (spring season) affect the growth of the fish populations. As a result, the size and the amount of fish in the Koshi river is small and lower as compared to past records.

8.3 Poaching

The establishment of the wildlife reserve has restricted access to the resources inside the reserve. The regulations of the reserve prohibit activities such as grazing of livestock, exploitation of any kind of vegetation resources or setting of those resources on fire, clearing land for agricultural or residential use, harming

any birds or animals and even walking inside the reserve without written permission from the warden (Sharma, 1991). In practice, penalties vary from 5 NRs to several thousands NRs for illegal fuelwood collection, grazing, grass-cutting and hunting. In contrast to this, people do not have the legal right to claim compensation for damage caused to their crops by wildlife.

Many poor people risk fines to earn extra income by poaching in the reserve. In addition, some people of higher socio-political status carry out illegal hunting. The poachers are sometimes caught by reserve staff or soldiers and penalized (Figure 8.9). In the absence of any official data on the number of poachers who have been caught for illegal hunting over the years, it is difficult to estimate the number of people engaged in this activity. In the last one year, about eighteen poachers were caught along with their hunting devices. In February and March 1993, 1 blue bull, 2 hog deer, 1 wild buffalo and 1 dolphin were found killed (Suwal, 1993).

8.3.1 Hunting

Hunting in any wild area of the *terai* has been a common practice in Nepal since historical times. The major hunting areas for the rulers of the country are located in this region. Similarly, the forests in the *terai* were a source of game for the native Tharus and other traditional castes until a few years ago. In the Koshi Tappu region, the hunting of wild boar, hog deer, spotted deer and birds was common prior to the declaration of the area as a reserve, and was one of the main reasons for the depletion of the wildlife populations in the region. After the official establishment of the reserve, hunting of birds or animals was banned but continues to be practiced illegally. As a result, the populations of most wild animals within the reserve have decreased in recent years.

Poachers use long traps, snares, spears, guns, explosives and trained dogs. Some local people, mostly living north of the reserve, are engaged in this activity. They sell venison and wild boar meat in the villages at a price of NRs 50.00 per kg. Moreover, the hunting of wild boar and deer by some villagers west of the reserve is undertaken as organized crime, because they are able to influence the guards. Gun shots may be heard even in the daytime in the western part of the reserve. It is believed that the meat is supplied by these poachers to Kathmandu.

Besides hunting inside the reserve, many large ungulates are killed by local people during high floods when they seek shelter in the cultivated fields. During the grass cutting season, they are disturbed in their shelters and flee to cultivated land, where they are usually killed. In other seasons also, some animals, especially wild buffalo and wild boar, feed on the crops in cultivated fields where they are sometimes killed. Explosives and electric fencing around the fields are used to kill such animals on the west and the east of the reserve respectively.

8.3.2 Bird trapping

The Koshi Barrage area is famous for bird markets. In this area, many people, from Nepal and India, are engaged in the trapping and sale of birds. The bird trappers use mist-nests to trap small birds, such as weavers, pipits and munias (Suwal, 1993). Sometimes, ducks are also trapped in the mist-nets. As the

Barrage area is out of the reserve, trappers do not face any legal restrictions on their activity. It is believed that this activity has decreased in recent years because of the decrease in the number and types of birds visiting the area. However, there is need for urgent measures to be taken to check this activity in order to conserve the bird diversity of the region.

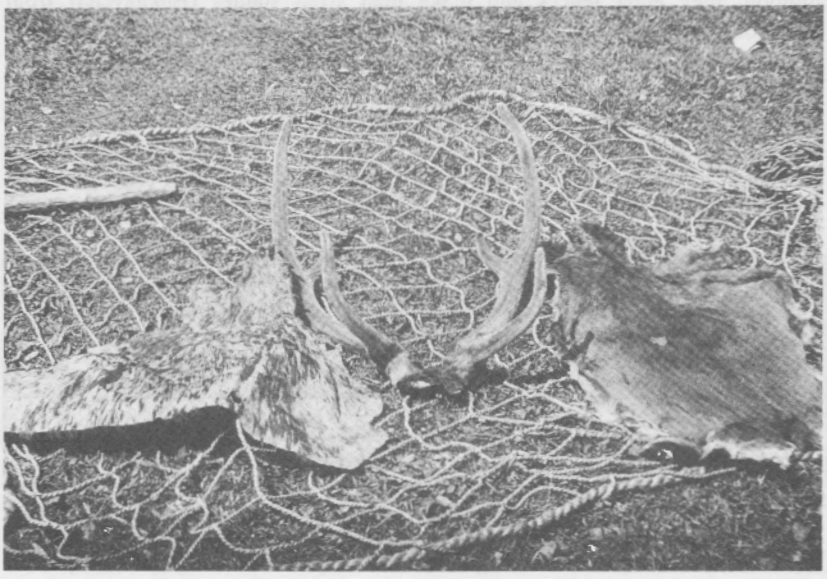


Figure 8.9 Fur and antler seized from a poacher (Photograph by Rajendra Suwal)

8.3.3 Poisoning birds and fishes

The use of pesticides, insecticides and fertilizers, which either directly or indirectly poison birds and fish, is common in the vicinity of Koshi Tappu. Rice grains, mixed with pesticides, are left on the fields and river banks, and near the marshes. Ducks and geese come to feed upon it and are left unconscious or dead. Bar-headed geese *(Anser indicus)* and ruddy shelduck *(Tadorna ferruginea)*, which visit the cultivated fields to feed upon the tender shoots of crops, fall victim to these traps most often (Suwal, 1993). The Lesser Adjutant Stork (*Leptoptilos javanicus*) is also threatened by the use of pesticides (Pokharel, 1996). Furthermore, when poison is used for fishing, other aquatic animals are also most likely affected. The death of body of a protected species of Gharial (*Gavialis gangeticus*) was found on Oct 24, 1994 and its death was somehow related to poisioning (Sharma, 1996). It is alarming that the birds and fish thus killed are sold in the local market for human consumption with little concern for the side-effects of these chemicals.

8.4 Crop raids by animals

Due to the presence of a large number of livestock inside the reserve, the wild water buffalo have to compete for resources and if there is inadequate food within the reserve, they raid adjoining crop fields. The frequency of visits by water buffalo to the crop fields is higher during the winter season and on the east of the reserve (Table 8.8). During the winter, people spend nights on the fields guarding their crops from wild animals (Figure 8.10). They try to keep wild animals away by making loud sounds by beating canisters and making fires during the night. In addition, they erect fences and make man sized statues (Bukhaycha) from bamboos and clothes in the fields. In all these activities, people keep loosing their productive labor (Sharma, 1996) which is not different from Royal Bardia National Park, where Studsrod and Wegge (1995) noted that the majority of farmers (92%) use to be engaged in such active measures.

Table 8.8 Index of the frequency of visit and the area of crop damaged by water buffalo

District	Index of the frequency of visit in different seasons			Area of crop damage (%)	
	Summer	Rainy	Winter	Paddy	Wheat
Sunsari	0.9506	0.9464	0.9547	28.98	26.03
Saptari	0.7461	0.6267	0.9339	18.42	21.87

Source: Field Survey, 1993

The most commonly crops, damaged by wild animals, are paddy, wheat , potato, sugarcane, maize and sweet potato. The household survey results showed that about one quarter of the crops in the field were damaged by wild animals in 1993. The damage has been found worse in recent years. Kherwar (1996) recorded 32 to 60 per cent damage to paddy and maize in 1994/1995. It was fairly higher than the damage recorded in other National Parks of the *terai* (Nepal and Weber, 1993; Studsrod and Wegge, 1995). Around the Royal Bardia National Park, the crop damage ranged between 24 and 47 per cent for wheat and lentil, respectively (Studsrod and Wegge, 1995). In Koshi Tappu, the percentage of the damage increases in the year when the flood is severe. Gordon (1987) estimated the damage of crops in a sugarcane field to be as high as 54.9% after the 1987 floods when the entire landmass of the reserve was underwater and the animals were forced out temporarily into the surrounding fields.

The damage to the crops does not happened to be uniform in all the villages (Table 8.9). Sharma (1996) found more damage to wheat in Shreepur village than in Kushaha, but it was opposite for paddy and potato. Differences in crop damage by different wildlife species to various crops in different villages were recorded around Royal Bardia National Park also (Studsrod and Wegge, 1995). In Koshi Tappu, since paddy and wheat are mostly damaged by wild buffalo, and potato by wild boars, the differences in damage to the specific crops in different areas can be used in determining the home range of wild buffalo for the proper management of the reserve and the buffer zone.

Figure 8.10 **Temporary hut in which farmers spend the night to guard their crops from wild buffalo**

Crop depredation by wild animals has adversely affected the economy of the local people and has increased poverty in the region (WMI/IUCN-Nepal, 1994; Kherwar, 1996). Thus, farmers when find their crops damaged by wild buffalo, they start to doubt the benefits of the reserve and try to compensate their loss by exploiting the resources from the reserve. Nepal and Weber (1993) found a similar situation in Chitwan National Park, where it was seen that people who experience more crop damage exploit the park more frequently than those who experience less damage.

Table 8.9 **Estimated loss of crops (per Bigha) in two villages between November 1994 and May 1995**

Crops	Kushaha		Shreepur Jabdi	
	Amount kg/Bigha	Currency NRs/Bigha	Amount kg/Bigha	Currency NRs/Bigha
Paddy	250	1,875.00	192	1,440.00
Wheat	140	980.00	412	2,884.00
Potato	1,000	6,000.00	1,400	4,200.00

Source: Sharma, 1996

Since there are about 93 wild buffalo in the reserve (Heinen, 1993), it is likely that the domestic feral cattle also visit the fields (Sah, 1993a; Sharma, 1996). Although people are allowed to capture animals other than water buffalo and to treat them as they like, this is hard to put into practice. The problem arises from the difficulty in identifying the water buffalo. Many semi-wild water buffalo are similar to the wild ones and identification is conducted by reserve staffs or soldiers who may not be able to distinguish between them. However, any harm done to a captured buffalo causes serious consequences if it is later identified as a wild water buffalo. A case is still under consideration since when a wild buffalo was killed by the people in Madhuban VDC by using electric fencing on December 28, 1994 (Sharma, 1996).

Although the locals do not like to have unnecessary conflict with large livestock herd holders, the frequent loss of domestic animals has been experienced in the past. Because of the absence of large predators, it is likely that feral buffalo might have been captured and killed by local people. Because of the damage done to agricultural crops by domestic/feral cattle, wild buffalo and wild boar, it is difficult to estimate the real loss of the crops due to wild animals and thus difficult to provide compensation. The National Parks and Wildlife Reserve Act 1973 allows people to kill wild boar which damage the crops in the field, but the farmers do not exercise such rights primarily because many do not know about such regulations, while others are afraid that they would be penalized by the soldiers and the reserve staff.

8.5 Developmental activities

As discussed earlier, the Koshi Barrage, constructed for the purpose of flood control, irrigation and power supply, has adversely affected the wild land of Koshi Tappu by accelerating the deposition of sand on the floodplain. In addition, the East-West highway has caused the death of several wild animals which are usually chased by fast vehicles on the road. One fishing cat (*Felis viverina*) and one wild buffalo (*Bubalus bubalis*) were killed by hitting by the bus within a period of four months, between Oct 1994 to Jan 1995 (Sharma, 1996). Similarly, a 132 KV transmission cable has been taken through the reserve for which eleven towers have been constructed inside the reserve. Since the Koshi Tappu region is an important staging site for migratory birds, the high voltage transmission cable is posing a threat to the birds flying in huge flocks. Larger birds, such as storks are also affected particularly during times of low visibility i.e., at night or during winter when the area remains covered with fog (Pokharel, 1996).

An Environmental Impact Assessment (EIA) is considered an integral part of any development project. It appears that, prior to the construction of the transmission cable, an EIA was not properly conducted. In the future, there was a plan to construct a 420 KV transmission cable, which would run from east to west, to distribute the power from the Arun III hydroelectric project was to be built in eastern Nepal. The transmission cable would cross the Koshi River somewhere in between Chatra in the north and the Koshi Barrage in the south. Near Chatra, the gorge of Koshi is the main route for migratory birds coming from Tibet to the Barrage. It was therefore suggested that the transmission cable should be laid along the Barrage and, if possible south of it (Sah, 1991). Although together with

the Arun III project, the plan of constructing such a transmission line has become uncertain for the time being due to financial and environmental reasons, it is, however, not sure that such type of construction will not be done in future, especially when there is strong political will to develop hydro-electric potential of the country. Thus, detailed studies will have to be done to assess the hazardous effects of such type of cable and to avoid repeating past mistakes.

8.6 Socio-political interferences

An ecosystem cannot be set aside for conservation purposes without social, economic and political considerations. The effort to conserve the resource in an isolated protected area, surrounded by dense human population, has started to be questioned, especially in developing countries where people have little or no access to alternatives. In the Koshi Tappu region also, local people have started to question whether wild buffalo have become more important for the Government than human lives. With this sentiment, the local people are putting pressure on politicians to provide them with more facilities and benefits from available resources. Politicians sometimes provide shelter to poachers or miscreants and when someone is caught by reserve personnel for illegal activities such as stealing poles, poaching, etc., local politicians often come to release them. Prior to the democracy movement in 1990, the bureaucratic forces used to be strong, and thus, were responsible for the major portion of illegal activities inside the reserve, such as livestock grazing by large livestock holders and hunting. Such political interferences were at a peak during the interim period when a group of people protested against the then warden, who was subsequently transferred.

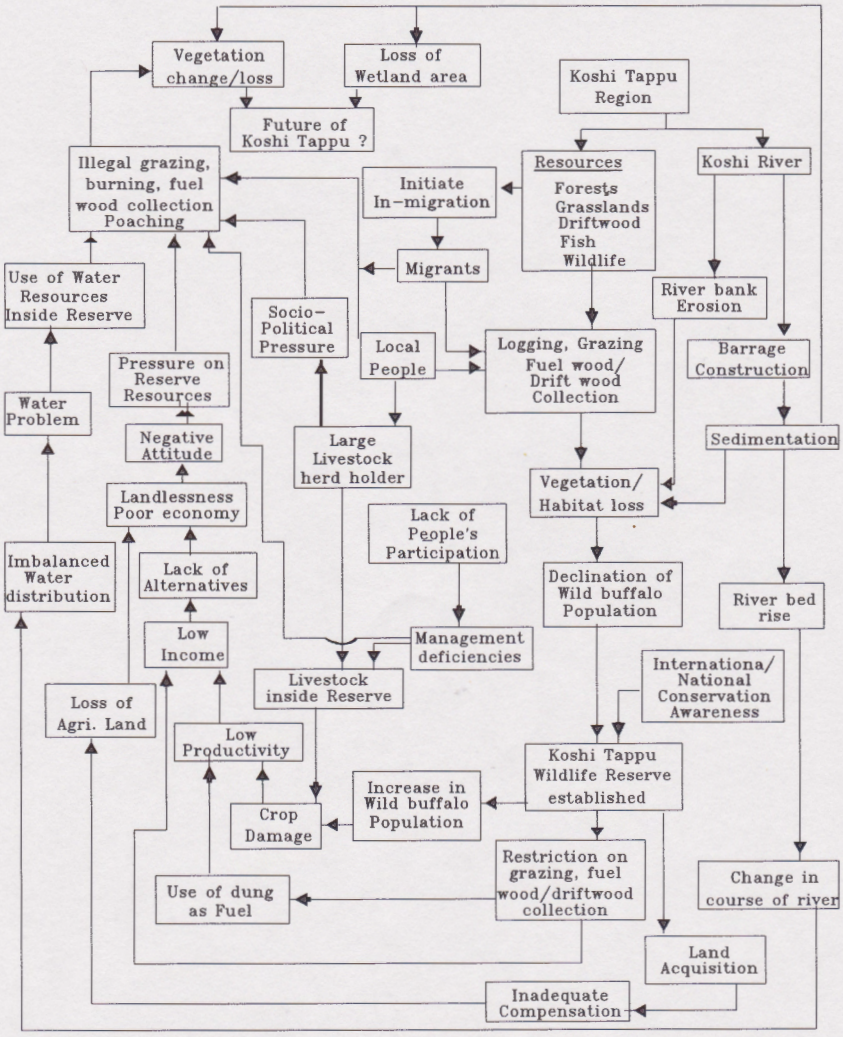
Recently, about 500 buffalo, which were grazing inside the reserve, were captured by reserve personnel (Suwal, 1993). The owners were asked to pay fines of NRs 100 per buffalo. Only a few of them paid the fine at that rate. A group of few hundred of the local people went to the Chairman of the District Development Committee and the Chief District Officer, and were successful in lowering the fine from NRs 100 to 20, but their demands of immediate fencing around the reserve, compensation for crop damage and provision of grazing land were not granted and poaching continues inside the reserve.

The reserve has become an issue used to rally public support by politicians. The existing conflicts also indicate that reserve staff have failed, not only in convincing the local people as to why they should have to sacrifice a part of their traditional right of the use of these resources, but also in seeking people's participation in management, which is now recognized as indispensable in the protected area management process. As a result, New regulation has provided opportunities to manage buffer zones around national parks and reserves with the participation of local people (HMG, 1996).

8.7 Conflicts threatening Koshi Tappu

With the establishment of the wildlife reserve, people have been denied the right to use the resources inside the reserve and they have no rights to claim compensation for the damage to their crops by wildlife. Similarly, except in specialized area within buffer zones, the responsibility for managing resources has been taken from people who live in the vicinity and has instead been transferred to a Government agency which is based in the distant capital. The costs of giving up access to the use of the resources falls on the rural people living in the vicinity of the reserve.

Large livestock herd holders continue to practice livestock grazing within the reserve, not only because of a lack of alternatives, but also due to a strong will to practice their tradition of livestock rearing and to exercise their traditional right to use the wetland resources of Koshi Tappu. In the absence of alternatives however, such activities continue to increase despite the risks of being caught. This poses a threat not only to the existence of the wildlife reserve but also to the wetlands of the region (Figure 8.11).



Figures 8.11 Causes of conflicts threatening the future of Koshi Tappu

CHAPTER 9

PEOPLE'S AWARENESS AND ATTITUDE

Once people are aware of the importance of conserving wetland resources and why they should safeguard these resources, it is likely that their attitude towards utilization and conservation of these resources will be positive. However, in reality, although people may be fully aware of the value of wetland resources, and even of the dangers of over-exploitation, they may be forced to over-exploit these resources in order to meet basic needs. Furthermore, attitudes towards conservation of different wetland resources may differ based on the importance of the resource for human use.

9.1 Awareness of the importance of wetland resources

People living around the Koshi Tappu region usually receive direct benefits from wetland resources such as vegetation, fish and water. At the same time, they may suffer from crop damage caused by wildlife. People living in the west of the reserve receive more benefits from the reserve than those in the east, where people face more problems from crop damage. Thus, their perception about the importance and conservation of wetland resources may differ for different resources (Table 9.1).

An awareness index has been used to compare the difference in awareness level among the people in the east and the west of the reserve. In addition, the awareness level and its relation with other socio-economic parameters such as age, education, landholding size, livestock size, on-farm income and off-farm income have been assessed.

9.1.1 Awareness of the importance of wetland vegetation

Most of the people around Koshi Tappu are aware of the vegetation in terms of its consumptive uses as fuel, fodder and other raw materials, but they place a value on the vegetation only when it is in immediate use. The direct benefits in terms of thatch grass cutting, fuel wood and fodder collection were found main reasons for their liking the reserve (WMI/IUCN-Nepal, 1994). Studsrod and Wegge (1995) also opined that the positive attitude among majority of respondents towards Royal Bardia National Park was due to the access to various types of grasses and the availability of irrigation water. The indirect benefits of vegetation such as the role it plays in river bank stabilization and as a means of maintaining sources of water were poorly recognized by the surveyed population (Table 9.2). They argued that the Koshi river erodes the river bank irrespective of the density of vegetation, and believed that they would be assured of water supply from the river provided there was no restriction on utilization.

