Chapter-II

CHAPTER II

Study area

2.1 THE LOCATION AND SIZE OF THE STUDY AREA

Pangolakha Wildlife Sanctuary is the largest wildlife sanctuary in Sikkim (Lepcha 2006; Lepcha *et al* 2007, 2009). It is situated at the southeastern part of the Sikkim and falls under the Himalayan biogeographic IBA Site Code no IN-SK-09. With the total area of 128 sq km (12,800 Hectares), the sanctuary belongs to the bio-geographical zone 2C (Central Himalayas) as recognized by Rodgers and Panwar (1988). It is located between 27° 08′ 03″ N latitude near *Phusrey* in southern tip to 27° 21′ 59″ N latitude in northern tip near Jelepla and extended from 88° 55′ 23″ E latitude near *Batangla* to 88° 41′ 28″ E latitude at *Simane Khola*. The lowest point of the sanctuary falls at the 27° 11′ 35″ N latitude and 88° 43′ 43″ E longtitute at *Chukha* river in between *Rigu* and *Sangha* rivers at the elevation of 1200 m. And, the highest elevation points falls on 27° 21′ 01″ N latitude and 88 ° 53′ 16″ E longitude at *Pinbriono* near *Dongchula* at the elevation of 4570 m. The sanctuary covers various climatic zones ranges right from the sub-tropical to alpine zone. The map of the location, vegetation type, landuse, elevation and drainage system of the PWS is mentioned at plate II,III &IV.

Based on information and relevant statistics collected from the area, the optimum size of the protected area was standardized considering the richness of the bio-diversity, availability and distribution of flora and fauna. The entire region is crossing along the international border between Sikkim, China, and Bhutan harboring the virgin forests and alpine pastures. The forest in the sanctuary is commencing from *Phadamchen, Zuluk, Lamateng, Barapathing, Men Men itso, Assam Lingzey, Bhusuk* and *Lagyap* formed the natural trail of many carnivores and ungulates, which is further connected with Pangolakha and Rachela Reserve Forest and the adjoining regions of Bhutan and West Bengal. Many of the species reported are either en-route into Sikkim via Bhutan or West Bengal on migration. The natural boundaries of sanctuary however do not proportionately follow the actual alignment; however, western alignment follows the *Rongli-Nathang-Jalepla* road. Further, a

large number of Army bunkers and settlement as well as civilian settlements fell along the road. The sanctuary also includes areas like *Pangolakha* Reserve Forest, *Rigu* south and north, *Rachela, Zuluk, Nathang, Lampokhari* and part of *Jalepla*.

2.2. LEGISLATION

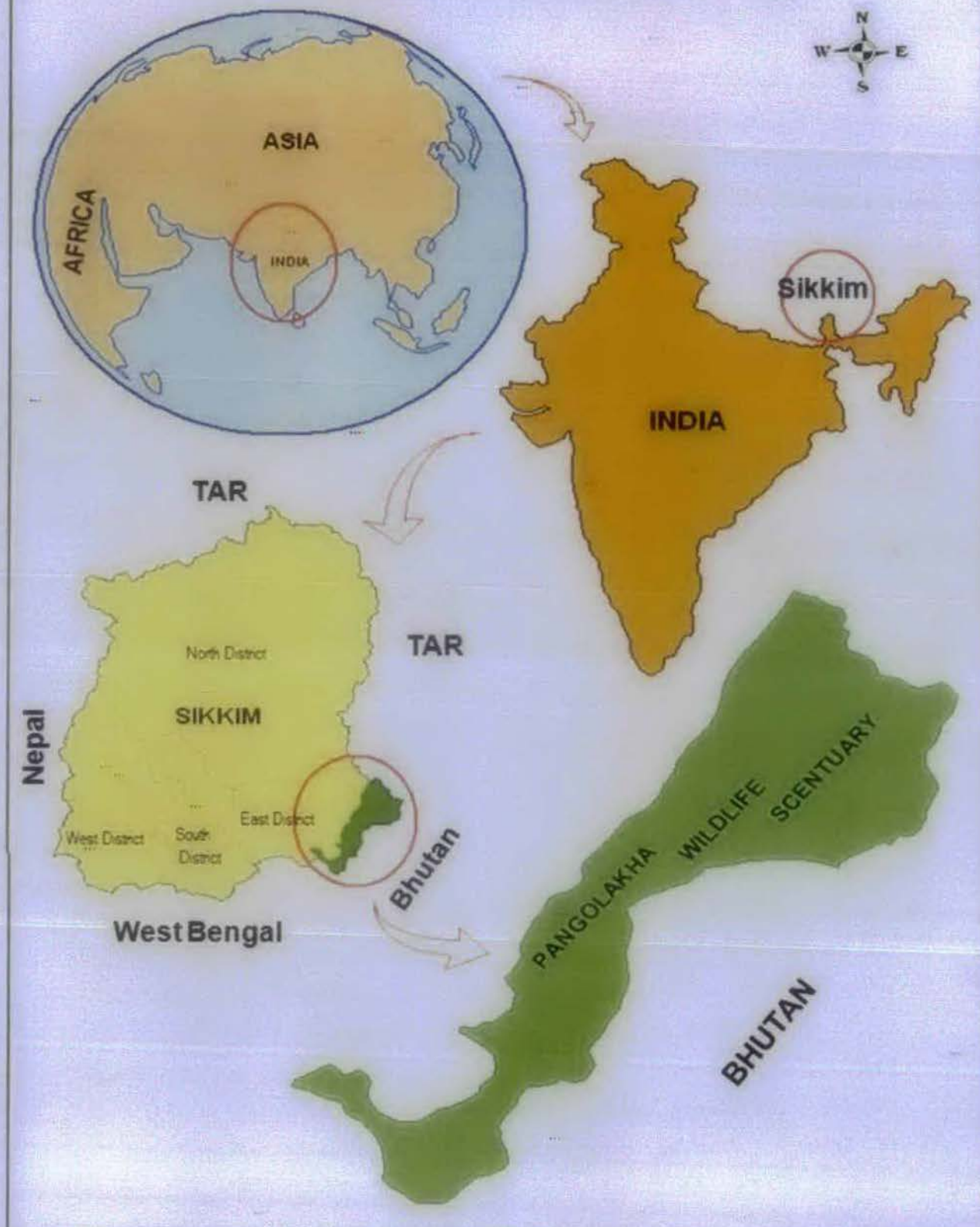
The Government of Sikkim declared Pangolakha Wildlife Sanctuary with its total area of about 128 sq km as Wildlife Sanctuary in the year 2002 through the notification no. 10 / 09 / WLC / 02 / 127, dated 05.09.2002 (Annexure- I). The reason behind the declaration of this sanctuary is for the protection of the both rare and endangered species of flora and fauna, apart from that area being extremely rich in biodiversity, inaccessible, virgin vegetations, wide range of topography, edaphic, altitudinal biotic composition and of complex species composition.

