

Koshi Tappu's Treasure: Grasslands or Wetlands?

Jay Prakash Sah

Abstract

Koshi Tappu Wildlife Reserve, located on the Koshi river floodplain in the eastern Terai of Nepal, has a vegetation that comprises both riverine forests and a large tract of grasslands, most of which become flooded during the monsoon and remain wet for several months of the year. These seasonally flooded wet grasslands, together with the swamps formed in depressions on the floodplain, are the ideal habitat for the last remaining population of wild buffalo (*Bubalus bubalis*) in Nepal. These grasslands are viewed in different ways by different people. Livestock herders who practice their traditional profession of livestock grazing in that area see Koshi Tappu as a treasure that will never be exhausted. Landless people in the adjoining villages and those who have lost their land to the reserve or as a result of the shifting of the Koshi river, more than a quarter of the population, want to convert the grasslands into agricultural fields. Conservationists see the wet grasslands and associated swamps and marshes, both within and outside the reserve, as a place of international importance in terms of staging and wintering sites for various trans-Himalayan migrating birds; the area has been listed as a Ramsar site (Wetlands of International Importance). The conflicting views of these different stakeholders are the root cause of the problems involved in the proper management of the reserve. An integrated management plan using a participatory approach is needed.

Introduction

There are different types of wetlands in the lowlands of Nepal varying from shallow lakes to rice fields. They include marshes, swamps, seasonally flooded grasslands, ditches, and any lowland depressions that are waterlogged for some part of the year (Sah 1993; BPP 1995; Bhandari 1998). Rivers, streams, canals, and paleo-channels are also considered as wetlands. Although wetlands possess economic, functional and existence values, they were considered until recently as wastelands by both the majority of people and by policy makers. In contrast, grasslands are seen by people as economically important resources for livestock rearing, which is an integral part of the agricultural system.

Conflicting uses of resources is very common in developing countries like Nepal. It becomes more common when the same resource means different things to different people. For industrialists, flowing water in a river is a means of diluting concentrated effluents; the same water is considered a means of livelihood by fishermen. Other wetlands are also used in different ways by different people. In contrast, conservationists see the wetlands as important ecosystems that should be conserved since they are rich in biodiversity and are important staging and wintering sites for migrating birds. Conflicts in use occur more frequently in a region where different units of a mosaic landscape are equally important in terms of economic, functional, and other ecological values. This is the situation in the Koshi Tappu region, located on the Koshi River floodplain in the eastern Terai of Nepal.

¹ Central Department of Botany, Tribhuvan University, Nepal

A large part of the Koshi Tappu region is occupied by grasslands most of which become flooded during the monsoon. It thus falls into the category of wetlands (Dugan 1990). Associated with these grasslands are paleo-channels, ox-bow lakes, swamps, and marshes, all of which possess both economic and functional values. The grasslands in Koshi Tappu are considered by livestock herders as a treasure that will never be exhausted. On the other hand, the wet grasslands with associated lakes, swamps, and marshes are an ideal habitat for the sole remaining population of wild water buffalo (*Bubalus bubalis*), and of international importance as staging and wintering sites for various trans-Himalayan migrating birds (Suwal 1993; Sah 1997). Thus it has remained a matter of controversy whether Koshi Tappu is most important for the grasslands or the wetlands. The present paper describes the extent of the grasslands and wetlands in the Koshi Tappu region, their relative significance, and the management issues. Finally, some recommendations are made for integrated management using a participatory approach.

Study Area

Koshi Tappu Wildlife Reserve, gazetted in 1976, lies on the floodplains of the Koshi river in the eastern Terai of Nepal. The reserve covers an area of 150 sq. km and its altitude varies between 75 and 81 masl. It extends from 26°33' to 26°45' N and 86°54' to 87°04' E. The eastern and western boundaries of the reserve run along the eastern and the western embankments that were constructed to prevent floods from entering agricultural fields. The southern boundary is parallel to the Koshi barrage, 6.5 km to the south, and the northern boundary runs through the flood plain from the eastern embankment near Prakashpur to the village of Tapeshwari, north of the Trijuga River (Figure 4).

Koshi Tappu Wildlife Reserve is drained by the Sapta Koshi River, a major tributary of the Ganges, and the Trijuga river which joins the Koshi river in this region. Most parts of the reserve are flooded in the rainy season and an enormous amount of sediment is deposited at this time. The soil quality within the reserve varies greatly depending upon the degree of sedimentation and the establishment of vegetation on the sediment in subsequent years. In the reserve area, soils are sandy, loamy sand, sandy loam, loam, and sandy clay loam.

The Koshi Tappu region has a tropical monsoon climate with an average annual rainfall of between 1,300 mm and 2,051 mm. The average daily maximum temperature ranges between 23.5° C and 33.4° C, the minimum between 7.8° C and 25.3° C, and the mean monthly temperature between 15.7° C and 29.2° C. Humidity remains high all the year round with the monthly average varying between 76% and 94%.

