CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

The Himalaya is among the youngest and structurally most complicated mountains, and its higher altitudes are well known for ecological uniqueness. Extending from the Indus in the west to the Brahmaputra in the east for about 2500 km length and 240-340 km width (Khosoo 1992), the Himalaya represents a great deal of variation in altitude, latitude, topography and exposition giving rise to considerable differences in eco-climate that resulted into high biological diversity. The intrinsic fragility of Himalayan ecosystem has brought this mountain as being the most critical in the world (Valdiya 1980). Himalaya is one of the twenty-six "Hot Spots" of biodiversity in India and is a reservoir of over 5000 glaciers with permanent ice and snow cover (Khoshoo 1992). It is the source of several large rivers together with their tributaries, which flown southward in the Indo-Gangetic plains and finally discharge into the sea. On this water potential depends the well being of the millions of people in the entire belt in Indo-Gangetic plains and northeast (Khoshoo 1992). Northeastern region of India which is the easternmost part of the Himalayan ranges is very rich in biodiversity and harbours the largest number of endemic and Schedule I species in the country (MacKinnon & MacKinnon 1986). The region is a meeting ground of Indo-Malayan and Indo-Chinese bio-geographical realms as well as Himalayan and Peninsular Indian elements (Khoshoo 1992). The region is also called as "Cradle of Flowering Plants" (Takhtajan 1969). Therefore, the effort during recent years has been to bring more and more land under conservation network in the Himalaya.

Agriculture and animal husbandry are main occupation of the majority of populace in the Himalayan regions. Nomadic graziers move along with their livestock to high altitude areas during summer months. Livestock rearing is an integral part of farming system throughout the Himalayan region. Dependence on livestock increases with increase in elevation, and economy at the high altitude areas is primarily dependent on animal and their byproducts (Purohit & Samant 1995). The health of an average animal is poor due to various reasons, and availability of fodder is considered one major constraint (Jackson 1981, 1983; Balaraman & Golay 1991). There has been an increasing awareness about grasslands as the source of fodder specially when more and more land is being utilized for production of food and other requirements for mankind. In hills the problem is more critical where tree fodder is depleting exponentially against rising bovine population and narrowing of pasture lands (Sundriyal 1995). Subsistence economy of hilly region has strong linkage between agriculture, livestock and rangelands (Sundriyal 1995).

For centuries the alpine meadows in the Himalayan region have been used for grazing by the migratory livestock of transhumance as well as livestock from adjacent lower valleys during summer months (Farooquee 1996). During the winter months the livestock come down to subtropical and temperate forested grounds (Miller 1996). Some of the families adopt stall feeding and collect fodder from the nearby forests with a little supplement from agroforestry species and residue of other agricultural byproducts. The alpine meadows have high species diversity and constitute nutritious pasture for livestock during the summer months. In Himalaya, the herbage productivity is mainly influenced by great seasonality of

climate i.e. summer, rainy and winter, and biotic pressure on it (Sundriyal 1995a).

The Sikkim State is the house of 4500 flowering plants, which consist of varieties of orchids, rhododendrons and medicinal plants (Singh & Chauhan 1998). The state also harbours 150 species of mammals, more than 550 species of birds, 26 species of reptiles, at least 11 species of amphibians, 48 species of fishes and over 600 species of butterflies (Lachungpa U 1998). In recent years the exploitation of the natural resources has increased tremendously that threatens the natural habitats, plants and animals and especially the endemic species. The Government of Sikkim has shown increased concern over such exploitations and thus is bringing new and pristine areas under conservation network (Lepcha 1997; Lachungpa C 1998).

In Sikkim, the farming is an integrated system of agriculture, animal husbandry and horticulture (Sundriyal *et al.* 1994). Most farming systems are mixed cropping with the exception of large cardamom growing (Sharma *et al.* 1992; Sharma & Sharma 1997). Agriculture is mainly to secure home consumption, although a small surplus is sold in the local market (Sundriyal *et al.* 1994). The cash income thus comes from either through sales of surplus food crops or through animal husbandry products. Substantial income is generated through large cardamom agroforestry system (Sharma & Sharma 1997; Sharma *et al.* 2000). The scope of dairy development in the state is very high and can generate more economic benefits compared to other developments. During recent years, there has been an increasing trend to look for off-farm income, particularly for Government services. Tourism services have also become very remunerative in recent years. This sector is receiving due attention from the

Government side (Sharma 1997). Tourism offers scope for involving people at different levels i.e. as porters, naturalist guides, pack animal owners, lodge operators, trek cooks, etc. Recently Sikkim Biodiversity and Ecotourism Project focused on human resource development initiatives through training, and also enhancement of infrastructure and tourism services, conservation of natural resources and channelizing the revenue generation (Anonymous 1997). Grazing impact by livestock and pack animals have been also realized whose carrying capacity have not been worked out. Unregulated and unscientific grazing could be detrimental to the rangeland health.

