Chapter 2
STUDY AREA

2.1 LOCATION

This study was carried out in the Chitwan National Park (CNP) and its buffer zone (BZ), located in the Dun valley and Siwalik hills in the South-Central lowland of Nepal (Figure 2.1). The Chitwan National Park was gazetted in 1973 and designated as UNESCO’s World Heritage Site in 1984 on account of its outstanding universal values. The park covers an area of 932 km² between 27° 16' 56'' to 27° 42' 14'' N and 83° 50' 23'' to 84° 46' 25'' E, while the buffer zone (27° 16' 56'' N to 27° 42' 13'' N and 83° 50' 44'' E to 84° 44' 58'' E) extends 750 km² area. But latest GPS survey of the park boundary and GIS digitization based on 1992 topo maps shows the park and buffer zone covers 1182 km² and 766 km² of area respectively (DNPWC, 2000). CNP spans across portions of four districts namely, Chitwan, Nawalparasi, Parsa and Makawanpur. The park encompasses a wide diversity of habitats and species within the elevation range between 110 and 850 msl.

CNP is connected through a natural linkage of Barandabhar Corridor Forest to the lesser Himalayan Mahabharat Mountains to the north, and is contiguous with the Parsa Wildlife Reserve in the east and the Valmiki Tiger Reserve in India to the South. The Narayani River and Daunne hill marks the western boundary of the park, the Rapti River marks the northern boundary and Someshor hill, Rapti River and Jungle road marks the southern boundary.

2.2 GEOLOGY AND SOILS

The Chitwan is a Dun valley in the inner Terai between Lesser Himalayan Mahabharat Mountain range and Lower Himalayan foothills- the Churia (Siwalik) range. Geological structures of Chitwan dun and Siwalik has been described by Stocklin and Bhattarai (1982), DMG (1984) and Tamrakar (2004).
Figure 2.1 Map showing the Chitwan National Park and Buffer Zone, Nepal.
The Park is characterized by the flood plains of the Rapti, Riyu and Narayani Rivers, and Siwalik hills. The flood plain consists of a series of ascending alluvial terraces laid down by the rivers and subsequently raised by Himalayan uplift (Berry et al., 1974). The terraces are composed of boulders, gravels, sand and mud set in a fine silt matrix (Laurie, 1978, Tamrakar et al., 2008). There is rough gradient from the higher-lying boulders and gravels to sand and silts, and then to low lying silt loams and silty clay loam (Berry et al., 1974).

Geologically, the lower ranges of the Siwalik hills are of mid-Miocene to early Pliocene fluvial origin consisting mainly of the poorly consolidated detritus of sandstones, conglomerates, quartzites, phyllites, and outwash deposits from the severely eroded Tertiary rocks of the mountains further north (Kimura, 1994). Main Frontal Thrust fault produces steep cliffs on south-facing slopes. The valleys composed of layers of boulders and gravels in a fine silty matrix graded roughly from the higher boulders and gravels to sands, silt loams and silty clay loams (Bolton, 1975).

The park soils are representatives of Chitwan dun valleys types (Gee, 1963). Most of the land inside park is loamy with fine sand. Hills soils are sandy loam and loamy rubble with stony surfaces less than 50cm from bed rock. Soil types found in the valley has been identified as sandstone, conglomerates, quartzites, shales, and micaceous sandstones during soil survey (HMG, 1968). Alluvial soils range from sand and coarse loams on new terraces to sandy and silty-clay loam on older terraces.

2.3 HYDROLOGY

The CNP is drained by Narayani, Rapti and Riyu Rivers and their tributaries (Figure 2.2). The Churia hills are of generally low permeability, and the high monsoon rainfall runs off in numerous ephemeral streams and in rivers, which swell to many times their dry season sizes (Laurie, 1978). Drainage on the flood plains is generally good but the streams and rivers are seasonal in the hill. During dry season, the flowing water is available only in some rivers in Churia range but the porous Bhabar
remains waterless. The standing water is confined to small lakes those are found throughout the park, generally on old river-courses. During the monsoon, extensive areas of grasslands and forests become inundated, and may remain waterlogged for long periods. In lowland areas, the river and streams often change the courses during flood times.

Figure 2.2 Map showing drainage system of the Chitwan National Park, Nepal.

