

CHAPTER III

The study area

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3.1 Sikkim

Sikkim, the 22nd state of India, with an area of 7,069 km² and a population of 4,05,505 (1991 Census) lies in the eastern Himalayan belt. It is situated between 27°4'26'' and 28°7'48'' N latitude and 88°55'25'' and 88°58' E longitude, and encircled by the Kingdom of Nepal on the west, Bhutan and Chumbi valley of Tibet (China) in the east, Darjeeling–Gorkha Hill Council of West Bengal in the south, and the Tibetan Plateau of China in the north. Administratively, the state has been divided into four districts i.e. East, West, North and South, with Gangtok as the state capital. Topography of the state looks like an amphitheater with the elevation ranging from 310 to 8598 m asl in less than one hundred kilometer stretch.

The climate in Sikkim varies from area to area due to variation in topography, landscape and nearness to snow clad mountains. The climatic data for a temperate site was recorded at Pangthang at the G.B. Pant Institute of Himalayan Environment and Development complex using automatic weather station during 1994–1996. Average annual rainfall was 3771 mm and 70% of this rain occurred during monsoon season. The daily annual temperature varied from 2.6°C during January to 23.7°C during July at different seasons of a year. The relative humidity ranged from 73% in April to 97% during July.

Twenty-six biodiversity hotspots have been identified in India and Himalaya is one of them (Khoshoo 1991). The eastern Himalaya is regarded as the “Mega Hot Spot” and Sikkim falls within this with 42% of its area under forest cover (Sudhakar *et al.* 1998). Protected areas in the state constitute about 40.7% where Khangchendzonga Biosphere Reserve and five wildlife sanctuaries viz. Singha Rhododendron Sanctuary, Khyangongla Alpine Sanctuary, Fabongla Wildlife Sanctuary, Maenam Wildlife Sanctuary and Varshey Rhododendron Sanctuary exists. These areas depict high biodiversity of the state. High mountain peaks characterized the area where the world’s third tallest mountain peak, Mt. Khangchendzonga (8598 m), in the world exists with beautiful snow covered range. The other peaks of interest are Mt. Siniolchu, Mt. Narsing, Mt. Pandim, Mt. Simvo, Mt. Kabur and Mt. Talung.

Religious festivals and folk dances are a common feature seen very often in the state due to diverse culture and ethnicity. Sikkim is also the site for pilgrimage hence the prayer flags can be seen almost anywhere in Sikkim on hill tops as an integral part of the landscape. The major ethnics of Sikkim are Lepchas, Bhutias, Nepalese and Limboos. Agriculture and animal husbandry are primary occupation of the people and their economy is mostly dependent upon it. Cardamom and ginger are the main cash crops. In recent years the state have become an attractive destination for visitors for its high biodiversity, unique landscapes, cultural and religious diversity, and it forms an ideal situation for religious, recreational and adventure tourism. The inflow of tourist is high and

around 136,144 domestic and 7266 international visitors arrived in the state during 1998.

The state has rich network of both lentic and lotic water bodies. The lotic waterbodies constitutes two important rivers i.e. “Tista” and “Rangit” with innumerable tributaries (Tamang 1992). The state is rich in lentic water bodies with 150 lakes situated all over the state (Roy and Thapa 1998a). The west district in particular has good network of water bodies. The important rivers in the district are Rathangchu, Rimbichu and Ramam khola, which ultimately merge in Rangit a tributary of Tista. There are around 20 lakes that are mostly situated on the southwestern part of the Khangchendzonga Biosphere Reserve. The famous lakes are Khecheopalri lake (1700 m asl), Kathok (1650 m), Tshoka lake (3000 m), Laxmi pokhari (3950 m), Lamh pokhari (3850 m) and Samiti lake (4100 m). Khecheopalri lake which is situated at the opposite hill of Yuksam, is approachable from Pemayangstey as well as Yuksam. These lakes are sites of pilgrimage and also forms major attractions for visitors.