The Khangchendzonga Biosphere Reserve provides a picturesque view of snowclad mountains, lakes, alpine vegetation, thick forest of temperate to subalpine zones, rich wildlife and thus holds to be the most popular tourist destination in Sikkim. Many village settlements with varied ethnic groups such as Lepchas, Bhutias, Limboos and Nepalese are in the buffer zone of the reserve and that surrounds the core zone (former Khangchendzonga National Park) while only a small settlement of 10 families of Tibetan origin settles inside the core zone at a place called as Tshoka. A 45- km Yuksam-Dzongri-Goecha La trekking corridor inside the Khangchendzonga Biosphere Reserve is one of the most important tourist destinations in Sikkim, which has identified as the priority area for tourism development by the State Government. The reserve receives supports a large number of animals from surrounding settlements as well as animals of nomadic graziers. Animals graze throughout the year at lower elevation pastures whereas during rainy and summer months at higher elevation pastures. The trail sites, camping grounds and surrounding of permanent

sheds at high altitudes show signs of overgrazing and deterioration of landscapes.

1.1 CONSERVATION AREAS OF INDIA VIS-A-VIS HIMALAYA

A "protected area" is a broad term given primarily to national parks and sanctuaries meant for affording protection to wildlife and their habitats. They also include game and biosphere reserves. The country's first wildlife sanctuary was set up towards the close of the last century as the Vedanthangal Bird Sanctuary in Tamil Nadu, however, the first National Park came into being only in 1936 in the Himalayan region with the setting up of the Hailey National Park in Uttar Pradesh, renamed as Ramganga National Park and finally as Corbett National Park. Many protected areas have been created after the enactment of Wildlife Protection Act of 1972. The state governments are empowered to constitute national parks and sanctuaries (Maikhuri *et al.* 1998). National parks and sanctuaries not only protect the wildlife but also help in educating the people about wild animals and plants and thus have importance in the present day context.

Biosphere reserves are protected areas of respective terrestrial, coastal and marine environments that have been internationally recognized for their value in conservation and in providing the scientific knowledge, skill, and human values to support sustainable development (Maikhuri *et al.* 1998). At the international level the biosphere reserve programs was launched under the auspices of the Man and Biosphere Programme in 1971 (Maikhuri *et al.* 1998). The first biosphere reserve came into being in 1976. Since then a wide network has steadily built up with about 300 biosphere reserves in more than 75 countries all over the world (Maikhuri *et al.* 1998). In India, the Indian National Man and Biosphere Committee, set up

by the Central Government, created a core group of experts in 1979 for submitting recommendations for potential areas to be constituted into biosphere reserves. The principles for declaring the area under network are; *in-situ* conservation of biodiversity (genetic resources, species, ecosystem) of natural and semi-natural ecosystems and landscapes; contribution to foster sustainable economic development of the human population living within and around the biosphere reserves and provide facilities for long-term ecological studies; environmental education and training; and research and monitoring related to local, national and global issues of conservation and sustainable development (Maikhuri *et al.* 1998). The present status of biosphere reserves in India is given in Table 1.1. Only 27% of the total area of India's biosphere reserves are in Himalayan region. In Sikkim, the area under conservation as national park/biosphere reserve and wildlife sanctuaries covers 40.66% of the total geographical land area of the state and many more areas are proposed for sanctuary status. The recently declared Khangchendzonga Biosphere Reserve and sanctuaries of Sikkim are presented in Table 1.2. Details of vegetation, wildlife and the linkages between flora, fauna and human interaction are not available in these conservation areas.