2.4 CLIMATE

The Chitwan valley has a sub-tropical climate with three major seasons: summer (pre-monsoon), monsoon and winter (post monsoon) seasons. Summer season, extending from late February to mid June, is hot and dry period of the year. The monsoon season is hot and humid, and lasts from mid June to late September. Winter extends from late October to late February and is generally a cool season.

Rainfall is well distributed during southeast monsoons. Monsoon arrives in mid June and continues till late September. The mean annual rainfall over the period from 2004 to 2007 was 2437 mm, 77.5% of which occurred within four months of monsoon season (May-September) (Figure 2.2). From April onwards sporadic thunderstorms and hailstorms occur. There is continuous increase of rainfall from March to July which slightly decreases in August and peaks again in September, and then decreases
till December (Figure 2.3). Winter months are relatively dry but a little rain occurs due to westerly wind.

Figure 2.3: Variation in mean monthly rainfall from 2004-2007 (Source: DHM/GovN).

The winter months (November to February) are colder and the nights and mornings are damp with heavy fog. January is the coldest month of year with mean minimum temperature recorded from 2004 to 2007 was 7.8°C. The temperature rises from January to May, stabilizes for four summer months and again decreases from September till January (Figure 2.4).

Figure 2.4: Variation in mean monthly temperature (°C) from 2004-2007 (Source: DHM/GovN).
Humidity is high all the year round except three dry months (April- June), with early morning readings of 100% relative humidity being recorded frequently at Bharatpur Meteorological station. Mean monthly relative humidity ranged between 89% in May and 98% in December (Figure 2.5). Mornings during the winter months are characterized by heavy mists which persist for several hours after dawn, particularly in the river valleys. Cool and dry northerly winds from the greater Himalaya and the Trans Himalayan plateau reduces the daily temperatures. From February, winds from the west and south west rises temperatures and reduces relative humidity to minimum in May.

![Figure 2.5: Variation of mean monthly Relative Humidity from 2004- 2007 (Source: DHM/GovN)](image)

Local variations in climates have been reported within the Chitwan valley due to location relative to hills, the rivers, terrain and vegetation condition within short distances (Laurie, 1978).

2.5 VEGETATION

The general vegetation characteristics of the Chitwan National Park have been described by Bolton (1975), Laurie (1978) and Mishra (1982). Vegetation of CNP is subtropical type, with mosaics of early successional flood plain communities in alluvial floodplain to climax Sal forest in relatively dry flat lands. About 70 percent of vegetation is predominantly Sal (*Shorea robusta*) forest, a moist deciduous vegetation
type of the Tarai region (Stainton, 1972; Dobremez, 1976). The remaining vegetation types include grassland, riverine forest on the more moist areas (Laurie, 1978, Mishra, 1982b; Gurung, 1983) and Sal with Chir Pine, Pinus roxburghii, the latter occurring on the drier southern slopes of the Churia range.

Using satellite images, I classified land cover types of the CNPBZ into 16 types with four types of Sal forest associations (lowland Sal forest, mixed Sal forest, hill Sal forest and degraded Sal forest), three riverine forest associations (Accacia/Dalbergia association, Trewia/Bombax association, mixed riverine forest), three tall grassland associations (swampy tall grass, tall grass on phantas and tall grass within Sal forest), two short grassland associations (floodplain grassland and short grasslands), two types of wetlands (river and lakes), exposed surface and cultivated areas (Chapter 3). The cultivated area includes settlements that are found only in the buffer zone and there are no settlements inside the CNP.

The Sal forest is the ecologically characteristic climax vegetation of the Terai (Stainton, 1972; Dobremez, 1976). The Sal (Shorea robusta) is intermixed with Terminalia tomentosa, T. bellerica, Dillenia pentagyna, Listea monopetala, Buchanania latifolia, Semecarpus anacardium in Sal forest. Riverine forest is composed of Dalbergia sissou, Acacia catechu, Trewia nudiflora, Bombax ceiba, Butea monosperma, Careya arborea, Ehretia laevis, Ficus spp.