The vegetation of the Koshi Tappu is mainly characterised by mixed deciduous riverine forest, *Acacia-Dalbergia* forest, grassland/savanna, and marshy vegetation. The mixed deciduous riverine forests are dominated by simal (*Bombax ceiba*); the *Acacia-Dalbergia* forest, locally called khair-sissoo forest, by *Acacia catechu* and *Dalbergia sissoo* in different proportions from almost pure stands of *Acacia catechu* in relatively moist places to pure stands of *Dalbergia sissoo* in dry uplands. About 40 per cent of the total area within the reserve is covered by grassland/savanna type vegetation most of which is flooded annually

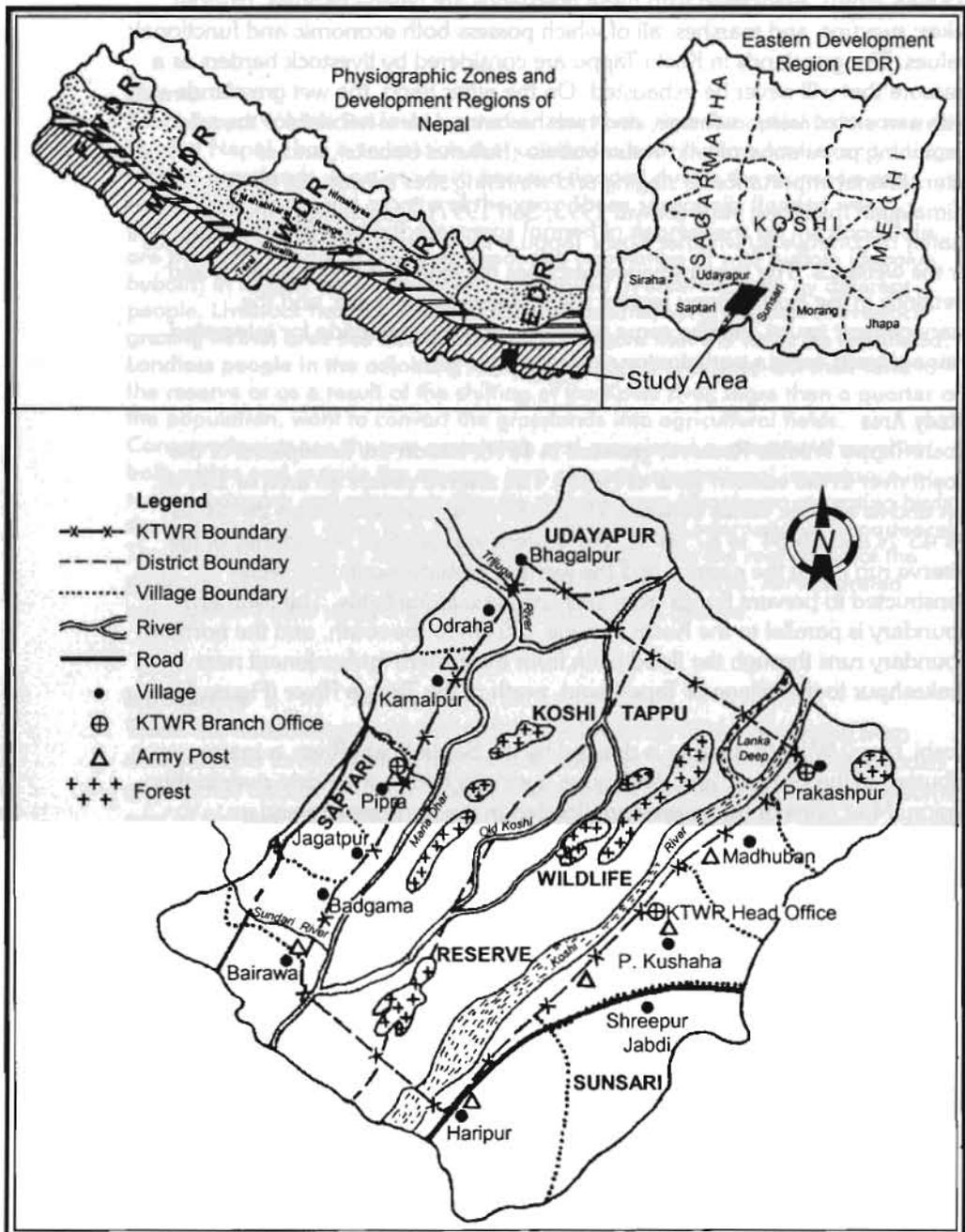


Figure 4: Map of the study area showing the location of Koshi Tappu Wildlife Reserve and surrounding villages

during monsoons. The major species are *Imperata cylindrica*, *Cymbopogon* sp., *Erianthus ravennae*, *Phragmites karka*, *Saccharum spontaneum*, and *Vetiveria zizanioides*. Marshy vegetation occurs at the fringes of ox-bow lakes along the eastern embankment of Kamal Daha, a naturally formed shallow lake near Kamalpur post, and in other lowland depressions inside the reserve. The marsh vegetation consists of all forms of aquatic plants from submerged (e.g., *Hydrilla verticillata* and *Ceratophyllum submersum*) to emergent (e.g., *Paspalidium* spp., *Persicaria barbata*, *Typha angustifolia*).