However, older people in the communities realized that the volume of water in the Koshi has dropped over the last 20 to 30 years, but were unaware of possible reasons behind this decrease. The local people failed to see any relation between vegetation and the availability of water since the sources of water they are

Table 9.1 Perceptions of people regarding importance and conservation of wetland resources

Statements	Sunsari			Saptari		
	A	DA	NA	A	DA	NA
Direct benefit from vegetation						
a. Forest as source of fuelwood and fodder	92.0	2.3	5.7	94.4	0.0	5.6
b. Vegetation in Grassland and marshes as source of fodder and weaving materials	94.3	1.1	4.5	88.9	1.4	9.7
Indirect benefits from vegetation						
a. Forest saves fertile soil	64.8	3.4	31.6	63.9	9.7	26.4
b. Forest saves source of water	47.7	51.1	1.1	45.8	2.8	51.4
c. Vegetation helps continuous flow of water	35.2	4.5	60.2	44.4	2.8	51.8
Change in vegetation distribution						
a. Vegetation cover decreasing	96.6	0.0	3.4	84.7	12.5	2.8
b. Amount of fodder decreasing	95.5	0.0	4.5	86.1	12.5	1.4
c. Vegetation types changing	47.7	48.9	3.4	44.5	6.9	51.4
d. Some plants have become rare in the region	88.6	3.4	8.0	55.6	27.8	16.7
Importance of Wildlife						
a. Wildlife as source of income through tourism	55.7	18.2	55.7	37.5	29.5	33.3
b. Wildlife as a means of entertainment	60.2	5.7	34.1	38.9	34.7	26.4
No. of wildlife decreasing						
a. No. of wild animals decreasing in the region	62.2	19.3	18.2	44.4	40.3	15.3
b. No. & types of birds decreasing	51.1	19.3	29.4	66.7	27.8	5.6
Vegetation & wildlife conservation						
a. Vegetation necessary for future generations	87.5	4.5	7.9	68.0	16.7	15.3
b. Wildlife conservation important for biodiversity conservation	47.7	21.6	30.7	29.1	27.8	43.1
Importance of the Koshi Tappu region for birds	59.1	20.5	20.5	73.6	1.4	25.0
Impact of grazing on wildlife						
a. Grazing disturbs Wildlife	31.8	35.2	33.0	15.3	68.1	16.7

Source: Field Survey, 1993.
A = Agree; DA = Disagree and NA = Not Known

dependent on are either groundwater, river water or rainwater. The relation between vegetation and the level of water in these sources is not apparent, particularly since groundwater resources have not been over-exploited in the area. This is different from the situation in the mountains where the status of surface water sources, the main source of water supply in these areas, depends upon the condition of catchments.

Table 9.2 Awareness (Awareness index*) among people about the utilization and conservation of wetland resources

Statements	Sunsari	Saptari
Direct benefits from vegetation	0.944	0.972
Indirect benefits from vegetation	0.612	0.623
Change in vegetation distribution	0.955	0.759
Importance of wildlife	0.655	0.457
Number of wildlife decreasing	0.651	0.709
Vegetation and Wildlife conservation	0.805	0.750

Source: Field Survey, 1993

* = See Appendix 6.1.

9.1.2 Awareness of the change in vegetation

The vegetation in Koshi Tappu is changing in terms of structure and cover. The majority of the forests have either disappeared or have been degraded to such an extent that they represent savannah rather than riverine forest. The grassland has become relatively open and the forest has regenerated in some parts of the reserve. Similarly, areas of bare land have converted to grassland in the western part of the reserve.

Most of the people in the villages east of the reserve witnessed the loss of vegetation due to shifting of the river and livestock grazing and so believed that the total vegetated area in the reserve had decreased over time, whereas people in the west believed that the total area of vegetation cover and its density had increased over time. However, more than three quarters of the people on both sides of the reserve realized that the types of the plants present in Koshi Tappu were changing. According to them, unpalatable grasses were increasing, but only few of them noted that this may have occurred due to grazing and burning.

It is noteworthy that large livestock holders in the villages east of the reserve did not agree that vegetation, especially grasses, had decreased inside the reserve. They thought that grass supply was inexhaustible. This attitude indicates that they want to continue grazing livestock in the reserve and do not wish to draw attention to the possible effects of over-grazing.

9.1.3 Perceptions on the importance of wildlife

Most of the people in the villages around Koshi Tappu did not think that wildlife inside the reserve possessed any conservation value, and did not understand why their government spent so many resources on the area. Only 37 per cent of local people liked the reserve because it protects wildlife (WMI/IUCN-Nepal, 1994).

However, about 50 per cent of the people in the villages to the east of the reserve realized that the wildlife could be a source of income through tourism. This factor was less important for people in the west because tourists, although few in number, usually come to the eastern side since that is where the headquarters and other logistic facilities are located. Moreover, tourists usually came for bird watching either along the eastern embankment or near the Barrage. Some of the people in the west of the reserve have noticed a decrease in the number of birds visiting the area.

People's awareness of the importance and conservation needs of wetland resources showed significant positive correlation with education, land holding size and participation in management (Table 9.3). An insignificant relation with age indicates that younger people were becoming more aware of the importance of vegetation and wildlife. Large livestock herd holders were in favor of the immediate utilization of resources within the reserve.

It is important to note that the decrease in dependence on vegetation and increase in educational level could have a positive effect on the awareness of the people which could later play an important role in building a favorable attitude towards conservation and towards the reserve.

Table 9.3 Correlation between people's awareness and socio-economic characteristics

Socio-economic parameters	Correlation Coefficient (r)
Respondent's age	0.0327
Respondent's education	0.4143**
Family education	0.5498**
Landholding size	0.2974**
Total income	0.3657**
Area of crop damaged	-0.0590
Amount of resource extraction	-0.0708
People's participation	0.3288**

Source: Field Survey, 1993

** significant at 0.01 level.

9.2 Attitude towards utilization and conservation

The attitude of the local communities towards utilization and conservation of resources was determined by asking them to express their views against several positive as well as negative statements as to whether they preferred immediate utilization of the wetland resources or its conservation for long-term benefits (Table 9.4). To have disagreed with the negative statement was considered a positive attitude. The attitude level index was then determined and categorized in different ways in order to establish its relation with other socio-economic parameters.

Table 9.4 Respondents' attitude towards utilization and conservation of wetland resources

Statements	Sunsari			Saptari		
	A	DA	NA	A	DA	NA
A. Utilization of land for cultivation	43.2	51.1	5.7	72.2	26.4	1.4
B. Restriction on vegetation use						
i) Restriction on fuel wood collection	34.1	59.1	6.8	16.7	73.6	9.7
ii) Restriction on grazing	33.0	59.1	8.0	22.2	66.7	11.1
C. Vegetation conservation						
i) Vegetation should be conserved	64.8	35.2	0.0	31.9	59.7	8.3
ii) Waste of land & resources in conserving vegetation.	29.5	34.1	36.4	41.7	27.8	30.6
iii) Benefit from vegetation and its conservation should go together	92.0	2.3	5.7	97.2	1.4	1.4
D. Wildlife conservation						
i) Wildlife should be conserved	47.7	40.9	11.4	27.8	59.7	12.5
ii) No priority to wildlife conservation	62.5	20.5	17.0	84.7	2.8	12.5
E. Willingness to participate in conservation	69.3	12.5	18.2	51.4	33.3	15.3
Index	0.6713			0.6799		

Source: Field Survey, 1993

A = Agree; DA = Disagree; NA = Not answered

9.2.1 Attitude towards utilization of land

About two thirds of the people in the villages west of the reserve thought that part of the reserve to the west of the Mariya dhar should be given to the people for cultivation. There are presently about 88 households living within the reserve in Jagatpur and Pipra Purba Village Development Committees (VDCs) and cultivating more than 100 ha of land which is a source of conflict between them and the reserve staff.

More people are asking for additional land because their own land holdings, which used to be flooded by the Koshi river before 1987, no longer receive floodwater since the river shifted its course. Land located between the southern boundary of the reserve and the Bhardah-Barrage linkage road is being cultivated by people from villages such as Bairwa, Portaha and Bhardah. Similarly, more than 500 households have started cultivation on the floodplain of the river north of the reserve. Part of this land was used for livestock grazing up to a few years ago. The cultivation on this land by some people has affected the perception, attitude and behavior of others. Moreover, this has caused a loss of grazing area and the grazing pressure on the reserve has increased.

Claims to the land west of the Mariya dhar have been strengthened by the fact that compensation for 465 ha of land within the reserve was not given to the owners. Although this land has been acquired by the reserve, it still legally belongs to the local people and they have to pay an annual tax on it. Thus, since they are legally the owners of the land, and continue to pay taxes on it, they have been motivated to reclaim the land.

Despite the presence of a large herd of livestock in the region, people still consider farming more important than livestock rearing. This indicates that livestock rearing is not equally profitable for all, particularly for those farmers with small landholdings. The reasons for this are inadequate food production due to small holdings, low productivity and the problem of finding grazing land. Large livestock holders, who are also large landholders, have enough food production and thus prefer livestock rearing. Since they take their livestock inside the reserve they can find adequate area for livestock grazing.

These differences in attitudes and land use preferences need to be incorporated into management plans for the reserve so as to minimize conflicts over land use within the community.

9.2.2 Attitude towards utilization and conservation of vegetation

Almost all people around Koshi Tappu opposed to the existing restriction on the collection of fuelwood and fodder. Some people in the villages east of the reserve believed that livestock grazing inside the reserve should be controlled.

In an area where land is scarce and there is widespread poverty, the question arises as to whether locking away precious resources in protected areas increases poverty. However, although these resources are essential for the livelihood of the local residents it is hard to ensure that poor people will benefit from access to these. For example, in Koshi Tappu, if grazing were allowed within the reserve, large livestock holders would reap relatively more benefits rather than the poor.

The utilization of any resource by a community depends on several factors, of which the crucial one is social stratification. Such stratification in terms of social as well as economic status is an integral part of the community in many developing countries. Benefits are usually derived from resources according to the status of the communities because the needs also differ accordingly. Hough (1988) found that in Michiru Mountain Conservation Area in Africa, wealthier land owners were more concerned about grazing cattle whilst poorer people were

concerned about building poles, collecting firewood and thatching grass. In Koshi Tappu it was found that landless people are concerned with the redistribution of land after clearing of vegetation while the large livestock herd owners, concerned with grazing within the reserve, suggested that the reserve could impose taxes on livestock grazing but that they themselves should be able to determine the tax brackets.

Attitude toward fuelwood was similar among all members of the community since it is needed by all and there is no viable alternative. Even though people in the west received more benefits from vegetation inside the reserve, most of them had negative attitude towards its conservation and wanted to receive immediate benefits from the resources. Most of the people did not consider vegetation resources as exhaustible. Extension services and conservation education should be an integral part of the management plan of any protected area such as Koshi Tappu.

9.2.3 Attitude towards Koshi Tappu Wildlife Reserve

It becomes difficult to establish a relationship between stakeholders when their interests are not clearly understood by each other. The rural people have been poorly informed as to why Koshi Tappu has been designated a reserve. A common question asked by them is whether wild buffaloes are so important that they should be saved at the cost of the economy of local people. A lack of awareness about the objectives of the reserve is clear and plays a role in building up a negative attitude towards the reserve. In addition, crop depredation by wild animals is one of the major reasons for disliking the reserve by 96 per cent of population from the adjoining villages (WMI/IUCN-Nepal, 1994).

About 65 per cent of the people in the east wanted the eastern boundary to be shifted to the west of the eastern embankment so that they can use the embankment for livestock grazing and fodder collection (Figure 9.1). However, this would not be favorable for wildlife since, during the monsoons, wildlife come to the embankment for shelter. If this area were left outside the reserve it would most probably become barren and vulnerable to erosion as is occurring in other parts of the embankment to the north and the south of the reserve.

Fencing around the reserve boundary was frequently advocated by the local people, but it was noted that this was only in response to raids on agricultural fields by wild buffalo since it was clear that fencing would restrict not only the movement of wild buffalo but that of local people as well. Fencing constructed in 1982 was destroyed in part by animals, but mostly by people. Evans (1987) counted 154 breaks along the 17 km fence on the eastern boundary and noted that 5.2 per cent of the damage had been caused by animals and 94.8 per cent by people, in order to gain access to resources inside the reserve. In recent years, the theft of fencing wire and wooden poles has become common (Sah, 1993a; Sharma, 1996). It is hard to see continuous fencing even for one km, since more than 75 per cent of the fence on the eastern boundary and almost all of it on the west has already been lost.

Some people are demanding electric fencing. During a visit by the Forest Minister in 1992, it was mentioned that the government was trying to seek

assistance from Japan for solar fencing and the local people wanted to have it installed as soon as possible. This kind of fencing can reduce crop damage by wildlife (Kherwar, 1996; Sharma, 1996), but it is unlikely that illegal grazing and the extraction of reserve products would stop.

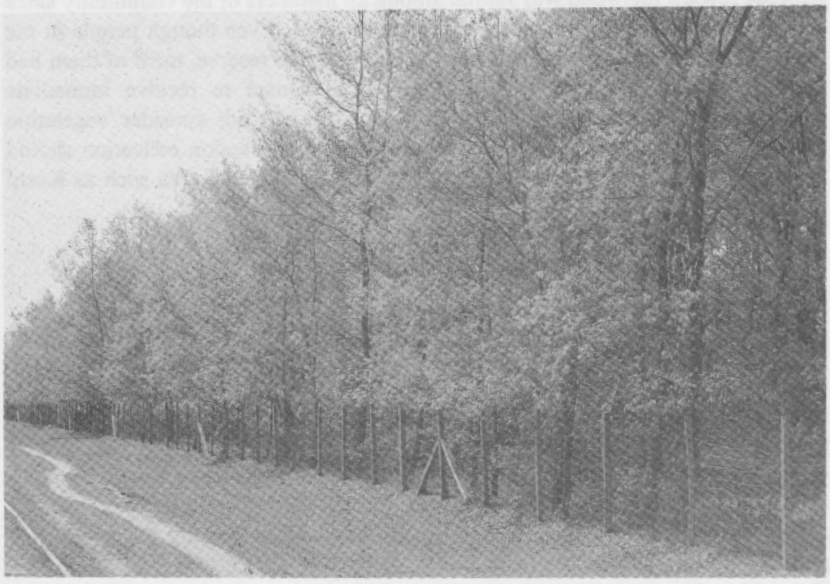


Figure 9.1 **Plantations on the eastern embankment are an attractive source of fuelwood and fodder for local people**

9.3 Variation in awareness and conservation attitude

The Conservation Attitude Index, calculated to compare the attitude of different groups, showed that despite easier access to the reserve, people in the west had more negative attitudes than those in the east (Figure 9.2). Muslims and lower caste of Hindus on both sides of the reserve thought more negatively about the wildlife reserve (Figure 9.3). Since these groups are mostly landless or have small holdings, they are completely dependent on the reserve's resources.

The Conservation Attitude Index indicates a strong relation between attitude and economic condition (Table 9.5). It is evident that 70 per cent of households with a negative attitude towards the reserve are marginal and small landholders (Figure 9.4). A relatively low attitude index for Yadavs (Table 9.6) revealed that attitude was determined not only by economic status, but by their dependence on vegetation as well. Although it was initially assumed that dependence on vegetation decreases with an increase in income in Koshi Tappu it has been found that more income means more investment in livestock which results in increased dependence on vegetation resources.

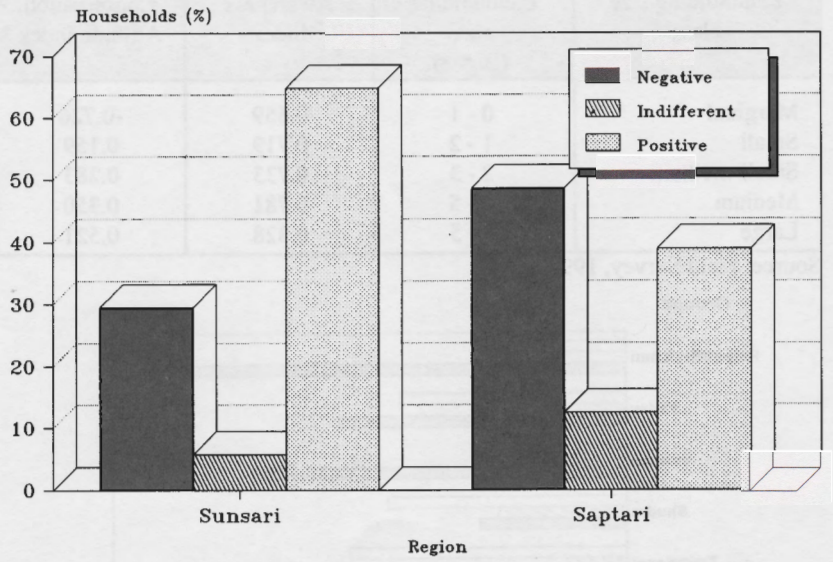


Figure 9.2 Distribution of population with different attitude by districts

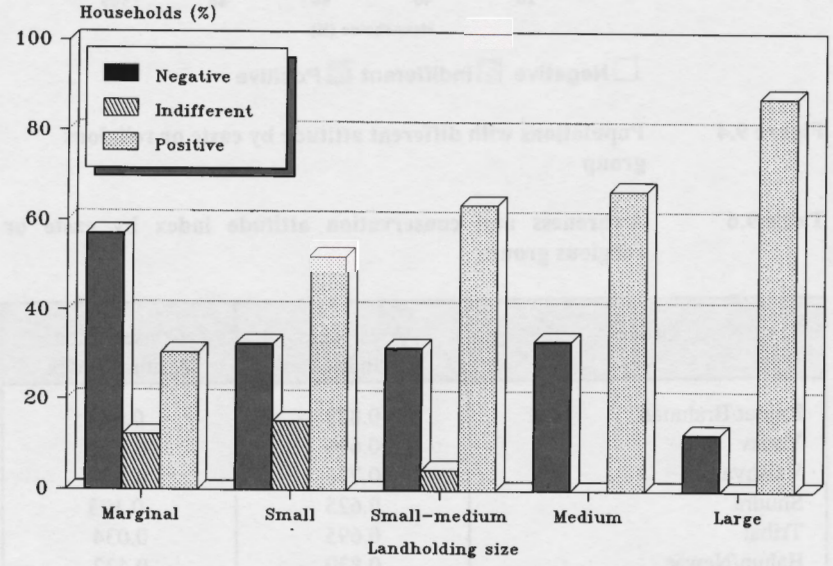


Figure 9.3 Populations with different attitude by landholding

Table 9.5 Awareness and conservation attitude index by landholding

Landholding size class	Landholding size (Bigha)	Awareness Index	Conservation Attitude Index
Marginal	0 - 1	0.659	-0.726
Small	1 - 2	0.719	0.159
Small-medium	2 - 3	0.733	0.283
Medium	3 - 5	0.781	0.350
Large	> 5	0.828	0.521

Source: Field Survey, 1993

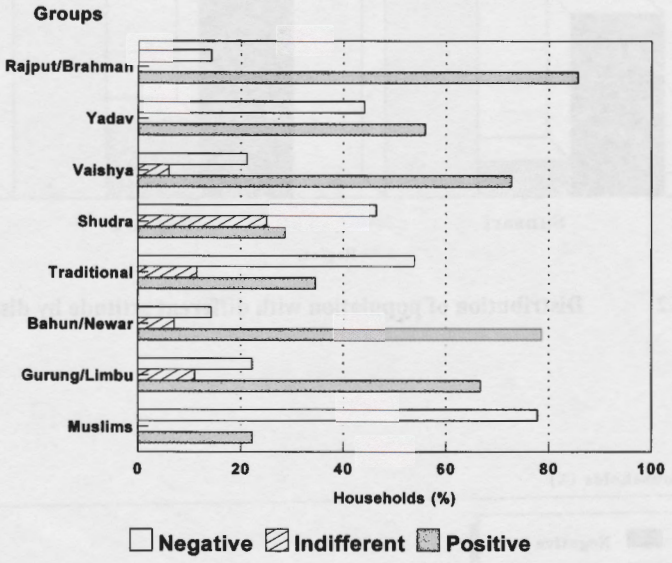


Figure 9.4 Populations with different attitude by caste or religious group

Table 9.6 Awareness and conservation attitude index by caste or religious group

Group	Awareness Index	Conservation Attitude Index
Rajput/Brahman	0.889	0.683
Yadav	0.696	0.128
Vaishya	0.776	0.377
Shudra	0.625	-0.103
Tribal	0.695	0.034
Bahun/Newar	0.830	0.532
Gurung, Limbu, etc.	0.788	0.509
Muslims	0.725	0.222

Source: Field Survey, 1993

The results of correlation analysis showed that attitude has significant positive correlation with education, landholding size, and awareness (Table 9.7). Age did not show any relation, while the area of crop damage had a negative impact on attitude.

Table 9.7 Correlation between conservation attitude and socio-economic characteristics

Socio-economic parameters	Correlation Coefficient (r)
Respondent's age	0.0616
Respondent's education	0.4638**
Family education	0.5948**
Landholding size	0.3295**
Livestock holding	0.2355*
Income from livestock	0.1613*
Total income	0.3660**
Area of crop damaged	-0.0327
Amount of resource extraction	-0.2275*
People's participation	0.4329**
Awareness	0.6070**

Source: Field Survey, 1993

* significant at 0.05 level; ** significant at 0.01 level.

Thus, it can be inferred from the above discussions that an increase in economic status and the education level coupled with a decrease in dependence on wetland resources through increased non-farm activities are necessary for building a positive attitude towards conservation. Similarly, people's participation in management activities has a positive impact on their awareness and attitude towards conservation.

CHAPTER 10

MANAGEMENT RECOMMENDATIONS

Over-utilization and external pressure continue to cause degradation to the wetlands of Koshi Tappu region, while aggravating conflicts over the resources within the Koshi Tappu Wildlife Reserve. This indicates that the long-term integrity of the site is far from assured. Thus, it is important to take initiatives in order to resolve, or at least mitigate, the existing conflicts outlined in the preceding chapters.