2.3. BOUNDARY AND DEMARCATION OF THE SANCTUARY

The Northern boundary of the sanctuary actually starts from the Zuluk and runs through the places like *Gnathang, Tukla, Neola, Kupup, Jalepla* etc. As such, the southern boundary of the sanctuary starts from the point where *Dichu* meets the internal boundary with Bhutan up to Rachila and further it runs along the state boundary with Neora Valley National Park, West Bengal. The eastern boundary starts from *Jalepla, runs along with the international boundary with China, TAR, meets the Tri-junctions,* and further runs the international boundary with Bhutan up to where to where the *Dichu* meets the Indo-Bhutan boundary. The western boundary starts from the points where the Reserve line of *Chandey* Reserve Forest meets with the boundary with West Bengal state and runs along the reserve line of *Chandey* Reserve Forest, *Bichkharka* Reserve Forest, *Pangolakha* Reserve Forest, *Singhaney Bans* Reserve Forest, *Tungsey* Reserve Forest and above north and south *Regu*, *Premlakha*, *Padamchen*. This area is now partially inhabited by the Border Security Force as well as the Indian army and the rest of the areas are mostly occupied by the Sherpas, few Bhutias, and others who helps the army in the form of the laborers, contractors, suppliers etc. Some of the important forests pockets under the sanctuary are *Panikharka* Reserve Forest (*Rachila*), *Chandaney* Reserve Forest (*Thami dara*), *Singhaney bhans* (Reserve Forest), *Maj kharka*, *Kheohyaklo* Reserve Forest (Zuluk), *Salami* Reserve Forest (*Nathang*), *Lungthung* Reserve Forest (outlet of *Dichu* & *Dokala*), *Pangola* Reserve Forest (Tukula interior) and Lampokhri

LOCATION MAP

PANGOLAKHA WILDLIFE SANCTUARY



(Rhododendrons and Juniperus forest). The lists of some important places of sanctuary and significant value are mentioned in Annexure-II.

Apart from that, the sanctuary is situated in extremely difficult terrains. Devoid of road communication to nearby areas, the accessibility inside the sanctuary is extremely difficult and tough. However, recently some facilities are being extended by the Department of Forests and by the Department of Tourism, Government of Sikkim (Annexure- III). Other facilities like tent, and necessary kits cum field equipments for trekking must have to be arranged by the visitors, while entering particularly in the far interior forests other than Panglakha, Rachela, Phusrey and Hathichereay. The lakes mostly located nearby the forest barracks are actually the main source of drinking water over here. Apart from that, there are few villages primarily inhabited by the local people including Lepcha, Bhutias, Sherpas, Limbos, Rais, Manger, Chettris and others. Some villages situated at the vicinity of the sanctuary has been involved in Eco-Development Committee to conserve the sanctuary (Annexure-III) and their representative assembly constituency are mentioned in Annexure-III.

2.3. SIGNIFICANCE OF THE STUDY AREA

The Pangolakha Wildlife Sanctuary (PWS) is located within the IUCN recognized Himalaya Hotspot (IUCN 2010) and has been identified as one of the richest storehouse of the biological resources. It is a compact terrain of 128 sq km and with recorded altitudinal range varying from 1200m near Simaney Khola to 4579 m at Pinbriongo near Donchulla. The entire Pangolakha range is one very difficult terrain guarded by steep mountain, dense forest etc. Due to such natural limitations, the natural habitats of flora and fauna of this sanctuary remained undisturbed for past many centuries and that has resulted into the formation of a significant plethora of diversity in regards to both the floral and faunal species. The sanctuary has its own distinct identity in regards to the existence of variety in orchids, ferns, bamboos, rhododendrons etc. The PWS covers a wide range of subtropical to alpine types of vegetation producing innumerable variation in habitat structure allowing much wider diversity of flora & fauna to settle within its periphery. In addition, the sanctuary also acts as a home for the many lower groups of plants. The sanctuary is also identified as one of the important repository of various economic plant wealth, especially the high valued medicinal plants and several other plants indispensable floral species directly or indirectly associated with the humanity. The present study has clearly indicates that the sanctuary is also a reservoir of high value Non-

Timber Forest Produces (NTFP) including bamboos, dyes and high altitude medicinal plants. Apart from that, the intensive knowledge on the flora of Pangolakha ridge and its adjacent regions would certainly improve our understanding about the flora *vis-à-vis* biodiversity of Sikkim (Singh & Chauhan 1998).

The landscape of the sanctuary is uniquely varied. The major portion of the sanctuary is occupied by the valleys, hills, rocks, meadows, barren alpine flat lands, and finally ends up with the huge mountain peaks in the northern direction. Existence of such varied landscape certainly contributes its own significant.

Most importantly, the glory of the sanctuary is further enriched by the presence of two important tri-juctions of Sikkim. The Rachela tri-junction (3100 m) amsl is situated at the southeastern part of the sanctuary and it is point where the borderline of Sikkim, West Bengal and the kingdom of Bhutan meets. Whereas, the other important tri-junction is known as *Batangla*, where the border line among Sikkim (India), Kingdom of Bhutan and Tibet Autonomous Region (TAR) meets. Both these points are of the extremely important in regards to their picturesque scenic beauties. It attracts numerous travelers for trekking, hiking, and birds watching almost throughout the year. Amazingly, one can view near about one-third part of Sikkim from these two points. Significantly, the sanctuary also acts as birthplace of some important rivers of east Sikkim like Rongli, Dichhu, and Ratey chu.

2.4. HISTORICAL SIGNIFICANCE OF THE STUDY AREA

The alpine region of the east Sikkim including Pangolakha range has occupied an important position in the history of Sikkim. It was during the sovereignty of British India the promotion of commercial intercourse with Tibet was undertaken through alpine region of east Sikkim. The places like Nathula, Jalepla, Gnathang, Lingtu, Kupup including Chumby valley (presently under the TAR) was under the administration of Sikkim's Chogyal (King) and believed to have belonged to Sikkim until about 2 hundred years ago. These places are noted for having the only national trade route of India to central Tibet, would therefore be of commercial as well as strategic importance, and remained an important pass way to Lhasa. The entire region was known for its splendid climate and scenic beauty and with the signs of material well-being, comforts, and believes to be a small commercial hub for people of Sikkim and Tibet. Tibet during those time are known for having very rich gold fields in the world, due to which the British India government often intended to capture the region including that part of Jalepla, to established their centre and could draw the railway line till Tsangpo river to

extent their goods (Waddell 1899). Britishers realized that the Sikkim, particularly east Sikkim, being indispensable point for their scientific mission to Lhasa. Therefore, a special permission was obtained to visit Lhasa from Chinese emperor. Britishers felt that the Tibetan occupation of east Sikkim could also invite friction and inconvenience for their nego-representative to Pekin, China (Rishley 1928).

