CHAPTER I

Introduction

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The "Himalaya" with its beauty in the form of natural-socio cultural components has once been regarded as powers and health regaining to human beings. A passage in Mahabharata, the religious epic of ancient India, describes a Himalayan peak as a refuge of hermits, 'treasury of sacred places' (Van Buitenen 1975). It is regarded as the place of the God and Goddess since ancient times and are the sites of meditation, because of the presence of snow-clad mountains widespread calmness, peacefulness, richness in flora and fauna, clean water and fresh soothing air. The mountains especially the Himalaya are sacred to the people of India and this highlights the cultural and spiritual factors that profoundly influence how people view and treat the environment. The value and belief associated with major sacred peaks of the world such as "Mount Olympus" of Greece, "T'ai Shan" of China, "Mount Fuji" of Japan, "Taranaki" of New Zealand and "Kailas" of Tibet underlie many of the ways in which members of different societies see the world and their place in it. Even the water flowing through many rivers and lakes has a special place for their existence and are associated with many legends.

The Himalaya extending between the latitudes 27° and 36° N and longitudes 72° and 98° E forms the northern boundary of the Indian sub-continent. The Indian Himalaya covers an area of 591000 km^2 (18%) and 51 million people live here (Palni *et al.* 1998). It extends about 2500 km from west to east with 240-340 km breadth and is broadly classified into three different zones, the western Himalaya, the central Himalaya and the

eastern Himalaya. The eastern Himalaya is recognized globally as biodiversity "Hot Spot". It is endowed with rich biodiversity and harbours the largest number of endemic and Scheduled I species than anywhere in India (MacKinnon and MacKinnon 1986). The eastern Himalaya including the states of northeastern India represents the transition zone between the Indian, Indo-Malayan, Indo-Chinese bio-geographic realm as well as a meeting place of Himalayan mountains with that of peninsular India and acts as a bio-geographic gate way. The Indian region with a total area of 3.29 million km^2 is one of the centers of diversity (Rao 1995). The Himalaya is the major source of water resources in India. There are nearly 15000 glaciers in Himalaya extending from the state of Kashmir in the west to Sikkim in the east and it processes 0.1 cubic kilometer of water during the summer season which is of great economic value (Kaul 1990). Various rivers originate from these glaciers from the Himalaya and are considered holy and these rivers feed many lakes. The Indo-Gangetic plain, one of the most fertile regions of India is the boon of Himalaya as it supports the cultivation of food grains and water supply to millions of people. In the eastern Himalaya, river Brahmaputra originate from Arunachal Pradesh and Tista from Sikkim. The catchment areas have a wide variety of ecological habitats that support an enormous diversity of aquatic and terrestrial flora and fauna. The impact of man on the Himalayan forest has been steadily increasing because of the stress created by ever rising population (Singh and Singh 1992).

The major Indian rivers that are fed from the Himalaya have been found to be carrying huge amount of sediments resulting into the degradation of soil fertility and landscapes. It has been found that one-

third of the total Himalayan land is derelict due to poor land maintenance, altered agricultural practices like cultivation on steep slopes and intensive land use practices. The total flow of water from the Himalaya to the plain is estimated to about 8.6 x 10^6 ha m of water per year and the Himalayan watersheds have been reported to produce sediment load of 16.4 to 921 ton/km^2 (Gupta 1983). The annual soil erosion rate in the Himalaya was estimated to be 5333 million tons of which about 29% is carried away by the rivers into the sea and 10% is deposited in surface storage reservoirs (Valdiya 1980).

1.1 Lake ecosystem

The great diversity of physiography, climate, soils and biota offers unlimited opportunities to understand the functioning of diverse ecosystems. In general, ecosystem approach of a study deals with the interaction of biotic and abiotic components and various pathways of energy and nutrient flow. Lake ecosystem studies mainly constitutes the three main components such as the lake water itself, the marshy land formed around it and the drainage basin i.e. its watershed which all couples and interacts with each other in some or the other way. In recent past human pressures have modified or destroyed ecosystems and ramified consequences with continued dependence on the functioning of many ecosystems.

The global water resource has been estimated about 1,560,000 km^2 of surface area and their distribution estimates 97.2% by oceans, 2.15% by ice caps and glaciers, 0.62% by ground water, 0.009 % by fresh water lakes, 0.008% by saline lakes, 0.005% by soil moisture and 0.0001% by

stream channels (Nace 1964). The global lakes represents a volume of 229,000 km^3 in which the freshwater lakes cover an area of 91,000 km^2 of the total water of the planet (Keller 1984). Although relatively fewer in number, 90% of the world's inland surface water supply is shared by 253 large lakes (Herdendorf 1982). The Northern Hemisphere constitutes over 87% of all the large lakes and the Southern Hemisphere with relatively few lakes found mostly in Africa. North America possess nearly half of all the large lakes but only one third of the world's total surface area for large lakes. Asia with one-fourth of these lakes has over 42% of the lake area. Africa, the only major locus for the large lakes, accounts for less than one-seventh of the world total lake by area (Herdendorf 1982). India has one large brackish water lake called 'Chilka' with an area of 1170 km^2 contributing 0.08% of the total area of the world lake area.

