

The Study Area

2.1 Physiography

Sikkim is the 22nd state and 2nd smallest state of the Indian Union. The state has the total area of 7096 sq. km and is situated between 27°46' to 28°7'48" N Latitude and 88°0'5" to 88°55'25"E longitude in the eastern Himalaya (Figure 1). As an important trans-boundary landscape, it shares border with countries like Bhutan (*ca.* 30 km long) represented by Pangolakha range in the east; Tibetan Autonomous Region of China (*ca.* 220 km long) represented by Chola range in the east and Trans-Himalaya region in the north; and Nepal in the west (*ca.* 100km long) represented by Singhalila range; however, towards the south, Sikkim shares border of *ca.* 80 km with Darjeeling district (West Bengal) of the Indian Union which is segregated by three river system viz., Teesta chu, Rangit chu and Rongpo chu. It stretches approximately 64 km from east to west and 114 km from north to south. The altitude in Sikkim ranges between 220m asl to 8598m asl.

Sikkim is bounded by some of the world's most important mountain ranges which are interspersed with numerous passes (La) connecting it to the neighboring countries. These passes are Jelep La (*ca.* 4300m asl), Nathu La (*ca.* 4300m asl), Cho La, Bhutan La (*ca.* 4000m asl) in the east; Dongkia La (*ca.* 5500m asl), Kongra La (*ca.* 5200m asl), Chorten Nyima La (*ca.* 5800m asl) in the north; and Chuwa Bhangyang (*ca.* 3200m asl) in the west. Sikkim is a state of mountainous terrain with cliff, deep gorges and the valleys. World's third highest mountain, Mt. Khangchendzonga (8,598m) is situated in Sikkim. Other important high mountains with above 6000m altitude in Sikkim are Mt. Siniolchu, Mt. Pandim, Mt. Kabru, Mt. Tinchengkhang, Mt. Rathong, Mt. Kokthang, Mt. Kanglakhang, Mt Paunhari, Mt. Pandim, Mt. Talung, Mt. Simvo and Mt. Jonseng. The peaks with little lesser altitude than 6000m are Mt. Masunyange, Mt. Yabukjakchen, Mt. Narsing and Mt. Lamaongden.

There are 84 glaciers in Sikkim; the most important of which are Zemu glacier (largest glacier in Sikkim; ca. 26 km long), Rathong glacier, Zum-thul Phuk glacier, Onglathang glacier, Tasha Khang glacier, Lhonak glacier, Hidden glacier, Talung glacier, Tista Khangse glacier, North Lhonak glacier, South Lhonak glacier, etc. The water from these glaciers is discharged into two major river systems in Sikkim, Tista and Rangit which is considered as the life line of Sikkim. Tista originates from Tista Khangse glacier in the north-eastern part of north Sikkim and Rangit has its origin from Rathong glacier in the western part of Sikkim; however, both the river systems takes its course towards southern direction.. The major tributaries of river Tista include Lachung chu, Zemu chu, Bakcha chu, Rangpo chu, Dikchu chu, Rangyong chu; at the same time, Tista receives water from many other tributaries also. Similarly, river Rangit receives water mainly from Rathong chu, Kalej khola, Relli chu and Rangbhang khola. There are about 104 small and big rivers and streams in Sikkim.

Sikkim has more than 227 lakes and wetlands and numerous hot springs located along different altitudes. Majority of these lakes and hot water springs are confined to high altitudes areas. Some of the high altitude lakes include, Tso Lhamu, Gurudongmar, Dudh Pokhari, Tsomgo, Samiti, Lam pokhari, Menmecho, etc. Similarly, the important hot springs in Sikkim are Phur-tsa-chu, Yumay samdong or Momey samdong, Yumthang, Ralong-tsa-chu, Borong, etc.