It was during the reign of Chogyal Thothup Namgyal, a British mission under the headship of Colman Macaulay visited Tibet in 1886 for the promotion of trade through a route between British-India and Tibet passing across the alpine region of east Sikkim. However, the mission was later withdrawn before completion due to the Tibet's interference. Consequently, a group of Tibetan force attacked and occupied the strip of Sikkim's territory south of Jalepla till the Lingtu. Britishers in another site could not tolerate for being the Chogyal of Skkim to be pro-Tibetan and do encourages trans-boarder infiltrations. Therefore, with *Hobson's choice* British-India government commenced military operations in march 1888 against Tibetan army to retaliate back the Tibetan attack at Gnathang on 22nd May 1888, which is presently, situated at the western edge of the Pangolakha Wildlife Sanctuary. The then most proficient Derbyshire regiment, the 32nd Pioneers Sikh regiment, Gorkha regiment and six mountain guns of nearly 2000 men retaliated against the Tibetan army and driven out of Lingtu on 20 March 1888. Consequently, the Tibetans were completely thrown out of Sikkim's territory after six month and the battle came to an end on 24th September 1888. However, quite a lot of British and Tibetan soldiers died in the battle. Sementary of several British soldiers are still subsisting near Gnathang government school. Later a fort was built by Britishers and was presumed to be the highest military point in the world, ever held by Europeans. The Indian army, Tibetans, Sherpas and few other communities presently engage the Gnathang. It is a landmark in the history of Sikkim, that the first Political Officer, Sir James Claude White appointed by the Biritish India government to maintain the administration in the region consequently after the battle.

After nearly a hundred years back in 1962, Chinese army once again attacked the Sikkim through Nathula pass (4389 m), located at the northwestern boundary of the Sanctuary and is one of significant strategic pass to China. Since then, Nathula pass had been remained for the subject of concern for both India and China. It is one of such international (border) frontiers in the world located at a tremendous height where, the troops of two hostile nations confront and coexist within an extremely short distance. Hence, it is one of an acutely sensitive spot in the scheme of both Indian and Chinese defense.

Most recently, the government of Sikkim under the patronage of the Government of India has reinitiated the international trade route between India and China. Sherathng near the Nathula pass has already enlisted in the Guinness book of world record for its host to the world highest ATM. Significantly, with the inaugural of community information Centre at Sherathang on 21 April 2006 has also enlisted its name in Limca Book of Records for its highest permanent cyber cave at an altitude of 4145 m.

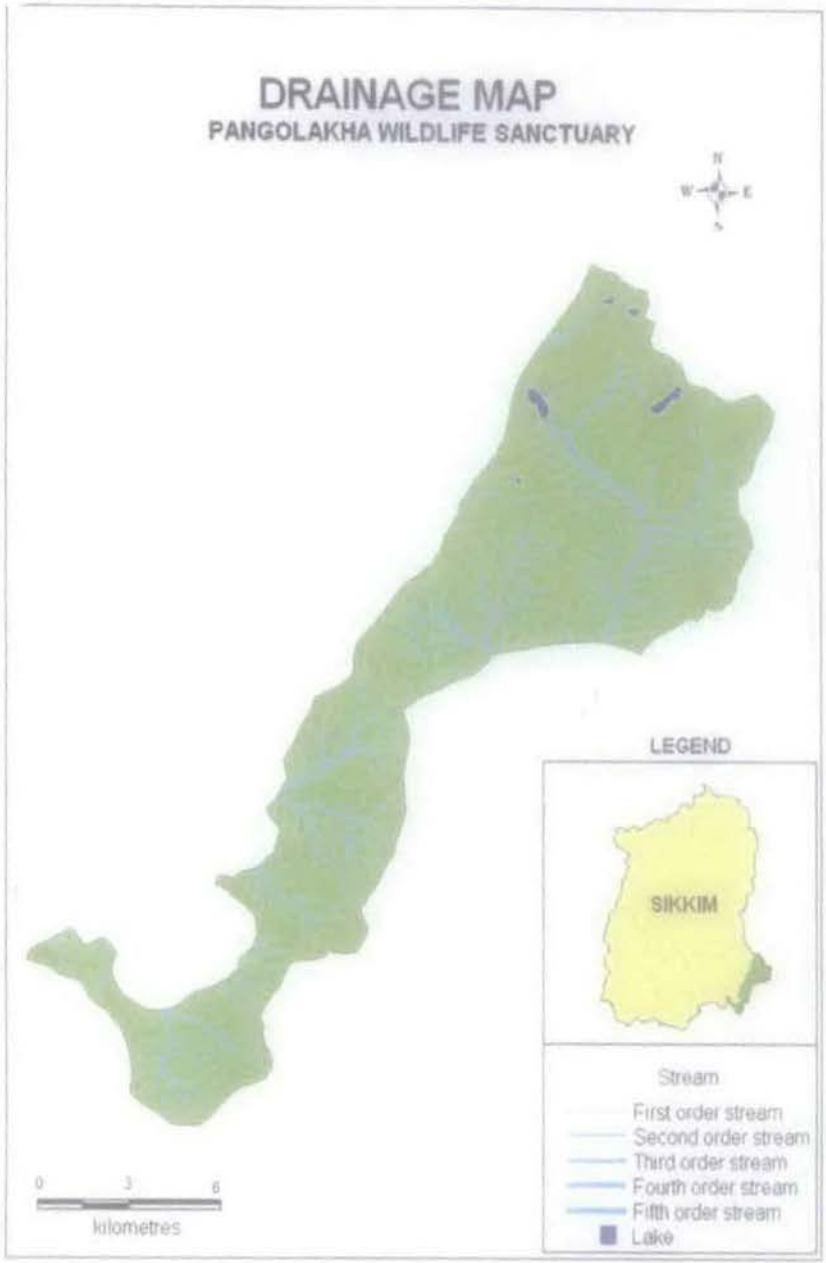
2.5. TOPOGRAPHY / MOUNTAIN PASS

The Pangolakha Wildlife Sanctuary is covering several terrain types, based on ground surface morphology characterized by smooth and broken surface. It is of alpine terrain with isolated, boulders or gregarious formation or rocks which and is generally treated as smooth surface. This type of terrain is prevailing at the base of mountain ranges and in saddles with altitude ranging c.242 m – c.4242 m. This type of terrain extended over 25 – 30% in the area.

The other type of terrain varies from distinct undulating broken surface including stream sites and deep gullies located along the ridge between West Bengal and Sikkim. It also included large rocks on the ground. This type of configurations was considered as broken terrain, which covered 30 – 40 % of total land.

The steep rocky outcrops with prominent narrow ledges and continuous rock formation with distinct array of boulder land caves were categorized as very broken terrain. These types of terrain are distributed above the villages with elevation ranging between c.131 m – 227 m and c.2727 m – 4394 m respectively.

