

**Livestock Grazing and Conservation of Biodiversity in
the High Altitude Ecosystem – An Integrated
Landscape Management Approach**

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Rajkot (Gujarat)**

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In
Wildlife Science**

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Certificate

This is to certify that the thesis of **Mr. Badrish Singh Mehra** entitled ***“Livestock Grazing and Conservation of Biodiversity in the High Altitude Ecosystem – An Integrated Landscape Management Approach”*** is an original piece of work, submitted to the Saurashtra University, Rajkot (Gujarat), for the award of the **Doctor of Philosophy in Wildlife Science.**

Mr. Mehra has put in more than six terms of research work embodied in this thesis under my guidance and supervision. The work presented in this thesis has not been submitted for any degree of any other University or Institution.

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Executive Summary

Introduction: An increasing emphasis on the maintenance of healthy, productive and diverse ecosystems has been laid in recent conservation policies, strategies and guidelines for the continued well-being of human societies and to the land itself. The word 'Conservation' as such implies wise sustainable resource use. The conservation of biodiversity or biological diversity calls for maintaining variety and variability of life and associated ecological processes. Maintaining biodiversity entails addressing resources at various biological levels *viz.*, genetic, species, population, community, ecosystem and landscape. Every element of biological diversity has some economic and ecological value. Several new tools and approaches have been described in recent past for the conservation of biodiversity. A network of biogeographically representative protected areas (PAs) has been recognized as a means of conservation. A network of PAs comprising National Parks (NPs) and Wildlife Sanctuaries (WLS) has been established in India. Although the present wildlife law in the country prohibits human settlements, cattle camps, and livestock grazing inside the NPs and allows only regulated grazing even in the case of WLS, in practice, this is not the ground reality in several of the PAs. More than 80% of the Indian PAs have cattle grazing.

The Study Area: The present study was undertaken in the Great Himalayan National Park Conservation Area (GHNPCA), Himachal Pradesh comprising three PAs *viz.*, the Great Himalayan National Park (GHNP), Tirthan Wildlife Sanctuary, Sainj Wildlife Sanctuary and an Ecodevelopment Zone (EZ) encompassing an area of 1,171 sq km. The GHNPCA represents the biogeographic zone – 2A North-West Himalaya and thus the study area lies in Kullu district of Himachal Pradesh and is located at the junction of two great faunal realms: Palaeartic to the north and Oriental to the south. The Conservation Area makes catchments of Tirthan, Sainj, Jiwa and Parvati rivers which together form the upper catchment of one of the major perennial rivers in the region i.e. river 'Beas'. Much of the eastern part of the GHNPCA is perpetually snow bound.

The local inhabitants in the GHNPCA have reared livestock since time immemorial and have followed transhumant pastrolism. According to the common belief amongst the local people, conservationists and wildlife managers, the livestock population and herd or flock size have increased substantially overtime; grazing practices are harmful to wildlife and also leading to large scale degradation; and unregulated grazing in forests and alpine pastures is not compatible with the long term conservation objectives.

The Aim And Approach: The present study therefore, aimed to assess various issues of livestock grazing on a regional landscape basis and to suggest a long term strategy for integrating sustainable grazing compatible to biodiversity objectives. The study formed a part of the major 5-year Forestry Research, Education and Extension Project (FREEP)

implemented in the GHNPFA and its surrounds. Several other multi-disciplinary research studies were also concurrently undertaken.

Earlier several isolated research studies on the specific different aspects of livestock grazing within and outside the country have been completed. They have hardly provided an insight on the implications of livestock grazing from the PA management perspective. It was therefore, decided to use a holistic approach for the various types of field assessments during the present study so as to understand the multiple dimensions of livestock grazing. The study thus, used a landscape approach to address this major concern of the PA management. The GHNPFA was recognized as one landscape. A hierarchical approach was adopted to make assessments at the stand, species, ecosystem and the landscape levels so as to make a systematic understanding of the physical, biological and social environments of the landscape *vis-à-vis* dependent livestock and the grazing practices of migratory pastoralists. A combination of traditional field assessments and modern techniques like remote sensing and GIS was used. Amongst traditional techniques, use of secondary information, questionnaires, interviews (villagers, pastoralists and PA officials), field estimates, inventories and ground quantification of various habitat variables were carried out.