Lehmkuhl (1994) has classified riverine grassland into eight different associations with ten phases. The floodplains are characterized by tall grass composed of Saccharum spontanum, S. bengalensis, S. munja, Narenga porphyrocoma, Imperata cylindrica, Themeda villosa, Arundo domax, Phragmites karka, etc. Important species of the short grasses include Cynodon dactylon, Chrysopogon aciculatus, Erogrostis japonica, Clerodon viscosum, etc.

Many lakes occur in the park and Barandabhar corridor forest in the buffer zone. A group of lakes has been designated as the “Beeshazar and Associated Lake Ramsar Site” in Barandabhar forest in the buffer zone. Several of oxbow type lakes are formed on old river beds which get flooded during monsoon, while in dry season they look like isolated lake (tal). Most of the lakes are found in riverine complex but Tamor Tal in Kasara and Beeshazar lake system are within the Sal forest. The
vegetation around most of the lakes of riverine complexes is *Trewia/Bombax* forest association and *Arundo-Phragmites* grassland association, where as the vegetations around the tal within Sal forest are the trees associated with Sal forest.

### 2.6 FAUNA

The CNP is rich in faunal diversity. Current checklists include 58 mammals, 539 birds, 56 herpeto and 124 fish species (Gurung, 1983; Edds, 1986; BPP, 1995; Shah and Tiwari, 2004; Baral and Upadhaya, 2006; Bhuju et al., 2007). The prominent mammalian species of CNP are tiger (*Panthera tigris*), leopard (*Panthera pardus*), sloth bear (*Ursus ursinus*), gaur (*Bos gaurus*), greater one-horned rhinoceros (*Rhinoceros unicornis*), Asian elephant (*Elephas maximus*), Dolphin (*Platanista gangetica*). Ungulate prey species includes chital (*Axis axis*), hog deer (*Axis porcinus*), Sambar (*Rusa unicolor*), muntjac (*Muntiacus muntjak*) and wild pig (*Sus scrofa*).

CNP and BZ comprise two of Important Bird Areas (IBA) in Nepal (Baral and Inskipp, 2001). CNP supports 539 species of birds including 266 species of migratory species (Baral and Upadhaya, 2006, Bhuju et al., 2007). This is due to the Park's wide range of habitat types in a tropical lowland location where the distributions of eastern and western species overlap (Inskipp, 1989). Globally threatened species include greater adjutant (*Leptoptilos dubius*), lesser adjutant (*Leptoptilos javanicus*), Pallas’s fish-eagle (*Haliaeetus leucoryphus*), greater spotted eagle (*Aquila clanga*), imperial eagle (*Aquila heliacal*), sarus crane (*Grus antigone*), bengal florican (*Houbaropsis bengalensis*), indian skimmer (*Rynchops albicollis*), white-throated bushchat (*Saxicola insignis*), jerdon’s babbler (*Chrysomma altirostre*), slender-billed babbler (*Turdoides longirostris*) and bristled grass-warbler (*Chaetornis striatus*). Important reptile species found in good numbers in the park are Gharial (*Gavialis gangeticus*), marsh crocodile (*Crocodylus palustris*), golden monitor lizard (*Varanus flavescens*) and Asian rock python (*Python molurus*). Important fish species of the park are *Barilius* spp. *Tor putitora*, *T. tor*, *Puntius* spp., etc. (Edds, 1986).
2.7 DISTURBANCE FACTORS AFFECTING PARK ECOSYSTEMS

Natural and physical forces such as floods, fires, erosion, and human disturbance contribute to maintain a mosaic of grasslands, riverine forests and Sal forests in various stages of succession.

2.7.1 Flood

The riverine forests and grasslands along the floodplains remain water logged during monsoon season. The rivers and streams carry large loads of sediments during flood and hence frequently change the course. Monsoon floods and river dynamism are important natural forces responsible to maintain the grasslands and riverine forest communities.

2.7.2 Fire

Annual burning in Chitwan valley is an ancient human practice (Bolton, 1975; Laurie, 1978). The grassland and surface litter of Sal forest are burnt between January and April (Mishra, 1982a). Most fires are lit either by villagers or park staff (Laurie, 1978) to remove outer dry layers of tall elephant grass and to get new grasses. The people are using the canes of elephant grass for construction of walls and partitions in traditional houses. Early fires during January-February have little effect on shrub and grassland, but the late fires during March-April penetrate most part of the forests. Heavy fires reduce species diversity of grasses, shrubs and trees; however, the annual burning seems to maintain the grasslands from woody encroachments except *Bombax ceiba*, the only fire resistant tree (Troth, 1976).