One of the significant attractions of the region is of its accountability of widespread and imperative passes to other countries. The major passes of Sikkim located in the alpine East Sikkim are Chola range, Nathula, Jalepla and Batangla. Out of which Nathula and Jalepla lead to Chumby valley in Tibet and Batangla lead to Bhutan. During the reign of the Chogyal dynasty the Chola pass was commonly used to access to Tibet. Nathula pass, located 2 km ahead of the Sherathang, is only pass where Chinese and Indian army troops face each other at breathing distance. Until 1962 both Nathula and Jalepla passes has been a part of the trade route between India and Tibet. The Young Husband regiment extensively used Jalepla pass situated near Kupup (Bathang Cho) in 1903 to attack Tibet, for which the pass is known as Young-Husband track


DRAINAGE MAP
PANGOLAKHA WILDLIFE SANCTUARY
N
W
E
S
LEGEND
SIKKIM
Stream
First order stream
Second order stream
Third order stream
Fourth order stream
Fifth order stream
Lake
0
3
6
kilometres

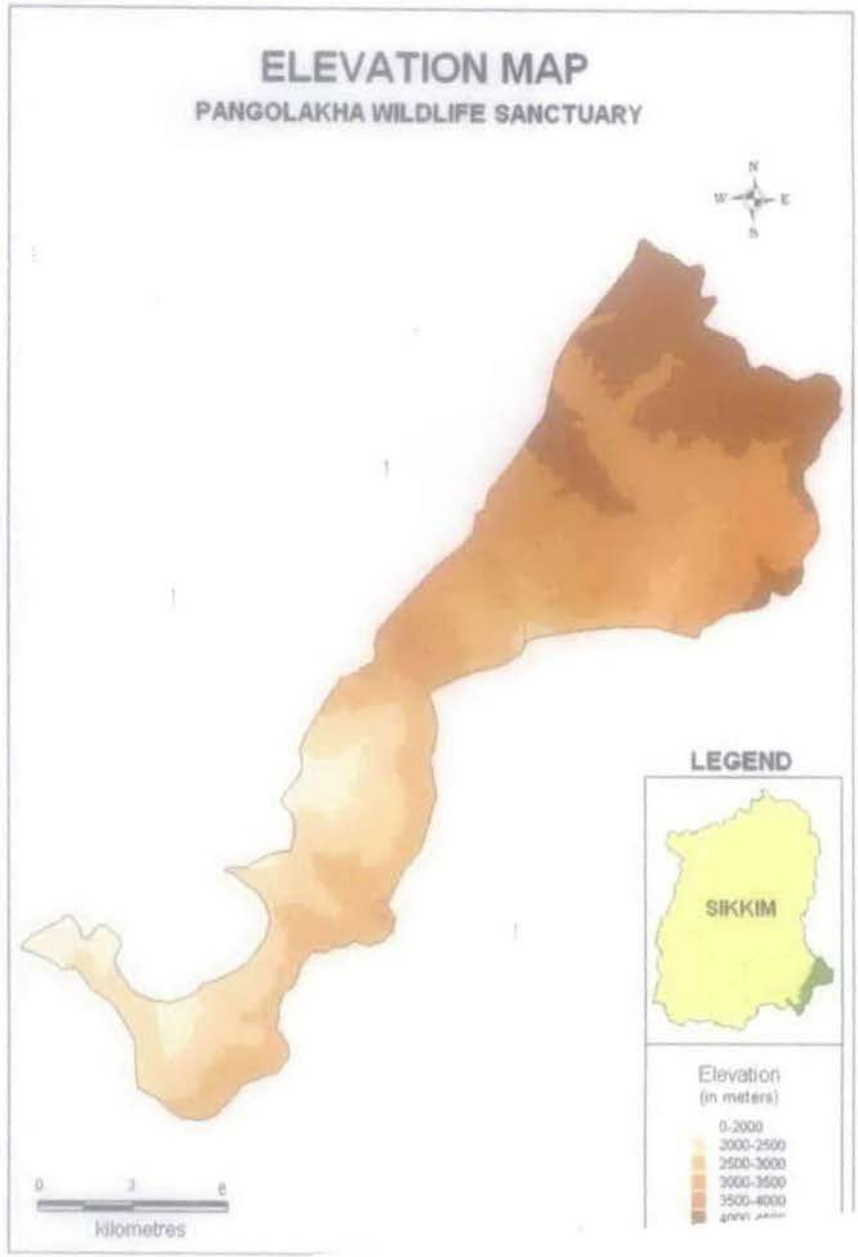

ELEVATION MAP
PANGOLAKHA WILDLIFE SANCTUARY
N
W
E
S
LEGEND
SIKKIM
Elevation
(in meters)
0-2000
2000-2500
2500-3000
3000-3500
3500-4000
0
3
6
kilometres

PLATE I II

2.6. GLACIERS

Himalayan glaciers have been in a state of general retreat since 1850 and recent publications confirm that, for many, the rate of retreat is accelerating. Jangpang & Vohra (1962), Srikanta & Pandit (1972), Vohra (1981), Oberoi *et al.* (2001) and many others have made significant studies on the glacier snout fluctuation of the Himalayan glaciers. However, a dramatic increase in the rate seems to have occurred in last three decades (Kaab *et al,* 2002).

Altogether, 84 Glaciers has been recorded in Tista basins, (Anonymous 2001a). Due to Climatic variation, the number of Glacier field is increasing, but the total area of the Glaciated region will be decreasing continuously. Obviously, this will have a profound impact on snow accumulation and ablation rate in the Himalayas, as snow and glaciers are sensitive to global climate change. In response to climate change, the glaciers in the major mountainous regions of the World as Himalayas, Alps, Rockies and Andes are retreating Casassa *et al* 2002). Glaciers in Caucasus Mountain have retreated from 700 to 3000 m in the last 100 years i.e. the average maximum rate of retreat is 30 m per annum (Mikhalenko 1997). Investigations in the Baspa basin in India have shown an overall 19 % deglaciation from 1962 to 2001 (Kulkarni & Alex 2003). Investigations carried out in the Himalayas suggests that almost all glaciers are retreating with an annual rate varying from 16 to 35 m (Dobhal *et al* 2004; Oberoi *et al.* 2001).When these ice fields are broken down then those results in the formation of moraine dammed lakes.

About 40 % landmass of the Sanctuary falls under the alpine region and remain under the snow cover from the moth of December to April but there are few other instances for having covered the land with snow for almost entire year. The piles of these permanent snows are also the source of the river waters flowing through the sanctuary.

2.7. LAKES AND SPRINGS

The lakes are the important water bodies and are the major sources of drinking water for all the living being exist under an ecosystem. As such, Sikkim also endowed with more than 150 lakes located at different altitudinal ranges, which are traditionally recognized to be sacred and holy (Roy & Thapa 1996). Alpine East Sikkim including Pangolakha range holds more than 25 lakes, which ultimately serves as source of water for the wild animals inside the sanctuary (Table 2.5). Most of these high altitude lakes are often being snow fed and remain snow covered during winter. However, some lakes tend to remain snow covered almost round the year. The dimensions of these lakes vary from few meters to around hundred meters in length, but most of these lakes appear to be shallow and deep as well. These are permanent water

bodies and seem to have formed through the continuous process of so-called "glaciations". Although all these lakes have their own specific names, some are devoid of, especially those, which are situated in isolated, or at much interior of the sanctuary. The lakes are pronounced as *Chhoka* or *Tso* or *Chona* in Bhutia; *Chho* or *Dah* by Lepchas; and *Pokhri* or *Jeel* in Nepali.