Of the total inland water sources of 7.4 million ha in India, natural and artificial lakes comprise about 98% and 2%, respectively. In general, natural lakes spread in the colder regions of the country and have been estimated to have a total area of 0.72 million ha (Jana 1998). Overall the Indian landscape is dotted with 4290 large lakes with innumerable smaller water bodies (Sugunan 1995, Suryanaryana 1996). A large number of natural fresh water lakes exists in the Himalayan belt up to the altitude of 5000 m where the climate varies between cold arid in west to humid tropic in the east (Fernando 1984, Gopal and Krishnamurthy 1993). These natural lakes have been formed by the diverse geological factors, such as glacial activity, landslides and the wind actions.

Sikkim adorns natural wealth in the form of vast lacoustrine system both lentic and lotic. These lacoustrine systems provide a habitat for the

rich aquatic biodiversity. There are around 104 streams and rivers forming the lotic system with Tista and Rangit as two major rivers with innumerable tributaries (Tamang 1992). The lentic system comprises of around 150 fresh water lakes (Roy and Thapa 1998a), which are situated at different altitudes as a galaxy through out the state. These lakes are mostly snow-fed; a few are rain-fed and spring-fed. The lakes in Sikkim are famous for wildlife habitat, tourist spots and also possess high religious values. They are considered sacred and are highly venerated by the ethnics in the state. Some of the important lakes of the state are Khecheopalri lake (1700 m asl), Nagi lake (1225 m) Green lake (5091 m), Hans pokhari (3660 m), Chhangu lake (3779 m), Memenchu lake (3800 m), Lamh pokhari (3850 m), Samiti lake (4100 m), Majur pokhari (4423 m), Gurudogmar lake (5399 m), and Chhumzomuichhokha lake (5480 m). Most of these lakes are used as halting place by many Trans-Himalayan migratory birds.

Khecheoplari lake in the west district of Sikkim is regarded as "wish fulfilling lake" by the Sikkimese people and many legends are associated with its existence. The lake is one of the pilgrimage site and a destination for adventure tourism for both national and international tourist thus becoming an important source of income generation by the local communities.

The rapidly expanding human and other bovine population and the developmental activities is narrowing the natural habitats that resulted in depletion of natural resources. Exploitation of non-timber forest products is intense. Heavy influx of tourists and other mountaineers has threatened the fragility of Himalayan mountains mainly in the form of trash deposits

and trampling. The adverse impacts arising out of their uncontrolled and unmanaged activities are continuously polluting the entire landscape and affecting the lake water as well. The resource extraction, grazing, trampling and the conversion of land into agricultural fields are major threats that are arising and increasing from population growth and their requirements. This unmatched biotic pressure has resulted in the loss of native species, sediment runoff resulting in filling up of water bodies and enhancement of nutrients thus threatening the aquatic life.

1.2 Sikkim biodiversity and ecotourism project

The "Sikkim Biodiversity and Ecotourism", was initiated in the west district of Sikkim and was supported by Biodiversity Conservation Network (BCN) under the Biodiversity Support Program (BSP), USAID. The project was a collaborative effort of the G.B. Pant Institute of Himalayan Environment and Development, The Mountain Institute, The Travel Agent Association of Sikkim and the Green Circle. The project aimed to conserve the biodiversity of the project sites (the trekking corridor of Khanchendzonga Biosphere Reserve in Yuksam-Goechha La route and Khecheopalri lake) by providing alternative economic incentives to the local community. The main project activities included (i) increasing community and private sector biodiversity conservation initiatives, (ii) increase economic returns from community based and TAAS ecotourism and (iii) improving and contributing to policy-making on conservation and ecotourism. Third activity of the project included the planning, monitoring and applied research at the project sites.

The present thesis sought to identify the threats that have effected on the longevity of the Sikkim Himalayan Khecheopalri sacred lake. Thesis work was undertaken at the Khecheopalri lake and the goal of the study was to increase knowledge on the key relationship between habitat structure, species composition and its surroundings for biodiversity conservation with particular reference to tourism and community involved activities. To study the impact of intervention on biodiversity of the Khecheopalri lake and its longevity, the ecosystem approach of the study has been undertaken with the watershed as a support system to the lake. Lake nutrient dynamics and its trophic status have been dealt in detail in relation to the disturbed land use of the watershed and other related biotic pressures. The peatland as the inter-linking system in between the open water surface of the lake and the watershed forest has been studied in relation to its role as filtering interface for the incoming sediments to lake. The cultural and spiritual aspects were always kept in mind while conducting the field studies. Beliefs and sentiments of the local communities were always respected and appreciated and all the field studies of the lake, peatland and watershed were planned accordingly.

1.3 Core hypotheses

Watershed management regimes and land-use practices will directly determine the longevity and quality of Khecheopalri Lake, by inducing changes in natural erosion and sedimentation processes and rates.

- Hypothesis I - Heavy grazing and fuelwood extraction poses a lesser threat to Khecheopalri lake than agricultural land-conversion.

- Hypothesis II - Khecheopalri lake's longevity is a function of the kind of land management regime present

1.4 Objectives

- To study the hydro-ecological parameters such as overland flow, soil erosion and nutrient loss, and sediment concentration in runoff water on land-use basis.
- To study the boggy area for it's role in filtering the incoming sediments from the runoff water and maintaining the health of the lake.
- To study the floral vegetation on marshy land of the lake and surrounding forests to understand the impacts of timber, fuelwood and fodder extraction, agricultural practices and grazing.
- To study the soil profile in boggy area and forest and estimation of nutrients from different sites in order to know the rate of siltation and nutrient flow.
- To study the ecological behaviour of the lake in relation to physico-chemical and biological parameters.
- To study the impact of tourism and religious activities like annual festival on the bio-physical environment and socio-economic issues in the Khecheoaplri lake area ■