The Landscape – Its Environment and Pastoralism: The spatial heterogeneity in terms of vertical and horizontal complexities arising due to varied land forms, altitudes, slopes, aspects and past management has characterized the landscape by a rich diversity of ecosystems, habitats and floral and faunal species. Landscape is featured by a marked altitudinal gradient from 1,300 m to 6,110 m a.m.s.l. The landscape harbours varied temperate forests, sub-alpine and alpine pastures. More than 1,500 species representing different plant and animal taxonomic groups have been described so far for the landscape.

Interestingly, > 87% area of the EZ lies below 3,200 m elevation, while on the contrary three PAs had 83.9% of their total area at >3,200 m altitude. The EZ harboured bulk of the forest and was highly deficient of alpine pastures. In contrast, the three PAs possessed disproportionately greater chunk of alpine pastures in comparison to EZ. Like any other mountainous landscape, the GHNPFA was also colonized well over 2,000 years ago and man has utilized the natural resources for himself and for his livestock. The dynamic landscape comprising diverse ecosystems, man and his livestock have thus co-evolved and they are tied up as a complex fabric. Almost entire human population residing in the GHNPFA was directly dependent on just 5.89% of the total landscape for agriculture and horticulture purposes. The landscape experiences harsh climatic conditions. Long winter season constrained major outdoor activities and natural resource use. The constraints have led to an increased dependence on the natural resources of forests, pastures and livestock rearing for sustenance and economy.

The landuse pattern revealed that different types of forests, grass patches and alpine pastures covered 62.1% of the total landscape while nearly 1/3 of the landscape was not available for any meaningful purpose as such areas were either constituted by rivers, water bodies, permanent snow or rocky slopes, cliffs and morains. The EZ which possessed the majority of the resident livestock had only 3.62% of the alpine pastures areas. The bulk of the alpine pastures i.e. 73.3% of the total alpine pastures were located in the GHNP area alone.

The study revealed that the age old practice of seasonal transhumant pastoralism and their life style largely remained unaffected despite several changes brought in during the different ruling regimes, new technologies and overall development since the Pre-colonial period to till date. The caste system has influenced the social structure, work distribution and resource use. The landscape had a total pressure of an estimated 33,000 to 38,000 livestock including resident of GHNPCA as well as migratory beyond the Conservation Area. Sheep and goat form bulk of the livestock. The pastoralism has remained the central point of traditions, lifestyles, activities, economy, self-sufficiency and sectoral linkages (pastures-forests-agriculture-household-market). The pastoralism is based on the sound principles of optimum seasonal use of natural resources while ensuring its long term sustainability and stability of grazing resources. Each pastoralist follows a well-defined grazing route, camping sites, grazing resources and duration of their stay or resource use in each of them during their summer migration to higher reaches or alpine pastures. Mainly four types of grazing resources viz., (a) Village pastures and village surrounds (VS); (b) Migratory Routes through different temperate and sub-alpine forests (MR); (c) Transitory Forest Camping Sites (TFCS); and (d) Alpine pastures (AP) were utilized by the migratory livestock. A total of 161 pastures were identified, listed and mapped. Out of this, 111 or 68.9% were located in the GHNP alone. Another 30 or 18.6% pastures were located in two other PAs. Thus, remaining 20 pastures or 12.4% of the total pastures visited by pastoralists in the GHNPCA were located in the EZ.