3.2 Khecheoplari Lake

3.2.1 Sacredness and legends

Many legends and belief are associated with the formation, existence, and sacredness of the “Khecheopalri lake”. The lake is situated in the west district of Sikkim which falls under the sacred landscape “Demazong”, a land of hidden treasures. It has been narrated during PRA (Participatory Rural Appraisal) exercises with the local communities at

Khecheopalri and Yuksam that Guru Padmasambhava, who is highly revered and worshipped by Sikkimese Buddhists was seen in a place called 'Hungri' in the 10th day of full moon of lunar eclipse. It is believed that the entire area was blessed by him. Four famous religious sites of this sacred landscape have been considered the four plexus of the body where Khecheopalri is one of them. Khecheopalri symbolises the thorax of the body (Khecheo-Flying Yoginies or the Taras; palri-palace) whereas the other three i.e. Tashiding symbolizes the head plexus (Tashi-holy sky; ding-island), Yuksam symbolizes the third eye (meeting place of three lamas) a place of meditation, and the Pemangstey the heart plexus (Pema-lotus; ngstey-center) of the body.

The most sacred among all lakes and highly revered by the local people is the lake "Khecheopalri" captivated by the magnificent beauty owing to lush green tract of forests (Photoplate 1). The place is dominated by the Lepcha community, and are the aboriginals of Sikkim. They followed 'Bon' or 'Mune' religion and indulged with the animal sacrifices (animism) to placate the various deities of forest, river and wind (Gawloog 1998). Presently they follow Buddhism and animal sacrifices are not common. But still the strong relationship with the nature was observed in their belief of sacredness associated with the Khecheopalri lake. The lake is originally named as Kha-Chot-Palri meaning the heaven of Padmasambha. It is the place where Guru Padmasambhava preached 64 yoginies. According to Buddhist, the lake is a dwelling place for the Goddess Tara Jestum Dolma, who is the mother of Lord Buddha and

particularly the Khecheopalri lake is considered to be her footprints. The people also worshipped the lake as “Cho Pema” the female Goddess. It has number of religious sites located all around the lake. Holy caves namely Dupukney, Yukumney and Chubukney are present where lamas incarnate and Rimpoches mediated. Foot prints of Macha Zemu Rimpoche can also be seen on a stone near the chorten. Two monasteries are present in the Khecheopalri area where the pilgrims and the local communities offer prayers. The Hindus believe that Lord Shiva meditated in the Dupuknay cave located just above the Khecheoplari lake, hence the place is also worshipped during ‘Nag Panchmi’.

As per the popular legend, it is said that there were two sister lakes in the northwestern part of the Himalayas. The elder lake is still present there but the younger lake migrated to western part of Sikkim in a place called Yuksam and settled in Labding pokhari. The people in Yuksam (the first capital of Sikkim) did not respect the Labding pokhari and disposed wastes into the lake water so goddess got dismayed and flew to the place called Chojo where it could not fit and hence again shifted little above in the present place called Khecheopalri. Still the dead Chojo lake is seen at the down hill with no open water surface except the marshy land with terrestrial vegetation (Photoplate 1).

The other legend states that the lake is called “Chho” as many years back, some Bhutia communities had settled around the lake Khecheopalri. They had herds of cattle that grazed in the dense forests around the lake. One day a white holy ox came out of the lake called

Chholang (Chho-lake, lang- ox), which was sent by the lake goddess. This white ox started to graze around the lake and finally mingled with the herds of cattle that belonged to the Bhutias. When the owner noticed a foreign animal in his herd, he tried to locate its owner. Eventually not knowing to whom this white ox belonged he slaughtered the animal for its meat and was surprised to notice that instead of blood a whitest milky discharge oozed out. He washed the discharge, cooked the meat and had a great feast with his friends. After that he realized that all his cattle and Bhutia communities in the locality started to vanish one by one facing strange ailments. It is believed that in this way the entire Bhutia community vanished from the Khecheopalri village. Now, mostly Lepcha settlement is found around the Khecheopalri lake and a very few Bhutias who married Lepchas are believed to have survived the dreadful curse.

The other story said that the Lepcha girl 'Nenjo Asha Lham' was blessed by the lake goddess and was given a precious gem, which was unfortunately lost by her mother. Till today people believe that the gem is treasured around and wishes are made at this lake for whatever a person desires. Many have been blessed and strong belief persists with the local and pilgrims visiting the lake. The Khecheopalri lake is therefore famous as the "Wish fulfilling lake" or shortly "Wishing lake". The local people has a belief that the lake is having a healing property as well.

Besides folklores, there are a number of religious festivals associated with the lake. The rites and rituals are performed according to

one's wish but the regular rituals are performed in the full moon and new moon days. The two main festivals associated with the lake are "Chog Tsho" that falls in the month of October and "Bhumchu" in the month of February/March.