Koshi Tappu Wildlife Reserve is surrounded by 12 densely populated village development committee areas (VDCs): to the east Haripur, Shreepur-Jabdi, Kushaha, Madhuban, and Prakashpur VDCs of Sunsari district; and to the west, Bairwa, Badgama, Jagatpur, Pipra-Purba, Kamalpur, and Odraha VDCs of Saptari district, and Tapeswari VDC of Udaypur district. Two wards of Prakashpur VDC, called Lanka Dweep, are located on the floodplain to the north of the reserve. People from these villages frequently visit the reserve to collect fuelwood, graze livestock, and fish.

Materials and Methods

The area of grasslands and wetlands in the Koshi Tappu region was calculated from a land use map of the area prepared with the help of aerial photographs taken in 1990-91 at a scale of 1:50,000 and Landsat TM Imagery from December 12, 1991 (path 140, row 42). The image data were supplemented by a two-month field survey in February and March 1993. Land use classification was done using a slightly modified USGS (United States Geological Survey) system (Anderson *et al.* 1976). The classification was mostly limited to level I, and in some cases to level II of the system. Since both the aerial photographs and the satellite images were obtained during the dry months, February and December, respectively, the area of wetlands might have been underestimated. The results might have been different if the data had been obtained during the monsoon period when most of the reserve area is flooded. Some parts of the seasonally flooded grasslands are very difficult to recognise as wetlands during the dry season even in the field, especially when they are burnt.

The significance of grasslands and wetlands in Koshi Tappu were assessed on the basis of their use by local people and the ecological functions they perform. To assess the use value, a household survey was carried out in some of the adjoining wards of all the 11 VDCs in Sunsari and Saptari districts that are adjacent to the reserve. Altogether 160 households were selected randomly from the list obtained from VDC offices and surveyed using a structured questionnaire. The focus was on the use of plant resources from the grasslands and wetlands of the reserve, and on people's attitudes towards the conservation of those resources in the reserve. In addition, large livestock herders who have been using the reserve to graze their livestock for many years, were interviewed informally to obtain an idea of their perception of the grasslands within the reserve. Information on other values of the grasslands and wetlands in the reserve was gathered from various sources. Finally, grassland and wetland management issues were identified from formal and informal discussions with reserve authorities and groups of local people, and personal observations.

Results and Discussion

Grasslands and wetlands together cover almost 92% of the total area of the Koshi Tappu Wildlife Reserve. Grasslands include both the dry grasslands of *Cymbopogon-Saccharum* and *Imperata-Saccharum* association type and the wet grasslands of *Saccharum-Typha* and *Saccharum-Phragmites* type. The latter are seasonally flooded and are also considered as wetlands (Dugan 1990). Other wetlands include permanent water bodies such as the Koshi river, the Trijuga river, and other streams; ox-bow lakes; marshes or seasonally flooded barren lands; paleo-channels; and swamps. Both wetlands and grasslands occur along a soil moisture gradient of very wet to very dry and are thus sometimes difficult to differentiate from each other. The main types of wetlands and grasslands found in Koshi Tappu and their prominent vegetation are described in the following under the sub-headings wetlands, wet-grasslands, dry-grasslands, and savanna.

Wetlands

The following types of wetlands are found in the Koshi Tappu region.

Rivers and streams—The perennial Sapta Koshi river, which is a snow-fed river originating in the Himalayas and Tibet, represents the main wetland habitat in the region. The Trijuga river originates in the Mahabharat region of Udayapur district and enters the reserve from the northwest. It is called Mariya dhar in the southern part of the reserve. At present, the main course of the Sapta Koshi river lies in the eastern part of the reserve, whereas the old channel of the Koshi and the Trijuga river still flow through the western part of the reserve. Two other small rivers, the Mahuli and the Sundari, originating in the *siwaliks* of Saptari district, enter the reserve from the west near the villages of Pipra Purba and Badgama, respectively.

A total water area of 1,426.5 ha (8%) was calculated from the land use map of the wildlife reserve prepared from satellite imagery taken in the month of December 1991. This represents the minimum water area. The area increases significantly after March, first as a result of the snow melting in the Himalayas, and later as a result of monsoon rains throughout its catchment area. A much larger area is under water during the monsoon floods. Furthermore, the Koshi river changes its course within the reserve between the two embankments and thus extensively modifies the area. In the middle portion of the reserve near Kushaha, the river recently shifted about 1 km to the west. The area which was under water in 1991 is nowadays barren land full of sands.

Barren Floodplain—The floodplain is a periodically flooded flat area between the river channel and the terrace or plateau delimiting the plain. The wildlife reserve is located on the alluvial floodplain, which receives alluvial deposits from the river in the form of sand and silt. A total area of about 2,300 ha (15.4%) was identified as barren floodplain from the land use map (dry season). The area has increased recently after the gradual shifting of the river to the west. The area becomes smaller in the rainy season when most of it becomes submerged following the rise in water level of the river and streams, and some acquires vegetation in the course of time. The barren floodplain is almost devoid of any vegetation, with the exception of some old sand-bars where *Tamarix dioica* and *Saccharum spontaneum* grow either in pure stands or in association.