In recent years, the concept of enforcing strict regulations on the use of reserve resources, and the effort to conserve protected areas as isolated islands, when these areas are surrounded by dense human populations, has been questioned. This is particularly true in developing countries where people have little or no access to alternatives (Hough, 1988). Realizing this fact, programs which would ensure a flow of economic benefits to the local community and would help resolve people-park conflicts, have been developed under new regulation in Nepal also (HMG/UNDP, 1996). To translate these programs into action, an UNDP funded three year project has been implemented in all the protected areas of the *terai* since October 1994. Although it takes time for the results to be visually precipitated, the present status of project outcomes, especially in the Koshi Tappu reserve, is far from expectations. One of the several reasons may be the lack of detailed information about the socio-cultural practices in the region. Thus, to be effective, these programs need to take into account the social structure, cultural practices and economic requirements of human communities.

In Koshi Tappu, where the sources of existing problems are varied and complex, an all-encompassing, holistic approach to management should be developed. It is clear from the findings of this study that the conflicts in the Koshi Tappu region center around the use of the reserve by local communities. A management regime which recognizes the value of the reserve's resources for the local communities while at the same time recognizing the requirements of the natural environment would be able to address the social and ecological problems of the area. Such a management regime should incorporate multi-sectoral integrated strategies and be suited to the particular requirements of both the reserve and the people dependent on the resources of the reserve.

The value of the reserve in maintaining and providing necessary materials for human use and shelter for the natural fauna and flora of the region, has been made clear by the results of this study. Both in terms of the natural environment as well as in terms of the human communities, Koshi Tappu Wildlife Reserve is a reservoir for resources which must be protected in order to ensure their continued availability for generations to come. A sustainable management regime for the reserve will have to be based on a number of considerations described in this chapter.

10.1 Extension of the reserve area

The present extent of the Koshi Tappu Wildlife Reserve is relatively small and inadequate given its mandate to protect the biodiversity existing in the region (FAO, 1980; WMI/IUCN-Nepal, 1994; BPP, 1995b). The National Conservation Strategy of Nepal states that additional areas can be included in a protected area if

these contain habitats essential to the survival of a significant population of terrestrial mammals, migratory birds and freshwater fish. Furthermore, Section 3 of the NPWR Act 1973 states that 'HMG may alienate or transfer ownership or alter the boundaries of national parks or reserve...'. Given the particular features of the reserve and the findings of this study, four specific areas have been identified for consideration of incorporation within the nature reserve.

a) An important area used as a staging site for a number of bird species lies near the Koshi Barrage outside the reserve. The birds in this area represent internationally important populations of wintering waterfowl and should thus be protected. Indeed, the presence of these populations formed a criteria on the basis of which the site was listed as a site of international conservation value by the Ramsar Convention. This extension southward poses no problem locally because of the absence of human settlements in the area. However, the extension, if approved, would require inter- governmental cooperation between Nepal and India because the area is currently leased to the State Government of Bihar in India for 199 years (BPP, 1995b). Even though Nepal has made no formal agreements for the management of international reserves, Nepal and India have a history of bilateral cooperation for the establishment of protected areas of separate identities on either side of the boundary. The presence of Balmiki Sanctuary, Dudhwa National Park and Katernighat Sanctuary in India close to the Royal Chitwan National Park, Shukla Phanta Wildlife Reserve and Bardia National Park in Nepal respectively, are notable examples. In addition, Nepal and India have cooperated on several other conservation efforts (Heinen and Kattel, 1992b).

b) A second area, 300 to 350 m wide, running the entire length of the wildlife reserve along its eastern boundary, is recommended for protection. This area comprises the seepage stream and marshes adjacent to the eastern embankment. The area is important for nesting, wintering and migrant bird species. However, apart from a 25 m strip on both sides of the abandoned railway track, the land is privately owned. This land would have to be acquired and due compensation would have to be provided to the owners. These wetlands also provide valuable sources of water for livestock and for irrigation and should be protected.

c) A third area includes the Trijuga forest and a corridor joining the reserve with the forest. The inclusion of the proposed 36,300 ha Trijuga Hunting Reserve as an extension of the Koshi Tappu reserve was already recommended in 1976, just after the legal declaration of the reserve (Wegge, 1976). But, it has never been implemented. Since then several changes have taken place in the region. The natural habitat joining the Trijuga forest and the Koshi Tappu reserve has been encroached by the people from neighboring villages. Thus, for the effective management of Trijuga forest and the Koshi Tappu reserve together in order to provide adequate range of habitats and refuge during the monsoon, a corridor needs to be established. That will include resettlement of 200 households and the restoration of natural vegetation in 2,500 ha of farmland and degraded forest (BPP, 1995b).

d) In the long-term, there is a need to consider extending the reserve to the north up to 10 km northeast of its northern boundary. It will add additional 7,000 ha to the reserve. Although BPP (1995b) has recommended to include this area in buffer zone and to allow the people to continue living there, it does not seem the sound solution because the villagers living on the floodplain north of the reserve are vulnerable to floods. In severe circumstances, these people may even be displaced by floods since they live in poor economic conditions and have inadequate means to combat floods (Elahi and Rogge, 1990). These people therefore have a strong propensity to move into the reserve. However, displacing them in order to extend the reserve will require careful planning in cooperation with these villagers so as to improve their conditions while at the same time extending the reserve.

10.2 Zonation of the reserve area

The existing NPWR Act does not provide for zonation except the creation of buffer zones surrounding the national parks and reserves. Nevertheless, the division of the reserve into different other zones would facilitate better management practices. Over recent years, land over much of the reserve area has been increasingly used as grazing pasture for livestock. With increasing pressure on wetland resources, it is unlikely that the area will remain intact for conservation purposes. The home range of the water buffalo (Heinen, 1993a) and the nesting and staging sites of rare bird species also have to be taken into consideration. Moreover, as the Koshi river plays an important role in fabricating the landscape in the area, there will be a constant need to monitor these zones and to make changes, when necessary. The different zones within the reserve should be as follows:

10.2.1 Core protection area

A core protection area comparable with the IUCN category I should be designated in order to preserve, protect and maintain natural wetland ecosystem and processes with an emphasis on promoting scientific study and maintenance of genetic resources. Grazing, fishing and potentially harmful activities in that zone should not be allowed. The home ranges of water buffalo (Heinen, 1993a) should be included in this zone. The area between the main course of the Koshi river and the eastern embankment should also be included in this zone, based upon its importance for breeding bird species.

A third area, including recently generated forests and the transitional zone which represents early stages of succession (Figure 5.11), should be included in the core protection area as well because the vegetation in this part of the reserve is very sensitive to human disturbance.

10.2.2 Conservation zone

Moderate grazing and extraction of other resources could occasionally be conducted in this zone, with the primary objective being the conservation of species and their habitats. Burning of vegetation should be prohibited. The area

between the Koshi river and Mariya Dhar in the southern part of the reserve should be included in this zone. Similarly, after the extension of the reserve, the area between the Barrage and present southern boundary can be included in this zone, where control fishing may help to improve socio-economic conditions of the people.

10.2.3 Buffer zone

A buffer zone is an area of controlled and sustainable land use which separates the protected area from direct human pressure (Orsdol, 1987). It provides an added layer of protection to the protected area as well as certain benefits to the adjoining rural communities (Mackinnon *et al.*, 1986). In Nepal, the NPWR Act 1973 defines a buffer zone as the peripheral area of the National park and Reserve for providing facilities to local inhabitants to utilize forest products. The importance of buffer zone for the wildlife of the protected areas is not clearly explained by the Act as well as the Buffer Zone Management Regulation 1996. It becomes more important, especially when it has been realized that the damage to the agricultural crops by wildlife is one of the major reasons for the park-people conflicts (Nepal and Weber, 1993; Heinen, 1993a; Sah, 1993a; WMI/IUCN-Nepal, 1994; BPP, 1995b; Kherwar, 1996), and that the home range of some wildlife like water buffalo (*Bubalus bubalis*) covers some area outside the reserve also (Heinen, 1993b). Similarly, the Act emphasizes the use of forest resources only. It overlooks the physiography of all protected areas in the *terai*. For example, in Koshi Tappu, there is hardly any forest surrounding the reserve. In stead, the use of aquatic bodies, including the Koshi river, for fishing and that of grasslands inside the reserve for grazing have been realized as major problems which need to be addressed for the proper management of the reserve. Thus, in Koshi Tappu, it is necessary that buffer zone can provide an area for the free movement of water buffalo, as well as an area which could help meet the fodder and fuelwood requirements of the people, and provide fishing sites and grazing land.

The nature and location of the buffer zone varies according to the needs of the people and size and location of the protected area. In Koshi Tappu, a `traditional use zone' inside the protected area (Mackinnon *et al.*, 1986) will be useful in the western part of the reserve between Mariya Dhar and the western boundary because of the presence of concentrated human settlements and intensive agriculture practised in the area just outside the boundary. This area can be used for controlled grazing. It becomes more relevant because people use Mariya dhar as a source of water for their livestock and take opportunities to graze them in between.

The buffer zone does not necessarily need to be a thin, linear strip following the reserve boundary, as is often the case. A more compact plantation on both public and private land close to the village will perform the same function of meeting village needs for firewood, fodder and timber and minimize the need for villagers to seek such resources in the reserve. In the east of the reserve, where there is no forest, this type of buffer zone seems to be a viable option at several locations between the villages of Shreepur-Jabdi and Prakashpur.

The responsibility for the management of this buffer zone should rest with a joint management body comprising both local people and officials from government

agencies. No vested interest of any agency should dominate the management activities, and it must be ensured that the protective functions of the buffer zone are maintained.

10.3 Boundary demarcation

Clear, identifiable boundaries delimiting the reserve area and its buffer zone should be made a priority in order to reduce conflicts over land use. At present, the boundaries in the north and the south are particularly vague and require clear demarcation.

To make the boundaries identifiable and to minimize crop damage by wild animals, local farmers desire fences around the reserve. A fencing program was undertaken around the Koshi Tappu Wildlife Reserve in 1982. The fencing was damaged in part by animals, but for the most part by local people who would often steal the wooden poles and fencing wire. Concrete poles with the forestry emblem may be a more permanent material. Furthermore, any fencing program would need to be integrated together with other strategies, such as the extension of the reserve to include the complete home ranges of the wild buffaloes and improved participation by local communities in the management of the reserve and its buffer zone.

10.4 Land compensation

Land inside the reserve near the village of Kamalpur on paper still belongs to the people, and they continue to pay an annual tax on the land. For effective management of the wildlife reserve, land ownership conflicts can only be resolved either by providing appropriate compensation or by returning the land to the people. Returning the land would cause a corresponding decrease in the reserve area which is already considered small for wildlife management. On the other hand, a substantial amount of money would have to be paid out if the land owners are to be adequately compensated at the current land prices.

Since the area concerned includes oxbow lakes and swamps with extensive growths of reeds and other tall grasses, it is important to keep the area as a part of the reserve. However, it is suggested that the area be considered as a buffer zone where sustainable use of the resources may be allowed. Thus, mutual agreement between the local people, the land owners and the reserve authorities could be achieved to finalize compensation and subsequent land use in the area.

10.5 Reducing the rate of sedimentation

There are indications that the Koshi river is damaging the vegetation over vast areas through river bank erosion and sedimentation. The construction of spur dams is one possible means by which to check river bank erosion. However, the presence of a dam along only one bank accelerates the erosion towards the other bank, as is evident in Koshi Tappu. A similar situation is evident in the case of

the Jamuna river in Bangladesh, where the formation of sand bars due to sedimentation on one side is resulting in accelerated erosion of the other bank (Kalam and Jabbar, 1991).

In Koshi Tappu, sedimentation is a major threat to the reserve. The high sediment load of the Koshi is deposited primarily in the reserve as the river slows down in this area in response to the Barrage. Mitigation measures to reduce the sediment load of the river involve off-site activities such as efficient watershed management in the catchment area while reducing the influence of the Barrage requires inter-governmental cooperation between the Indian and Nepalese Governments.

In the catchment area, accelerated surface erosion can be minimized through reforestation, the construction of inward sloping bench terraces, mulching of the surface and reducing overgrazing. Even so, the bulk of sediment is generated through natural processes such as mass wasting in the riparian zone and through low level undercutting by incising streams. These actions are beyond the capacity of humans to manipulate (Bruijnzeel and Bremmer, 1989).

On-site reduction of the sedimentation rate depends upon regulation of the Barrage. In the monsoon period, from June until September, the annual flow of this Himalayan river is at a maximum. During this period, the sediment load in the river also significantly increases. It would thus be necessary to permit maximum outflow of water during this period in order to reduce the sedimentation rate in the reserve. However, this would have to be done without increasing the likelihood of flooding downstream. Reduction in sedimentation is relatively difficult and will require not only off-site measures but inter-governmental cooperation as well.

10.6 Vegetation restoration

It is desirable to restore the vegetation on the floodplain, marshes and aquatic bodies. Natural succession depends upon the availability of parent seeds. Colonizing species usually disperse their seeds widely, employing wind, water or animals as dispersal agents, and they readily colonize cleared land. The difficulty lies with the regeneration of trees of the climax forest. Although regeneration of *Dalbergia sissoo* has taken place rapidly in Koshi Tappu, the use of plant propagation and plant seedlings has become necessary for other tree species needed as food, shelter and nesting habitat for forest dependent species. For example, wild water buffaloes feed on the bark of *Adina cordifolia* (haldu), fruit of *Aegale marmelus* (bel) and the leaves of *Terminalia* sp. and *Bauhinia* sp. Lesser adjutant stork (*Leptoptilos javanicus*) prefers to have nesting sites on simal (*Bombax cieba*) (Pokharel, 1996).

Vegetation restoration in aquatic bodies such as the small lakes along the eastern embankment is associated with sedimentation. Once sedimentation is reduced, the seeds buried in the river beds can germinate.

An accelerated fluvial action arrests succession in grassland stages which might develop in forest in absence of such action (Lehmkuhl, 1989). Thus, the reduction in sedimentation at least in some regions of the reserve will help succession

towards forest to be faster. In addition, overgrazing and frequent burning in the area cause the soil to turn acidic and degraded to such extent that regeneration of tree species becomes difficult (Mackinnon *et al.*, 1986). Although seeding from aircraft, planting of small seedlings and sticks of coppiceable secondary forest trees can be an effective means by which to establish forest cover in open grasslands, at the first stage it is necessary to prevent further burning and overgrazing.

10.7 Livestock and grazing land management

Due to the absence of public grazing land in the villages near the reserve, livestock are taken to graze either inside the reserve or in the wetlands along the eastern embankment. People have very few fodder trees on their farms. Raising pasture land is also not widely practiced, except by a few households during the rainy season. These are mostly households with small landholdings which can hardly support round the year food requirements. The large landholders, who also own large herds of livestock, do not manage pasture land or cultivate fodder tree plantations on their farm because they graze their livestock within the reserve, which they claim as their traditional right.

Sixteen years after the establishment of the reserve, thousands of livestock roam inside the reserve all year round as though there were no regulations to restrict them. Some livestock which belong to rich households have been occasionally captured and herders have been penalized. Where livestock grazing is to be allowed, there would have to be some grazing land management practices initiated by reserve authorities.

Large livestock herd holders are socio-politically powerful and can influence decisions. Hence, the influences of inequalities in wealth and disparities in political power regarding conservation issues cannot be overlooked (Murdock, 1980: cited in Heinen, 1993b). Thus, strong political commitment is a pre-requisite to any action. A participatory approach in which the local community, national and local political leaders and government agencies are involved would facilitate any attempts to resolve this conflict. Furthermore, any decision concerning livestock herders must take into account their practical problems as well, otherwise, imposed decisions could be ineffective in the long run. A traditional occupation practiced for hundreds of years cannot be terminated suddenly through authoritative action.

It was decided during the course of three formal meetings between the government and people's representatives held during recent years that livestock from the reserve would either be taken out or killed. Participants at the meeting included the government district officer and elected representatives of surrounding village development committees. Unfortunately, the livestock herders were not present. However, two local representatives expressed the view that the livestock should be taken out of the reserve only when there was alternative grazing land, but these opinions were ignored. As a result, the decisions taken in the meeting have never been materialized. The livestock problem in Koshi Tappu is complex in nature and one of the main causes of conflict. A multi-sectoral approach must be adopted to reduce the conflicts.

10.7.1 Determining grazing capacity

Grazing, if carried out at an appropriate level, is an integral part of nature conservation and increases species diversity (Vin, 1990). .It was concluded from a study in the Gir forest of India that a healthy wildlife population can be maintained in association with light grazing by livestock (Berwick, 1976). In the wetlands of Koshi Tappu, grazing and harvesting of grasses hinder natural succession which would otherwise occur through silt deposition and the accumulation of organic matter. This would also result in the loss of some plants important for bird species (Davies, 1993). Thus, through proper management of the grazing areas on a rotational basis, grazing can substantially contribute to the local economy and provide environmental stabilization (Phillips *et al.*, 1989; cited in Nepal and Weber, 1993). Hence, once the zonation of the reserve has been completed, the grazing capacity of those zones which could offer various degrees of grazing should be determined.

10.7.2 Reduction in livestock herd size

A reduction in the size of cattle herds may seriously impede the farm manure supply and jeopardize the availability of animal draught power (Thapa and Weber, 1990). However, in Koshi Tappu, the livestock herd size of some owners has to be decreased in order to reduce pressure on the wetlands.

A gradual reduction in the number of livestock is generally preferable. The skewed distribution of livestock in the Koshi Tappu region indicates that the large numbers of livestock owned by a small number of large farmers need to be decreased. Shooting of feral buffaloes and an auction of captured cows have been adopted as solutions in the past and is considered as the best solution by some conservationists (Suwal, 1993). But it is possible that this type of action not only affects the economy of the local people but that their attitude towards the reserve becomes increasingly negative and hostile. Thus, before adopting such extreme measures, there is a need of continuous dialogue between authorities, political leaders and the livestock owners to reach an agreement in order to avoid socio-political pressure by large livestock owners and ensure political commitment.

Once an agreement is reached to reduce the number of livestock, a market facility will be needed for which the ban on exports could be relaxed for the given period. It will facilitate the implication of the decision if the livestock are bought by an agency and sold in districts far from that area or in the Indian market. The agency facilitating these transactions should be under the supervision of a management committee including reserve staff, local people, political leaders and representatives from concerned organizations. In case of failure to implement the agreement, the committee should have the right to capture the livestock from the reserve and sell them with negotiable compensation to owners.

For the remaining livestock, a grazing permit could be issued with a tax for utilization of the grazing land in the conservation zone and buffer zone. During the field survey, it was found that the large livestock holders were interested in paying such a tax. Recently, the demand of such a provision has come publicly (Kathmandu Post, 1995; cited in BPP, 1995b). Revenue from such tax should be invested in development activities to be used as incentives for the poor to

participate in public activities.

10.7.3 Increasing the stall feeding practice

Stall feeding is a better way to manage livestock in order to reduce grazing pressure and ensure healthier livestock. Interventions necessary for the promotion of stall feeding should be a part of the Reserve Management Plan since this would help reduce grazing pressure within the reserve. The availability of water, especially in the west, can be a hindering factor. For this purpose, incentives to dig ponds in each ward of the villages can help to some extent. Such ponds can provide additional economic benefits through fisheries as well.

A shift from free grazing to stall feeding may effect the division of labor in the household since grazing is supervised mainly by children. Stall feeding needs fodder supply from the outside and will require the labor of adults. However, this may be minimized by a supply of farm fodder grown on their own farms or community plantations.

a. Fodder tree plantation

As per objectives of the Park-People project, plantation of fodder trees on public land such as sides of roads, canals (Jamua Nahar in the east and branches of Chandra Nahar in the west) and the railway track, as well as on private land in between agricultural fields, should be encouraged to increase fodder supply. The preferred fodder plants are *Artocarpus lakucha, Ficus glumerata, Ficus lacor* and *Dendrocalamus* spp.

Emphasis should be given to family forestry or small user groups. There are a number of advantages to the family centered or small user group forestry program:

- It can maximize the use of interstitial spaces in agricultural land and other marginal land.
- Ownership will be unambiguous and therefore there will be no doubts as to who benefits in the future.
- The system reduces the overhead costs of planting and protecting trees by utilizing family labor.
- The successful model of the Small Farmer Development Project, undertaken by the Agricultural Development Bank can be applied.

A nursery should be established in collaboration with the District Forest Office, from where other technical assistance can also be obtained. Nurseries must be very responsive to changing demands for different species as farmers' decisions keep on changing according to market demand and the availability of forest resources in the nearby reserve forests.

b. Fodder grass cultivation

In particular, medium to large land holders could be convinced to cultivate fodder grasses in their field although this will be hard to implement since this reduces crop production. However, by increasing the land use intensity and practicing multiple as well as rotational cropping, productivity levels may be maintained and

possibly improved.

10.7.4 Improvement of livestock health

Since most livestock in the area are unhealthy and unproductive, there is a tendency amongst farmers to increase livestock numbers as a compensatory measure. The availability of medicine and veterinary services is essential to improve the health of livestock, especially in the east, where the general health condition of livestock has decreased in the last few years due to the disease facsioliosis. Introduction of improved breeds of livestock, suited to the *terai*, is equally important.

a. Establishing veterinary services

To avoid loss of livestock due to severe diseases as well as to provide technical assistance to the local people on animal husbandry, at least four veterinary service centers, two on each side of the reserve are necessary. These centers may be established in the villages of Madhuban and Haripur on the east, and the villages of Badgama and Kamalpur on the west.

b. Introducing improved breeds of the livestock

To reduce the number of unproductive livestock without affecting the production, the introduction of improved breeds of livestock is suggested. Livestock breeds are usually developed and selected, especially in developed countries, for their ability to produce a single product at a high level of efficiency, within a given production system. But the Nepalese farmers often maintain livestock with multiple objectives, which should not be ignored in designing the breed development programs.