The Grazing Resources – Current Status: The empirical results based on field assessments on the floral species diversity, biotic pressure and overall status of selected grazing resources under above four categories indicated high and unique diversity. In contrast to the common belief, the biotic pressure including the livestock grazing pressure was highly localized and thus, confined to smaller areas. As such the resource pattern in different types of grazing resources at any one time was widely distributed. Comparative to other adjoining similar areas, the overall grazing pressure in the GHNPCA was quite low. This low pressure was also well distributed across various sub-watersheds, scattered village surrounds, several migratory routes and numerous temperate, sub-alpine and alpine pastures. Obviously, this type of spatial and temporal use of grazing resources despite transhumant pastoralism being practiced over a long period of time has allowed to maintain a high level of species diversity. The present study has not yielded any evidence, which

reflected severe impairment of natural system and its diversity. Moreover, the floral and faunal communities in the GHNP/PCA have well adapted to livestock grazing and to some extent they are thus grazing dependent. Though some adverse impact on habitats, particularly distribution and abundance of floral and faunal species was recorded due to allied activities of pastrolists and others *viz.*, herb collectors, visitors, pilgrims, etc., however, no alarming or severe impact of livestock grazing on the landscape, its varied wildlife and other ecological values was observed.

The traditional way of seasonal resource use, mixed economy and simple life style had so far provided self-sufficiency to the local people. The present study amply indicated that the GHNP/PCA is probably one of the typical examples wherein the livestock grazing practised over a long period of time has probably not demonstrated any severe adverse affect on the landscape and its values. Indeed livestock grazing was efficiently regulated by the pastrolists year after year despite difficult terrain and harsh climatic conditions.

However, these mechanisms of self-sufficiency have been increasingly hindered due to growing demands, market forces; faulty landuse practices; curtailment of seasonal spatial resource use; and over-burdening of already limited and depleted available grazing resources. People have enjoyed extensive rights granted to them during the Colonial period till recent past. The traditional rights including that of grazing by migratory livestock in the alpine pastures in the largest constituent of the GHNP/PCA i.e. the Great Himalayan National Park covering 754.6 sq km or 64.4% of the landscape have been recently extinguished in order to bring out the final notification of the GHNP.

Pastrolism – Future Implications and Recommendations: Under the changed scenario due to the exclusion of traditional multiple resource use in the GHNP and subsequent active protection of natural resources would definitely lead to an overall recovery of forests and pastures in the GHNP after a long history of gradual degradation, if any. This way, the conservation goals expected of a National Park would be fulfilled. However, at this stage it is difficult to predict that how this overall ecological recovery would affect individual plant and animal species or even the overall diversity at the species level. Further, the non-availability of 64.4% of the total area of landscape or GHNP possessing 68.9% pastures visited by migratory livestock is likely to overburden the remaining area by several fold increased livestock pressure, which would ultimately accelerate the degradation process of those remaining grazing resources. Consequent to this, the default elimination of sheep and goat husbandry, creating unnecessary hardship for dependent communities and loss of overburdened grazing resources in the GHNP/PCA could only be expected. Increased conflicts and some setback to the newly initiated ecodevelopment strategy adopted by the PA management cannot be over ruled.

The study also points out that usually the livestock and pastoralists have been solely blamed for any type of destruction or decline of biodiversity. Natural factors, market forces, other resource use, past management practices, faulty landuse and other illegal activities (poaching, etc.) together are probably having a greater, compounding and permanent influence.

The study recommends for delineation of PA boundaries in high altitude landscape carefully on the basis of physical characteristics and availability of representative natural resources considering the vertical and horizontal landscape intricacies and large scale variations in the physical environment. The study also recommends to maintain a diversity of diversity or a mosaic through spatial distribution of variety of habitats, patch sizes, seral stages and forest/pasture stand attributes and structures while maintaining connectivity among them. The livestock grazing in the region can be and should be practised on the sound principles of spatio-temporal use of grazing resources instead of overburdening them at any given time. This calls for the distribution of uniform livestock pressure as far as possible across different villages, migratory routes, camping sites, grazing resources, sub-watersheds and the overall landscape. A conservation awareness campaign for the local community is also recommended so as to educate them about the ill-effects of site-specific pressure exerted by lopping and girdling of trees, etc. At the end and consequent to the closure of traditional migratory livestock grazing in the GHNP, the present study suggests for a comprehensive strategy for experimental research and in-built long term ecological monitoring for the sound PA management so as to ensure a long term sustainability of the unique and diverse high altitude ecosystem of the GHNPCA.