Some of the fascinating lakes of the alpine East Sikkim are Chhangu, Bidang tsho, Men-men tsho etc. Their popularity for aesthetic and scenic beauty is known worldwide. The congenial climate, rich biodiversity, blooming flowers, panoramic view of mountains and valleys, pristine lakes and forests contribute the growth of tourism in the state. It is now estimated that approximately 4 lakhs of tourists has visited this area in the year 2007. The simulation based on the trend of tourists visited in past are expected to be jump up from 7.6 – 10.4 lakhs of tourist would visits Sikkim during the year 2017 (Joshi & Dhyani 2009). Therefore, having being an important contributor for the tourism sector in Sikkim, these resourceful lakes will certainly play a crucial role for such steady rise in the inflow of tourists that may have direct or indirect impact on the economic growth of the state as well.

Table 2.5. Lists of important natural lakes of East Sikkim including PWS.
[AES: Alpine East Sikkim. PWS : Pangolakha Wildlife Sanctuary.]

Natural lakes of East Sikkim	**Location**	**Importance in nature**
Changu lake	*AES*	*Tourism, religious & alpine flowers*
Men-miot Tso	*AES*	*Tourism, religious and Fishery.*
Jelepla Tso	*AES*	*Wild life & habitat of waterfowl.*
Sherathang tso	*AES*	*Domestic use & migratory birds*
Bithang Tso	*PWS*	*Tourism & migratory birds.*
Chhukhya Tso	*PWS*	*rich vegetational diversity*
Chuu Tso	*PWS*	*Wildlife habitat*
Lampokhari	*PWS*	*migratory birds & wildlife*
Kafing dah, (Singhaney bans)	*PWS*	*Wildlife & migratory birds.*
Chhokhy Tso	*PWS*	*Rich vegetational diversity*
Doka tso	*PWS*	*wildlife habitat*
Jor Pokhri	*PWS*	*wildlife & avifauna*
Uor Pokhri	*PWS*	*Wild life*
Pangla tso	*PWS*	*high diversity of vegetations*
No Name	*PWS*	*water source for wildlife*
Bhewsa tso	*PWS*	*Wildlife & rich habitation.*
Syabiyuka Tso	*PWS*	*Wildlife habitat*
Thosa tso	*PWS*	*Wildlife &Avifauna*
Annonymous lake	*PWS*	*Wildlife habitat*
Annonymous lake	*PWS*	*Wildlife habitat*
Annonymous lake	*PWS*	*Wildlife & avifauna*
Rongli Pohkri(Lungthung)	*PWS*	*Wild life*
Mul kharka Pokhri	*PWS*	*Wild life & birds,*
Tongey pokhri(Premlekha)	*PWS*	*Wild life*
Gnathang tso	*PWS*	*Wildlife*

2.9. FAUNAL RESOURCE OF THE STUDY AREA

Sikkim Himalayas upholds a significant plethora for faunal bio-diversity. Having being remained isolated and undisturbed for past many centuries, the forests of the Pangolakha Wildlife Sanctuary also turns out to be one of the reservoir for the numerous faunal species including mammals, birds, butterflies, beetles, snakes etc. which eventually contribute an additional significant enchantment of life of the sanctuary (Anonymous 2000). The reason being is its extremely varied topographical exposition. The report also reveals about the availability of ungulates, carnivores and birds from the pockets of *Singanebase*, *Thamdara*, *Jalepla*, *Sher peak*, *Rachela*, and *Pangolakha* .

According to Lachungpa *et al.* (2003), the three important biomes for the faunal species have been identified within the sanctuary. This biome includes Biome 5, Biom-7, and Biome 8. Remarkably, the Biome-5 with an altitude ranges above 3600 m amsl contributes the existence of 48 species, that of 11 are recorded from study area. In contrast, the Biome-7, situated in between the altitudinal range of 1800 m to 3600 m amsl, contributes 112 species, again 14 species are reported within the study area. However, only two faunal species have been reported from the Biome-8 so far.

The sanctuary also supports a large number of species, which have been enlisted for highly vulnerable and volatile mammalian species. The Indian Bison, Takin, Serow, Goral, Barking Deer, Himalyan Langur, Red Panda, Leopard Cat, Large Indian Civet etc. and Pheasant, Tragopan and flock of partridges as well as large numbers of birdlike including migratory ducks were reported from the area (Lachungpa *et al.* 2003). The list of faunal resource of PWS is mentioned at Annexure-IV.

Interestingly, the study area is also recorded for one of the noted establishment for the migratory route of tiger, through the Neora Valley, which is situated in the southeast direction of the sanctuary. The record reveals that the tigers use this belt of forest for more than hundred years ago. The existence of Red deer in eastern Sikkim through the display of trophies and hunting record identified as a sub-species of *Cervus elephus*, either *C.E. wallichi* or the probable synonym *C.E Affinis*. However, so little has been known about it, probably extinct (Dolan & Killmar 1988) considered it "almost as a mythical animal" (Schaller 1996, 1998). The occasional anthropogenic interference in the forests of Chumby region (TAR) might have been drives those rare species of Deer back into Bhutan through the Pangolakha forest. Red Panda, Musk deer and Bharal (blue sheep) are among the highly endangered animals very rarely sighted during the last decade (Lama 2001).

However, the practice of poaching inside the sanctuary has been a common phenomenon prior to the declaration of the sanctuary, though legal and illegal poaching of endangered animal species for meat, hides, fur and other medicinal applications is resulting in depletion of their population (Lama 2001).

Sikkim Himalaya including Pangolakha Wildlife Sanctuary sustains enormous water resources in the form of rivers, streams and lakes. The total estimated length of rivers of the state is about 900 km and area of ponds and lakes are 0.1 and 3.2 thousand hectors, respectively. All this water bodies are known to have been home for the various species of fishes. Tamang in 1993 recorded about 48 species of fishes from Sikkim. However, only 37 species were recorded in 2001 (MoEF 2002). It is note worthy to mention that most abundantly available members of Cyprinidae family was *Scizothorax* spp with maximum length of this species recorded at 60.0 cm (Talwar & Jhingran 1991).

It was indicated by several studies that both anthropogenic as well as natural factors influence the fish population in the rivers. Overexploitation and faulty fishing techniques might be the major factors affecting the fish germplasm. The availability frequency of different kinds of fish decreased as indicated by 82.94 % of fishers. It was also confirmed by the reports of Tamang (1993).

Sikkim also occupies an important position in Eastern Himalaya Endemic Bird fauna (Islam & Rahmani 2004). Of the 1295 species of birds reported from Indian Subcontinent (Inskipp *et al.* 1996) of which Sikkim harbors 572 species (Acharya and Vijayan 2007). These species represents 45 % of the total birds within 0.21 % of the geographical area of India. Out of the 22 restricted range species of this Endemic Bird Area, 19 (including genus *Sphenocichla*) are confined to this region (Stattersfield *et al* 1998; Rasmussen & Anderton, 2005; Jathar & Rahmani 2006). Of these 19 endemics, ten are reported to occur in Sikkim, whereas, *Arborophila mandellii* and *Brachypteryx hyperythra* are two such species which falls under threatened and near threatened category of IUCN. Of the 78 globally threatened bird species of the Indian Subcontinent, 16 threatened (two critically endangered, one endangered and 13 vulnerable) and four near threatened species live in Sikkim (www.iucn.org/.). Of these 20 species, three are endemic to the Eastern Himalaya.