Tourist attractions as fishing, boating and swimming are strictly prohibited in the lake by the local communities, but the unrevealed scenic beauty of the lake makes it a site for major tourist destination. The local belief and traditions has kept the lake water not to be used for any other purpose except for rites and rituals but the watershed forest is neglected. The offerings made by the pilgrims and the tourists in the lake water has also some negative impacts on the lake health.

3.2.2 Physical features

3.2.2.1 Location, lake formation and physiography

Khecheopalri lake is situated 147 km away from the capital town of Gangtok. It is situated at $27^{\circ}22'24''$ N latitude and $88^{\circ}12'30''$ E longitude at an altitude of 1700 m asl. The lake represents the original neve region of the ancient hanging glacier being formed by the scooping action of the glacier and a moraine ridge is seen lower down forming the southern bank of the Lethang valley (Raina 1966). The lake has been estimated to be more than 3500 years old.

The lake is surrounded by forested Ramam watershed (12 km^2) and falls on the southern limit of Khangchendzonga Biosphere Reserve (Buffer Zone IV) limiting on the RF boundaries of Khecheopalri. It has an

open water surface area of 37,900 m² with a mean water depth of 7.2 m. The lake is well drained from the watershed with internal seepage, flow from 2 perennial and 5 seasonal inlets and outflow through the one major perennial outlet. The lake drainage area constitutes 91 ha out of which 68 ha falls in the inlet streams coming from the watershed and 23 ha falls directly to the lake which brings the sediments and nutrients to the lake (Fig 3.1). An aquifer is expected to be opening at the lake bottom. The lake is a halting place for Trans-Himalayan migratory birds. These migratory birds visit the lake during winter season from November to March. This lake side provides recreational tourism besides pilgrimage and some visitors go to different locations in Khecheopalri area on trekking.

The lake is surrounded with marginal vegetation forming “Kettle hole bog” dominated by species of *Sphagnum*. The bog has an area of 70,100 m² with the peat formation of around 2–5 m depth. The morphometric data of the lake, bog and its watershed are presented in Table 3.1.

3.2.2.2 Geology

The West District of Sikkim is located in the lesser Himalayan Zone. During the early period of the geological history, deep water marine sediments exhibiting considerable facies variation were deposited over the major part of the district and were later subjected to repeated folding, faulting and thrusting movements. The different epochs of accumulation of sediments, their conversion into rocks of different types, uplift and

subsequent erosion repeated over million of years, eventually gave rise to the present deposition of the different types of rocks. Three groups of rocks have been recorded in the district namely, the Darjeeling group, the Daling group and the Gondawana group. The Darjeeling group of rocks occupy the southwestern part of the district that encompasses the Khecheopalri lake watershed. This group comprises the high-grade gneisses containing quartz and feldspar with streaks of biotite (Geological Survey of India 1984).

3.2.2.3 Soil

The lake watershed has been disturbed by the pressure of grazing agricultural land use, fodder and fuelwood collection and land slides. Hence, the soil analysis was done for two sites considering disturbed and relatively undisturbed sites. The soil of the area was sandy loam in nature. The soil texture showed that the percentage of gravel was higher in disturbed site (20.08%) than the undisturbed site (18.87%) which decreased with depth. The percentage of the clay was lower in the disturbed site compared to undisturbed site. Proportion of the sand increased in disturbed condition compared to undisturbed site. Trampling by the grazing animals was the main cause of change in soil texture at disturbed sites. Soil texture of lake watershed is presented in Table 3.2.

Soil moisture increased with depth from 27.1% to 30.9% in undisturbed site and decreased with depth in disturbed site from 23.9% to 21.6% stating the low infiltration rate in highly disturbed site and higher runoff. Bulk density showed a marked difference in the two site

conditions. The lower values were obtained in undisturbed sites compared to the disturbed sites where the soil was more compact. Soil was acidic and pH ranged from 5.5 to 5.9. Organic carbon, total nitrogen and total phosphorus were higher in the undisturbed sites compared to highly disturbed sites. Total nitrogen and organic carbon decreased with depth in both the site conditions whereas the total phosphorus increased with depth in both the sites (Table 3.2).

3.2.3 Climate

3.2.3.1 Rainfall

The climate of this area is moonsonic and classified into three seasons viz., spring (March-May), rainy (June-October), and winter (November-February). Although the climate is moonsonic, the distribution of rainfall is highly influenced by the complex topography and the region experienced frequent rainfall of varying intensity and duration. The bulk of the rainfall (85%) occurs in the rainy season. The winter months receive very scanty rainfall. Rainfall peaked during July in 1997 and August in 1998. During July and August more than 30% of rainfall was recorded during two years of the study period. The average annual precipitation was 3899 mm in 1997 and 3776 mm in 1998. The temporal distribution of rainfall during 1997 and 1998 are presented in Fig. 3.2.