Native breeds can withstand feed deficiencies, whereas livestock with greater than 25% exotic breeding may not survive in production systems based on the supply of feed in low quantity (Yazman and Oli, 1990). Therefore, a livestock breed improvement program should be designed after careful considerations of socio-economic conditions, farmer's objectives and production resources.

10.8 Management of sources of energy

From the findings of this study, it is clear that conflicts arising due to the shortage of fuelwood, which is a major source of energy in rural areas, need to be addressed. To combat the energy problem, it is necessary to increase supply as well as promote the efficient use and conservation of energy resources.

10.8.1 Driftwood collection and distribution

To increase the local supply of fuelwood, the first step could be to grant local people permission to collect driftwood from the river. Presently, such wood drifts downstream near the Barrage, where it is collected mostly by the people living along the India-Nepal border. User group representatives from all villages surrounding the reserve, whether it falls within the buffer zone or not, should be

formed to participate in this activity so that people from all villages are proportionally benefited, otherwise most of the wood will be collected in the upper portion of the river in buffer zone only. This is more likely to be happened if the provision of drift wood collection will be available in buffer zone only as stated in the Buffer Zone Management Regulation, 1996.

After the monsoons, a number of logs may be found lying on the floodplain which people should be allowed to collect on a similar basis as for grass cutting. That is, a period of time should be allocated for this activity for a nominal fee. Alternatively, driftwood can be collected by the reserve management body after the monsoon and can be sold to the local people at a nominal price. The latter system however, would make the people more dependent on the authorities and therefore permission for independent collection is preferable.

10.8.2 Increase in the tree cover

The riverine forests of the reserve are immature and vulnerable to floods. It is unlikely that substantial amounts of firewood can be extracted from the forests of the reserve. Thus, to increase the amount of available fuelwood requires an increase in tree cover on the farmland as well as on public land.

The preferred firewood is *Dalbergia sissoo* (sissoo) which can be planted in mixed plantations with fodder trees on public as well as private land. The plantation of *D. sissoo* has recently been popular in several districts of the *terai.* In Dhanusha and Siraha districts, tree cover has been found increased since early eighties only because of sissoo plantation. In the villages, the concept of community and private forestry has to be developed since those are not popular in the region. In particular, participation of poor people in such activities remains low since they can sell their labor in other regions of the country for competitive wages. Their participation may be increased by offering them direct incentives.

10.8.3 Reduction in energy consumption

The most efficient way to reduce energy consumption in rural areas is to use more efficient cooking stoves since the traditional wood-fired stove has low efficiency (Sharma, 1991). The improved stoves also help to reduce harmful exposure to high concentrations of suspended particles.

In the communities around Koshi Tappu, the use of improved stoves is negligible. Reserve staff and army should initiate the use of improved stoves and alternative fuels to reduce the consumption of fuelwood. In order to be accepted, the stoves must be adapted to suit local needs. Success also depends upon how people perceive the need to economize fuel. Quality control of an improved stove is equally important as a poorly maintained stove with poor fittings may be as inefficient as any stove or open fire.

10.8.4 Alternative sources of energy

Along with an increase in the supply of fuelwood and reduced consumption, the development of alternative sources of energy is also important. Since livestock is common in the area, the most promising alternative is bio-gas, locally called

'*gobar* gas'. It is not a high technology and can be constructed from local materials with the help of local people. To produce bio-gas, cow dung mixed with water hyacinth (*Eichornia crassipes*), which has infested the water bodies and marshes along the embankment, can be used.

The gas can be used for lighting as well as cooking. People will not have to be exposed to smoke in their kitchen. Thus, the use of bio-gas can help in improving environmental conditions as well. Similarly, people in this area burn animal dung and this reduces the availability of fertilizer. Hence the use of bio-gas can save fertilizer as well as reduce the cutting of trees. Since the women are mainly engaged in collecting the fire wood, the use of bio-gas can help to reduce their work load and to support them to be engaged in more productive job as well as in caring their children's health which is an acute problem in the region.

While the daily maintenance expenses of these biogas plants is negligible, initial costs are high. The quotation price of Bio-gas and Agricultural Tools Development Company (P) Ltd. to construct a medium sized plant which produces about 2 cubic meter bio-gas/day was NRs 21,281.00 for the *terai* for the year 1995/96. Realizing the high initial cost, a range of subsidies, based on the size of the biogas plant, is provided by the government through the Agricultural Development Bank. Since 1991, the amount of such subsidies is NRs 7,00.00 in the *terai*. In addition, NRs 2,600.00 is provided by UNICEF to those owners who are willing to attach their toilet to their bio-gas plants (Bhattarai, 1996). Furthermore, there are several means, technical and non-technical, that can be adopted to reduce the construction cost of a bio-gas plant. Some of them are the use of shell structure, reduction of HRT (hydraulic retention time), reduction in gas storage capacity and the use of local materials and local labors (Bhattarai, 1996).

An economic analysis of the biogas plants in Nepal shows that, despite some technical problems, a plant of 10, 15 or 20 cubic meters is economically profitable, provided an average of 25 per cent subsidy is offered (Silwal, 1991). Even a small plant which produces 2 cubic meter bio-gas per day, equivalent to 10 units (kilo watt hour) of electricity, can save NRs 1,280.00/month (Bhattarai, 1996). One way to popularize it is to install plants for smaller user groups under the Small Farmer Development Project and through private enterprises. Since 1993, the construction of the plants based on Deen bandhu Model (means friend for the people), a cheapest model in India, has been done around Royal Chitwan National Park by Integrated Rural Community Development Center (IRCDC) in collaboration with IUCN/USAID. Being encouraged from the achievements from those plants, more families have become interested to construct bio-gas plants there. They are even willing to establish Bio-gas Development Committee to take care of maintenance of the plants (Bhattarai, 1996). In addition, taking the inflation rate in account since 1991, the amount of subsidy, being given from the Government can be increased. Moreover, there are some large farmers around the Koshi Tappu reserve who can easily afford the expense provided they are made aware of its benefits.

Another alternative source may be solar energy but, given the present infrastructure cost it would be difficult to introduce it on a large scale. In the survey, more than two thirds of the respondents expressed the view that they

could shift to kerosene if it were made available at subsidized rate (Sah, 1993a), however, kerosene cannot be considered a sound alternative because it will increase dependency on exogenous resources.

10.9 Promotion of income generating activities

The poor economy of the local people hinders education and makes local communities more dependent on the wetland resources in Koshi Tappu. Therefore, the management of the wetlands should be aimed at the economic development of the region, while maintaining the conservation goals of the reserve. The ongoing Park-People Project is mandated to carry out such kind of activities. The following steps can be considered by the project to improve the economic conditions of the people in the region.

10.9.1 Increase in opportunities for non-farm income

Income from non-farm activities reduces the farmer's dependence on wetland resources. An increase in non-farm opportunities will increase the economic status of the people substantially. Initially, the most feasible opportunities are the development of tourism and cottage industries.

a. Development of eco-tourism

Koshi Tappu Wildlife Reserve, in its extended form, can be a popular tourist site. In its present form, the reserve has less value because the Barrage, which is a preferred site for bird watching, is outside the reserve. Presently, tourism agencies know little about Koshi Tappu and tourists have to inquire from more than half a dozen travel agencies in Kathmandu before they have adequate information on how to reach the site. The lack of infrastructure in the vicinity of the reserve also plays a negative role. Because of all these factors, tourism has not been popular in this area.

Despite several limitations, there is great prospect for tourism in the region. In addition to avi-fauna and water buffalo, the presence of the gangetic dolphin (*Platanista gangetica)* and Gharial (*Gavialis gangeticus)* are popular attractions. The facilities for visitors could include elephant rides, boat rides, nature hikes, a primitive lodging facility run by the reserve staff and a small canteen run by the army. Some business entrepreneurs from Kathmandu have perceived the prospects of tourism in this area and have established camp-sites near the village of Prakashpur.

The cultural heritage of the area can also be promoted. The Tharu culture in Chitwan district is a major attraction for tourists in the Royal Chitwan National Park. In the vicinity of Koshi Tappu, the culture of the aboriginal people such as Jhangar, Bantam and Tharu, may be as attractive. Similarly, the Saptari district as a whole, is famous for its Maithili culture and could be an attraction for tourists.

Furthermore, there is the possibility of `rafting' from Dolal Ghat near Kathmandu to Tribeni in the Sun Koshi river, to the Barrage in the Sapta Koshi river. Similarly, the construction of a road from the highway near Kushaha to the

Baraha Chhetra can attract Indian tourists to visit the Hindu pilgrimage sites of Baraha Chhetra and Ramdhooni, located 15 km and 1 km north of the reserve, respectively.

The negative impact of tourism on natural resources and culture cannot be overlooked. There is the need to promote eco-tourism with emphasis on nature conservation and protection. Similarly, the income from tourism should go to the local economy as is practiced in the Annapurna Conservation area, rather than to city based enterprises as occurs in the Chitwan National Park. Employment opportunities from eco-tourism should be made available to the local people and the revenue thus generated should be invested in the economic development of the area.

b. Development of cottage industries

The existing small scale rural industries, such as manufacturing of ropes, mats, baskets, chairs, stools and earthen pots, should be promoted. *Saccharum* sp. and *Eichornia crassipes* can be used as raw materials for paper production in low cost scheme (Vasudevan *et al.*, 1984 and Brij Gopal, 1989). Agriculture based industries can also be developed. The promotion of forestry, especially replanted forests of *Dalbergia sissoo* can also open up a few employment opportunities since people can be engaged in carpentry and wood carving. For these purposes, it will be imperative to provide credit at nominal rates of interest, to increase market facilities and to provide training to improve the quality of the products.

The target groups should be the landless, small farmers, lower castes, women and skilled technicians. Small Farmer Development Projects in the villages of Madhuban and Odraha are involved in these activities, although their impact on economic development should be evaluated and if necessary, improved. Similar organizations should be established in other villages as well.

10.9.2 Increase in farm-income

When the size of agricultural land becomes a limiting factor, an increase in productivity per unit of land by increasing cropping intensity becomes necessary in order to increase farm-income. In this area, cropping intensity is not very high (1.51 to 1.83), and can be increased. Moreover, coordination between the reserve and other agencies should be established to promote integrated farming systems which include agroforestry, fishery and livestock rearing.

The introduction of permaculture may also be attempted (Suwal, 1993). Permaculture is a synthesis of agriculture, landscape architecture and ecological principles where plants, animals, buildings and water sources are coordinated to make the best use of the terrain in order to establish beneficial interaction, and to effectively utilize time, space and resources without damaging the ecosystem. Adopting this system, a model farm has been established in the Amaduwa village, a few kilometers east of the reserve (INSAN, 1993: cited in Suwal, 1993). Such a system can be practiced by the villages along the eastern embankment.

Adequate irrigation facilities and the availability of fertilizer are two major pre-requisites for integrated farming. An irrigation project is presently allowed to use

water from seepage stream and marshes in the east of the reserve. A small dam will be built near Galpharia, south of the village of Kushaha. Similar projects near the villages of Madhuban and Haripur should be launched. However, such activities should be a part of an integrated management system so that their impact on the wetland ecosystem, such as changing water levels in the aquatic bodies, can be assessed and used effectively in wetland management (van der Valk, 1990).

The use of chemical fertilizers deteriorates the soil conditions in subsequent years, thus, the use of organic fertilizer needs to be promoted. Water hyacinth (*Eichornia crassipes*), grown in aquatic bodies in the east of the embankment can be utilized as compost to increase the yield (Dhar and Shrivastava, 1976). Water hyacinth can also be used as a bed for mushroom culture. The use of cow dung as fertilizer should be promoted instead of its use as fuel.

10.9.3 Fishery development

Fish farming is one of the most important sectors of agriculture in the *terai*. However, despite the great potential to develop fisheries in the Koshi Tappu region, it was not popular due to the plentiful supply of fish from the Koshi river in the past. At present, fish production in the area is solely dependent on fishing in natural water bodies like oxbow lakes, river channels, seepage stream and marshes, where the amount of fish available has been dwindling in recent years.

A fish stocking program in Indra Sarowar, a reservoir created due to Kulekhani dam, and in the lakes of Pokhara valley, has benefited the local fishermen. In Koshi Tappu, a large expanse of water near the Barrage and the main stream of the river are important sites for fish stocking. Similarly, cage culture can be practiced in the canal outside the reserve. The fishermen should be trained in fish culture and harvest methods similar to training imparted to fishermen in the Pokhara valley.

In most parts of the *terai*, fishery suffers due to shortage of water in the ponds during the months of April and May. But in this region, the seepage stream in the west of the eastern embankment is a perennial source of water. The stream as such can be used for fish stocking. In addition, a series of ponds along the stream can be dug and used for fish culture. There are some ponds in between the villages of Prakashpur and Kushaha and are important staging and nesting sites for birds.

The agricultural fields around the Koshi Tappu are mostly wetland paddy fields where water accumulates during the monsoons and post monsoon period. Fish farming in the paddy fields provides an additional source of income. The only requirements are technical assistance and initial capital. A Fishery Development Division should be established in Sunsari District near the reserve, and the capacity of the present Fatehpur Fishery Development Division in the Saptari district, which has inadequate staff and resources, should be strengthened.

10.10 Enhancement of information dissemination and awareness

Until people understand the importance of wetland ecosystems of the region and why they should safeguard them, and are aware of the actions required to do so, no management plan can be successful. However, given adequate information and training, once the people begin to appreciate the reserve and its benefits, their attitude towards it may be expected to change.

a. Mapping and monitoring of the wetland resources

Since the conditions of the wetlands change regularly, not only due to anthropogenic activities but also due to natural successional process, the survey and detailed mapping of the wetlands and the extent of their available resources should be carried out regularly with the help of Geographic Information Systems (GIS) and Remote Sensing, supplemented by field surveys. In addition, regular monitoring of the population of large ungulates, dolphins, *gharial* and migratory birds should be carried out to better understand their population dynamics.

b. Conducting research

The limitations of the research in Nepal have serious implications for designing long-term biodiversity conservation programs (Heinen and Yonzon, 1994). Thus, the research should be an integrated component of biodiversity conservation in Koshi Tappu also. The ecological behavior of the wildlife, including home range and the pattern of habitat use by the wild buffalo should be determined with the help of radio telemetry devices. Several similar studies have been done on other animals such as Rhinoceros, Red Panda, Hog Deer, Crocodiles etc., in other protected areas of the country. Similarly, banding and tracking long distance migratory birds by satellite radio telemetry should be implemented to document their migration routes, stop over places, hazards during travel and so on. Additional field studies including social-anthropology should also be conducted to understand resource-base, exploitation and management practices in greater detail.

Although some research on Koshi Tappu has been conducted, published or unpublished documents are not available at the head office of the reserve. Therefore, an establishment of a documentation section, research facilities, and accommodation for visiting scientists at the headquarters of the reserve is necessary to facilitate research and information dissemination.

c. Increasing the education level in the community

Awareness of the local people can be increased through formal and informal education. To promote formal education in the villages near Koshi Tappu, schools, like the lower secondary schools of the villages of Kushaha and Haripur, have to be upgraded to secondary schools and the facilities in other schools have to be improved. Similarly, the level of free education in public school should be gradually increased up to Grade 10. In the primary schools, incentives to poor households are necessary to reduce the drop out rate of their children.

d. Providing conservation education

Informal conservation education in the region should be promoted through schools, mobile exhibition, observation tours and workshops. Lessons about conservation can be provided through establishing contacts with local educational institutions or directly with schools. Staff from the reserve, most preferably an education officer can visit the school to teach lessons on conservation (Mackinnon *et al.*, 1986).

Up until a few years ago, the reserve was sponsoring an essay competition among school children on the subject of the importance of the wildlife reserve. This should be restarted. In addition, local tours for the students to visit the reserve can provide opportunities for them to learn about the nature and its importance. Furthermore, at least one workshop per year for the school teachers and social workers will help to publicize the objectives and benefits from the reserve. Mobile exhibitions with audio-visual aids and conservation education materials should be held at meeting places such as schools and *hat-bazaar* (periodical market). An observation tour to the Chitwan National Park conducted in November 1992 for the local leaders and the social workers has left a positive impression on the people's attitudes towards the reserve.

To enhance eco-campaigning, some national NGOs such as the Nepal Environment Conservation Group, Nepal Bird Watching Club, Environmental Camps for Conservation Awareness (ECCA) etc., should be encouraged to establish offices in the region and to involve local educated youths. They can help also in seeking cooperation from the local people in conservation activities.

Such endeavors will assist local villagers in meeting their subsistence needs and in helping the reserve managers in protection of vulnerable resources in the face of tremendous exploitation pressure by the reserve's neighboring communities.

10.11 Strengthening management capability

10.11.1 Strengthening the reserve organization

To manage the extended reserve area, the present staff and logistic facilities of the reserve will be inadequate. The structure of the organization, responsible for the management, needs to be reviewed. The officers responsible for community participation and development, administration and education and publicity should be separate but their activities should be coordinated by a senior officer. Unambiguous job descriptions must be introduced so that staff at all levels understand their responsibilities and their rights. Undoubtedly, the employment of local people as staff in the reserve can strongly affect the attitude of the people in surrounding communities and enhance the protection of the reserve.

Effective communication between the local communities and the reserve staff depends on the training, skills and mobility of the staff. In the past, most of the education and training of the staff, both before and after entry to DNPWC, emphasized the biological and technical aspects of forestry and wildlife management. In recent years, training in human resource development and

communication skills have been recognized as being of critical importance in resolving conflicts and in establishing better relations with local communities. In this respect, appointment of several trained staffs with handsome salaries under the Park-People Project can be considered as a positive step. At the same time, to avoid any moral depression in permanent reserve staffs, it has become equally important to provide them both training and facilities like the project staffs. Any discrepancies in the facilities provided to the project and reserve staffs should be avoided. Otherwise there will be a strong chance for having interest conflicts between them, which will have certainly adverse affect on whole management system.

To enhance mobility, improved logistic facilities are important. At present, there is only one vehicle and an inadequate budget for fuel. Furthermore, incentives to the staff in the form of rewards and training opportunities help to maintain integrity towards carrying out their responsibilities.

10.11.2 Establishment of linkages with international agencies

Since the Koshi Tappu region includes Wetlands of International Importance, coordinating with international organizations involved in wetland management can improve the management of the region. Such organizations could be approached to seek core funds for more detailed research on reserve-people interaction, status of migratory birds, successional changes in the floodplain and aquatic bodies, dynamic behavior of the Koshi river, autoecology of important wetland plant and animal species, ethnobotany etc.

10.11.3 Evaluation of management activities

Continuous evaluation by an evaluation group including representatives from Ministry of Forest, Department of National Parks and Wildlife Reserve and District Administrative Offices, naturalists from academic institutions, political leaders and local representatives from villages is required. This is needed to ascertain if management plan objectives are being achieved, to judge whether the human and financial resources provided for this purpose are sufficient to attain expected results, and to improve the art of conservation management.

10.12 Approaches in planning and management

10.12.1 Participatory approach

Biodiversity conservation without people's participation is not possible, especially where the people are dependent on biological resources for their livelihood. People's participation is also important in order to utilize the indigenous knowledge of a local community which may be valuable for management decisions for the reserve (Baines, 1984; Ovington, 1984). People's negative attitudes can be diluted by involving them in decision making processes related to planning and management, and thus, the conflicts between the local people and the reserve authorities may be resolved.

People will take part in management only when they develop a sense of

permanence, protection and responsibility. They should realize that the resources belong to them, and if used on a sustainable basis, will fulfil their needs for a longer period of time. Similarly, if they develop a sense of responsibility to manage the resources, their participation will be more effective. Respecting the sovereignty of the local people is a key issue in ensuring cooperation between them and reserve. The bottom-up approach used at Annapurna conservation area respects and enhances local sovereignty (Hough and Sherpa, 1989).

The role of the people in management depends upon their aptitude, interests, as well as formal education and training offered (Nepal and Weber, 1993). However, it is important to ensure that people from all social groups, small landholders and women are proportionally represented, and not by self styled representatives. This may be achieved by forming user groups at the ward level and then a committee at the village level. This approach is the key point of ongoing Park-People Project for buffer zone management (HMG/UNDP, 1996). In Koshi Tappu, however, the reason of the formation of only five user groups, covering less than 0.5 per cent of affected population, during the first half of the project period has to be analyzed carefully and appropriate measures have to be taken in future. At present, there is no representation of woman in any user committee. If the trend continues, the effectiveness of the user group will be questionable because that is the women who most of the time deal with the day to day problems of fuelwood and fodder collection. To avoid this problem, it should be made mandatory for all committees to have certain percentage of their members be represented by women.