Oxbow lakes, riverine marshes—Like any other floodplain, the Koshi floodplain is characterised by the presence of oxbow lakes and back swamp lakes with marshes on their fringes. The most important oxbow lakes are ‘Kamal Daha’, meaning ‘lotus pond’, located in the far west of the reserve near the village of Kamalpur, and three lakes in the eastern part of the reserve along the eastern embankment near the village of Kushaha. There is an extensive marshy area on the fringes of these lakes. Apart from these areas the majority of the important marshes, lakes, and reservoirs are situated outside the wildlife reserve between its southern boundary and the barrage. In addition, there is a seepage stream with a 100-250 m wide strip of marshes on its fringes east of the eastern embankment. There are several man-made ponds of 0.5 to 2 ha located along the embankment outside the reserve.

The vegetation in the oxbow lakes and marshes consists of aquatic plants from different groups: submerged (*Hydrilla verticillata*, *Ceratophyllum submersum*, *Potamogeton crispus*); free-floating (*Azolla pinnata*, *Lemna minor*, *Spirodela polyrrhiza*, *Pistia stratiotes*, *Eichornia crassipes*); rooted-floating (*Hydrocharis dubia*, *Hygorrhiza aristata*, *Ipomaea aquatica*, *Nelumbo nucifera*, *Nymphoides indicum*); and emergent (*Cyperus sanuguin*, *Fimbristylis aestivalis*, *Paspalidium spp.*, *Persicaria barbata*, *Phragmites karka*, *Typha angustifolia*).

Swamps—In contrast to the relatively permanent water bodies, swamps are wetlands where the soils remain saturated with water long after the monsoons. About half of the area inside the wildlife reserve is grassland, dominated by combinations of *Phragmites*, *Saccharum*, *Typha*, and *Vetiveria* in different associations, which becomes flooded annually during the monsoons. This type can be recognised easily in the field by the presence of wetland vegetation dominated by *Typha-Vetiveria* and *Saccharum-Vetiveria* associations. Because of the dominance of *Typha angustifolia* and *Vetiveria zizanioides* this type of wetland is sometimes considered to be wet grassland.

Wet Grasslands

A large area inside the wildlife reserve is grassland, dominated by *Cymbopogon*, *Imperata*, *Phragmites*, *Saccharum*, and *Typha* in different associations. Some of these grasslands are wet grassland or ‘seasonally-flooded grassland’. Dugan (1990) included seasonally flooded grasslands as a sub-type of wetlands. Three different types of wet grassland are found in Koshi Tappu,

Typha-Saccharum—*Typha angustifolia* is usually found in shallow marshes. The association with other species, such as *Saccharum spontaneum*, indicates areas that dry up seasonally. Other associated species include *Persicaria barbata*, *Tetragium serrulata*, *Scoparia dulcis*, and *Sida rhombifolia*.

Saccharum—Pure stands of *Saccharum spontaneum* are found in the area with frequent flooding where there is a higher amount of sediment deposition. Associated species such as *Blumea lacera*, *Persicaria barbata*, *Desmodium sp.*, *Diplazium esculantum*, and *Sida cordata* are far from being dominant.

Saccharum-Phragmites—This type of grassland is very common in the Koshi Tappu region. It is dominated by *Saccharum spontaneum* and *Phragmites*

karka, and found in diverse environments, such as on the relatively stabilised floodplain, in moist places, and in the riverine forest. Both species can withstand standing water, and grow as tussock-forming perennials. Their growth is favoured by inundation of the area for longer periods. Peet *et al.* (1999) thought that this type of association in Koshi Tappu represents degraded grassland from the more widespread *Phragmites karka* and *Phragmites karka-Saccharum spontaneum-Saccharum arundinaceum* associations. The associated species in this type of grassland include *Alternanthera sessilis*, *Sida rhombifolia*, *Tamarix dioica*, *Vetiveria zizanioides*, *Azeratum conyzoides*, *Calapogonium mucunoides*, *Centella asiatica*, *Lindernia pumila*, *Plantago major*, *Tetragymma serruatum*, and *Uraria logopoies*.

Dry-Grasslands

The grasslands present in relatively dry areas comprise *Saccharum-Imperata*, *Imperata*, and *Saccharum-Cymbopogon* associations. This type of area is subjected to frequent burning and livestock grazing.

Saccharum-Imperata—This type of association is common in those areas that remain dry throughout the year or become inundated only briefly. This type of vegetation is common in open forests where grazing is common. The dominant species are *Saccharum spontaneum* and *Imperata cylindrica*.

***Imperata* stands**—Pure stands of *Imperata cylindrica* are formed in areas that are open, dry, and highly disturbed. In Koshi Tappu, this type of grassland is found in the northern and southern parts of the central portion of the reserve where the herds of livestock, that reside permanently within the reserve graze intensively, as in Chitwan and Bardia (Dinerstein 1979).