3.2.3.2 Temperature

The study area falls in a temperate belt and typical temperate climate prevailed. Maximum temperature ranged from 4.3 °C in January to 23.9

°C in July-August during 1997-98. Minimum temperature varied between 2.7 °C in January to 17 °C in August in 1997-98. Highest temperature recorded was 24 °C in August and lowest of 2.5 °C in January during the study period. Temporal variations in mean maximum and minimum temperatures are presented in Fig. 3.2.

3.2.4 Lake, bog and watershed vegetation

History on the vegetation of the surrounding Khecheopalri forest showed that around 2500 years ago the lake watershed had dense mixed broad-leaf forests and poorly developed ground vegetal growth. The Pollen analysis of a sedimentary profile from Khecheopalri lake with three ¹⁴C dates i.e., 2280±110 years B.P., 2380±110 years B.P. and 1680±130 years B.P. at different depths (C. Sharma 1996, personal communication) showed exceedingly high pollen values of *Quercus*, followed by *Alnus* and *Pinus* and other arboreal elements. Presently the forest is highly disturbed with dominance of *Castanopsis tribuloides*, *Machilus edulis*, *Symplocos theifolia*, *Eurya acuminata*, and *Viburnum cordifolium*. The *Quercus*, which was a dominant species around 2500 years ago, has a mere presence now. The dominant ground vegetation of the forest included *Elatostema sessile*, *Brachiaria eruciformis*, *Selaginella* sp., *Plantago erosa*, *Oenanthe thomsonii*, and *Cyperus rotundus*. Important climbers in the forest are *Piper* sp., *Rhaphidophora glauca*, *Smilax zeylanica*, *Stephania rotunda* and *Citrullus colocynthis* and epiphyte recorded was *Vaccinium vacciniaceum*.

The bog around the lake showed a wide spectrum of vegetation ranging from hydrophyte to terrestrial and algae to angiosperm. The bog is dominated by *Sphagnum* spp. with other species such as *Brachiaria eruciformis*, *Acorus calamus*, *Saccharum* sp., *Juncus* sp., *Polygonum* sp., *Oenanthe thomsonii* and *Fimbristylis* sp. The dominating shrub species in the bog included *Rhododendron lindleyi*, *Arundo donax*, *Vaccinium nummularia*, *Berberis wallichiana*, *Viburnum cordifolium* and *Aconogom molle*. A few tree species that have regenerated in the bog forest edge are *Machilus edulis*, *Magnolia campbellii*, *Acer* sp., *Castanopsis tribuloides* and *Alnus nepalensis*.

Some hydrophytic plants and plankton were recorded from the lake water during the course of the study period. The plants recorded were *Aponogeton monostachyon*, *Ceratophyllum* sp., *Monochoria vaginalis* and *Scirpus* sp. Dominating phytoplankton recorded were *Spirogyra* sp., *Mougeotia* sp., *Cosmarium* sp., *Euastrum* sp., with a few zooplankton such as *Arcella* sp., *Diffugia* sp., *Keratella* sp., *Notholoca* sp., *Cyclops* sp. and *Zonomyxa* species■

Table 3.1 Morphometric data of the Khecheopalri lake and its watershed

Parameters	Values
Latitude (North)	27° 22' 24"
Longitude (East)	88° 12' 30"
Altitude (m)	1700
Open water surface area (m ²)	37,900
Maximum water depth (m)	11.2
Minimum water depth (m)	3.2
Mean water depth (m)	7.2
Estimated water volume (m ³)	2,72,880
Boggy area (m ²)	70100
Total bog and lake water area (m ²)	1,08,000
Total Ramam watershed area (km ²)	12
Watershed area falling directly to lake and bog (ha)	91

Table 3.2. Soil physico-chemical characteristics of undisturbed and disturbed site conditions at two depths (0-15 cm and 15-30 cm) of the Khecheopalri lake watershed. Soil pH and nutrient values are mean \pm 1 S.E. ($n=3$)