2.7.3 Grass Cutting

Since 1978, local villagers have been permitted to enter the park each year to collect thatch grasses (Mishra, 1982a) and the grass cutting program (GCP) of the CNP is regarded as being very successful in gaining local people's acceptance of park. The GCP opens the park for short period (previously 14 days but now less than a week), where villagers may collect four essential products that are not available to them elsewhere, namely thatch grass (mainly *Saccharum spontaneum* and *Imperata cylindrica*) for roof, reeds (mainly tall grass species such as *Saccharum narenga*,...
Themeda spp., Arundo spp., Typha elephantinam, Phragmites karka and Cyperus spp.), rope bark (Helicteres isora) and rope grass (Eulaliopsis binata). Straeds and Helles (2006) estimated that the almost 50,000 tones of biomass were removed from the Park during ten days access of grass cutting in 1999; the total gross economic value of the GCP in 1999 was more than $1 million. Illegal fuel wood was the single most important product extracted from CNP and accounted for half of the total quantity and economic value of all resources collected (Straeds and Helles, 2000). Recently, Bhrikuti Paper Mill at Gaidakot is buying grasses harvested from the CNP. Long term impact of commercial exploitation of grasses on park ecology and socio-economy of local people is yet to be evaluated.

2.7.4 Tourism

Chitwan National Park is one of the most popular touristic destinations in Nepal. Tourism has concentrated in Suaraha area, where over 60 hotels operate and about 75% of the entry permits are issued from Sauraha. Visitors are taken to the core zone of the park on elephant, vehicles and on foot. Some adverse impacts of tourism on the biodiversity of the park are damage to the vegetation, disturbance to wildlife and pollution are visible (Aryal, 2005).

2.7.5 Other Human Disturbances

National Park and Nepal Army Protection force respectively employs 270 staff and about 800 army personnel, and about 700 staff from 7 concessionaire hotels dwells inside the park. In 2007, there were 55 and 68 domestic elephants respectively with the park and 7 concessionaire hotels. These elephants regularly grazed inside the park and several trees are regularly lopped to provide fodder. Besides, there are some illegal encroachments for grazing, thatch and fodder grass cutting, firewood collection, timber cutting, bamboo and vegetable collection and other non timber forest product (NTFP) collection. These illegal but fairly conspicuous encroachments into the park over the years have caused concern (Nepal and Weber, 1993; Kattel, 1995; Stræde and Helles, 2000; Dinerstein, 2003). Fishing activity is common in all rivers along the park border by local Bote who dependent on fish for their livelihood.
2.8 BUFFER ZONE AND ITS MANAGEMENT

A buffer zone (BZ) covering approximately 750 km$^2$ area was established around the CNP in 1996 (Sharma, 1998) to give protective layer to the National Park and to meet the resource needs of local people. Thirty five Village Development Committees (VDCs) and two municipalities are partly or almost wholly lie in the buffer zone. The BZ covers areas of national forest which are managed under community forestry, rivers, open land, streams and lakes, a plantation and private lands as well. Cultivated agricultural land (46%) is dominant land use category in the BZ followed by forest (43 %), shrub land, grassland and others (DNPWC, 2000) (Figure 2.6). The resources in the buffer zone in jointly managed by elected buffer zone management committee and park manager. In order to save the endangered wildlife and minimize conflicts, the buffer zone management committee has set some animal preventive infrastructure such as trenches, fences, watch towers and electric fences. 30-50 % of the park revenue is channeled for the buffer zone programme.

![Land use (%)](image)

Figure 2.6 Land use in the Buffer Zone of the Chitwan National Park.

The buffer zone of CNP is inhabited by population of 223,260 from 36,193 households of various ethnicities; however Tharus are the main indigenous people (DNPWC, 2000). The agriculture is the dominant occupation among the people living in the buffer zone. As in most part of Terai, rice (*Oryza sativa*) is planted in June- July and harvested in November- December. However, in areas with permanent water source rice is grown twice in a year. Wheat (*Triticum avvenea*) and mustard (*Brassica* sp.) are most important winter crops.