Introduction

1.1 The Preamble

The high altitude landscape comprising varied ecosystems - sub-tropical, temperate and sub-alpine forests and alpine pastures in the Himalayan region harbours rich biodiversity and represents one of the most important, fragile and threatened life support system on the earth. The Himalayan mountain ranges representing two prominent Indian biogeographic zones viz., the Trans-Himalaya and the Himalayas, together occupy nearly 10.9% of the country's total land surface (Rodgers and Panwar, 1988). However, their values in terms of natural resources is much greater than the area implies. The most important resource is water. Nearly one-third of the country's population in the Indo-Gangetic Plains are totally dependent on the Himalayan rivers for drinking, irrigation, electricity and industry. Moreover, since time immemorial local people have used forests and pastures throughout the Himalayan region for multiple uses and values. Among these, prominent ones are collection of herbs and medicinal plants, fuelwood and fodder, agriculture and livestock grazing. Pastoralists migrate from lower reaches to alpine pastures every summer along with large herds of sheep and goat. Indeed, traditionally the livestock rearing in the region has been the backbone of local economy. However, in recent years it has been felt that traditional land use practices and ever increasing human

demands are probably neither sustainable nor conducive to the long term biodiversity conservation objectives.

1.2 The Major Project

In order to ensure long term conservation goals, a World Bank aided project on the Conservation of Biodiversity through ecodevelopment approach was undertaken by the Himachal Pradesh Forest Department (HPFD) in the Great Himalayan National Park Conservation Area (GHNPCA). The project has been designated as the **"Forestry Research Education and Extension Project (FREEP)"**. The FREEP had three main objectives: (i) to improve Protected Area (PA) management; (ii) to reduce people's dependencies on PAs through village ecodevelopment; and (iii) to organise and conduct research, monitoring and education programmes to support PA management. The research and monitoring component under the major project was assigned to the Wildlife Institute of India (WII), Dehra Dun. As a part of the five-year research project, the present study (one of the major tasks) was undertaken which aimed to address different aspects of livestock grazing while integrating this with the overall conservation objectives of GHNPCA.

1.3 The Justification of the Present Study

During the last 2-3 decades, several survey studies on the status and floristics of high altitude forests and alpine ecosystems have been undertaken in different regions of the Himalayan biogeographic zone. Likewise, several studies dealing

with the inventory, mapping and classification of grazing and forest resources; successional changes, productivity performance, plant-animal interactions, diet selection by grazing animals, nutritional value of preferred plants, habitat use by wild herbivores and socio-economics and mitigation aspects of pastoralism are available. As such the subject of grazing land ecology has been dealt extensively throughout the country. But, the alpine pastures in the North-West Himalaya are probably the least investigated ecosystem. Virtually either very little or scattered information exists on different aspects of livestock grazing and dependent pastoralists. It is not intended here to present an exhaustive review of literature. Most of the past studies either focus on autecology or synecology. Probably none of the studies has tried to integrate different dimensions of livestock grazing and its associated management issues. Realising the traditional dependence of local people on livestock rearing in and around the GHNPCA and its long term implications for the conservation of biodiversity and overall environmental security of the highly fragile ecosystem, the present study was undertaken. This is probably the first attempt wherein an integrated landscape management approach was used for assessing various issues of livestock grazing alongside the biodiversity concerns in the conservation area.