The bird fauna of Eastern Himalaya, especially land birds, is enriched compared to the rest of the Indian subcontinent of similar or even larger area (Ali 1962; Daniels 1992; Ali & Ripley 2001, Price *et al.* 2003). The diversity of vegetation, with abrupt variation in elevation and climatic conditions, created diverse habitats, forming of continuous larger tract of evergreen vegetation ultimately formed a meeting point of various zoogeographical realms

favours the immense richness in birds diversity (Inskipp *et al.* 1996).

The study area is also found to be rich in avifaunal, where major mountain passes of Sikkim such as *Donkyala, Nathula, Jelepla, Rachela* are situated. These passes are identified to be the routes for migratory water birds. Numerous wetlands and associated water bodies eg. Bedang Tso Lake, Lampokhri and numerous other anonymous lakes existing inside the sanctuary are observed to be regularly visited by Himalayan Monal (*Lophophorus impejanus*), locally called as Feydong. (Lachungpa *et al.* 2003). Bidang tsho (3880 m) is one of the important amongst other alpine lakes of east Sikkim. Noted by Mr Blandford for its natural glacier lake (Waddell 1899) is source of drinking water for numerous animals and other avifaunal species.

According to C. Lachungpa, name *Bedang Tso* might have been semantized through it. Lachungpa *et al.* (2003) also reported the mass migration of birds of prey such as Red Kites and unidentified eagles including Brahminy Shelduck from the area. It is also note worthy to mention that some globally threatened bird species like Eurasian Woodcock and Wood Snipe are also reported to live here. (Anonymous 2001). According to the Lachungpa *et al.* (2003) Hill Pigeons including Himalayan Monal, Gold-naped Black Finch, Fish-Eagle Large Cormorant, and Bar-headed Geese, Greater Spotted Eagle, *Red*-breasted Hill-Partridge, *Wood* Snipe, *Rufous*-necked Hornbill, Slender-billed Babbler- Black-breasted Parrotbill and Hodgson's Prinia are also some of the common bird species noted from the forest patch of the Pangolakha range. The Tibetan Eared Pheasant, which is considered as a threatened species, were also reported from Bedang Tso and Jalepla in the year 2003. The Common hill partridges of Sikkim are also being sighted in forest of Pangolakha.

Significantly, the habitat fragmentation through anthropogenic pressure on bird species is a increasing concern of Eastern Himalaya including Sikkim and is the major reason for decline of many rare and threatened bird species particularly in Sikkim (Chettri 2000; Chettri *et al* 2001; Acharya & Vijayan 2007).

2.10. VEGETATIONAL STRUCTURE OF STUDY AREA

In the present study, the vegetative structure of the Pangolakha Wildlife Sanctuary is demarcated in between elevation of 1800 m to 4600 m amsl and above. The altitudinal ranges are predominantly distinguished by their rich floristic compositions. The vegetation however is conspicuously under the domain of angiosperms followed by ferns and its allies and gymnosperms. (*Abies webbiana, Tsuga dumosa, Taxus bacca* and of domesticated *Pinus longifolia* and *Cryptomeria japonica).*

The alpine meadows remain covered with perpetual snow for 5 – 6 months (December to April) of the year. Such areas are with comparatively lesser floristic richness and its composition. However, the flora as a whole represent with characteristically interesting and distinctive of its usefulness occurrence in species vise.

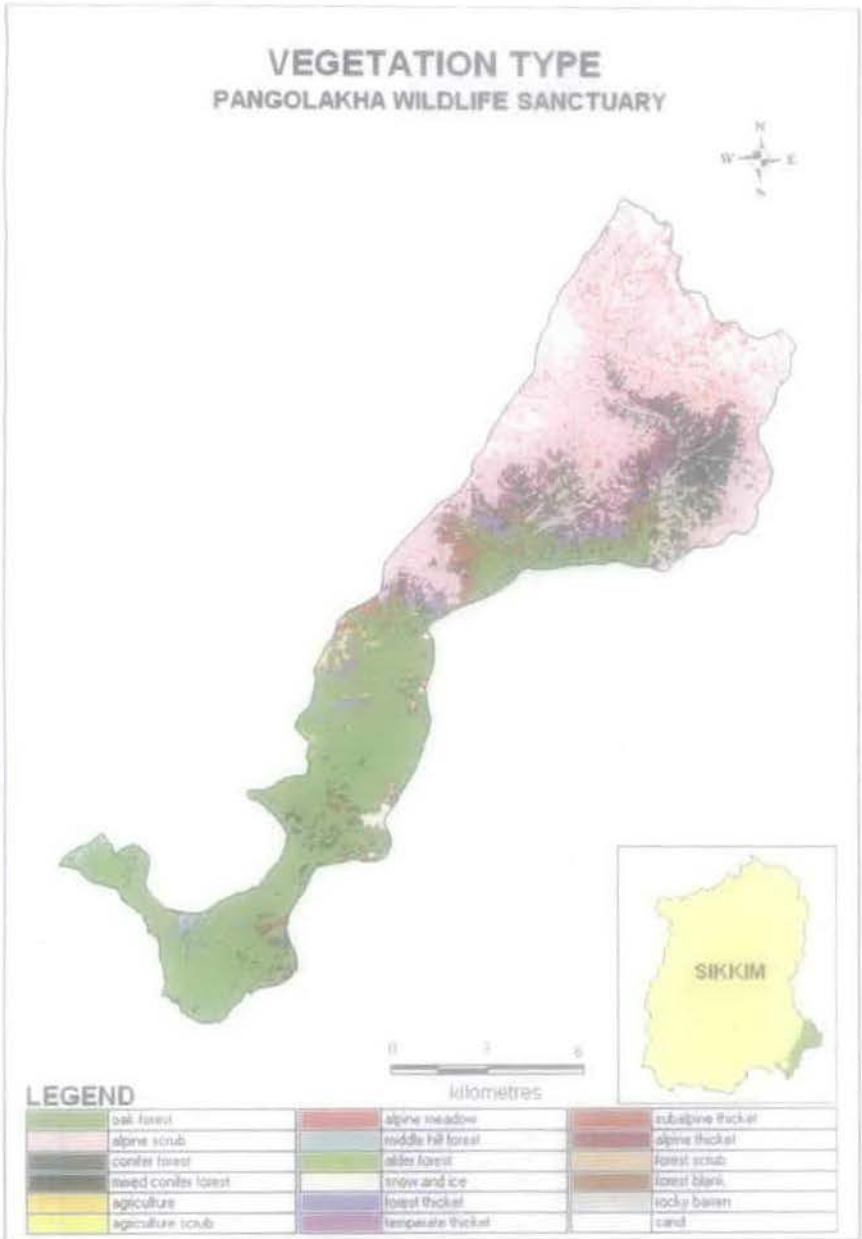
Hence, for the present study, the vegetation has been classified into a number of groups with the incorporation of some negligible studies made by the Department of Forests, Government of Sikkim (Anonymous 2000), which is mainly based on its dominant species composition distributed along the altitudinal elevations.