Cymbopogon-Saccharum—This type of association was found in relatively dry areas that are less disturbed. It is characterised by the dominance of *Saccharum spontaneum* and *Cymbopogon pendulus*.

Savanna Vegetation

Some portions of the grassland represent a savanna habitat (having been formed through degradation of the forest or regeneration of trees in the grasslands) with trees scattered throughout. *Dalbergia sisso*, *Acacia catechu*, and *Bombax ceiba* trees are found scattered in grasslands mostly of *Saccharum-Phragmites* and *Saccharum-Imperata* association types.

Significance of the Wetlands and Grasslands

Both the wetlands and the grasslands in Koshi Tappu are important resources that are used legally or illegally by local people. However, since extensive wetland areas also exist outside the reserve, the wetlands inside the reserve are used less intensively by people than are the wet grasslands and dry grasslands. The Wildlife Reserve Regulations 1977 (HMG 1977) do not officially allow the use of any resources from the Wildlife Reserve, thus it is hard to say that any object within the reserve has use values. However, here we assume that if permission is given to use products from the wetlands and grasslands, e.g., grass harvesting during the dry season, people will use them freely. Thus they can be considered as resources, reserves of commodities that have a use value to man,

either directly or indirectly (Ehrenfeld 1976). Many researchers have considered grasses in the protected areas to be important resources for local people (Lehmkuhl *et al.* 1988; Heinen 1993; Brown 1997). This means they possess some use values, which typically involves some human interaction with the resource (Barbier *et al.* 1996). It is important to consider the use values of the wetlands and grasslands because the local people in Koshi Tappu, legally or illegally, use their products.

Use values may be direct or indirect (Barbier *et al.* 1996). Direct use values include both commercial and non-commercial uses, indirect use values are generally regulatory ecological functions, which are sometimes considered as functional values (Dugan 1990). The indirect use values were difficult to quantify. In this study some indirect values were assessed subjectively. Existence values, a form of non-use values or non-economic values (Ehrenfeld 1976), help in evaluating the significance of wetlands and grasslands as they involve subjective valuations by individuals (Barbier *et al.* 1996).

Use Values of Wetlands

Fishing—Despite the ban on fishing inside the reserve, the Trijuga river and the old channel of the Koshi river are the main fishing sites for the fishermen living in the vicinity of reserve in Badgama, Pipra Purba, Kamalpur, and Odraha VDCs. About 90% of households of fisherman caste are landless in these VDCs. They are solely dependent on fishing within the reserve since there is no alternative site for fishing outside the reserve. Fishing, snail collection, and other human disturbances are high in Kamal Daha, despite its location near the Kamalpur post, because it is the only source of stagnant water in this area. Similarly, fishing is common in the main channel of the Koshi river near the northern and southern boundaries of the reserve. Outside the reserve, fishing is common in the Koshi river and associated marshes near the barrage and in the seepage stream flowing to the east of the eastern embankment. Altogether 115 households were found to be solely dependent on fishing. In this area, one fisherman catches 2-4 kg of fish per day and sells them in the local market.

Livestock grazing—Livestock grazing is also common in the wetlands, especially in the marshes which dry up in the dry season and the seasonally flooded grasslands. Grazing in wetlands is common in Madhuban, Kushaha, Shreepur-Jabdi, and Haripur VDCs, situated to the east of the reserve. People cannot cross the Koshi River daily from these villages, thus they take their livestock to the marshes along the seepage stream, the eastern embankment, and the swamps between the Koshi river and the embankment. The density of livestock grazing in this area peaked in the late afternoon, reaching 6 to 10 livestock units per hectare. Domestic animals from Badgama and Vardah villages also come to the south-western part of the reserve for grazing. In addition, thousands of cattle that reside permanently within the reserve regularly graze in the marshes located along the fringes of the Trijuga River and the southern border of the reserve.

Fuelwood collection—There is hardly any forest left outside the reserve in the adjoining VDCs, especially along the embankments in Sunsari and Saptari districts, and fuelwood is very scarce in this region. Because of the fuelwood shortage, people mostly use agricultural residues, cattle dung, and *dhadi* for

cooking. *Dhadi*, which is composed of dry weeds and dry minor woody products, is mostly obtained from the dry wetlands of the reserve. In addition, driftwood lying on the barren floodplain is also collected occasionally and used as fuelwood. A total of 1.4 tonnes/household per year of fuelwood and *dhadhi* was extracted from Koshi Tappu. The use of fuelwood and *dhadi* from the reserve was more intensive in the west (70.4%) than the east (29.6%) as a result of the easy access to the reserve from the west.

Irrigation—After the river shifted to the eastern part of the reserve, a seepage stream formed to the east of the eastern embankment. The water from this stream is used by the people of Madhuban, Kushaha, Shreepur-Jabdi, and Haripur VDCs for irrigation.