1.4 Biodiversity Concerns and the Landscape Approach

With a temporal shift in thinking, perception and enforcement of recent conservation laws and policies, it is considered appropriate first to briefly dwell upon the various approaches applied world wide for the conservation of biodiversity, before going into details of the present study. The Wildlife

(Protection) Act (Anon., 1972); the Forest (Conservation) Act, 1980 (Bagga, 1989); National Forest Policy (GOI, 1988); National Conservation Strategy (Anon., 1992); UNCED Convention on Biological Diversity, 1992; and the initiation of bold and innovative efforts like the Project Tiger, 1973; Planning for Protected Area Network in India (Rodgers and Panwar, 1988) focusses on the legal and policy foundations relevant to the environmental security and conservation of biodiversity.

Increasing emphasis on the conservation of biological diversity or biodiversity calls for maintaining variety and variability of life and associated ecological processes. Maintaining biodiversity entails addressing resources at various biological levels *viz.*, genetic, species, population, community, ecosystem and landscape (Marcot, 1989 and 1992; Noss, 1990(a); Hunter, 1990 and 1991; Williams and Marcot, 1991; Walker, 1992; Salwasser, 1995; Darden and Marcot, 1995; Naveh, 1995; Biodiversity Guidebook, 1995).

There has been a growing awareness among people that healthy, productive and diverse ecosystems are essential for the continued well-being of human societies and to the land itself (Davis, 1989; Salwasser, 1995). Thus, the resource managers, world-over are facing complexities arising, on one hand due to a complete shift in thinking, concepts, and approaches *viz.*, timber production to forest conservation, sustained yield to sustainability of ecosystems, single species management to the conservation of biodiversity, etc. while on other hand fast-shrinking forests, excessive grazed grazing lands, and further aggravating human demands on these resources lead to conflicts. A network of

biogeographically representative protected areas (PAs) has been recognised as a means of conservation.

1.4.1 Protected Area Management - Challenges: A network of protected areas (PAs) comprising National Parks (NPs) and Wildlife Sanctuaries (WLS) has been established in India (Rodgers and Panwar, 1988). Although the Wildlife (Protection) Act, 1972 prohibits human settlements, cattle camps, and livestock grazing inside the NPs and allows only regulated grazing even in the case of WLS after its second time amendment in 1991, in practice this is not the ground reality in several of the PAs (Mathur, 1991). Kothari *et al.* (1989) in their review on the management of Indian PAs have reported that about 80% of the PAs have cattle grazing, about 25% of them have more than 50 head of cattle per sq km apart from goats.

Except a few sporadic successful relocation schemes of shifting village settlements from the NPs, desired level of success has not been achieved due to conflicting socio-economic-political considerations. For the want of such relocations and extinguish of rights and concessions, several NPs still await their final legal notification. As remarked by Brown (1971) and stated by Mathur (1991), Kothari *et al.* (1989), the most serious threat faced by Indian wildlife or PAs is not so much by poaching as by the irreversible destruction of habitat is being induced by man either directly or indirectly through his domestic animals.

The resource managers, particularly foresters are expected to address three timeless forestry goals viz., (i) ensure environmental security by protecting soil,

water, air and biological diversity; (ii) meet the basic needs of the people who depend on them for food, fuel, shelter, livelihood and recreation, and unity with nature; and (iii) contribute to short and long term social and economic development.

1.4.2 Biodiversity Conservation - Prospects: In spite of above described complexities and challenges faced by resource managers, ample opportunities and directions have been highlighted in the recent literature for managing different ecosystems for multiple values and uses. Several new tools and approaches those have been described in this regard are: flagship and umbrella species management (Marcot, 1989 and 1991; Hunter, 1990); coarse and fine filter approach (Hunter, 1991; and Biodiversity Guidebook, 1995); watershed management (Kunkle, 1986; Franklin, 1992); multiple purpose silviculture (Benskin and Bedford, 1995; Brand and LeClaire, 1994); sustainable forest management (Lanly, 1995); integrated resource or environmental management, (Hunter, 1990; Teer, 1991; Marcot, 1992; Salwasser, 1991, 1994, and 1995); holistic landscape conservation - Williams and Marcot, 1991; Naveh and Lieberman; 1993, and Naveh 1995; Karr, 1992 and 1994; Lucas, 1992; Risser *et al.* 1984; Noss, 1983, 1987, and 1990 (a) and (b).