1.2 REVIEW OF LITERATURE

International scenario

Focus of this thesis is on the impact of livestock grazing on vegetation and soil properties, the review of literature has concentrated on these aspects only. The effect of grazing and environmental factors like rainfall on annual net primary productivity, species dissimilarity, quantitative and qualitative changes on herbage utilization are well

documented worldwide (Gardner & Hubbell 1943; McGinnies 1943; Canfield 1948; Gardner 1950; Biddiscombe 1953; Ketling 1954; Launchbaugh 1955; Johnson 1956; Kucera 1956; Tomanek & Albertson 1957; Carr & Turner 1959; Klipple & Costello 1960; Dix 1959; Orr 1980; Hurd 1961; Penfound 1964; Duvall & Linnartz 1967; Pieper 1968; Brown & Schuster 1969; Williams 1968, 1969; Kennan 1969; Risser & Kennedy 1972, 1975; Pearson & Whittaker 1974; Smith & Schmutz 1975; Breman & Cisse 1977; Sims *et al.* 1978; Rawes 1981; Floret 1981; Laycock & Conrad 1981; Waser & Price 1981; Chew 1982; Ayyad & El-Kadi 1982; Holechek & Stephanson 1983; Edroma 1984; Bock *et al.* 1984; Wood & Blackburn 1984; Belsky 1986; Collins 1987; Gibson 1988; Roundy & Jordan 1988; Lewis *et al.* 1988; Novellie 1988; Abulfaith *et al.* 1989; Thurow & Hussein 1989; Brady *et al.* 1989; Milchunas *et al.* 1989; Hofmann & Ries 1989; Dormarr *et al.* 1989).

Effect of livestock grazing on soil chemical properties has been studied by many workers (Ruess & McNaughton 1987; Dormaar & Willms 1990; Dormaar *et al.* 1990; Manley *et al.* 1995) and had reported the increase of soil organic carbon and nitrogen due to livestock grazing while other studies have found no response in soil organic carbon and nitrogen to grazing (Milchunas & Lauenroth 1993; Kieft 1994; Mathew *et al.* 1994). On the other hand it has been reported that grazing reduced soil organic carbon and increased soil organic nitrogen (Bauer *et al.* 1987). In contrary there is a report that says grazing losses soil carbon and organic carbon (Holland *et al.* 1992). Precipitation and temperature limit aboveground biomass production and soil organic matter (Parton *et al.* 1987), and influence the rate of litter decomposition and nutrient cycling (Charley 1977).

Alpine areas have been the centre of curiosity and investigation since long past. The early alpine studies centered upon descriptions of plant communities and floristic (Cooper 1908; Holm 1927; Cox 1933). During recent years studies were centered on integrating meso- and micro-environmental data to explain plant community patterns and production potentials (Bliss 1956, 1963, 1966, 1969, 1979; Johnson & Billings 1962; Douglas & Bliss 1977; Scott & Billings 1964; Kuramoto & Bliss 1970; Webber & May 1977). Some workers also synthesized the studies of International Biological Program for characterizing and understanding of structural and functional relationships in alpine ecosystems (Bliss 1977; Tieszen 1978; Brown *et at.* 1980; Tieszen *et al.* 1981; Bliss 1962; Scott & Billings 1964; Bliss 1966; Whittaker 1966). Estimation of primary productivity and yield in alpine and arctic vegetation has been assembled by Bliss (1962a). More detailed analysis of field standing crops and productivity in two widely separated alpine regions have been provided by Scott & Billings (1964) and Bliss (1966). Bliss (1962a) says that annual shoot productivity of tundra ecosystem are within the range of 40-128 g m^{-2} $year^{-1}$ but may be as low as 3 g m^{-2} $year^{-1}$ in high arctic. On the world-wide basis, grasslands (including savanna and shrub steppe) represent the potential natural vegetation on 25% of the land surface (Shantz 1954), and account for about 16% (1.89×10^{10} tons $year^{-1}$) of terrestrial-plant communities (Whittaker & Likens 1975).

Indian scenario

Grasslands of tropical India have been studied vastly by various workers like Pandeya (1961, 1964), Singh (1967, 1968), Singh & Yadav (1974), Billore & Mall (1976), Bisht (1980), etc.

At higher altitudes of the western Himalaya, Mani (1978), Pandey (1981), Gupta (1984, 1985, 1986), Sundriyal (1986), Ram *et al.* (1988, 1989), Sundriyal & Joshi (1990), have done extensive work on grassland ecology. In 1906 Duthie presented the revised catalogue of plants of Kumaon and adjacent areas of Garhwal, originally based on the collections of plants made by Strachey and Winterbottom during 1846-1849, including the works of Wallich, Royle, Falconer and Thomson. Rau (1964) has made comprehensive collections from different altitudes of North Garhwal. Rau (1975) has also published an extensive compilation of high altitude flowering plants of the western Himalaya. Royle, Coventry and Blatter studied the beautiful plants of the western Himalaya (Rau 1975) laying more emphasis on Kashmir valley in the extreme west of the Himalaya. Dhar & Kachroo (1993) did a good account on floral composition of Kashmir Himalaya. Agarwal (1959) and Gupta (1974) have reported different types of grasses in the western Himalaya. Numata (1983) and Tsuchida (1983) have done similar work in the Nepal Himalaya.