Later, a management board with the representatives from user groups, local NGOs, other organizations like VDCs, schools, should be formed to provide advise on management aspects. In addition, the user groups could be formalized as local institutions with authority and responsibility for the joint protection and management of the grazing land, planted trees and other resources in partnership with reserve staff.

10.12.2 Integrated approach to management

Development in a single sector cannot be sustainable and a single agency cannot deal with issues in diverse fields. The development issues in agriculture, forestry, small scale industry and education sector are managed by the concerned agencies. These agencies rarely work together in addressing particular management problems. As a result, conflicts usually arise between developmental activities and the agencies responsible for their management.

Coordination among all the concerned agencies is essential for the effective management of wetlands in the region, i.e., an interdisciplinary approach for the community development and wetland resource management is required. For this purpose, a Community Development Center should be established in each VDC to coordinate all development activities. Such a center must be governed by a management committee formed by members of the VDCs, concerned organizations and the wildlife reserve. Community Development fees should be raised along with the entrance fees collected from visitors.

10.12.3 Establishment of a conservation area

It is apparent that the conservation of nature and natural resources, and economic development can go hand-in-hand if multi-disciplinary integrated approaches, supplemented by people's participation are adopted in the management of an area, as has been initiated in the Annapurna Conservation Area (Bunting and Sherpa, 1989). This becomes particularly noteworthy in an area of high natural, aesthetic, religious and cultural values. In the vicinity of Koshi Tappu also, there are several such isolated locations, which are important from the natural, aesthetic, religious and/or cultural point of view. It is proposed therefore that, in addition to expanding the actual Koshi Tappu Wildlife Reserve, plans for the creation of a larger Conservation Area in the region should be developed.

a) Trijuga Hunting Reserve (Proposed) lies north-east of the reserve and covers 53,200 ha area of Sal and Mixed Deciduous Forest. Several species of wildlife, including the endangered Bison, are still found in this forest. Within the forest, there is a place, called `Devhatia'. It is believed that this was a site of jewellery market for the Hindu gods and after each rainy day, people still go there to search for pieces of gold and jewels.
b) Ramdhooni Forest, a pilgrimage site for Hindus lies to the south east of the reserve. It is believed that here the Lord Rama had spent some nights during his exile. This forest is also a refuge for migrating wild elephants. However, the forest is being degraded due to logging, fuel wood extraction and livestock grazing. Recently, a road has been planned through the forest.
c) Baraha Chhetra is one of the four major pilgrimage sites for Hindus. It lies on the bank of the Koshi river and is one and half hours walk from Chatra.
d) Chakarghati-Chatra-Baraha Chhetra forest lies in the north on the way to BarahBa Chhetra from the reserve. The forest has been highly degraded in recent years due to its continuous exploitation and lack of management activities.
e) Chandra canal, Nepal's first irrigation project lies adjacent to the Trijuga forest near the village of Fatehpur, located 2 km to the north-west of the reserve. The watershed area has been degraded and needs proper management.

In addition to all these places, most portions of the important wetlands lie outside the reserve, near the Koshi Barrage and in the east towards the eastern embankment. The importance of all these places highlights the need for the establishment of a large conservation area and for multi-disciplinary approaches to be adopted for the management of such an area in order to conserve biodiversity, natural heritage, cultural heritage, religious sites and landmarks of national and international importance. Such an approach can promote large scale eco-tourism in the entire area and would aid in the economic development of the region.

Although a detailed study is required to formulate a long term management plan for the whole region, in addition to the activities suggested above, the following steps are essential in order to achieve the broad goals of the management of Koshi Tappu Wildlife Reserve and adjoining areas:

creation of a vegetation corridor by afforestation to join the wildlife reserve, Ramdhooni forest and Trijuga forest in order to facilitate wildlife

ranching;

- management of the forest en-route to Baraha Chhetra on the basis of sustainable utilization; and
- development of the unregistered land between the Trijuga forest and the reserve as grazing land.

The key for the implementation of these policies is long term financial and political commitment and the improvement of management. Reserve management must be prepared to assign a large share of its budget and human resources to monitor outside the reserve boundaries for the effective management of the wetlands in the region.

The extension of Koshi Tappu Wildlife Reserve, creation of zones within the reserve and the creation of a larger Conservation Area in the region are suggested based on the findings of this detailed study of both ecological and socio-cultural conditions and requirements of the area. The biodiversity presently maintained by the reserve and surrounding wetlands is clearly in grave danger given the socio-economic conditions of the local communities who are dependent on these resources for their survival.

Changing attitudes towards the reserve and enhancing local commitment to the sustainable use and protection of the area's natural resources will require innovative and concerted efforts by governmental and conservation bodies. Koshi Tappu presents conservationists and social scientists with challenges that must be met if we are to save the rich resources of the reserve while improving the lives of the communities dependent on these resources.

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APPENDICES

Appendix 1.1

Management Categories of Protected Areas

HMG, Nepal (The National Park and Wildlife Conservation Act, 1973)	IUCN categories (IUCN, 1992)
I) National Park An area set aside for conservation, management and utilization of mammals, birds, vegetation, and landscape together with the natural environment.	**II) National Park** To protect natural and scenic areas of national or international significance for scientific, educational and recreational use.
II) Strict Nature Reserve An area of ecological significance or significant in other respects, set aside for scientific study.	**I) Scientific Reserve/Strict Nature Reserve** To protect nature and maintain natural processes in an undisturbed state in order to have ecologically representative examples of the natural environment available for scientific study, environmental monitoring, education, and for the maintenance of genetic resources in a dynamic and evolutionary state.
III) Wildlife Reserve An area set aside for the conservation and management of mammals, birds and other resources and their habitat.	**IV) Managed Nature Reserve/ Wildlife Sanctuary** To assure the natural conditions necessary to protect nationally significant species, group of species, biotic communities, or physical features of the environment when these require specific human manipulation for their perpetuation. Controlled harvesting of some resources may be permitted.
IV) Hunting Reserve An area set aside for the conservation and management of birds and mammals and other resources to provide hunting to hunters.	**VIII) Multiple-Use Management Area/Managed Resource Area** To provide for the sustained production of water, timber, wildlife, pasture, and outdoor recreation, with the conservation of nature primarily oriented to the support of the economic activities (although specific zones can also be designed within these areas to achieve specific conservation objectives).

Appendix 1.2

List of threatened and endangered animal species protected by Nepalese law (HMG, 1983). The species associated with wetlands are asterisked (Bhandari, 1993).

Zoologincal Name	Common name
Mammals	
Ailurus fulgens	Red panda
Antilope cervicapa	Black buck
Bos grunniens	Wild yak
Bos gaurus	Gaur bison*
Bubalus bubalis	Wild buffalo*
Canis lupus	Wolf
Caprolagus hispidus	Hispid hare
Cervus duvaceli	Swamp deer*
Elephus maximus	Wild elephant*
Felis bengalensis	Leopoard cat
Felix lynx	Lynx
Hyaena hyaena	Striped hyaena
Macaca assamensis	Assamese rheus monkey
Manis crassicaudata	Pangolin
Moschus muschiferus	Musk deer
Neofelis nebulosa	Clouded leopard
Ovis ammon	Great Tibetan sheep
Panthera tigris	Tiger*
Panthera uncia	Snow leopard
Pantholops hodgsoni	Tibetan antelope
Platanista gangetica	Gangetic dolphin*
Prionodon pardicolor	Lingsang
Rhinoceros unicornis	One-horned rhinoceros*
Sus salvanus	Pigmy hog
Tetracerus quadricornis	Four-horned antelope
Ursus arctos	Brown beer
Birds	
Buceros bicornis	Great hornbill
Catreus willichii	Cheer pheasant
Ciconia ciconia	White stork*
Ciconia nigra	Black stork*
Grus grus	Saurus crane*
Houbropsis bengalensis	Bengal florican
Lophophourus impeyanus	Impeyan pheasant (Danphe)
Sypheotides indica	Lesser florican
Trogopan satyra	Crimson-horned pheasant
Reptiles	
Gavialis gangeticus	Gharial crocodiles*
Python spp.	Python*
Varanus flavescens	Golden monitor lizard*

Appendix 3.1

Analytical data of the representative soil profiles near Koshi Tappu

Locality	Depth (Cm)	pH	Organic matter (%)	Nitrogen (%)	Phosph-rous (kg/ha)	Potas (Kg/ha)	Mechanical Analysis			Soil type
							Sand (%)	Silt (%)	Clay (%)	
Sakardahi	0-47	8.1	0.1722	0.063	6.18	96.77	88.5	10.6	0.9	Sand
village (100 m	47-77	6.5	0.7749	0.077	8.24	172.03	38.7	39.5	21.8	Loam
east of the	77-94	7.0	0.4592	0.049	10.30	112.90	71.1	20.0	8.9	Sandy loam
western bund)	94-109	7.3	1.1148	0.280	9.27	37.63	97.6	2.0	0.5	Sand
	109-142	6.4	0.6888	0.077	6.18	134.40	50.1	28.0	21.9	Loam
Rampur-Malahniya	0-22	7.8	1.0332	0.161	8.24	241.92	31.9	53.7	14.4	Silty loam
village (75 m	22-37	8.1	0.6314	0.070	4.12	215.04	23.9	59.7	16.4	Silty loam
west of the	37-59	8.1	0.5740	0.049	10.30	198.91	35.6	54.1	12.3	Silty loam
western bund)	59-140	7.4	0.6833	0.001	6.18	241.92	25.4	45.1	29.5	Clay loam
Pipra Purba	0-24	5.5	0.8040	0.070	29.88	118.27	55.0	27.7	17.3	Sandy loam
village	24-45	6.1	0.5740	0.056	10.50	96.77	59.0	25.7	15.3	Sandy loam
Ward no. 5	45-75	6.3	0.2870	0.056	6.18	107.52	59.6	27.1	13.3	Sandy loam
	75-140	6.3	0.2290	0.055	7.21	107.52	55.6	29.1	15.3	Sandy loam
ShreepurJabdi										
village (0.8 km	0-11	7.4	1.2628	0.077	8.24	150.63	67.1	31.1	1.8	Sandy loam
east of the	11-22	7.6	0.4018	0.063	6.18	80.64	62.6	37.1	0.4	Sandy loam
eastern bund)										

Source: Pradhan et al., 1967

Appendix 3.2

Monthly Mean Rainfall at Chatara and Fatehpur

Month	Chatara											Phatehpur				
	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1982	1983	1984	1985	1986
January	10	0	2	7	0	13	0	10	56	3	2	0	14	39	0	0
February	26	2	8	52	11	9	1	2	16	7	0	0	0	18	0	0
March	0	16	45	1	13	39	24	3	3	2	0	11	0	0	10	0
April	80	89	59	22	8	90	65	56	61	14	107	28	63	36	7	27
May	151	219	94	57	126	144	101	239	213	179	192	57	79	130	130	53
June	454	300	511	307	350	377	280	389	572	219	239	71	291	433	231	119
July	664	366	616	741	286	680	438	704	825	578	389	253	492	370	355	333
August	1013	743	254	516	210	549	249	267	150	208	255	108	243	79	167	346
September	220	190	136	256	383	250	397	370	704	255	315	362	284	269	336	316
October	156	165	33	173	45	0	73	96	119	242	138	43	9	23	119	5
November	4	37	25	10	0	0	5	0	0	58	100	20	0	0	21	21
December	0	22	0	85	0	0	0	21	0	8	23	0	22	5	46	3
Total	2778	2149	1783	2227	1432	2151	1633	2157	2719	1773	1760	953	1497	1402	1422	1223

Source: HMG, 1986

Appendix 3.3

Monthly mean relative humidity (%) at Phatehpur, Saptari

Month	1983		1984		1985		1986		Average	
	0840	1740	0840	1740	0840	1740	0840	1740	0840	1740
January	86	87	90	91	90	93	83	91	87.25	90.50
February	84	83	83	77	91	88	82	82	85.00	82.50
March	74	68	76	76	81	81	78	80	77.25	76.25
April	67	65	75	77	84	80	83	81	77.25	75.75
May	77	75	88	86	89	92	81	79	83.75	83.00
June	85	80	89	88	90	74	84	84	87.00	81.50
July	85	79	89	87	84	85	84	78	85.50	82.25
August	86	86	86	88	82	80	81	84	83.75	84.50
September	86	86	88	91	86	85	81	80	85.25	85.50
October	83	89	92	94	86	85	82	86	85.75	88.50
November	83	94	85	90	76	86	76	82	80.00	88.00
December	86	95	90	94	89	87	85	92	87.50	92.00
Average	82	83	86	87	86	85	82	83	84.00	84.50

Source: HMG, 1986

Appendix 3.4

Monthly maximum and minimum temperature at Phatehpur, Saptari

Month	1982		1983		1984		1985		1986	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
January	25.4	8.6	22.8	7.4	23.3	6.8	22.0	6.7	24.4	9.4
February	25.7	9.2	25.8	9.0	24.8	10.2	24.1	8.8	25.2	11.3
March	29.4	12.8	30.5	11.4	30.6	16.3	31.4	15.3	32.0	14.6
April	33.9	19.7	32.5	15.4	33.9	19.8	33.4	21.2	33.1	20.1
May	35.7	22.4	32.6	21.0	32.7	22.7	32.6	20.9	31.7	19.5
June	31.5	23.3	33.1	22.9	32.5	24.8	33.0	23.5	32.7	24.5
July	32.4	25.3	33.3	24.3	31.1	24.8	32.2	25.0	33.3	25.4
August	32.8	25.6	33.2	26.0	33.3	24.0	32.7	25.5	33.6	25.6
September	31.2	23.7	32.2	25.1	32.0	24.9	31.3	24.8	32.0	25.0
October	30.8	19.2	32.7	20.8	30.8	19.8	31.6	20.3	31.3	19.3
November	27.2	17.1	29.4	13.5	27.7	12.6	27.8	14.3	28.2	16.9
December	24.8	9.9	25.4	7.5	25.1	9.1	24.6	9.9	25.1	9.7
Average	30.1	18.1	30.3	17.0	29.8	18.0	29.7	18.0	30.2	18.4

Source: HMG, 1986.

Appendix 3.5

Sediment load (% of the value at Gorge) and river bed level of the Koshi river

Place	Distance (km)	Suspended Sediment	High flood level (m)	Bed level (m)
Nepal				
Chatara	0.0	109.0	110.18	102.16
Golpharia	17.7	111.0		
Raniganj (Barrage)	41.9	-	70.74	65.08
Hanumannagar	51.5	141.5		
India				
Bhaptiahi	74.1		56.98	51.79
Supaul	114.3		48.38	44.27
Karahara	124.0	96.5		
Dhamra Ghat	210.9		36.25	19.58
Basua	238.3	27.5		
Nagachia	296.2		33.35	17.19
Kursela	318.8	24.0	31.70	11.12

Source: Godbole, 1986

Appendix 3.6

Flood level slope and river bed slope of the Koshi river

Place	Distance (km)	HFL Slope (m/km)	Bed Level (m/km)
Chatara - Raniganj	0 - 41.86	0.950	0.890
Raniganj - Bhaptiahi	41.86 - 74.06	0.500	0.420
Bhaptiyahi - Supaul	74.06 - 114.31	0.210	0.190
Supaul - Dhamra Ghat	114.31 - 210.91	0.120	0.230
Dhamra Ghat - Nagachia	210.91 - 296.24	0.320	0.023
Nagachia - Kursela	296.24 - 318.78	0.074	0.057

Source: Godbole, 1986

Appendix 3.7

Flood Records in the Koshi River

Year	Date	Water discharge	
		(cu.ft./sec)	(m^3/sec)
1947	31 July	312,350	8,746
1948	12 July	478,649	13,402
1949	19 July	395,640	11,078
1950	20 August	340,661	9,539
1951	24 August	256,284	7,176
1952	24 September	306,443	8,580
1953	30 July	191,418	5,360
1954	24 August	855,237	23,947
1955	7 August	196,692	5,507
1956	29 August	192,000	5,376
1957	12 August	266,000	7,448
1958	25 August	373,000	10,444
1959	10 August	211,000	5,908
1960	28 September	254,000	7,112
1961	20 August	293,000	8,204
1962	2 August	371,000	10,388
1963	16 September	270,000	7,560
1964	22 September	380,000	10,640
1965	11 August	235,000	6,580
1966	24 August	382,000	10,696
1967	9 July	312,000	8,736
1968	5 October	913,000	25,564
1969	28 July	287,326	8,045
1970	15 July	489,800	13,714
1971	12 June	430,000	12,040
1972	28 July	378,205	10,590
1973	18 October	347,050	9,717
1974	5 August	450,000	12,600
1975	28 July	324,950	9,099
1976	23 August	334,850	9,376
1977	26 August	274,640	7,690
1978	28 July	347,106	9,719
1979	24 August	471,196	13,193
1980	19 July	215,199	6,026
1981	22 August	282,180	7,901
1982	19 July	246,106	6,891
1983	4 July	311,403	8,719
1984	17 September	664,437	18,604
1985	5 September	457,712	12,816
1986	2 August	282,963	7,923
1987	11 August	523,711	14,664

Year	Date	Water discharge	
		(cu.ft./sec)	(m^3/sec)
1988	26 August	400,190	11,205
1989	19 September	472,912	13,242
1990	12 August	406,675	11,387
1991	16 August	361,009	10,108

Source: Koshi Project (Cited in WMI/IUCN-Nepal, 1994)

Appendix 4.1

List of plant species found in Koshi Tappu

Family and Species	Local Name	Habit	Ref.
Acanthaceae			
Hemigraphis hirta		H	2
Justicia adhatoda L.	Asuro	S	1
Justicia procumbens		PT	2
Thunbergia grandiflora		C	2
Aizoaceae			
Mollugo lotoides L.		H	1
Alismataceae			
Ottelia alismoides (L.) Pers.	Panikhar	RS	1
Sagitaria trifolia L.	Laph	H	1
Amaranthaceae			
Achyranthes aspera L.	Chirchiri	S	1
Achyranthes bidentata Blume	Datiun	S	1
Alternanthera sessalis (L.) DC	Saranchi	H	1
Amaranthus spinosus L.	Kande	H	1
Amaranthus viridis L.	Latte	H	1
Celosia argentea	Sarwari	H	2
Deeringa amaranthoides (Lam.) Merrill		H	2
Anacardiaceae			
Mangifera indica L.	Aam	T	1
Annonaceae			
Meliusa velutina		T	2
Apocynaceae			
Cascabela thevetica (L.) Lippold in Fedde	Jharkanail	T	1
Holarrhena pubescens (Buch-Ham.) Wall.	Indrajau	T	1
Thevetia peruviana	Kaner	S	2
Araceae			
Alocasia sp.	Kacchu	E	2
Pistia stratiotes L.	Kumbhi	FF	1
Ascelpediaceae			
Calotropis gigantea (L.) Dryand	Akaun	S	1
Cycenachium auriculatum		C	2
Tylophora tenerrima		PT	2
Bombacaceae			
Bombax ceiba (L.)	Simal	T	1
Boraginaceae			
Cynoglossum zeylanicum		H	2
Burseraceae			
Garuga pinnata Roxb.	Dabdabe	T	1
Ceratophyllaceae			
Ceratophyllum demersum L.	Patai	SM	1

Family and Species	Local Name	Habit	Ref.
Chenopodiaceae			
Chenopodium ambrosoides L.	Bethe	H	1
Commelinaceae			
Commelina bengalensis L.	Surgurejhar	H	2
Commelina paludosa Blume	Kane Sag	H	1
Compositae			
Ageratum conizoides L	Gandhe	H	1
Artemisia indica Willd.	Titepate	H	1
Bidens pilosa L.	Kurro	H	1
Blumea aromatica DC.	Musada	H	1
Blumea lacera (Burm. f.) D.C.		H	2
Cirsium wallichi i D. C.	Thakal	H	1
Conyza canadensis		H	2
Conyza joponica		H	
Cyathocline purpurea (B-H) ex D. Don.	Galfule	H	1
Eclipta prostrata (L.) Roemer & Schulter	Bhangraila	H	1
Eriogeron acer		E	2
Eupatorium adenophorum Spreng.	Banmara	H	1
Eupatorium odoratum L.	Banmara	S	2
Gnaphalium affine D. Don		H	1
Gynura nepalensis		H	2
Siegesbeckia orientalis L.	Kure Gandhe	H	2
Spilanthus calva D.C.	Lato ghans	H	1
Spilanthus pseudo-acumella		H	2
Tridex procumbens		H	2
Vernonia anagalis aquatica	Thurjhuri	H	2
Vernonia cinerea (L.) Less.	Mirchaiya	H	1
Xanthium strumarium L.	Lapetuwa	H	1
Convolvulaceae			
Ipomoea aquatica Forssk.	Karmaiya Sag	RF	1
Ipomoea carnea Jacq.	Karmaiya Sag	S	1
Ipomoea gradiflora Roxb.		S	2
Cordiaceae			
Ehretia acuminata Roxb.	Dhatrange	T	1
Crassulaceae			
Sedum multicaule		H	2
Cruciferae			
Draba elata		H	2
Cucurbitaceae			
Cucumis sp.		C	2
Cucurbita sp.		C	2
Momordica charantia L.	Jangli Karela	C	1
Solena heterophylla Lour.	Banparwal	C	1
Cyperaceae			
Cyperus compressus L.	Motha	E	1