Most of the above stated approaches are of recent origin, they largely provide insight but lack in details of field implementation, demonstration and appropriate

examples of successful case studies. Some of the above concepts and strategies are briefly highlighted below:

- (i) Initially the term biological diversity or biodiversity meant different things to different people (Noss, 1990b). Now with the advent of growing knowledge biodiversity is seen as an environmental end point. It is amply clear that biodiversity is a variety and variability of all life forms along with associated ecological processes and therefore includes all domestic, cultivated and wild plants and animals.
- (ii) Biodiversity concerns can be better dealt holistically, rather than in the traditional and fragmentary species-by-species manner by just management of rare and endangered, keystone, indicator species or some guilds. The intent is to maintain in perpetuity all native species of plants and animals across their historic ranges.
- (iii) Management of biodiversity is relevant to landscape regardless of administrative boundaries. Landscape units (a watershed or series of similar and interacting watersheds) are the basis on which the success of biodiversity management can be evaluated.
- (iv) The conservation of biodiversity depends on a co-ordinated strategy, effective communication and joint participation by all concerned.
- (v) Where past forest management practices or other biotic influences have resulted in degraded forest or grazing land situations, biodiversity can be restored to some extent over time by managing the land to create - or recover - the required ecosystem elements.

1.5 The Main Aim

In the above context, the present study was undertaken in the Great Himalayan National Park Conservation Area (GHNPCA) and its surrounds with an aim to assess various issues of livestock grazing on a regional landscape basis and to suggest a long term strategy for integrating sustainable grazing compatible to biodiversity objectives.

1.6 The Hypotheses

The study aimed to address some common pertinent questions *viz.*,

- Is the current level of livestock grazing in the study area compatible with the long term conservation objectives?
- Can livestock grazing co-exist with other sympatric wild species?, and
- How best the diversity and productivity of forests and alpine pastures can be maintained in future along side sustainable livestock grazing?

1.7 The Objectives

In order to achieve requirements of the above stated aim and answer the hypotheses posed, the following objectives were set forth:

- (a) To make inventories of grazing resources and dependent livestock in the study area.
- (b) To classify, assess and determine utilisation pattern of available grazing resources, and provide information on their conservation status.
- (c) To develop an understanding of ecological relationships with greater emphasis on alpine pastures.
- (d) To suggest a long term monitoring programme for recording changes resulting due to livestock grazing.
- (e) To provide management prescriptions both at the landscape and site specific level for sustainable livestock grazing in the area.

1.8 Organisation of the Thesis

This thesis contains Six Chapters. The Chapter 1 deals with the general introduction highlighting the concerns arising due to livestock grazing in the fragile high altitude Himalayan landscape *vis-a-vis* biodiversity conservation, the major research project, rationale of the study, the main aim, hypotheses posed and the objectives set-forth. The Chapter 2 describes the study area and various approaches adopted to achieve the objectives of the present study. The Chapter 3 profiles the landscape, its environment and also presents an assessment on the distribution, types and extent of grazing resources. This

Chapter highlights the physical, biological and socio-economic environments of the landscape and attempts to establish linkages with different aspects of livestock grazing in the study area. The Chapter 4 describes the structure and composition of various grazing and fodder resources, assess the current biotic pressures on these resources, and also determine their overall conservation status. The Chapter 5 examines the grazing practices and determines socio-economics of the graziers. The Chapter 6 discusses the present study adopting a holistic approach to evaluate biological, sociological and conservation implications of current livestock grazing practices *vis-à-vis* with the changing scenario, policies, law and consequent life styles. This Chapter concludes the study by presenting specific recommendations for the site as well as landscape level management approaches while emphasizing future research and integral monitoring needs. The Chapter 6 is followed by a list of references.