2.2 Geology

Major portion of the Sikkim Himalaya is in the Lesser and Greater Himalayan zone; however, Sikkim is located in eastern part of the Indian Himalayan Region, and is covered by Precambrian rock assumed to be much younger in age. Sikkim is considered as a young mountain system, still in the process of formation, with highly folded and faulted rock strata at several places. The mountain system in Sikkim generally runs in east-west direction, while the chief ridges run in more or less north-south direction. The northern portion of the state is deeply cut into escarpment, while the southern portion is comparatively open which is basically due to the direction of the main drainage (southern). The northern, eastern and western portion of the state constitutes of hard massive gneissose rocks which are capable of resisting denudation;

however, the central and southern portion constitutes of soft, thin, slate and half-schistose rocks which are highly susceptible to weathering. Owing to the presence of gneissic group of rock in Sikkim, the soil represents brown clay type and is generally shallow and poor. Soil is coarse-loamy to fine-loamy in texture, contains large amount of iron oxide, neutral to acidic in nature and very poor in mineral content, while it is rich in organic content. In fact, over 50 percent of the land is barren and inhospitable in Sikkim. In many places, the soil is good for the crops; it is sandy alluvial in the lower regions and black, white or red in the higher hills.

2.3 Climate

Sikkim has a peculiar climatic condition which varies from tropical heat in the lower valleys to the freezing cold in the higher altitudes. State is basically divided into: sub-tropical humid type (upto 1500 m asl), semi-temperate type (1500 m asl to 2000 m asl), temperate type (2000 m asl to 3000 m asl), alpine snow forest type (3000 m asl to 4000 m asl), alpine meadow type (4000m asl to 6000m asl), and arctic type (above 6000 m asl) [Chaudhury, 1998]. The zone above 6000 m asl remains permanently snow covered throughout the year due to its closeness to the tropic of Cancer; however snow comes down upto 2500 m asl during winter.

Sikkim Himalaya is presumed to be the most humid place in the entire Indian Himalaya because it is situated very close to Bay of Bengal and is directly exposed to moisture laden southwest monsoon. Sikkim is one of the rainiest regions in India as it comes direct on the path of the monsoon clouds; nonetheless, the rainfall varies with varying altitude. Sikkim receives rain from mid-February to early-November, but, the intensity is higher during late-May to early-September. The monsoon normally occurs from June to August, of which July is the wettest month of the year receiving total rainfall upto *ca.* 5000 mm (Pangthang, east Sikkim), which is the highest in the eastern Himalaya. The downpour is very less in the northern part of Sikkim because the monsoon cloud dries out by the time it reaches the northern barrier.

The temperature is not uniform in the state due to variability in the altitude. At lower altitudes (220 m asl to 1500 m asl), the temperature varies between 6^oC and 35^oC;

moderate altitude (1500 m asl to 2000 m asl) experiences temperature between 2⁰C and 26⁰C; and the altitudes between 2000m asl and 3000m asl experiences temperature between 0⁰C and 15⁰C. At altitudes between 3000m asl and 4000 m asl, the temperature drops below freezing point during winters and at altitudes above 4000 m asl, the temperature drops down below freezing point almost every night and the temperature goes below -40⁰C during winter. The relative humidity remains above 70% throughout the year in most part of the state.

2.4 Flora

Sikkim is a part of the Indo-Burmese biodiversity hotspot and has unique geographical features having wide range in altitude, high precipitation, etc., which makes it a home to a rich diversity of flora and fauna from tropical region to arctic region which differs from valley to valley. The state has 46 percent of its total geographical area under the forest cover harboring approximately 4500 species of flowering plants (26 percent of the country). There are a record of over 450 tree species, 36 species of rhododendrons, 500 species of medicinal plants, 523 orchid species, 362 species of fern and its allies, 8 tree fern species, 11 oak species, 16 conifer species, 23 bamboo species, 60 primula species and 150 species of wild edible plants. Sikkim is famous for its orchids and rhododendrons and harbors 72 percent of the rhododendron species of the country. For having various potential biological resources, Sikkim offers greater possibilities for nature based entrepreneurs to people (Badola and Aitken, 2010).