Biomass distribution of the Himalayan pastures are reported (Kaul & Sapru 1973; Yadav & Kakati 1974; Singh LN *et al.* 1975, Saxena & Singh 1980; Numata 1983; Melkania & Tandon 1983a, 1983b; Bisht & Gupta 1985; Gupta SK 1986; Tiwari 1986; Agarwal & Goyal 1987; Srivastava 1987; Joshi *et al.* 1988; Ram *et al.* 1989; Ramakrishnan & Ram 1988; Rodgers 1990; Sundriyal & Joshi 1990; Rikhari *et al.* 1992; Gupta RK 1993; Sundriyal 1995). There is a varying trend in aboveground phytomass at different areas showing 1000 kg ha^{-1} in low production grasslands to about 10,000 kg ha^{-1} at lower and mid-altitudes, and between 400-5000 kg ha^{-1} for high altitude grasslands in the Himalaya. Kira & Shidei (1967), Yoda (1968), Maruyama (1971) and Nautiyal (1982) have reported that the

productivity in terms of dry weight biomass of plant decreases with the increasing altitude. In the Himalaya, productivity increases slightly from the western to central and maximizes in the eastern Himalaya, probably due to better growing conditions (Sundriyal 1995a). Joshi & Srivastava (1991) and Sundriyal *et al.* (1993) has documented effects of intermittent grazing. Saxena & Singh (1980) in the western Himalaya carried out relationship between forage yield and climatic condition. Grazing performance and quality and quantity of herbage production for dietary requirement have been made by Jackson (1981, 1983) and Balaraman & Golay (1991). Clipping, intermittent or rotational grazing are reported beneficial to the plant productivity (Srivastava 1987; Sundriyal *et al.* 1993; Rikhari & Negi 1993). A number of agroforestry species, which are good fodder, are being maintained by villagers throughout the Himalaya for meeting the fodder requirement of livestock (Pal *et al.* 1979; Balaraman 1981; Bhatt 1991; Sundriyal *et al.* 1994). Animals have the natural instinct of choosing habitats, vegetation types and plant species or parts of vegetation as per quality and availability of forage (Srivastava 1987; Agarwal & Dhasmana 1989; Singh 1991; Sundriyal 1994)

Economy and conservation of biodiversity can be regarded as interlocking to each other. Environmental degradation in grazed system is frequently exacerbated by socio-economic constrains in both developed (Conner 1991) and developing countries (Standford 1983). Noy-Meir (1993) emphasized the effect of grazing regime on forage quality and utilization, species composition and seasonality of supply are often just as important for animal production and economic success. In this wide sense, grazing optimization is a central concept of rational range management for production and on this aspect a lot of workers has done exclusive works

(Bartoloma 1993; Briske 1993; McNaughton 1993; Noy-Meir 1993; Painter & Belsky 1993; Mazacourt *et at.* 1998). Multiple factors (altitude, slope, aspect, basal coverage, soil types, biotic pressure and succession status) influence to grassland composition and are reported (Patil & Pathak 1980; Saxena & Singh 1980; Singh & Saxena 1978; Melkania & Tandon 1983a, 1983b; Gupta 1986). Singh & Naik (1987) reported overgrazing of about 9000 km^2 in UP hills. In the Central Himalaya 5.084 cattle units are grazing on per hectare land, which is about 2-3 times higher than the actual carrying capacity of the land (Pandey *et al.* 1982). A similar situation has also been reported in Nepal (Giri 1989).

The status and ongoing research activities concerning flora and fauna and their conservation strategies of biosphere reserves of India are available; Nilgiri in Tamil Nadu (Neelakantan 1998), Karnataka region (Yekanthappa 1998), Kerala region (Sinha 1998), Nanda Devi (Kumar 1998), Nokrek (Ashutosh 1998), Great Nicobar (Anonymous 1998a), The Gulf of Mannar (Anonymous 1998b), Manas (Agarwalla 1998), Sunderban (Singh 1998), Similipal (Srivastava & Singh 1998), Dibru-Saikhowa (Anonymous 1998c) and Dihang-Debang (Anonymous 1998d). All these researches are mainly based on compositional survey and pattern characterization. No detail report is available on livestock grazing, their causative effect on plants and soil, and on the relationship with rural economy. The present study is an attempt to find out the relationship between plant, animal, soil and economy related to livestock and their products and tourism related livestock entrepreneurial in a protected area.