The Study Area and Approach

2.1 The Study Site

The present study was carried out in the Great Himalayan National Park (GHNP) and its surrounds. Hereafter, called as the GHNP Conservation Area (GHNPCA). The area is situated between latitude 31°33'00" and 31°56'56" North and longitude 77°17'15" to 77°52'05" East. The study area comes under the biogeographical zone - 2A North-West Himalayas (Rodgers and Panwar, 1988). Administratively, the Great Himalayan National Park lies in Kullu District of Himachal Pradesh and is located on the junction of two great faunal realms: Palaearctic to the north and Oriental to the south (Mackinon *et al.* 1986). The conservation area makes catchment of Tirthan, Sainj, Jiwa and Parvati rivers which together forms the upper catchment of one of the major perennial rivers in the region i.e. river 'Beas'. Much of the eastern part of the GHNPCA is perpetually snow bound or under snow (Sharma, 1987). The human population exists only on the western and the north western boundary of the park, the other area are demarcated by high ridges and peaks. The GHNPCA is having three constituent PAs i.e. GHNP and two Sanctuaries (Tirthan and Sainj), these were declared by two subsequent gazette notification(s) in the year 1984 and 1994, respectively (IIPA, 1995).

The GHNP area is free from village settlements, except it continued to have old rights and concessions mainly related to the right of way, collection/harvest of various forest produces and use of alpine pastures for livestock grazing until the recent past. The final notification of GHNP was long due for the want of settlement of these rights and concessions granted to local people earlier (Anderson, 1886). It was however, by the intervention and specific directives issued by the Supreme Court of India as a result of the Public Interest Litigation (PIL) praying for the effective conservation of protected areas in the country by ensuring early enforcement of legal provisions made under the Wildlife (Protection) Act, 1972 that the process of settlement in the case of GHNP was accelerated. At last, the Government of Himachal Pradesh issued the final notification no. FFE – B – F (3) – 2/99 dated 28 May, 1999 for GHNP. This sudden process of settlement and issue of the final notification after a long gap from the date of initial notification in the year 1984 has resulted primarily into: (i) the abrupt acquisition of traditional rights and concessions (specifically collection of medicinal herbs and livestock grazing) to local people by paying compensation; and (ii) slight alterations in the legal boundaries and area statistics of GHNP. Since the present study was carried out during 1995-1998 prior to the final notification, the collection and analysis of field data was already completed prior to the recent development. It was only at the time of final writing/synthesis of this report that the local situation pertaining to the livestock grazing in GHNP has altered and thus, called for a second look to the grazing problem in the changed scenario and its implications for conservation and pastoralism as such. In view of the above stated position, the presentation of results, graphics and discussion are mainly based on the pre-

revised status. However, likely implications of recent development have been appropriately looked into while describing specific recommendations for the management.

The GHNPCA covers an area of 1,171 sq km and its four constituents (**Fig 2.1**) are: (i) the Great Himalayan National Park (GHNP), (ii) Sainj Wildlife Sanctuary (Sainj WLS), (iii) Tirthan Wildlife Sanctuary (Tirthan WLS), and (iv) Ecodevelopment Zone (EZ). A comparative account of the area statistics for the constituent PAs and EZ prior to and after the recent legal changes is presented below in **Table 2.1**.