On the basis of variability in altitudes, Sikkim is divided into three different vegetation zones, tropical, temperate and alpine with their distinguishable plant species composition. For example, the tropical regions (220 m asl to 1500 m asl) are covered with the forests of *Shorea*, *Adnia*, *Dalbergia*, *Dillena*, *Artocarpus*, *Ficus*, *Bahunia*, *Litsea*, *Terminalia*, *Schima*, *Syzgium*, *Engelgardtia*, *Castanopsis*, *Pandanus*, *Cythia*, *Michelia*, *Saurauia* sps, etc. Apart from these, several varieties of orchids, laurels, bananas are available in this region. In the temperate regions (1500 m asl to 4000 m asl), forests comprises of *Alnus nepalensis*, *Acer*, *Betula*, *Magnolia campbellii*, *Rhododendron*, *Larix*, *Berberis*, *Michelia*, *Engelhardtia spicata*, *Quercus*,

Nyssa sessiliflora, *Abies densa*, *Tsuga dumosa*, *Larix griffithiana*, *Taxus baccata*, etc. Besides, numerous species of herbs of medicinal importance such as, *Aconitum*, *Podophyllum*, *Picrorhiza*, *Rheum*, *Swertia*, *Nardostachys*, *Polygonatum*, etc., are found in this zone. The Alpine region (4000 m asl to 6000 m asl) consists of shrubs and scrubs of rhododendrons, junipers, etc. In addition, there exists various species of *Primula* and *Mecanopsis*. The altitude above 6000 m asl remains permanently under snow cover.

Sikkim harbours several endemic floral species, viz. *Acronema pseudotenera*, *Anaphalis cavei*, *Anemone demissa*, *Coelogyne treutleri*, *Mahania sikkimensis*, *Podophyllum sikkimense*, *Rhododendron sikkimense*, etc. The species of the eastern Himalaya endemic to Sikkim includes *Abies densa*, *Betula utilis*, *Larix griffithiana*, *Rhododendron baileyi*, *Rhododendron camelliiflorum*, *Rhododendron ciliatum*, *Rhododendron glaucophyllum*, *Rhododendron grande*, *Rhododendron lanatum*, *Rhododendron lindleyi*, *Rhododendron wallichii*, *Rhododendron wightii*, etc. The endemic orchid of Sikkim includes *Bulbophyllum trichocephalum* var. *capitatum*, *Calanthe anjanii*, *Calanthe yuksomnensis*, *Cremastra appediculata* var. *sonamii*, *Cymbidium whiteae*, *Dendrobium eriiflorum* var. *sikkimensis*, *Pantlingia paradoxa*, etc. For its floral richness, several botanical explorations have been conducted in Sikkim by famous botanist and naturalist all over the world including Sir J.D. Hooker, Sir G. King, C.B. Clarke, G.H. Cave, W.W. Smith, and J.M. Cowan who accounted their collection in different books.

2.5 Fauna

The beauty of variety of plant diversity in Sikkim is further enhanced multifold by the availability of wide variety of faunal components, which include 150 mammal species, 552 bird species, 690 butterflies and 1500 moth species, 29 reptile species, 10 amphibian species, and over 48 fish species.

Amongst most important and rare animals found in Sikkim, the Snow leopard, Red Panda, Musk deer, Barking deer, Himalayan Thar, Goral, Blue sheep, Serow, Gazella, Tibetan wolf, Himalayan black bear, Clouded leopard, Leopard cat, Jungle cat,

Himalayan marmot, etc. are prominent. Many of these species are now listed in the IUCN red data book. Some of these animals are now included in the list of schedule I species of the Wildlife (Protection) Act, 1972 and are given special protection which includes Blue sheep, Clouded leopard, Himalayan Thar, Musk deer, Red Panda, etc.