Recreation—Recreation in the wetlands is considered by Barbier *et al.* (1996) to be one of the direct use values. The wetlands in Koshi Tappu are regularly visited by bird watchers. Rafting from the Sunkoshi River to the barrage has also become popular in recent years. The number of nature tourists almost tripled from 150 in 1994 to 500 in 1999 (Koshi Tappu Wildlife Camp and Unlimited Aqua Bird: personal communication).

Other uses—Many wetland plants such as cattails (*Typha angustifolia*) and vetiver (*Vetiveria zizanioides*) were found to be harvested illegally from the swampy area of the wildlife reserve for commercial purposes. People legally harvest cattails from the marshes near the Barrage and export them to India on a commercial scale. Several other wetland plants, such as *Alternanthera sessilis*, *Ipomaea aquatica*, *Ludwigia adscendens*, *Scirpus kysoor*, and *Tamarix dioica* are regularly collected for household use. WMI/IUCN-Nepal (1994) has given a detailed account of the plants being used from the reserve.

Existence Values of Wetlands

Habitat of Water Buffalo (*Bubalus bubalis*)—The wetlands, seasonally flooded grasslands, swamps, marshes, and rivers in Koshi Tappu, provide a suitable habitat for the last remaining population of wild water buffalo (*Bubalus bubalis*) in Nepal. The establishment of the reserve in this area has helped to restore the population from a low of 40 (Gupta and Mishra 1972) to the present number of about 125 to 150.

Rich Biodiversity—The wetlands in Koshi Tappu support a rich biodiversity. Altogether, 236 plant species, 80% of which are estimated to be wetland plants, have been recorded so far (Sah 1997). Similarly, 84 species of fish (WMI/IUCN-Nepal 1994) and 23 species of mammals (BPP 1995) have been recorded from the reserve and adjoining wetland area. The five hectare Kamal Daha in the western part of the reserve has such a diversity of fish (29 spp. WMI/IUCN-Nepal 1994) that it can be considered as a living aquarium (Jeevan Shrestha; Personal communication). In addition, a few individuals of the rare gharial (*Gavialis gangeticus*), freshwater crocodile (*Crocodylus palustris*), and Gangetic dolphin (*Platanista gangetica*) species are also found in the Koshi river inside the reserve, as well as a small number of all three Nepalese otter species (*Lutra lutra*, *Lutrogale perspicillata* and *Aonyx cinerea*), and the fishing cat (*Felis viverrina*).

The Koshi Tappu region is considered a birds' paradise by bird watchers. A total of 461 bird species have so far been recorded from Koshi Tappu (Anonymous 1997), more than 180 of them wetland dependent species. It is not certain how many of these were recorded in the reserve itself. Many bird species visit the wetlands outside the reserve, especially the seepage stream to the east of the eastern embankment and the reservoir and marshes near the Koshi barrage. About 32 species found in this region are either threatened, rare, or endangered bird species. (Heinen 1986; WMI/IUCN-Nepal 1994). These include the swamp partridge (*Francolinus gularis*), Bengal florican (*Houbaropsis bengalensis*), white-tailed rubythroat (*Luscinia pectoralis*), and blue whistling thrush (*Myiophonus caeruleus*).

Cultural Heritage—The Koshi river, as a tributary of the Ganges, is considered a holy river by the local people. People take ritual baths in this river, especially south of the barrage, on many occasions such as Dashraha (celebrated in June) and Chhatha (celebrated in October or November). The people of this region have a cultural attachment to the river. Fishermen see the Koshi river as the means of their livelihood, indigenous people of other castes such as Tharus, Donbar, Jhangar, and Bantar depend on the Koshi river for their daily life.

Use Values of Grasslands

The results of the household survey showed that more than two thirds of local people residing in the vicinity of the reserve considered the grasslands of Koshi Tappu to be important and unlimited resources which would never be exhausted. They had strong attitudes about using these resources for different purposes. Grasslands in the Koshi Tappu region have the following use values.

Livestock grazing—People living in the vicinity of the Koshi Tappu region have been using the grasslands and forests to graze livestock for centuries. After the area was declared a wildlife reserve, such activities were legally banned. Nevertheless, livestock herders of different socioeconomic status have continued such practices to the present. Many large livestock herders, who mostly belong to the Yadav caste (literally milkmen), keep their livestock (cattle and buffalo) inside the reserve permanently. About 50 households own 10,000 to 12,000 livestock units; none has less than 100 units, while some have more than 500 units (Kherwar 1996; Sah 1997). They are mostly from different villages in Sunsari and Saptari districts. Some of their relatives from India also keep cattle inside the reserve. Many other householders take their livestock inside the reserve every morning and bring them back in the late afternoon. The total number of livestock taken to the reserve daily was estimated to be 15,000 to 17,000 in the west and 3,200 in the east from the livestock holdings per household and the proportion of households taking their livestock inside the reserve during most of the year except the rainy season.

Besides the availability of grasses, the other main incentive for livestock owners to keep their buffalo inside the reserve is that they prefer to cross-breed them with the wild population to get hybrids, which are more valuable in the Indian market. A second-year hybrid may be valued at 50-80% more than an ordinary buffalo.