Sikkim Himalaya

Hooker (1875) gave a comprehensive account on the floristic wealth of Sikkim Himalaya. Smith (1911) recorded the vegetational components of alpine and subalpine areas of South-East Sikkim. Smith & Cave (1911) studied the floristic composition of alpine and subalpine of Lhonakh Valley in Sikkim. A comprehensive work on medicinal plants from Sikkim Himalaya was also reported (Biswas 1956). A good account of the flowers of Himalaya was given by Polunin & Stainton (1984) but a very little was mentioned about Sikkim Himalaya. Pradhan & Lachungpa (1990) reported 38 species of *Rhododendron* from the Sikkim. Kumar and Singh (1993) reported about 250 species of grasses from Sikkim Himalaya. Balaraman & Golay (1991) carried out livestock and management studies of Sikkim emphasizing more on livestock health and maintenance. Village ecosystem study covering livestock rearing in the Mamlay watershed of South Sikkim was made by Sharma *et al.* (1992). Paljor (1997) has reported livestock economy and its impact on the environment in North Sikkim. Indo-Swiss Project has reported compiled comparative livestock health and development in six villages of Sikkim namely Luing, Central Pandim, Namthang, Poklok-Nandugaon, Dodak and Dentam (Kurup 1997).

No work has been done on monitoring and applied research on plant, animal and soil interaction especially of livestock grazing and its causative effect on the environment in the Sikkim Himalaya especially in the Khangchendzonga Biosphere Reserve. The present thesis deals with the findings of studies on livestock grazing, agriculture and tourism linkages. This work emphasizes on the impact of grazing on vegetation, nutrient and

soil properties and its dynamics and linkages on rangeland and biodiversity for development of management and conservation strategies.

Table 1.1 Present status of conservation (biosphere reserves) areas in India.

Status	Name of the biosphere reserves	State (s)/UT	Date of notification	Area (km^2)
Declared	Niligiri	Karnataka, Kerala and Tamil Nadu	01/08/1986	5520.0
	Nanda Devi	Uttar Pradesh	18/01/1988	2236.7
	Nokrek	Meghalaya	01/09/1988	820.0
	Great Nicobar	Andaman & Nicobar	06/01/1989	885.0
	Gulf of Mannar	Tamil Nadu	18/02/1989	10500.0
	Manas	Assam	14/03/1989	2837.0
	Sunderbans	West Bengal	29/03/1989	9630.0
	Similipal	Orissa	21/06/1994	4374.0
	Dibru-Saikhowa	Assam	28/07/1997	765.0
	Dehang-Debang	Arunachal Pradesh	02/09/1998	5111.5
	Khangchendżonga	Sikkim	07/02/2000	2619.9
Identified	Namdapha	Arunachal Pradesh	-	-
	Valley of flowers	Uttar Pradesh	-	-
	Thar desert	Rajasthan	-	-
	Little Rann of Kutch	Gujrat	-	-
	Kaziranga	Assam	-	-
	Andaman	Nicobar	-	-
			-	-
Proposed	Abujmarh	Madhya Pradesh	-	-
	Pachmarhi	Madhya Pradesh	-	-
	Amarkantak	Madhya Pradesh	-	-
	Cold Desert	Jamu & Kashmir and Himachal Pradesh	-	-
	Seshachalam	Andhra Pradesh	-	-
	Chintapalli	Andhra Pradesh	-	-
	Lakshdweep Islands	Lakshdweep	-	-

Source: Maikhuri *et al.* 1998.

Table 1.2 Protected areas in Sikkim

Biosphere reserve/Sanctuary	Name of the Biosphere reserve/sanctuary	District (s)	Elevation (m)	Area (km^2)
Biosphere reserves	Khangchendzonga	North & West	1600-8598	2619.92
Sanctuaries	Shingba Rhododendron	North	3300	43.00
	Kyongnosla Alpine	East	3292-4110	31.00
	Fambong Lho Wildlife	East	1524-2750	51.76
	Barsey Rhododendron	West	1700-4500	104.00
	Maenam Wildlife	South	-	35.34
Total	-	-	-	2885.02

Source: Maikhuri *et al.* 1998.