1. Temperate broad-leaved (1800 – 2400 m)
2. Temperate cold forest (2400 – 2800 m)
3. Temperate conifer forest or sub-alpine forest (2800 – 3400 m)
4. Alpine vegetation/ Alpine scrubs (3400 m and above)

2.10.1 Temperate Broadleaved Forest (1800 – 2400 m)

The temperate broad-leaved forests extended up to the elevation of 2400 m amsl. The vegetation in this range is hold together in considerable compact association of numerous average height trees of its significance. Evergreen and deciduous trees occupy comparatively lesser proportion of the vegetation. The important points or areas located inside the sanctuary such as *Subaney dara, Prem Lakha, Tal Kharkha, Mul Kharkha, South regu, North regu, Singhaney Bans, Chuktum, Kingsa, Buddha (Takney),* adjoining part of *Neora* valley etc. The vegetations of this type are composed of dominating laurels etc, simultaneously formed a thick canopy with other species to form the mixed type vegetation. There is however, an indication of rare fungi, lichens and other saprophytes as well as epiphytes associated with afore mentioned tree vegetation.

The chief characteristic of this type of vegetation is of its enormous variation of habits i.e. herbs, shrubs, climbers, twiners, creepers and prostrate elements arecommon and are distinctly prevalent. The forests in this range are of marked distinction of being compact composition of numerous species of trees like: *Schema wallichi, Chukrasia tabularis, Betula cylindrostachys, Alnus nepalensis, Acer campbellii, Quercus lamellosa, Q. pachyphylla, Q. lineata, Magnolia campbellii, Michelia doltsopa, Michelia cathcartii, Betula alnoides, Prunus napaulensis, P. cerasoides, Castanopsis hystrix, C. tribuloids, Machilus edulis, Symplocos glomerata, S. theaefolia, Eurya japonica, Evodia fraxinifolia, Taxus baccata, Rhododendron arboreum, Toona ciliata* etc. The vegetation is further enriched by many species of shrubs, viz. *Aucuba himalaica, Maesa chisia, Neillia thirsifloris, Gaultheria griffithiana, Elsholtzia*


VEGETATION TYPE
PANGOLAKHA WILDLIFE SANCTUARY
N
W
E
S
SIKKIM
0
3
6
kilometres
LEGEND
oak forest
alpine scrub
conifer forest
mixed conifer forest
agriculture
agriculture scrub
alpine meadow
middle hill forest
alder forest
snow and ice
forest thicket
temperate thicket
subalpine thicket
alpine thicket
forest scrub
forest blank
rocky barren
sand

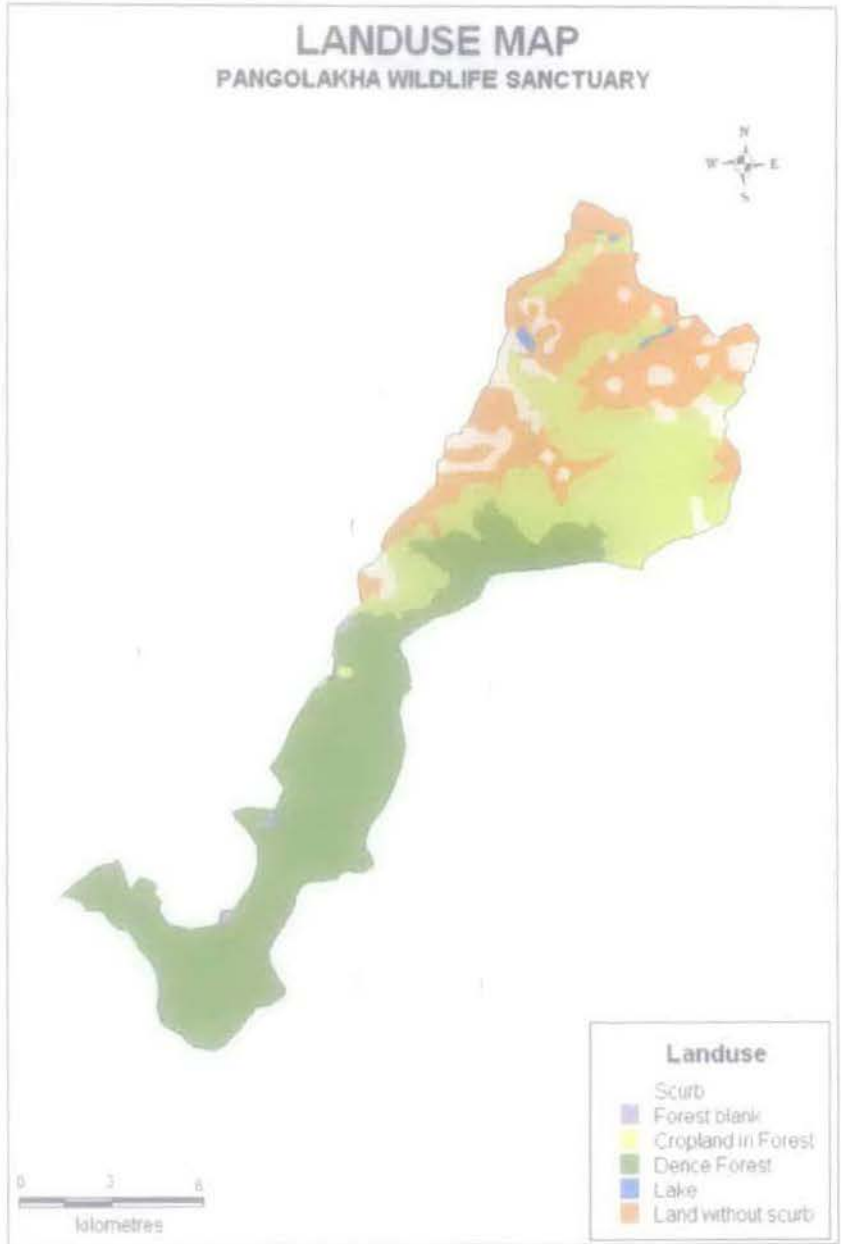

LANDUSE MAP
PANGOLAKHA WILDLIFE SANCTUARY
N
W
E
S
0
3
6
kilometres
Landuse
Scurb
Forest blank
Cropland in Forest
Dence Forest
Lake
Land without scurb

PLATE IV

fructicosa, Ilex crenata, Rubus lineatus, Leycesteria formusa, L. stipulata, Viburnum erubescence and of various species of bamboos. All the species put together to constitute a magnificent thick layer of dense shrubby canopy. Apart form this, there is predominant composition of herbaceous species like *Potentilla polyphylla, P. sundaica, Prunella vulgaris, Didymocarpus aromaticus, Chirita macrophylla, Begonia sikkimensis, Campanula pallida, Fragaria nubicola, Impatiens bracteata, Voila biflora, Cynoglossum glochidiatum, Hemidesmus indicus,* etc.