With regard to the bird species diversity, Sikkim represents highest bird richness in terms of total geographical area. About 50 percent of the bird species of the Indian sub-continent (1400 species) are present in Sikkim. Nevertheless, bird species like Blood Pheasant, Crimson horned Pheasant, Forest eagle owl, Himalayan golden eagle, Monal Pheasant, Lammergeyer, Tibetan snowcock, etc., have been listed in schedule I of the Wildlife (Protection) Act, 1972; bird species like Black naked Crane, Himalayan Griffon, Tibetan Snowcock, Snow Partridge, Snow Pigeon, Snow Finch, Mountain Finch, etc., have become endangered in Sikkim.

2.6 Protected Area Network

With a view to conserve the rich biodiversity, wide areas of Sikkim have been included in the protected area network. There are 8 protected areas in Sikkim viz., Khangchendzonga Biosphere Reserve, Fambong Lho Wildlife sanctuary, Kyongnosla Alpine Sanctuary, Barsey Rhododendron Sanctuary, Maenam Wildlife Sanctuary, Singba Rhododendron Sanctuary, Kitam Bird Sanctuary and Pangolakha Wildlife Sanctuary covering 46.93% of the total geographical area).

2.7 Social profile

As per the official Provisional Population Census 2011, the population of Sikkim is approximately 0.61 million (0.05% of the total population of the country) with 0.32 million male population and 0.29 million female population. The gender ratio of females per 1000 males is 889; the state has overall literacy rate of 82.20% (male: 87.30%; female 76.53%). The overall density of the population in the state is 86 per sq. km. East district, especially the capital, Gangtok being cosmopolitan, is the most populated while north district is the least populated. There are mainly three ethnic communities in Sikkim, viz., Nepali, Bhutia and Lepcha; however, many other communities from different parts of India have made their way to Sikkim and are

mostly involved in trade and other related works. Nepali constitutes more than 50 percent of the total population of the state as it includes many sub-communities, followed by Bhutia and Lepcha. There are three official languages spoken in the state: Nepali, Bhutia (Sikkimese) and Lepcha; however, Nepali has become the lingua franca of the state and English as the medium of education. Other languages spoken in Sikkim include Hindi, English, Gurung, Limboo, Magar, Rai, Sherpa, Tibetan, Tamang, etc. Hinduism and Buddhism are the main religion followed by the people of Sikkim; nevertheless, Sikkim also has a small population of Christians and Muslims.

2.8 Economic profile

Sikkim is an agrarian state. Agriculture forms the backbone of the economy of the state and animal husbandry forms an integral part of majority of the household in Sikkim (Badola, 2009). The people practice mixed farming. The major cash crops grown in the state are cardamom and zinger; the state is the largest producer of large cardamom and has the largest area under cardamom cultivation in India. Besides, people grow potatoes, mandarin, guava, kiwi fruit, passion fruit, maize, paddy, finger millet, mustard, barley, wheat, and other vegetables; however, the production is still at low level and yet to reach the commercial level. Beside, small area in South Sikkim has tea plantation which is rated very high in the international tea market.

In Sikkim, livestock farming comprise of cattle, sheep, pigs, goats, poultry, yak, etc. depending upon the altitude which plays a significant role in the economy of the rural household. Tourism is the major upcoming industries in Sikkim which has increased the revenue of the state multifold times. The state is one of the most important destinations for nature, cultural and religious tourism. The other main industries in Sikkim are distilleries, breweries, pharmaceuticals, juice factory, etc. Also, there are multiple small scale industries in Sikkim which are important in boosting the economy of the state. Apart from these, upcoming several small and big Hydel power projects will be another main source of revenue to the state. There exists several minerals such as, copper, zinc, lead, coal, quartzite, dolomite graphite, etc., which are mined from Sikkim.