Physico-chemical parameters	Site			
	Undisturbed		Disturbed	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm
Moisture content (%)	27.10 \pm 0.42	30.90 \pm 0.32	23.90 \pm 0.41	21.60 \pm 0.89
Bulk density (g/m ³)	0.80 \pm 0.12	0.78 \pm 0.13	1.01 \pm 0.22	1.02 \pm 0.21
Soil texture (%)				
Gravel	19	14	20	17
Sand	70	73	74	78
Silt	7	7	2	2
Clay	4	5	3	3
pH	4.48 \pm 0.07	4.92 \pm 0.02	4.51 \pm 0.03	4.59 \pm 0.01
Soil nutrients (%)				
Organic carbon	4.22 \pm 0.08	4.10 \pm 0.15	4.11 \pm 0.02	4.10 \pm 0.01
Total nitrogen	0.50 \pm 0.02	0.35 \pm 0.05	0.45 \pm 0.02	0.29 \pm 0.01
Total phosphorus	0.178 \pm 0.01	0.179 \pm 0.01	0.098 \pm 0.04	0.125 \pm 0.01

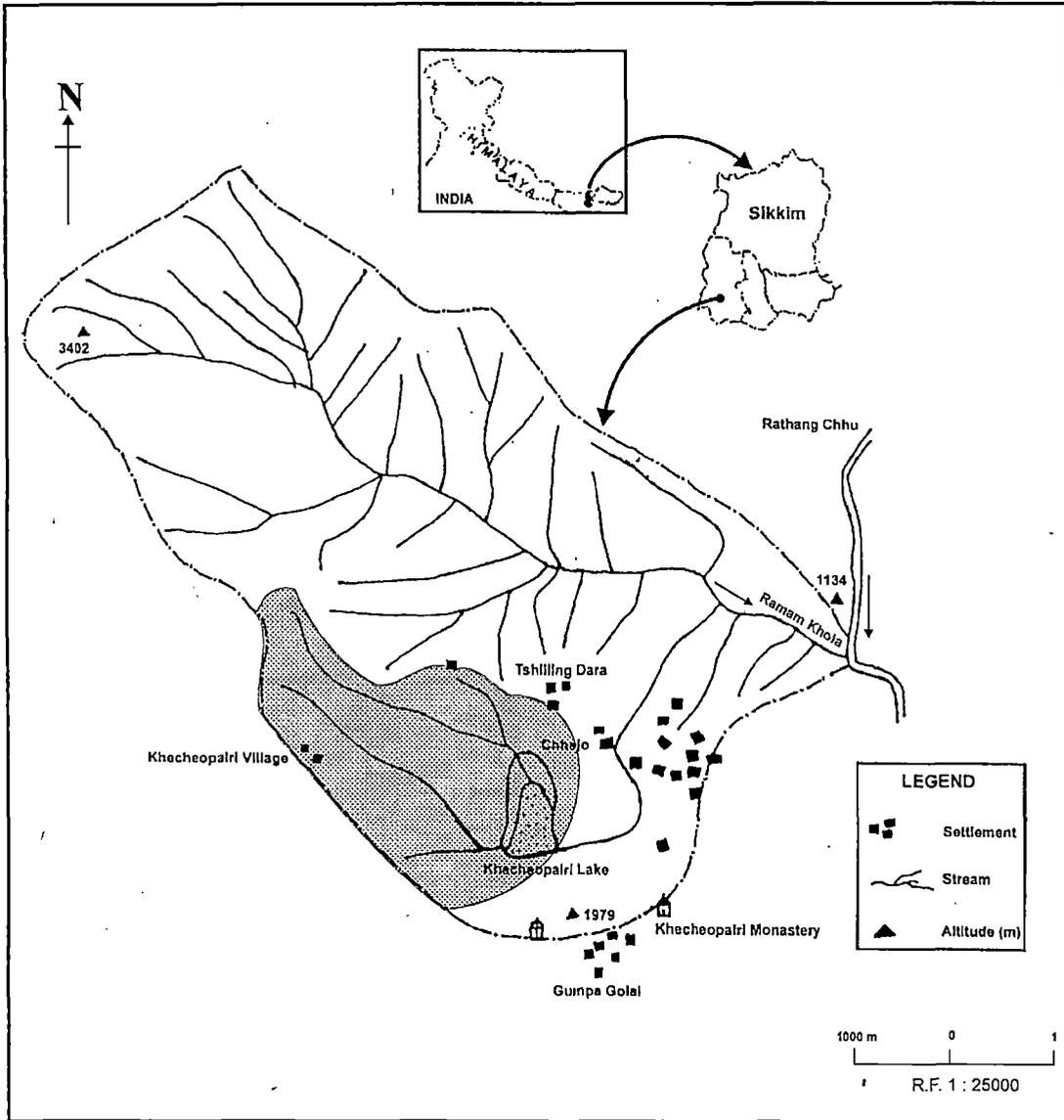


Fig. 3.1 Location map of Khecheopalri lake and Ramam watershed. The darkly shaded portion is the catchment that directly drained into the lake