2.10.2. Temperate Cold Forest (2400 – 2800 m)

The dense forests of tall trees gradually replaced by grassy slopes and scattered trees in this zone. The prominent floristic components under the temperate cold forests are of *Acer, Quercus* and *Rhododendron.* Remarkably, the vegetations of the forest type is further distinguished by commendable occurrence of herbs, shrubs, and the sporadic appearance of numerous strangling climbers. The major components of broad-leaved tree species include *Acer campbellii, Betula utilis, Engelhardtia spicata, Exbucklandia populnea, Ilex dipyrena, Quercus lineata, Q. lanata, Q. lamellosa, Lithocarpus pachyphylla, L. elegans* etc. As such, the oak forests are the characteristic feature of this vegetation zone.

The notable shrubs observed under this vegetation are *Aconogonum molle, Agapetes saligna, Dichroa febrifuga, Gaultheria fragrantissima, Helwingia himalaica, Daphne bholua, Holboellia latifolia, Rubus lineatus, Rubus paniculatus, R. macilentus, Vaccinium retusum, Arundinaria malling, Dendrocalamus hamiltonii, Smilax glaucophylla, Vaccinium retusum, Lyonia ovalifolia, Piptanthus nepalensis, Principia utilis, Rhododendron grande, R. falconeri, Viburnum erubescens, Zanthoxylum oxyphylum* etc.

The herbaceous plants being the chief component and are most dominant in the vegetation viz. *Anemone vitifolia, Arisaema jacquemontii, Ajuga lobata, Aster tricephalus, Cardamine impatiens, Fragaria vesca, Clintonia alpinea, Hemiphragma heterophyllum, Primula denticulata, Gallium mollugo, Valeriana wallichii, Aristolochia griffithii, Gnaphalium affine, Fimbristylis dichotoma, Potentilla fulgens, Elsholtzia strobilifera, Fragaria nubicola, Voila pilosa, Hydrocotyle himalaica, Poa annua, Streptolirion volubile, Carex spp.* etc. It is rather, notable to observe that species like *Alnus nepalensis* and *Thysanolaena latifolia* extensively inhibit to the areas comprising of degraded and sliding landmass.

2.10.3. Temperate Conifer Forest or Sub-alpine Forest (2800 – 3400 m)

The sub-alpine vegetations of Pangolakha Wildlife Sanctuary that ranges from 2800 – 3400 m is characteristically distinct with the presence of a mixed forest comprising of *Rhododendrons*

and *conifers*. The major indicators that distinguish sub alpine forest from that of cold temperate forest are by he presence of numerous tree species like *Acer caudatum, A. campbillii, A. sikkimensis, Quercus lineata, Q. pachyphylla, Magnolia campbellii. Tsuga dumosa, Larix griffithiana, Picea spinulsa, Abies densa, Euonymus frigidus, Enkianthus deflexus* etc. However, the *Rhododendron* forests gradually dominate as the elevation increases. In between the trees like *Larix griffithiana, Abies densa, Picea spinulosa,* and *Tsuga dumosa* appeared uniformly inside *Arundinaria* spp, and mixed silver fir trees. Significantly, the forest now symbolized with strong under growth of *Berberis wallichiana, Enkianthus deflexus, Euonymus frigidus*, followed by some species of *Lonicera, Rubus, Ribes, Gaultheria* etc. The most predominant shrubs in these forests are the species of *Rhododendron* e.g. *R. barbatum, R. edgeworthii R. grande, R. arboreum, R. falconeri, R. dalhousie, R. griffithianum, R. glaucophyllum, R. niveum, R. vaccinoides, R. campylocarpum, R. thomsonii, R. lepidotum* and *R. campanulatum* etc. Some rare and interesting herbs found here are the *Panax pseudoginseng, Swertia chirayita, Valeriana wallichiana, Gallium mollugo, Fragaria rubiginosa* and *Podophyllum hexandrum.* Most interestingly, it has been observed that the formation of *Rhododendron arboreum* in Rachela ridge has attained its optimum with extremely high density and huge girth, which is *hitherto* rarely occurred in other parts of the state.

2.10.4. Alpine Vegetation / Scrub (3400 m and above)

George A. Gammie (1893) during his visit in Sikkim in the year 1892, classified the alpine region of East Sikkim into two parts, Sub-alpine and Alpine regions, According to him the altitude ranging upto 3100 m as a sub-alpine or temperate region and above that is termed as alpine zone.

However, in the present study the alpine vegetation or an alpine scrub is marked to be ranges from 3400 m and above. Some of the noted areas covered under this vegetation type are Jalepla, Bhim Base, Lampokhari, Nathang, Kupup, Panglakha, Rachela etc. At lower altitudes, the vegetations under this category are transformed into shrubby habit. The scrubs formed of *Rhododendron, Berberis, Euonymus, Gaultheria, Vaccinium, Salix* etc. are the major elements, while *Rhododendron anthopogon* and *R. setosum* form the dense tussocks near the sub-alpine mountaintops. The most dominating herbaceous species distributed under such vegetation are *Aconitum ferox, Anaphalis contorta, Cassiope fastigiata, Meconopsis paniculatus, Primula capitata, P. sikkimensis, Sedum multicaule,* and species of *Arenaria, Epilobium, Potentilla, Polygonatum, Rhodiola* etc. The vegetation is further enriched by the

presents of species having tremendous medicinal value viz. *Aconitum heterophyllum, Podophyllum hexandrum, Panax pseudoginseng, Neopicrorhiza scrophulariifolia* etc.

With the rise of elevation, the vegetations further transform into typical alpine moorland type, where the growth of trees are completely arrested. Rather, the stunted bushy growth of *Rhododendron anthopogon, R. lepidotum, Salix caliculata, S. lindleyana, Myricaria germanica, Cotoneaster microphylla, Rosa sericea, Lonicera tomentella* and *Rhododendron nivale* are more regular and uninterrupted. The existence of *Rhododendron nivale* in this condition, is interestingly being observed in the altitude of 4600 m amsl, which is *hitherto* not seen in other part of the Sikkim. Most importantly, the plants like *Polygonatum campanulatum, Nardostachys jatamansi, Rheum australe* were once common at Kupup, Nathang, Baba mandir area are now rarely met with. The vegetation is further enriched by the mosaic growth of *Rhododendron anthopogon, R. campanulatum, R thomsonii, R. setosum,* and species of *Ranunculus, Primula, Aconitum, Voila, Fragaria, Meconopsis, Potentilla, Arisaema,* etc.

The flowering plants prevail here are comparatively distinct and the majority of the herbs and shrubs represented themselves with more bright colors which is presumed to be adaptation to attract the insects for pollination; with the exception of *Delphinium,* Lamiaceae, Asteraceae and primroses which are remarkably devoid of odor. The species of alpine shrubs are also signifying with their procumbent habits e.g. *Rhododendron nivale, Diplarche multiflora* etc. The tree limit of alpine vegetation is though appeared variable but mostly held between 3000 m to 4000 m. Species *of Carex, Kobresia, Festuca, Stipa, Poa* etc occupies the grassy areas and in the higher cliffs such vegetation is composed of different species of *Draba, Lonicera, Meconopsis, Saussurea, Saxifraga, Leontopodium* and *Tanacetum* etc.