Fodder collection—During the field survey, more than 90% of households in the villages located in the close vicinity of the reserve in the west and north were found to be bringing fodder from the reserve. Each household collected one to three bundles per day. In the east, this depended on the opportunities people had to enter the reserve. In one morning, 200 people were found between Kushaha and Prakashpur, 100 of them from Madhuban where there is an army post.

Fuelwood collection—People from the villages to the west of the reserve collect fuelwood in the form of *dhadhi* from the grasslands and savanna.

Thatch grass—The harvesting of thatch grass, locally called 'khar' and 'dhadhi', is legally permitted in the protected areas of Nepal. In Koshi Tappu, permission is given for a one-week period. Until recently this used to be 15 days. *Imperata cylindrica* is the most favoured thatch grass harvested by the local people. The other grasses harvested during this period are *Phragmites karka* and *Saccharum spontaneum*. During the grass-cutting season, swampy areas are visited by relatively few people because of the swampy conditions and the presence of a high proportion of less preferable grass species. No systematic research has been done on the amount of grass harvested since 1987, when Heinen (1993) estimated that its value lay between 3.7 and 5 million NRs.

Other uses—Many other plants found in the grasslands of the Koshi Tappu region are used by local people for different purposes. The most extensively used is a fern *Dryopteris chochleata*. This fern is harvested on a commercial scale from the western part of the reserve and is supplied to Kathmandu. Other plants include *Alternanthera sessilis*, *Diplazium esculantum*, *Eclipta prostrata*, *Leucas cephalotus*, *L. indica*, *Lippia nudiflora*, and *Vernonia cineria*, which are used as green vegetables. Similarly, wild varieties of vegetables like *Solena heterophylla* and *Momordica charainta* are also harvested from the grasslands.

Existence Values of Grasslands

Grasslands are also considered rich in biodiversity. No detailed study was made of the species composition in the grasslands during my field trip. However, in a study conducted by WMI/IUCN-Nepal (1994) more than 30 species of plants were found in different grasslands. Grasslands have an important role in Koshi Tappu as the habitat of wild water buffalo. Altogether, eight species of mammals were recorded in the grasslands and savanna by WMI/IUCN-Nepal (1994). Many bird species in Koshi Tappu are also grassland birds. Mr. Hem Sagar Baral of Bird Conservation Nepal (BCN) is conducting research into the population of grassland birds.

The above results show that both the wetlands and grasslands are valuable in the Koshi Tappu region (Table 2). However, under the present conditions, their relative importance in terms of their use and existence values differ. The grasslands are more intensively used by the local people than the wetlands. On the other hand, the wetlands seem to have more existence values than the grasslands if the adjoining areas are also included (Figure 5).

Table 2. Different values of wetlands and grasslands in the Koshi Tappu region under present conditions

Value	Wetlands	Grasslands
Direct Use Values		
1. Grazing	**	*****
2. Fishing	***	-
3. Fuelwood collection	*	***
4. Fodder collection	*	****
5. Other products	***	****
6. Irrigation	****	-
7. Recreation	****	*
Indirect Use Values		
1. Ground water recharge	****	*
2. Flood control	****	**
3. Sediment retention	**	****
Non-use/Existence Values		
1. Biodiversity richness	****	**
Cultural Values	**	-

Note: the number of stars shows the relative value

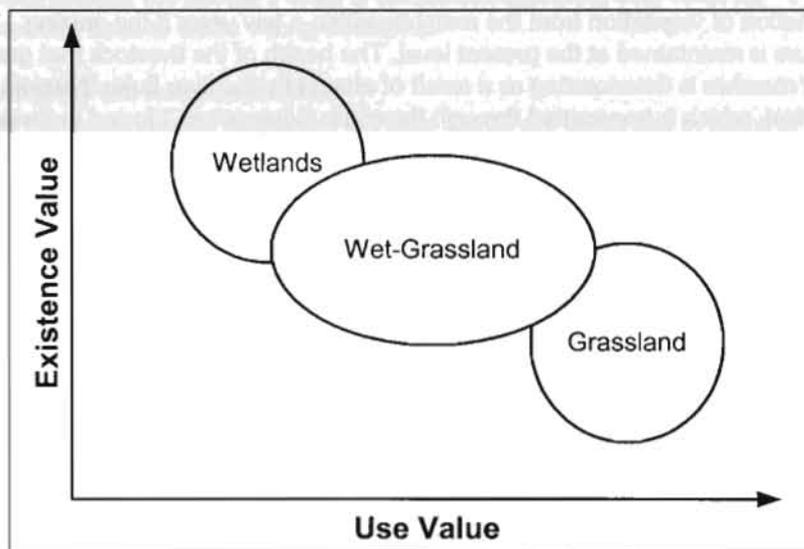


Figure 5. Relative use and existence values of wetlands, wet-grasslands and grasslands in the Koshi Tappu region under present conditions

Factors Threatening the Wetlands and Grasslands

Both the wetlands and grasslands in the Koshi Tappu region are important, but they are threatened both by natural calamities and anthropogenic disturbances. The main problems in managing the wetlands and grasslands in the Koshi Tappu region are as follow.