Family and Species	Local Name	Habit	Ref.
Cyperus cyperoides	Motha	E	1
Cyperus difformis L.	Motha	E	1
Cyperus diffusus Vahl.	Motha	E	1
Cyperus digitatus Roxb.	Chatari	E	1
Cyperus distans L.f.	Motha	E	1
Cyperus esculantus L.	Motha	E	2
Cyperus globosus Allioni		H	2
Cyperus rotundus L.		H	1
Cyperus sanuguin Olentus Vahl.		E	1
Fimbrystylis aestivalis (Retz.) Vahl		E	2
Fimbrystylis dichotoma		H	2
Fimbrystylis ovata		H	2
Fimbrystylis squarrosa (Vahl) Kunth	Motha	E	1
Kyllinga brevifolia (Roxb.) Hassk	Motha	E	1
Kyllinga nemorelis		H	2
Schoeneplectus mucronatus Stapf et Hubb.	Mothi	E	1
Scirpus kysoor Roxb.	Kaysoor	E	1
Scirpus setaceus L.	Mothi	E	1
Euphorbiaceae			
Croton sparsiflorus		H	2
Euphorbia hirta L.	Dudhe	H	1
Euphorbia rosea		H	2
Mallotus phillipinensis (Lam.) Muell.-Arg.	Sindure	T	1
Macaranga postulata		T	2
Phyllanthus emblica L.	Amla	T	1
Phyllanthus glaucus		H	2
Phyllanthus simplex		H	2
Trewia nudiflora L.	Pithari	T	1
Graminae			
Arundo donax L.	Khadai, Khar	H	1
Carex microglochin Wahlenb.	Damthi Khar	E	1
Cympogon pendulus (Nees ex Steud.) W. Watson	Khar	H	1
Cynodon dactyolon (L.) Pers.	Dubo	H	1
Digitaria ascendens		H	2
Digitaria ciliaris (Retz.) Kopeler	Banso	H	1
Echinochloa colonum (L.) Link	Sama	H	1
Echinochloa cruss-gallii (L.) P. Beauv.	Sama, Telar	E	1
Echinochloa picta		H	2
Eragrostis cynosuroides	Kush	H	1
Eragrostis tenella (L.) Roemer and Schult	Banso	H	1
Erianthus ravennae (L.) Beauvois		H	1
Eulaliopsis binata (Retz.) C. E. Hubbard	Babiyo	H	1
Heteropogon contortus (L.) Beauv.	Chupi ghas	H	1
Hygorhyza aristata (Retz) Nees ex Wright & Arn		RF	1
Imperata cylidica (L.) Beuvois	Siru	H	1

Family and Species	Local Name	Habit	Ref.
Paspalidium flavidum (Retz) A. Camus		E	1
Paspalidium punctatum (Burm.) A. Camus		E	1
Paspalidium zeylancia		H	2
Paspalum distichum L.	Banso	E	1
Phalaris arundinacea L.	Leu	SM	1
Phragmites karka (Retz.) Trin ex Steudes	Narkat	E	1
Saccharum spontaneum L.	Kans	E	1
Setaria glauca (L.) P. Beauv.	Bankauni	H	1
Setaria pallidefusca (Schum.) Stapf et. Hubb.	Bankauni	H	1
Themeda arndinaceae (Roxb.) Ridgley	Khar	H	1
Vetiveria lausonii (Hook f.) Blatter & Mccann	Khaskhas	H	1
Vetiveria zizanoides (L.) Nash	Katari jhar	H	2
Heliotropiaceae			
Heliotropium strigosum Willd.		H	2
Hydrocharitaceae			
Hydrilla verticillata (L.f.) Royle	Khesi, Leu	SM	1
Hydrocharis dubia J. R. Drumm ex Burev		RF	1
Vallisnaria spiralis	Panikhar	RS	2
Vallisneria natans (Lour.) Hara	Panikhar	RS	1
Juncaceae			
Juncus bufonius L.	Motha, Jwane	H	1
Labiatae			
Colebrookea oppositifolia Sm.	Dhurseli	H	1
Leucas cephalotus (Roth) Spreng.	Dronapuspi	H	1
Leucas indica		H	2
Leucas mollissima		H	2
Hyptis suaveolens		H	2
Pogostemon glaber Benth.		H	2
Lauraceae			
Litsea monopetale (Roxb.) Pers.	Kadmero	T	1
Leguminosae			
Pithecellobium dulce	Jalebi	T	2
Acacia arabica	Babul	T	2
Acacia catechu (L.f.) Willd	Khair	T	1
Albizia chinensis (Osbeck.) Merr	Siris	T	1
Atylosia scarabaeoides (L.) Benth	Jangali rahar	H	1
Calpagonium nucunoides Desv.		H	1
Cassia fistula L.	Rajbriksha	T	1
Cassia occidentalis L.	Panwar	S	1
Crotolaria pallida AIt.	Sanai	H	1
Dalbergia sissoo Roxb.	Sissoo	T	1
Desmodium multiflorum		PT	2
Desmodium triflorum (L.) DC		H	1
Indigofera linifolia	Sagino	PT	1
Spatholobus parviflorus (Roxb.) Kuntze	Debre Lahra	C	1

Family and Species	Local Name	Habit	Ref.
Tamarindus indica L.	Imli	T	1
Uraria lagapodiodes (L.) Desv.	Tanki	H	1
Uraria picta		H	2
Lemnaceae			
Lemna minor L.	Leu	FF	1
Lemna perpusilla Torrey	Leu, Pani Jhyau	FF	1
Spirodela polyrrhiza (L.) Schleiden	Leu	FF	1
Wolfia globosa (Roxb.) den Hartog & Plas	Leu	FF	1
Lentibulariaceae			
Utricularia aurea Lour.	Chamati	SM	1
Lythraceae			
Ammania baccifera L.		H	1
Rotala rotundifolia (Buch-Ham. ex Roxb.) Koec.		E	1
Malvaceae			
Abutilon indicum	Kanghi	H	2
Sida acuta Burm. f.	Bariyar	H	2
Sida cordata	Bariyar	H	2
Sida rhombifolia L.	Bariyar	H	1
Urena lobota L.	Nalukure	S	1
Meliaceae			
Azadirachta indica A. Juss.	Nim	T	1
Menispermaceae			
Stephania glandulifera Miers	Gurje Lahara	C	1
Stephania japonica (Thunb.) Miers	Gurje Lahara	C	1
Menynthaceae			
Nymphoides cristatum O. Kunze	Serkhi	RF	1
Nymphoides hydrophyllum (Lour.) O. Kuntze	Koka	RF	1
Nymphoides indica (L.) O. Kuntie	Koka	RF	1
Mimosaceae			
Mimosa pudica L.	Lajvanti	H	1
Mimosa rubicaulis Lam.	Arhari Kanda	T	2
Moraceae			
Artocarpus lakoocha Wall.	Jangali Barhar	T	1
Ficus hirta		PT	2
Ficus ovata		C	2
Ficus semicordata Buch-Ham ex Sm.	Khanyu	T	1
Ficus subincisa Buch-ham. ex Sm.	Sahur	T	1
Myrtaceae			
Eugenia jombolana Lam.	Jamun	T	1
Syzygium cumini (L.) Skell	Jamun	T	1
Nyctaginaceae			
Boerhavia diffusa L.		C	1
Nymphaeceae			
Euryale ferox Salisb.	Makhan	RF	1
Nelumbo nucifera Gaertn.	Kamal	RF	1

Family and Species	Local Name	Habit	Ref.
Nymphaea stellata Willd.		RF	1
Onagraceae			
Ludwigia adscendens (L.) Hara	Sawar	RF	1
Orchidaceae			
Spiranthes sinensis (Pers.) Ames.	Tutiya	H	1
Oxalidaceae			
Oxalis corniculata L.	Chariameli	H	1
Plantaginaceae			
Plantago erosa Wall.	Isapgol	H	2
Plantago major L.	Palanki	H	1
Polygonaceae			
Persicaria barbata (L.) Hara	Bishnair/Pirre	E	1
Persicaria glabra (Willd.) Gormes	Bishnair/Pirre	E	1
Persicaria hydropiper (L.) Spaeck	Bishnair/Pirre	RF	1
Persicaria lapaphifolia (L.) S F Gray	Bishnair/Pirre	E	2
Persicaria tenella	Bishnair/Pirre	H	2
Polygonum plebejum R. Br.	Bishnair/Pirre	H	1
Rumex nepalensis Spreng.	Halhale	H	1
Pontederiaceae			
Eichornia crassipes (Mart.) Solms.	Jalkumhi	FF	1
Monochoria hastata (L.) Solms.	Koka	E	1
Monochoria vaginalis (Burm. f.) c. Pres	Panauti khar	E	1
Potamogetomaceae			
Potamogeton crispus L.	Panikhar	RS	1
Potamogeton lucens L.	Panikhar	RS	2
Potamogeton nodosus Poir.	Panikhar	RS	1
Potamogeton pectinatus L.	Panikhar	RS	1
Ranunculaceae			
Ranunculus aquitalis L.	Nakore	SM	1
Ranunculus diffusus DC.	Nakore	H	1
Rhmnaceae			
Zizyphus mouritiana Lam.	Bair	T	1
Rubiaceae			
Anthocephalus cadamba Miquel	Kadam	T	1
Rutaceae			
Aegle marmalos (L.) Corr.	Bel	T	1
Citrus medica L.	Bimiro	T	1
Salicaceae			
Salix tetrasperma Roxb.	Bains	T	1
Sapotaceae			
Madhuca longifolia (Koenig.) Macbride	Mahuwa	T	1
Scrophulariaceae			
Lindernia pussila (Willd) Boldingh		H	1
Scorparia dulcis L.	Mitha Jhar	S	1
Torenia cordifolia		H	2

Family and Species	Local Name	Habit	Ref.
Solanaceae			
Datura stramonium L.	Dhatur	H	1
Solanum aculeatissimum		S	2
Solanum erianthum D. Don		H	1
Solanum indicum L.		H	2
Solanum nigrum L.	Bhutkul	H	1
Solanum torvum Sw.	Jangli Bhanta	H	1
Solanum xanthocarpum Schrad et Wndl	Kanthakari	H	1
Tamaricaceae			
Tamarix dioica Roxb. ex Roth.	Jhauwa	S	1
Tiliaceae			
Grewia disperma		T	2
Grewia oppositifolia	Phalsa	T	1
Grewia optiva J. R. Drumm. ex Burret	Phalsa	T	1
Triumfetta rhomboides Jacq.	Jaropat	H	1
Trapaceae			
Trapa natans var. bispinosa (Roxb.) Makino	Singara	RF	1
Typhaceae			
Typha angustifolia L.	Pater	E	1
Ulmaceae			
Trema orientalis	Khari	T	2
Umbelliferae			
Centella asiatica (L.) Urb.	Ghodtapad	H	1
Hydrocortyle rotundifolia		PT	2
Oenanthae javanica (Walex DC) Mauvetre		H	1
Boehmeria hamiltonia		S	2
Verbenaceae			
Lippia nodiflora (L.) Rich	Bukuna khar	H	1
Callicarpa macrophyla Vahl	Dahigji, dahigw	H	1
Clerodendron infortunatum Gaertn.	Rajbeli	S	1
Clerodendron viscosum Vent.	Bhant	S	1
Lantana indica Roxb.	Nilkanda	S	1
Vitaceae			
Parthenocissus capriolata		C	2
Tetrastigma serulatum		H	2

Source: 1. Sah, 1993a; 2. WMI/IUCN-Nepal, 1994
C = Climber, H = Herb, S = Shrub, T = Tree, PT = Prostrate and Trailer,
E = Emergent, RS = Rooted sub-merged, SM = Sub-merged
FF = Free floataing, RF = Rooted floating

Appendix 4.2

List of auatic macrophytes found in Koshi Tappu

Species	Family	Local Name
Sub-merged:		
Ceratophyllum demersum L.	Ceratophyllaceae	Patai
Hydrilla verticillata (L.f.) Royle	Hydrocharitaceae	Khesi, Leu
Phalaris arundinacea L.	Graminae	Leu
Ranunculus aquitalis L.	Ranunculaceae	Nakore
Rooted-submerged:		
Ottelia alismoides (L.) Pers.	Alismataceae	Panikhar
Potamogeton crispus L.	Potamogetomaceae	Panikhar
Potamogeton lucens L.	Potamogetomaceae	Panikhar
Potamogeton nodosus Poir.	Potamogetomaceae	Panikhar
Potamogeton pectinatus L.	Potamogetomaceae	Panikhar
Vallisnaria spiralis	Hydrocharitaceae	Panikhar
Vallisneria natans (Lour.) Hara	Hydrocharitaceae	Panikhar
Free-floating:		
Azolla imbricata (Roxb.) Nakai	Salvinaceae	Pani Uneu
Eichornia crassipes (Mart.) Solms.	Pontederiaceae	Jalkumhi
Lemna minor L.	Lemnceae	Leu
Lemna perpusilla Torrey	Lemnceae	Pani Jhyau
Marsilea crenata Presl.	Marsileaceae	Charpate
Pistia stratiotes L.	Araceae	Kumbhi
Sagitaria trifolia L.	Alismataceae	Laph
Spirodela polyrrhiza (L.) Schleiden	Lemnceae	Leu
Wolfia globosa (Roxb.) den Hartog & Plas	Lemnceae	Leu
Rooted-floating:		
Euryale ferox Salisb.	Nymphaeceae	Makhan
Hydrocharis dubia J. R. Drumm ex Burev	Hydrocharitaceae	
Hygorhyza aristata (Retz) Nees ex Wright & Ar	Graminae	
Ipomoea aquatica Forssk.	Convolvulaceae	Karmaiya Sag
Ludwigia adscendens (L.) Hara	Onagraceae	Sawar
Nelumbo nucifera Gaertn.	Nymphaeceae	Kamal
Nymphaea stellata Willd.	Nymphaeceae	
Nymphoides cristatum O. Kunze	Menynthaceae	Serkhi
Nymphoides hydrophyllum (Lour.) O. Kuntze	Menynthaceae	Koka
Nymphoides indica (L.) O. Kuntie	Menynthaceae	Koka
Persicaria hydropiper (L.) Spaeck	Polygonaceae	Bishnair
Trapa natans var. bispinosa (Roxb.) Makino	Trapaceae	Singara
Emergents:		
Carex microglochin Wahlenb.	Graminae	Damthi Khar
Cyperus compressus L.	Cyperaceae	Motha
Cyperus cyperoides	Cyperaceae	Motha
Cyperus difformis L.	Cyperaceae	Motha

Species	Family	Local Name
Cyperus diffusus Vahl.	Cyperaceae	Motha
Cyperus digitatus Roxb.	Cyperaceae	Chatari
Cyperus distans L.f.	Cyperaceae	Motha
Cyperus esculantus L.	Cyperaceae	Motha
Cyperus sanuguin Olentus Vahl.	Cyperaceae	
Echinochloa colonum (L.) Link	Graminae	Sama
Echinochloa cruss-gallii (L.) P. Beauv.	Graminae	Sama, Telar
Equisetum sp.	Equisetaceae	Horse's tail
Fimbrystylis aestivalis (Retz.) Vahl	Cyperaceae	
Fimbrystylis squarrosa (Vahl) Kunth	Cyperaceae	Motha
Juncus bufonius L.	Juncaceae	Jwane
Kyllinga brevifolia (Roxb.) Hassk	Cyperaceae	Motha
Monochoria hastata (L.) Solms.	Pontaderiaceae	Koka
Monochoria vaginalis (Burm. f.) c. Pres	Pontederiaceae	Panauti khar
Paspalidium flavidum (Retz) A. Camus	Graminae	
Paspalidium punctatum (Burm.) A. Camus	Graminae	
Paspalum distichum L.	Graminae	Banso
Persicaria barbata (L.) Hara	Polygonaceae	Bishnair
Persicaria glabra (Willd.) Gormes	Polygonaceae	Bishnair
Persicaria lapaphifolia (L.) S F Gray	Polygonaceae	Bishnair
Rotala rotundifolia (Buch-Ham. ex Roxb.) Koe	Lytheraceae	
Schoeneplectus mucronatus Stapf et Hubb.	Cyperaceae	Mothi
Scirpus kysoor Roxb.	Cyperaceae	Kaysoor
Scirpus setaceus L.	Cyperaceae	Mothi
Typha angustifolia L.	Typhaceae	Pater
Wetland/Marshy Plants:		
Alocasia sp.	Araceae	Kacchu
Alternanthera sessalis (L.) DC	Amaranthaceae	Saranchi
Bidens pilosa L.	Compositae	Kurro
Centella asiatica (L.) Urb.	Umbelliferae	Ghodtapad
Chenopodium ambrosoides L.	Chenopodiaceae	Bethe
Cirsium wallichi i D. C.	Compositae	Thakal
Commelina bengalensis L.	Commelinaceae	Surgurejhar
Commelina paludosa Blume	Commelinaceae	Kane Sag
Cyathocline purpurea (B-H) ex D. Don.	Compositae	Galfule
Cynodon dactyolon (L.) Pers.	Graminae	Dubo
Eclipta prostrata (L.) Roemer & Schulter	Compositae	Bhangraila
Eragrostis tenella (L.) Roemer and Schult	Graminae	Banso
Eriogeron acer	Compositae	
Eupatorium adenophorum Spreng.	Compositae	Banmara
Euphorbia hirta L.	Euphorbiaceae	Dudhe
Fimbrystylis dichotoma	Cyperaceae	
Fimbrystylis ovata	Cyperaceae	
Ipomoea carnea Jacq.	Convolvulaceae	Karmaiya Sag
Leucas cephalotus (Roth) Spreng.	Labiatae	Dronapuspi

Species	Family	Local Name
Lippia nodiflora (L.) Rich	Verbenaceae	Bukuna khar
Mimosa pudica L.	Mimosaceae	Lajvanti
Oenanthae javanica (Walex DC) Mauvetre	Umbelliferae	
Phragmites karka (Retz.) Trin ex Steudes	Graminae	Narkat
Plantago erosa Wall.	Plantaginaceae	Isapgol
Polygonum plebejum R. Br.	Polygonaceae	Bishnair
Pteris vittata L.	Pteridaceae	Uneu
Rumex nepalensis Spreng.	Polygonaceae	Halhale
Saccharum spontaneum L.	Graminae	Kans
Setaria glauca (L.) P. Beauv.	Graminae	Bankauni
Setaria pallidefusca (Schum.) Stapf et. Hubb.	Graminae	Bankauni
Tamarix dioica Roxb. ex Roth.	Tamaricaceae	Jhauwa
Uraria lagapodiodes (L.) Desv.	Leguminosae	Tanki
Vetiveria lausonii (Hook f.) Blatter & Mccann	Graminae	Khaskhas
Vetiveria zizanoides (L.) Nash	Graminae	Katari jhar
Xanthium strumarium L.	Compositae	Lapetuwa

Source: After Shrestha, 1996.