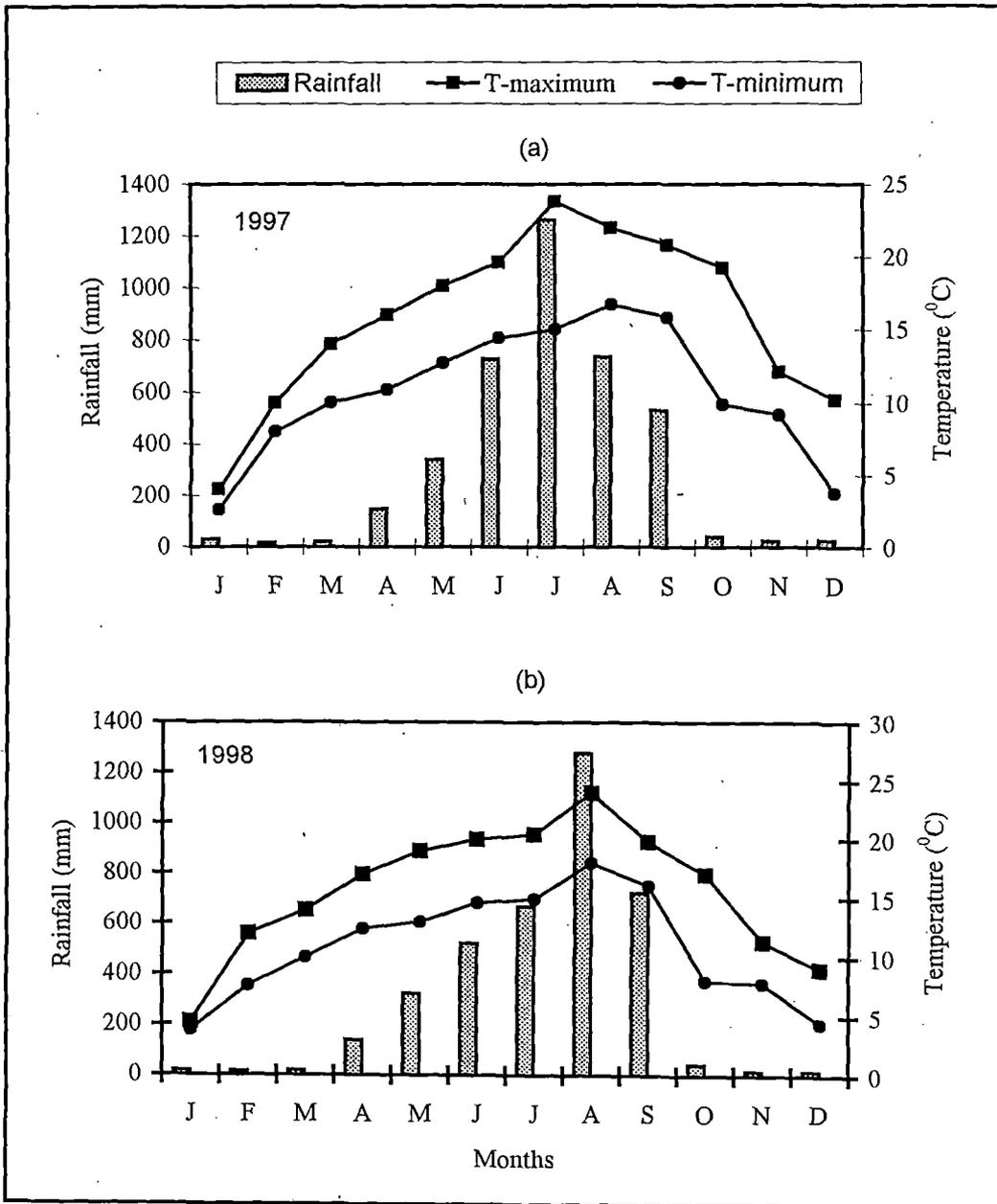


Fig. 3.2 Temporal distribution of rainfall and maximum and minimum temperature at the Khecheopalri lake