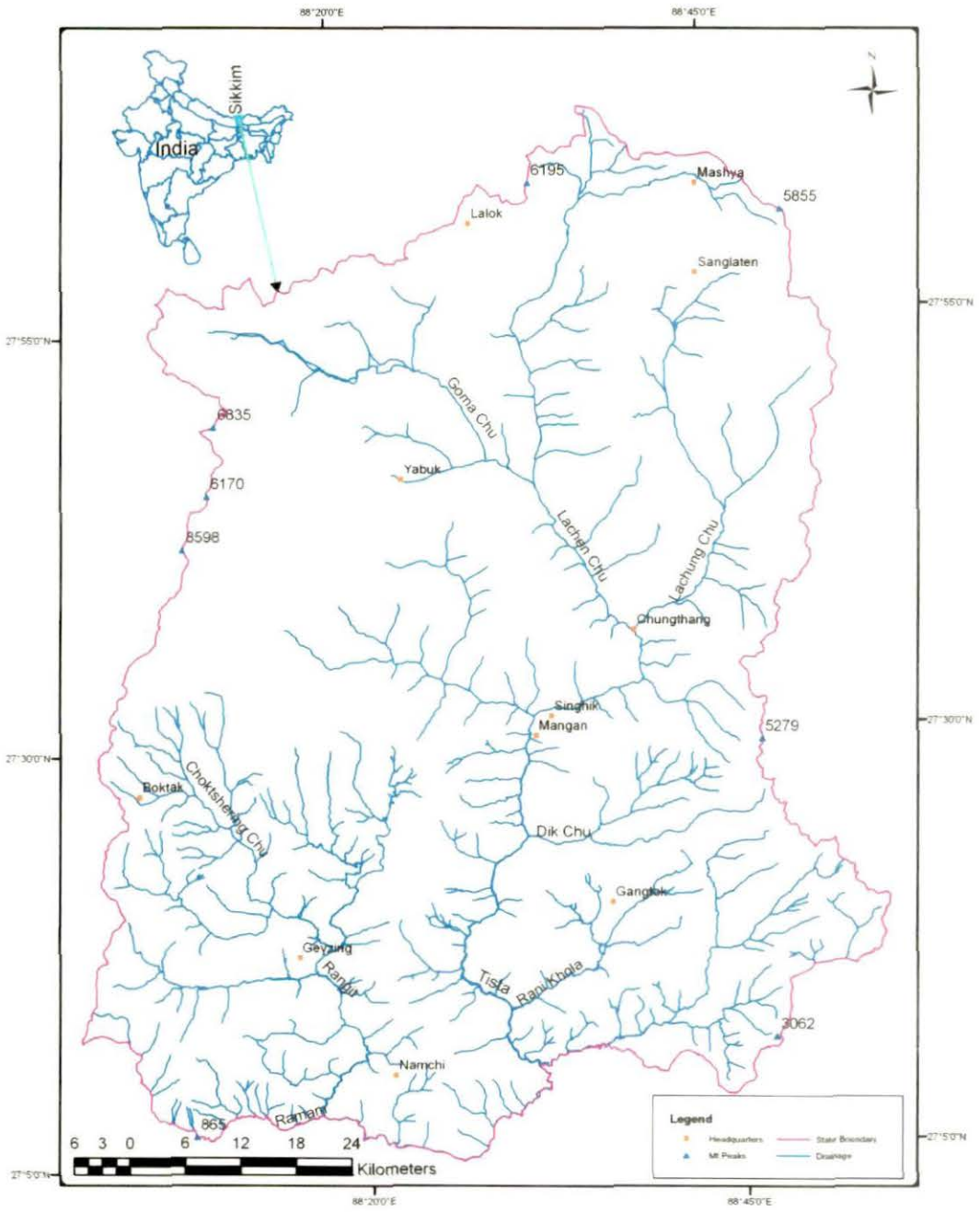


Figure 1. Location map of Sikkim