Appendix 4.3

List of fish species found in the wetlands of Koshi Tappu

Family and Species	Local Name	Reference
Clupeidae		
Gudusia chapra Ham.	Suia	1
Engraulidae		
Setipinna phasa Ham.	Gan Kabai	1
Notopteridae		
Notopterus notopterus Pallas	Golhai	1
Cyprinidae		
Acrossocheilus hexagonolepis Mc Clelland	Katli	1
Amblypharyngodon mola Ham.	Mara	1
Aspidoparia jaya Ham.	Mara	1
Aspidoparia morar Ham.	Harda, Bhegna	1
Barilius barila Ham.	Chahale	1
Barilius barna Ham.	Pothi	1
Barilius bendelisis Ham.	Guderi	1
Barilius bola Ham.		1
Barilius jalkapoorei Shreshtha	Jalkapoor	1
Barilius tilio Ham.	Fageta	1
Barilius vagra Ham.	Fageta	1
Catla catla Ham.	Catla	1
Chagunius chagunio Ham.	Pathar Chatti	1
Chela chaeius Ham	Chelwa	2
Chela labuca Ham.	Chalwa	1
Cirrhinus mrigala Ham.	Naini	1
Cirrhinus reba Ham.	Rewa	1
Crossocheilus latius Ham.	Buduna	1
Danio aequipinnatus Day	Chithari Pothi	1
Danio dangila Ham.	Chithari Pothi	1
Danio devario Ham.	Chithari Pothi	1
Danio rerio Ham.	Bhitti	1
Esomus danricus Ham.	Deduwa, Darai	1
Garra annandalei Hora	Lahare Buduna	1
Garra gotyla Gray	Buduna	1
Garra lamta Ham.	Duduwa	1
Labeo angra Ham.	Rohu	1
Labeo bata Ham.	Tikauli	1
Labeo boga Ham		1
Labeo calabasu Ham.	Basrahi	1
Labeo coeruleus Ham.		2
Labeo dero Ham.	Gurdi	1
Labeo gonius Ham.	Kursa	1
Labeo pangusia Ham.	Kalnacha	1

Family and Species	Local Name	Reference
Labeo rohita Ham.	Rohu	1
Labeo sindensis Day	Rohu	1
Osteobrama cotio Ham.	Gurda	1
Oxygaster argentea Day	Chalwa	1
Oxygaster bacalia Ham.	Chalwa	1
Oxygaster gora Ham.	Chalwa	1
Oxygaster phulo Ham.	Chalwa	1
Puntius chilinodes Mc. Clelland	Pothi	1
Puntius chola Ham.	Sidhra	1
Puntius clavatus Mc. Clelland	Sidri	1
Puntius conchonius Ham.	Pothi	1
Puntius gelices Ham.	Pothi	1
Puntius sarana Ham.	Bada Pothi	1
Puntius sophore Ham.	Chanda Pothi	1
Puntius ticto Ham.	Darahi, Sidhara	1
Rasbora daniconius Ham.	Khasara	1
Solmostoma oxygaster bacaila Ham.		2
Tor putitora Ham.	Sahar	1
Psilorhynchidae		
Psilorynchus sucatio Menon & Dutta	Tite Machh	1
Homolopteridae		
Balitora brucei Gray		1
Cobitidae		
Acanthophtealmus pangia Ham.		1
Botia dayi Hora	Baghi	1
Botia histrionica Blyth		1
Botia lochata Ham.		2
Botia lohachaita Chaudhari	Bagha	1
Lepidocephalichthys annandalei Chaudhari	Lata	1
Lepidocephalichthys guntea Ham.	Lata	1
Noemacheilus botia Ham.	Gadela	1
Noemacheilus rupicola Mc Clelland	Gadela	1
Noemacheilus rupicola inglisi Hora	Gadela	1
Noemacheilus savona Ham.		1
Noemacheilus scaturigina Mc. Clelland		1
Somileptes gongota Ham.		2
Siluridae		
Ompok bimaculatus Bloch	Pabata	1
Wallago attu Schneider	Padani	1
Bagridae		
Leiocassis round Ham.		1
Mytus aor Ham.	Kanti	1
Mytus bleekeri Day	Tengri	1
Mystus cavacius Ham.		2
Mytus seenghala Sykes	Tengra	1

Family and Species	Local Name	Reference
Mystus tengara Ham.	Tengra	2
Mytus vittatus Bloch	Tengra	1
Rita rita Ham.	Rita	1
Amblycepidae		
Amblyceps mangois Ham.	Baljung	1
Sisoridae		
Bagarius bagarius Ham.	Gonch	1
Gagata cenia Ham.	Gonch	1
Gagata nangra Ham.		1
Gagata viridescens Ham.		1
Glyptothorax annaldalei Hora	Capre	1
Glyptothorax cavia Ham.	Capre	1
Glyptothorax horai Shaw & Shebbeare	Kotel	1
Glyptothorax telchitta Ham.	Kotel	1
Hara jerdoni Day		1
Nangra viridescens Ham.		2
Sissor rhabdophorus Ham.		2
Pseudohereis sulcatus Mc Clelland	Cabre	1
Chacidae		
Chaca chaca Ham.		2
Schilbeidae		
Ailia colia Ham.	Banspatti	1
Clupisoma garua Ham.	Jalkapoor	1
Clupisoma montana Hora	Jalkapoor	1
Eutropichthys vacha Ham.	Bachwa	1
Pseudeutropius antherinoides Bloch	Patasi	1
Saccobranchidae		
Heteropneustes fossilis Bloch		1
Claridae		
Clarias batrachus Linn.	Singhi	1
Belonidae		
Xenentodon cancila Ham.	Mungari	1
Cyprnnodontidae		
Aplocheilus panchax Ham.		1
Mugelidae		
Rhinomugil corsula Ham.		1
Channidae		
Channa gachua Ham.	Chenga	1
Channa marulius Ham.	Saura	1
Channa orientalis Schleiden	Helae	1
Channa punctatus Bloch	Garai	1
Channa sophore Saura	Saura	1
Channa stewartii Ham.		2
Channa striatus Bloch	Saura	1

Family and Species	Local Name	Reference
Amphipnoidae		
Amphipnous cuchia Ham.	Bam	1
Chandidae		
Chanda nama Ham.		2
Chanda ranga Ham.		2
Ambassidae		
Ambassis nama Ham.	Nati	1
Ambassis ranga Ham.	Nati	1
Nandidae		
Badis badis Ham.		2
Nandus nandus Ham.	Dhewari	1
Sciaenidae		
Sciaena coitor Ham.	Bhola	1
Anabantidae		
Anabas testudineus Ham.		2
Belontidae		
Colisa fasciatus Schneider	Khesara	1
Colisa lalius Ham.		1
Colisa sota Ham.		2
Gobidae		
Glossogobius giuris Ham.	Bulla	1
Mastacembelidae		
Macrognanthus aculeatus Bloch	Gainchi	1
Mastacembelus armatus Ham.	Chuche bam	1
Mastacembelus pancalus Ham.	Kant Gainchi	1
Tetrodontidae		
Tetraodon cutcutia Ham.	Phokcha	1

Source: 1. Shrestha, 1980 (in Shrestha, 1990); 2. WMI/IUCN-Nepal, 1994.

Appendix 4.4

Checklists for the bird species of Koshi Tappu

Family and English Name	Scientific Name	Ref.
Podicipitidae		
Great Crested Grebe*	*Podiceps cristatus*	3
Little or Red-Necked Grebe*	*Podiceps ruficollia*	4
Little Grebe*	*Tachybaptus ruficollis*	3
Pelecanidae		
Spot-billed Pelican*	*Pelecanus philippensis*	1
Phalacrocoracidae		
Great Cormorant*	*Phalacrocorax carbo*	3
Indian Shag	*Phalacrocorax fusciocollis*	3
Little Cormorant*	*Phalacrocorax niger*	2
Anhingidae		
Oriental Darter*	*Anhinga melanogaster*	2
Darter	*Anhinga rufa*	3
Ardeidae		
Grey Heron*	*Ardea cinerea*	3
Purple Heron*	*Ardea purpurea*	3
Indian Pond Heron*	*Ardeola grayii*	3
Eurasian Bittern*	*Botaurus stellaris*	2
Cattle Egret*	*Bubulcus ibis*	3
Green-backed Heron*	*Butorides striatus*	4
Black Bittern*	*Dupetor flavicollis*	2
Large Egret*	*Egretta alba*	3
Little Egret*	*Egretta garzetta*	3
Intermediate Egret*	*Egretta intermedia*	3
Cinnamon Bittern*	*Ixobrychus cinnamomeus*	4
Yellow Bittern*	*Ixobrychus sinensis*	1
Black-crowned Night Heron*	*Nycticorax nycticorax*	2
Ciconiidae		
Asian Open-billed Stork*	*Anastomus oscitans*	3
Woolly-necked Stork*	*Ciconia episcopus*	4
Black Stork*	*Ciconia nigra*	2
Black-necked Stork*	*Ephippiorhynchus asiaticus*	3
Greater Adjutant Stork*	*Leptoptilos dubius*	1
Lesser Adjutant Stork*	*Leptoptilos javanicus*	4
Painted Stork*	*Mycteria leucocephala*	1
Black-necked Stork*	*Xenorhynchus asiaticus*	4
Threskiornithidae		
Eurasian Spoonbill	*Platalea leucorodia*	1
Glossy Ibis	*Plegadis falcinellus*	4
Red-naped Black Ibis*	*Pseudibis papillosa*	4
Oriental White Ibis*	*Threskiornis melanocephalus*	1

Family and English Name	Scientific Name	Ref.
Anatidae		
Pintail Duck*	*Anas acuta*	3
Northern Shoveler*	*Anas clypeata*	4
Common Teal*	*Anas crecca*	3
Falcated Duck*	*Anas falcata*	3
Eurasian Wigeon*	*Anas penelope*	4
Mallard*	*Anas platyrhynchos*	3
Spotbill Duck*	*Anas poecilorhyncha*	3
Garganey*	*Anas querquedula*	3
Gadwall*	*Anas strepera*	3
Greylag Goose*	*Anser anser*	4
Bar-headed Goose*	*Anser indicus*	1
Baer's Pochard*	*Aythya baeri*	4
Common Pochard*	*Aythya ferina*	3
Tufted Duck*	*Aythya fuligula*	3
Ferruginous Duck*	*Aythya nyroca*	4
Fulvous Whistling Duck*	*Dendrocygna bicolor*	4
Lesser Whistling Duck*	*Dendrocygna javanica*	1
Smew*	*Mergus albellus*	4
Goosander*	*Mergus merganser*	4
Red-crested Pochard*	*Netta rufina*	3
Cotton Pygmy Goose (Teal)*	*Nettapus coromandelianus*	3
Comb Duck*	*Sarkidiornis melanotos*	1
Brahminy Duck*	*Tadorna ferruginea*	3
Accipitridae		
Shikra	*Accipiter badius*	4
Goshawk	*Accipiter gentilis*	3
Steppe Eagle	*Accipiter nipalensis*	3
Northern Sparrow Hawk	*Accipiter nisus*	4
Eurasian Black Vulture	*Aegypius monachus*	2
Lesser-Spotted Eagle	*Aquila pomarina*	4
Steppe Eagle	*Aquila rapax nipalensis*	4
Tawny Eagle	*Aquila rapax vindhiana*	4
White-eyed Buzzard	*Butastur teesa*	4
Common Buzzard	*Buteo buteo*	2
Long-legged Buzzard	*Buteo rufminus*	4
Short-toed Eagle	*Circaetus gallicus*	2
Eurasian Marsh Harrier*	*Circus aeruginosus*	4
Hen Harrier	*Circus cyaneus*	4
Pale Harrier	*Circus macrorourus*	3
Pied Harrier	*Circus melanoleucus*	4
Montaegue's Harrier	*Cirus pygargus*	2
Black-shouldered Kite	*Elanus caerulus*	4
Oriental White-backed Vulture	*Gyps bengalensis*	3
Eurasian Griffon Vulture	*Gyps fulvus*	2
Long-billed Vulture	*Gyps indicus*	4

Family and English Name	Scientific Name	Ref.
White-tailed Eagle*	*Haliaeetus albicilla*	1
Pallas's Fish Eagle*	*Haliaeetus leucoryphus*	1
Brahminy Kite*	*Haliastur indus*	4
Rufous-bellied Eagle	*Hieraaetus kienerii*	2
Booted Eagle	*Hieraaetus pennatus*	4
Black Eagle	*Ictinaetus malayensis*	4
Black (Parish) Kite	*Milvus migrans*	3
Egyptian Vulture	*Neophron percnopterus*	3
Crested Honey Buzzard*	*Pernis ptilorhyncus*	4
Red-headed Vulture	*Sarcogyps calvus*	4
Crested Serpent Eagle	*Spilornis cheela*	4
Changeable Hawk Eagle	*Spizaetus cirrhatus*	4
Pandionidae		
Osprey	*Pandion haliaetus*	3
Falconidae		
Red-necked Falcon	*Falco chicquera*	1
Laggar	*Falco jugger*	4
Peregrine	*Falco peregrinus*	3
Eurasian Hobby	*Falco subbuteo*	4
Common Kestrel	*Falco tinnunculus*	4
Red-thighed Falconet	*Microhierax caerulescens*	4
Phasianidae		
Common Quail	*Coturnix coturnix*	3
Black Francolin	*Francolinus francolinus*	4
Swamp Francolin	*Francolinus gularis*	2
Grey Partridge	*Francolinus pondicerianus*	3
Red Junglefowl	*Galllus gallus*	4
Blue Peafowl	*Pavo cristatus*	3
Jungle Button Quail	*Perdicula asiatica*	3
Common Bustard Quail	*Turnix suscitator*	4
Yellow-legged Button Quail	*Turnix tanki*	4
Gruidae		
Demoiselle Crane	*Anthhropoides virgo*	3
Sarus Crane	*Grus antigrone*	3
Common Crane	*Grus grus*	3
Siberian Crane	*Grus leucogeranus*	3
Rallidae		
Brown Crake*	*Amauromis akool*	4
Ruddy Crake	*Amauromis fuscus*	5
White-breasted Waterhen*	*Amauronis phoenicurus*	3
Coot	*Fulica atra*	3
Watercock*	*Gallicrex cinerea*	1
Common Moorhen*	*Gallinula chloropus*	3
Purple Moorhen*	*Porphyrio porphyrio*	4
Ruddy-breasted Crake*	*Porzana fusca*	1
Baillon's Crake*	*Porzana pusilla*	1

Family and English Name	Scientific Name	Ref.
Water Rail*	*Rallus aquaticus*	3
Otididae		
Bengal Florican*	*Houbaropsis bengalensis*	1
Jacanidae		
Pheasant-tailed Jacana*	*Hydrophasianus chirurgus*	1
Bronze-winged Jacana*	*Melopidius indicus*	4
Charadriidae		
Kentis Plover*	*Charadrius alexandrinus*	4
Little Ringed Plover*	*Charadrius dubius*	4
Ringed Plover*	*Charadrius hiaticula*	3
Lesser Sand Plover*	*Charadrius mongolus*	1
River Plover*	*Hoplopterus duvaucelii*	4
Red-wattled Plover*	*Hoplopterus indicus*	4
Yellow-wattled Plover*	*Hoplopterus malabaricus*	4
Eastern Golden Plover*	*Pluvialis dominica*	3
Pacific Golden Plover*	*Pluvialis fulva*	4
Grey Plover*	*Pluvialis squatorola*	3
Grey-headed Lapwing	*Vanellus cineereus*	3
Red-Wattled Lapwing	*Vanellus indicus*	3
White-tailed Lapwing	*Vanellus leucurus*	3
Yellow-wattled Lapwing	*Vanellus malabaricus*	3
Spur-winged Lapwing	*Vanellus spinosus*	5
Northern Lapwing	*Vanellus vanellus*	4
Scolopacidae		
Common Sandpiper	*Actitis hypoleucos*	4
Dunlin	*Calidris alpinus*	3
Little Stint*	*Calidris minutus*	4
Temminck's Stint*	*Calidris temminckii*	3
Common Snipe*	*Gallinago gallinago*	4
Pintail Snipe*	*Gallinago stenura*	4
Broad-billed Sandpiper	*Limicola falcinellus*	3
Black-tailed Godwit*	*Limosa limosa*	1
Eurasian Curlew*	*Numenius arquata*	4
Whimbrel	*Numenius phaeopus*	1
Ruff	*Philomachus pugnax*	3
Spotted Redshank*	*Tringa erythropus*	4
Wood Sandpiper*	*Tringa glareola*	4
Common Sandpiper*	*Tringa hypoleucos*	3
Common Greenshank*	*Tringa nebularia*	4
Green Sandpiper*	*Tringa orchropus*	4
Marsh Sandpiper*	*Tringa stagnatilis*	3
Common Redshank*	*Tringa totanus*	3
Rostratulidae		
Painted Snipe*	*Rostratula benghalensis*	4
Recurvirostridae		
Black-winged Stilt*	*Himantopus himantopus*	1

Family and English Name	Scientific Name	Ref.
Burhinidae		
Northern Stone-curlew*	*Burhinus oedicnemus*	3
Great Stone Curlew*	*Esacus recurvirostris*	4
Glariolidae		
Indian Courser	*Cursotius coromandelicus*	1
Little Pratincole*	*Glareola lactea*	1
Laridae		
Herring Gull*	*Larus argentatus*	2
Brown-headed Gull	*Larus brunnicephalus*	1
Slender-billed Gull	*Larus genei*	1
Great Black-headed Gull*	*Larus ichthyaetus*	1
Common Black-headed Gull*	*Larus ridibundus*	4
Sternidae		
Whiskered Tern*	*Chlidonias hybridus*	1
Gull-billed Tern*	*Gelochelidon nilotica*	1
Black-bellied Tern*	*Sterna acuticauda*	4
Little Tern*	*Sterna albifrons*	4
River Tern*	*Sterna aurantia*	4
Caspian Tern*	*Sterna caspia*	1
Common Tern*	*Sterna hirundo*	4
Rynchopidae		
Indian Skimmer	*Rynchops albicollis*	1
Columbidae		
Emerald Dove	*Chalcophaps indica*	4
Rock Pigeon	*Columba livia*	4
Spotted Dove	*Streptopelia chinensis*	4
Collared Dove	*Streptopelia decaocto*	4
Oriental Turtle Dove	*Streptopelia orientalis*	4
Laughing Dove	*Streptopelia senegalensis*	4
Red Turtle Dove	*Streptopelia tranquebarica*	4
Orange-breasted Green Pigeon	*Treron bicincta*	4
Yellow-footed Green Pigeon	*Treron phoenicoptera*	4
Pompadour Green Pigeon	*Treron pompadora*	4
Psittacidae		
Alexandrine Parakeet	*Psiotta eupatria*	4
Blossom-headed Parakeet	*Psittacula cyanocephala*	4
Slaty-headed Parakeet	*Psittacula himalayana*	4
Ring-necked Parakeet	*Psittacula krameri*	4
Cuculidae		
Rufous-bellied Plaintive Cuckoo	*Cacomantis merulinus*	5
Lesser Coucal	*Centropus bengalensis*	4
Greater Coucal	*Centropus sinensis*	4
Pied Crested Cuckoo	*Clamator jacobinus*	4
Common Cuckoo	*Cuculus canorus*	4
Indian Cuckoo	*Cuculus micropterus*	4
Oriental Cuckoo	*Cuculus saturatus*	2

Family and English Name	Scientific Name	Ref.
Common Koel	*Eudynamys scolopacea*	4
Hodgson's Hawk Cuckoo	*Hierococcyx fugax*	2
Common Hawk Cockoo	*Hierococcyx varius*	4
Drongo Cuckoo	*Surniculus lugubris*	4
Sirkeer Cuckoo	*Taccocua leschenaultii*	5
Strigidae		2
Short-eared Owl	*Asio flammeus*	4
Soptted Little Owl	*Athene brama*	4
Dusky Eagle Owl	*Bubo coromandus*	4
Forest Eagle Owl	*Bubo nipalensis*	4
Jungle Owlet	*Glaucicium radiatum*	4
Asian Barred Owlet	*Glaucidium cuculoides*	4
Brown Fish Owl*	*Ketupa zeylonensis*	4
Brown Hawk Owl	*Ninox scutulata*	4
Caprimulgidae		
Savanna Nightjar	*Caprimulgus affinis*	5
Indian Nightjar	*Caprimulgus asiaticus*	4
Large-tailed Nightjar	*Caprimulgus macruntrus*	4
Apodidae		
Little Swift	*Apus affinis*	4
Crested Tree Swift	*Hemiprocne coronata*	4
White-throated Needletail	*Hirundapus caudacutus*	4
Alcedinidae		
Common Kingfisher*	*Alcedo atthis*	4
Pied Kingfisher*	*Ceryle rudis*	4
White-breasted Kingfisher*	*Halcyon smyrnensis*	4
Stork-billed Kingfisher*	*Pelargopsis capensis*	4
Meropidae		
Chestnut-headed Bee-eater	*Merops leschenaulti*	4
Green Bee-eater	*Merops orientalis*	4
Blue-tailed Bee-eater	*Merops philippinus*	4
Coraciidae		
Indian Roller	*Coracias benghalensis*	4
Upupidae		
Hoopoe	*Upupa epops*	4
Bucerotidae		
Indian Grey Hornbill	*Tockus birostris*	4
Capitonidae		
Blue-throated Barbet	*Megalaima asiatica*	4
Coppersmith Barbet	*Megalaima haemacephala*	4
Picidae		
Rufous Woodpecker	*Celeus brachyurus*	4
Lesser Golden-backed Woodpecker	*Dinopium benghalense*	4
Fulvous-breasted Pied Woodpecker	*Dendrocopus macei*	4
Eurasian Wryneck	*Jynx torquilla*	4
Grey-headed Woodpecker	*Picus canus*	4

Family and English Name	Scientific Name	Ref.
Streak-throated Green Woodpecker	*Picus myrmecophoneus*	4
Alaudidae		
Oriental Skylark	*Alauda gulgula*	4
Greater Short-toed Lark	*Calandrella brachydactyla*	4
Sandlark	*Calandrella raytal*	4
Ashy-crowned Finchlark	*Eremopterix grisea*	4
Crested Lark	*Galerida cristata*	2
Bengal Bushlark	*Mirafra assamica*	4
Hirundinidae		
Ashy Woodswallow	*Artamus fuscus*	3
Red-rumped Swallow	*Hirundo daurica*	4
Barn Swallow	*Hirundo rustica*	4
Brown-throated Sand Martin	*Riparia paludicola*	4
Collared Sand Martin	*Riparia riparia*	2
Laniidae		
Brown Shrike	*Lanius cristatus*	4
Great Grey Shrike	*Lanius excubitor*	4
Long-tailed Shrike	*Lanius schach*	4
Bay-backed Shrike	*Lanius vittatus*	4
Oriolidae		
Golden Oriole	*Oriolus oriolus*	4
Black-hooded Oriole	*Oriolus xanthornus*	4
Dicruridae		
Bronzed Drongo	*Dicrurus aeneus*	4
White-bellied Drongo	*Dicrurus caerulescens*	4
Spangled Drongo	*Dicrurus hottentottus*	4
Ashy Drongo	*Dicrurus leucophaeus*	4
Black Drongo	*Dicrurus macrocercus*	4
Artanadae		
Ashy Woodswallow	*Artamus fuscus*	5
Sturnidae		
Jungle Mynah	*Acridotheres fuscus*	4
Bank Mynah	*Acridotheres ginginianus*	5
Common Mynah	*Acridotheres tristis*	4
Asian Pied Starling	*Sturnus contra*	4
Chestnut-tailed Starling	*Sturnus malabaricus*	4
Brahminy Starling	*Sturnus pagodarum*	4
Corvidae		
Jungle Crow	*Corvus macrorhynchos*	4
House Crow	*Corvus splendens*	4
Rufous Treepie	*Dendrocitta vagabunda*	4
Red-billed Blue Magpie	*Urocissa erythrorhyncha*	4
Campephagidae		
Black-headed Cuckoo-shrike	*Coracina melanoptera*	4
Black-winged Cuckoo-shrike	*Coracina melaschistos*	4
Large Cuckoo-shrike	*Coracina novaehollandiae*	4