Flooding and Sedimentation—Frequent flooding in the Koshi river leads to a high mortality of the wild water buffalo which is the main target species of protection in this region. The mortality rates due to flood vary from 12% as in 1987 (Heinen 1993) to 40% as in 1968 (Dahmer 1978). Sedimentation in the Koshi Tappu region has increased since the barrage was constructed. Sedimentation causes the riverbed to rise and is thus the main cause of the shifting behaviour of the Koshi River in this region. Sedimentation also threatens the existence of the ox-bow lakes situated to the west of the eastern embankment. Furthermore, shifting of the Koshi river towards the west may result in drying up of the seepage stream located to the east of the eastern embankment.

Livestock grazing—Livestock grazing inside the reserve is seen as a chronic management problem. The intensive grazing in Koshi Tappu has adversely affected plant diversity in the grasslands and savanna, destroying the habitat and possibly creating problems of genetic erosion in the population of wild water buffalo (yet to be confirmed by research).

Intensive grazing in the marshes, especially in the eastern part of the reserve, 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 at the present level. The health of the livestock that graze in the marshes is deteriorating as a result of attacks by the liver fluke (*Fasciola hepatica*), which is transmitted through the snails (*Viviparis* sp.) found in these marshes.

The problem of livestock grazing in Koshi Tappu has its roots in the social structure of the communities, cultural practices, and lack of political determination. Further causes are lack of alternatives for the large livestock herders, and insufficient resources in the protection unit of the reserve. In addition, people living in Bairwa, Badgama, Pipra Purba, Kamalpur, and Odraha VDCs face problems of water scarcity and are dependent on the river inside the reserve as a source of water for their livestock. Once they take their livestock to the Trijuga or Mariya dhar to drink, they take the opportunity to allow them to graze as well.

Grass harvesting—Permission given to the local people to harvest grasses from the reserve once a year helps gain support for the reserve, but it also has some negative effects. For example, theft of fuelwood in this season is common, and is the reason why the grass-cutting period was shortened from 15 days to 7 days. In addition, many wild animals are killed or injured during this period when they find their habitat disturbed and try to flee (Sah 1993). During this season, people also burn the grasslands.

Fishing—Illegal fishing in the wetlands inside the reserve creates confrontation between fishermen and reserve staff. Fishing during the spawning period also affects the growth of the fish populations. As a result, the size and number of fish in the Koshi River are both lower now than in earlier times.

Development Activities—The Koshi Barrage has adversely affected the wild land of Koshi Tappu by accelerating the deposition of sediments on the floodplain. Similarly, the 132 KV line constructed through the reserve is posing a threat to the wetland birds flying in huge flocks.

Presence of a Transitional Zone—When land becomes barren following 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. On the other hand, vegetation such as grassland may become severely degraded and look like barren land as a result of intensive grazing and frequent burning. Land which is in transition from wetlands to grasslands covers almost one fourth of the area of Koshi Tappu (22.8%) and may be categorised as 'transitional zone'. This area may be more vulnerable to human disturbance and needs special consideration for management.

Socio-political Interference—When reserve authorities try to enforce the regulations strictly, the large livestock herders seek the help of a political leader to ask the authorities to be liberal. When poachers or miscreants are caught breaking the regulations, local politicians come to release them. Under the present system, the people's voice is considered supreme. This voice is sometimes used to make wrong decisions.

Conclusions and Recommendations

Both the wetlands and grasslands in Koshi Tappu are important in terms of use and existence values. However, the use values, especially the consumptive use, should be handled carefully without compromising the goals of conservation. Consumption of the resources may cause their deterioration (Lemons 1987). The competing goals of conservation and use cannot both be maximised (Hardin 1968) nor can either be abandoned because the area is not only the prime habitat of the last remaining population of wild buffalo (*Bubalus bubalis*) and the location of nesting and wintering sites of a number of birds, but also a site which provides local people with various products for their livelihood. Thus it is recommended that livestock grazing in Koshi Tappu should be phased out gradually but not abruptly. Abrupt reduction would damage the whole social and economic setting of the communities in the adjoining villages, where livestock rearing is not only an integral part of the economy but also a part of the traditional culture of some ethnic groups. The process and benefits of a gradual reduction in livestock numbers has been described elsewhere (Sah 1993 1997).

In the Koshi Tappu region, it is the existence value of the wetlands that has led the international community to include this region in the list of Ramsar Sites (Wetlands of International Importance). But what the region is recognised for lies mostly outside the reserve in areas such as the reservoir and marshes near

the barrage and the seepage stream with marshes to the east of the eastern embankment. That is why the extension of the wildlife reserve up to the barrage is widely advocated (WMI/IUCN-Nepal 1994; BPP 1995; Sah 1997). However, prior to any decision, the challenges and consequences of such extension need to be well evaluated.

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