Family and English Name	Scientific Name	Ref.
Small Minivet	*Pericrocotus cinnamomeus*	4
Rosy Minivet	*Pericrocotus roseus*	2
Irenidae		
Common Iora	*Aegithina tiphia*	4
Golden-fronted Leafbird	*Chloropsis aurifrons*	4
Pycnonotidae		
Red-vented Bulbul	*Pycnonotus cater*	4
Red-whiskered Bulbul	*Pycnonotus jocosus*	4
Timaliidae		
Abbott's Babbler	*Trichastoma abbotti*	4
Striated Babbler	*Turdoides earlei*	4
Jungle Babbler	*Turdoides striatus*	4
Muscicapidae		
Grey-headed Flycatcher	*Culicicapa ceylonensis*	4
BLue-throated Blue Flycatcher	*Cyornis ruberculoides*	4
Red-breasted Flycatcher	*Ficedula parva*	4
Asian Brown Flycatcher	*Muscicapa latirostrits*	4
Asian Sooty Flycatcher	*Muscicapa sibirica*	4
Vetditer Flycatcher	*Muscicapa thalassina*	4
Asian Paradise Flycatcher	*Terpsiphone paradisi*	4
Rhipiduridae		
White-throated Fantail Flycatcher	*Rhipidura albicollis*	4
Monarchidae		
Black-naped Monarch	*Hypothymes azurea*	4
Sylviidae		
Thick-billed Warbler*	*Acrocephalus aedon*	4
Paddy Field Warbler	*Acrocephalus agricola*	4
Black-browed Reed Warbler	*Acrocephalus bistrigiceps*	1
Blyth's Reed Warbler	*Acrocephalus dumetorum*	4
Clamorous Reed Warbler*	*Acrocephalus stentoreus*	1
Chestnut-crowned Bush Warbler	*Cettia major*	4
Pale-footed Bush Warbler	*Cettia pallidipes*	4
Red-headed Faintail	*Cisticola exilis*	4
Streak Faintail Warbler	*Cisticola juncidis*	4
Striated Marsh Warbler*	*Megalurus palustris*	1
Common Tailorbird	*Orthotomus sutorius*	4
Tickell's Warbler	*Phylloscopus affinis*	4
Chiffchaff	*Phylloscopus collibita*	4
Smoky Warbler*	*Phylloscopus fuligiventer*	1
Dusky Warbler	*Phylloscopus fuscatus*	4
Sulphur-bellied Warbler	*Phylloscopus griseolus*	4
Yellow-browed Warbler	*Phylloscopus inornatus*	4
Large-billed Leaf Warbler	*Phylloscopus magnirostris*	4
Blyth's Crowned Warbler	*Phylloscopus reguloides*	4
Greenish Warbler	*Phylloscopus trochiloides*	4
Grey Capped Prinia	*Prinia cinereocapilla*	4

Family and English Name	Scientific Name	Ref.
Striated Prinia	*Prinia criniger*	2
Yellow-bellied Prinia	*Prinia flaviventris*	1
Graceful Prinia	*Prinia gracilis*	1
Grey-breasted Prinia	*Prinia hodgsoni*	4
Plain Prinia	*Prinia inornata*	4
Ashy Prinia	*Prinia socialis*	4
Golden-spectacled Warbler	*Seicercus burkii*	4
Turididae		
White-capped Redstart	*Chaimarrornis leucocephalus*	4
White-capped Rock Thrush	*Chaimarrornis leucocephalus*	4
White-rumped Shama	*Copsyschus malabaricus*	4
Asian Magpie-Robin	*Copsyschus saularis*	4
Siberian Rubythroat	*Luscinia calliope*	4
White-tailed Rubythroat	*Luscinia pectoralis*	2
Bluethroat	*Luscinia svecica*	4
Blue-capped Rocked Thrush	*Monticola cinclorhynchus*	4
Blue Rock Thrush	*Monticola solitarius*	4
Blue Whistling Thrush	*Myiophoneus caerulcus*	2
Black Redstart	*Phoenicurus ochruros*	4
Pied Bushchat	*Saxicola caprata*	4
Grey Bushchat	*Saxicola ferrea*	4
Hodgson's Bushchat	*Saxicola insignis*	1
White-tailed Stonechat	*Saxicola leucura*	4
Comon Stonechat	*Saxicola torquata*	4
Indian Robin	*Saxicoloided julicata*	4
Dark-throated Thrush	*Turdus ruficollis*	4
Tickell's Thrush	*Turdus unicolor*	4
Orange-headed Ground Thrush	*Zoothera citrina*	4
Scaly Thrush	*Zoothera dauma*	4
Paridae		
Great Tit	*Parus major*	4
Motacillidae		
Olive-backed Pipit	*Anthus hodgsoni*	4
Richard's Pipit	*Anthus novaeseelandiae*	4
Rosy Pipit*	*Anthus roseatus*	4
Tree Pipit*	*Anthus trivially*	2
White Wagtail*	*Motacilla alba*	4
Grey Wagtail*	*Motacilla cinerea*	4
Citrine wagtail*	*Motacilla citreola*	4
Yellow Wagtail*	*Motacilla flava*	4
White-browed Wagtail*	*Motacilla maderaspatensis*	4
Dicaeidae		
Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	4
Nectariniidae		
Purple Sunbird	*Nectarinia asiatica*	4
Little Spider Hunter	*Arachnothera longirostra*	5

Family and English Name	Scientific Name	Ref.
Zosteropidae		
Oriental White-eye	*Zosterops palpebrosa*	4
Passeridae		
House Sparrow	*Passer domesticus*	4
Eurasian Tree Sparrow	*Passer montanus*	2
Yellow-throated Sparrow	*Petronia xanthocollis*	4
Ploceidae		
Black-breased Weaver	*Ploceas benghalensis*	1
Streaked Weaver	*Ploceas manyar*	1
Baya Weaver	*Ploceas philippinus*	4
Estrildidae		
Red Avadavat	*Amandava amandava*	1
Chestnut Munia	*Lonchura malacca*	4
Scaly-breasted Munia	*Lonchura punctulata*	4
Striated Munia	*Lonchura striata*	4
Emberizidae		
Yellow-breasted Bunting	*Emberiza aureola*	4
Chestnut-eared Bunting	*Emberiza fucata*	4
Black-faced Bunting	*Emberiza spodocephala*	1
Crested Bunting	*Melophus lathami*	4

Source: 1 = Inskipp and Inskipp, 1985; 2 = Scott,1989; 3 = Shrestha,1993, 4 = Suwal,1993, and 5 = WMI/IUCN-Nepal, 1994.

Appendix 4.5

Summary of rare and new bird records for the Koshi Tappu area

English Name	Species Name	Month	Place	Record Type
Little Cormorant	*Phalacrocorax niger*	2	KT	M
Eurasian Bittern	*Botaurus stellaris*	2	KT	M
Black Bittern	*Dupetor flavicollis*	2	KB	N
Black-crowned Night Heron	*Nycticorax nycticorax*	3	KT	T
Black Stork	*Ciconia nigra*	3,4	KT	T
Greater Adjutant Stork	*Leptoptilos dubius*	9,10	KB	T
Eurasian Spoonbill	*Platalea leucorodia*	11	KT	T
Oriental White Ibies	*Threskiornis melanocephalus*	9,10	KT	T
Eurasian Black Vulture	*Aegypius monachus*	All	KT,KB	B
Common Buzzard	*Buteo buteo*	10	KT	E,N
Short-toed Eagle	*Circaetus gallicus*	3,11	KT	R
Montegue's Harrier	*Circus pygargus*	3	KT	M,E
Eurasian Griffon Vulture	*Gyps fulvus*	All	KT	B
White-tailed Eagle	*Haliaeetus albicilla*	10	KT	T
Rufous-bellied Eagle	*Hieraaetus kieneri*	10	KT	N
Hodgson's Hawk	*Hierococcyx fugax*	3	KT	O
Swamp Patridge (Francolin)	*Francolinus gularis*	5	KT	TH*
Bengal Flrican	*Houbaropsis bengalensis*	5	KT	EE*
Black-tailed Godwit	*Limosa limosa*	12	KB	T,M
Herring Gull	*Larus argentatus*	10	KB	M
Gull-billed Tern	*Gelochelidon nilotica*	10	KB	T
Oriental Cuckoo	*Cuculus saturatus*	3	KT	E,N
Short-eared Owl	*Asio flammeus*	12	KT	M
Crested Lark	*Galerida cristata*	3	KT	N
Collared Sand Martin	*Riparia riparia*	9,11	KB	M
Rosy Minivet	*Pericrocotus roseus*	3	KT	M
Striated Prinia	*Prinia criniger*	10	KT	E,N
White-tailed Rubythroat	*Luscinia pectoralis*	3	KT	E
Blue Whistling Thrush	*Myiophoneus caeruleus*	10	KT	E
Hodgson's Bush Chat	*Saxicola insignis*	10	KT	R,T
Tree Pipit	*Anthus trivialis*	3	KT	M
Eurassian Tree Sparrow	*Passer montanus*	2	KT	R

Source: Heinen (1987); * = From WMI/IUCN-Nepal (1994)
B - Recorded during breeding season
E - New or rare low elevaional record
EE - Endangered Species
M - Rare sighting of a migratory species
N - Range extension within Nepal
O - Hasn't been recorded in Nepal in past 100 years
R - Rare sighting of a resident species
T - Recorded in a month different from that in previous records
TH - Threatened Species
KB - Koshi Barrage; KT - Koshi Tappu Wildlife Reserve

Appendix 5.1

Landuse pattern and its change between 1959 and 1991.

Landuse	Area (ha)					
	1959* (a)	1978* (b)	Change** (1959-78)	1991 (c)	Change** (1978-91)	Change** (1959-91)
Agricultural Land	1713.3 (11.39)	1326.2 (8.84)	-387.1 (-22.60)	250.3 (1.62)	-1075.9 (-81.13)	-1463.0 (-85.39)
Forest	2932.4 (19.54)	1227.5 (8.18)	-1704.9 (-58.14)	1185.6 (7.92)	-41.9 (-3.41)	-1746.8 (-59.57)
Grasslands	5634.9 (37.54)	3432.6 (22.87)	-2202.4 (-39.08)	4598.6 (30.62)	1166.0 (+33.97)	-1036.3 (-18.39)
Water	3145.6 (20.95)	2626.3 (17.49)	-519.3 (-16.51)	1425.5 (9.50)	-1200.8 (-45.72)	-1720.1 (-54.68)
Sand, Gravels	1586.8 (10.56)	4224.8 (28.16)	2638.0 (+166.25)	2300.9 (15.36)	-1923.9 (-45.54)	714.1 (+45.00)
Swamps	- -	2175.5 (14.46)	2175.5 -	1652.1 (10.98)	-523.4 (-24.06)	1652.1 -
Marshes	- -	- -	- -	179.4 (1.19)	179.4 -	179.4 -
Transitional zone	- -	- -	- -	3420.4 (22.77)	3420.4 -	3420.4 -

Source: a. Topo Map Sheets 72 J/14, 72 N/2

b. Land Utilization Map Sheets No. 72 j/14, 72 N/2

c. Landsat TM Image, Dec. 12, 1991.

* = Figures in paranthesis are the percentage of the total area.

** = Figures in paranthesis are the percentage of change in area.

Appendix 6.1

Different Indices

1. Education Level Index (ELI)

$ELI = (f_{il}*00+f_{li}*2+f_{pr}5+f_{ls}*7+f_{hs}*10+f_{in}*12+f_{gr}*14)$

Where,

ELI	=	Education Level Index			
f	=	Proportion of population having specific level of education			
il	=	Illiterate	li	=	Literate
pr	=	Primary	ls	=	Lower Sec
hs	=	Higher Sec.	in	=	Intermediate
gr	=	Graduate			

2. Land Quality Index (LQI)

$LQI = L_A (1.0) + L_D (0.8) + L_S (0.6)$

Where,

LQI	=	Land Quality Index
L	=	Landholding of specific type of land
A	=	Awal
D	=	Doyam
S	=	Sim

3. Landholding Size Unit (LHSU)

$LHSU = L_{OO}*(1.0) + (L_{SI}+L_{RI})*0.25 + (L_{SO}+L_{RO})*0.75$

Where,

LHSU	=	Landholding Size Unit		
OOL	=	Owner Operated Land		
SI	=	Shared In	RI=	Rented In
SO	=	Shared Out	RO=	Rented out

4. Livestock Unit (LSU)

LSU = Buffalo* (1) + Cattle *(.8) + Goat/Sheep/Pig* (.2)

5. Livestock Size Index (LISI) = Livestock Unit/Household size

6. Vegetation Resource Utilization Index (VRUI)

VRUI = f*(fuel wood use+fodder use + grazing + others)/4

Where,

VRUI	=	Vegetation Resource Utilization Index
f	=	Proportion of respondents using vegetation for particular purpose

7. Awareness Index

AWI	=	$(f_A*1.0 + f_D*0.0 + f_N*0.33)/n$
Where,		
AWI	=	Awareness Index
f	=	Proportion of respondents in particular category
A	=	Agree
D	=	Disagree
N	=	Do not know
n	=	Number of statements

8. Conservation Attitude Index

CAI	=	$(f_A*1.0 + f_D*-1.0 + f_N*0.0)/n$
Where,		
AWI	=	Awareness Index
f	=	Proportion of respondents in particular category
A	=	Agree
D	=	Disagree
N	=	Do not know
n	=	Number of statements

Appendix 8.1

List of ethnobotanically important plants and their use

Species	Useful parts	Use/Remarks
Plants of Food Value		
Aegle marmalos	Fr	eaten raw
Alocasia sp.	Corm	as vegetable
Alternanthera sessalis	Lf	as green vegetable
Amaranthus spinosus	Lf	" "
Amaranthus viridis	Lf	" "
Anthocephalus cadamba	Fr	eaten raw or as vegetable
Bombax ceiba	Fl	making curry
Chenopodium ambrosoides	Lf	as green vegetable
Diplazium esculantum	YF	" "
Echinochloa colonum	Sd	as food in femine
Echinochloa cruss-gallii	Sd	" "
Eclipta prostrata	YS	as green vegegable
Eugenia jombolana	Fr	eaten raw
Euphorbia hirta	YS	as green vegetable
Euryale ferox	Sd	as dry fruit or in making podridge
Ipomoea aquatica	YS	as green vegetable
Leucas cephalotus	YS	" "
Leucas indica	YS	" "
Leucas mollissima	YS	" "
Lippia nodiflora	Lf	" "
Ludwigia adscendens	Lf	" "
Mangifera indica	Fr	eaten raw
Momordica charantia	Fr	as vegetable
Phyllanthus emblica	Fr	eaten raw
Pithecellobium dulce	Fr	" "
Scirpus kysoor	Rt	" "
Solanum indicum	Fr	" "
Solanum nigrum	Fr	" "
Solanum torvum	Fr	" "
Solena heterophylla	Fr	as vegetable
Syzygium cumini	Fr	eaten raw
Tamarindus indica	Fr	eaten raw and as spice
Trapa natans var. bispinosa	Fr	eaten raw
Vernonia cinerea	Lf	as green vegetable
Zizyphus mouritiana	Fr	eaten raw
Plants of Medicinal Use		
Achyranthes bidentata	St	as tooth brush
Artemisia indica	Lf	in scratches
Azadirachta indicâ	f, St, S	as tooth brush, disinfectant etc.
Bombax ceiba	Fl	in diarrhoea

Species	Useful parts	Use/Remarks
Centella asiatica	Lf, St	as carminative
Clerodendron viscosum	YS	in dysentry
Dalbergia sissoo	Lf	insect repelant
Eclipta prostrata	Lf	in fungal toe infection
Eupatorium adenophorum	Lf	as blood coagulent in fresh cuts
Euphorbia hirta	St	as disinfectant in fresh cuts
Ficus subincisa	St	as tooth brush
Gnaphalium affine	Lf	Astringent
Lippia nodiflora	Lf	in indigestion
Mimosa pudica	Rt	to cure wounds
Nelumbo nucifera	Fl	as blood purifier
Polygonum plebejum	Rt	as against recurrent weeping of child
Sida cordata	Lf	for curing pilow
Solanum indicum	Sd	smoke used in toothache
Thevetia peruviana	Fr	as poison
Thunberia grandiflora	Lf	to cure old wounds
Plants of Fodder Value		
Acacia arabica	Lf	
Acacia catechu	Lf	
Alysicarpus vaginalis	Lf	
Artocarpus lakoocha	Lf	
Carex microglochin	Lf	
Commelina paludosa	Lf	preferred by pigs
Cynodon dactylon	Lf	
Cyperus diffusus	Lf	
Cyperus digitatus	Lf	
Cyperus distans	Lf	
Cyperus esculantus	Lf	
Cyperus rotundus	Lf	
Dalbergia sissoo	Lf	
Digitaria ascendens	Lf	
Digitaria cilliaris	Lf	
Echinochloa colona	Lf	
Echinochloa crus-gallii	Lf	
Equisetum sp.	St	
Eragrostis tenella	Lf	
Ficus ovata	Lf	
Ficus semicordata	Lf	
Ficus subincisa	Lf	
Fimbrystylis dichotoma	Lf	
Fimbrystylis squarossa	Lf	
Garuga pinnata	Lf	
Grewia disperma	Lf	preferred by water buffalo
Gynura nepalensis	Lf	
Imperata cylidrica	Lf	

Species	Useful parts	Use/Remarks
Mimosa pudica	Lf	yields better quality milk and ghee
Phragmites karka	Lf	only young leaves in limited extent
Pithecellobium dulce	Lf	
Polygonum plebejum	Lf	
Rotala rotundifolia	Lf	
Saccharum spontaneum	Lf	as an excellent fodder
Schoeneplectus mucronatus	Lf	
Scoparia dulce	Lf	
Setaria pallidefusca	Lf	
Tamarix dioica	Lf	preferred by water buffalo
Trewia nudiflora	Lf	preferred by water buffalo
Tylophora tenerrima	Lf	
Typha angustifolia	Lf	
Vernonia cinerea	Lf	
Plants for Handicraft items		
Cyperus distans	St	in making mats
Imperata cylindrica	Inf	in making cushion
Pharagmites karka	Inf	as broom
Saccharum spontaneum	Lf	in making mats
Typha aungustifolia	Lf	in making mats
Tamarix dioica	Tw	as broom
Vetiveria lausonii	Rt	in making screens
Plants for Religious Purpose		
Aegle marmalos	Rt, Fr	for worshiping Gods
Anthocephalus cadamba	WP	religious tree
Azadirachta indica	Tw	for worshiping Gods
Cascabela thevetica	Fl	for worshiping Gods
Cassia fistula	Fr	for worshiping Gods
Cynodon dactylon	Tw	for worshiping Gods
Eragrostis cynosuroides	WP	for worshiping Gods
Madhuca longifolia	WP	a relegious tree
Mangifera indica	Tw	for worshiping Gods
Nelumbo nucifera	Fl	for worshiping Gods
Plants as Bio-fertilizer		
Eichornia crassipes	WP	in rice fields and potato fields
Monochoria hastata	WP	in rice fields and potato fields
Pistia stratiotes	WP	in rice fields and potato fields
Plants for Fish-poisoning		
Persicaria barbata	Lf	for fishing
Persicaria glabra	Lf	for fishing
Persicaria lapaphifolia	Lf	for fishing
Plants of Other uses		
Acacia catechu	St	to extract catechu to be used as *kattha*
Abutilon indicum	St	for fiber
Bombax ceiba	Fr	for fiber

Species	Useful parts	Use/Remarks
Crotolaria pallida Alt.	St	for fiber
Grewia oppositifolia	Fr	for fiber
Hydrilla verticillata	WP	in aquarium
Imperata cylindrica	Wp, Inf	in thatching roofs, Inf. in making lamps
Ipomoea carnea	WP	as hedge plant
Saccharum spontaneum	WP	for thatching
Thevetia peruviana	Fl	having horticultural value
Vetiveria zizanoides	Rt	to extract an essential oil

Source: After WMI/IUCN-Nepal, 1994

In = Infloresece, Lf = Leaf, Fl = Flower, Fr = Fruit, Rt = Root, Sd = Seed

St = Stem, Tw = Twig, WP = Whole plant, YF = Young frond, YS = Young shoot

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IUCN
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