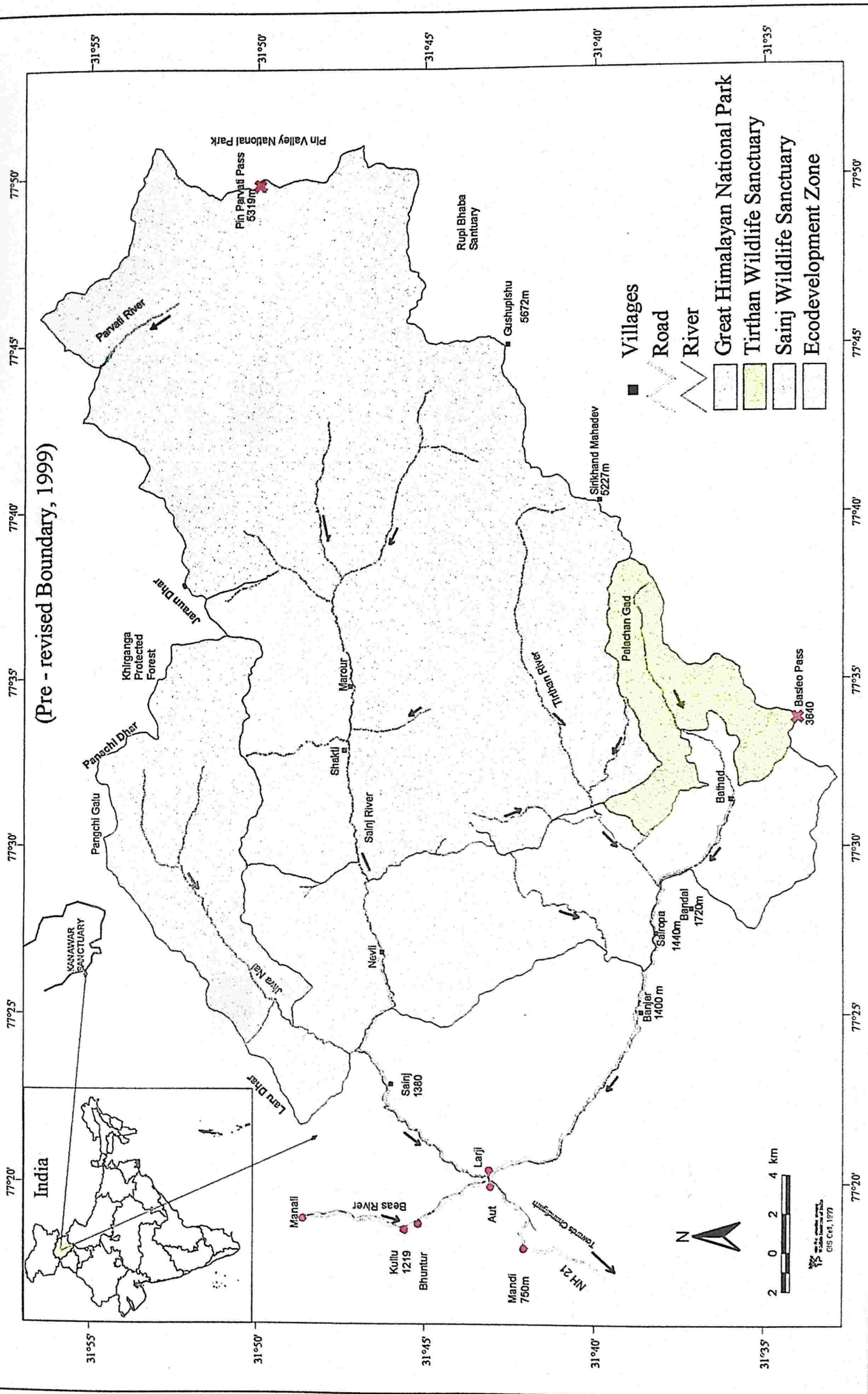
Table 2.1 - Area Statistics for the GHNPCA

Sl. No.	Category	Pre-revised Area (sq km)	Revised Area (sq km)
1	Great Himalayan National Park (GHNP)	765.0	754.4
2	Tirthan Wildlife Sanctuary (Tirthan WLS)	61.0	61.0
3	Sainj Wildlife Sanctuary (Sainj WLS)	90.0	90.0
4	Ecodevelopment Zone (EZ)	255.0	265.6
Total Area		1,171.0	1,171.0

The **Table 2.1** indicates that as such the total area of GHNPCA remained unaltered. However, there was a slight area adjustment of 10.6 sq km between the GHNP and EZ. Details of the geographical boundaries of GHNPCA have been described by Negi (1996).

The Sainj WLS has two villages, namely Shakti and Maror. The Ecodevelopment Zone on the western periphery within a radial distance of 5 km

(Pre - revised Boundary, 1999)



GIS C-4, 1977

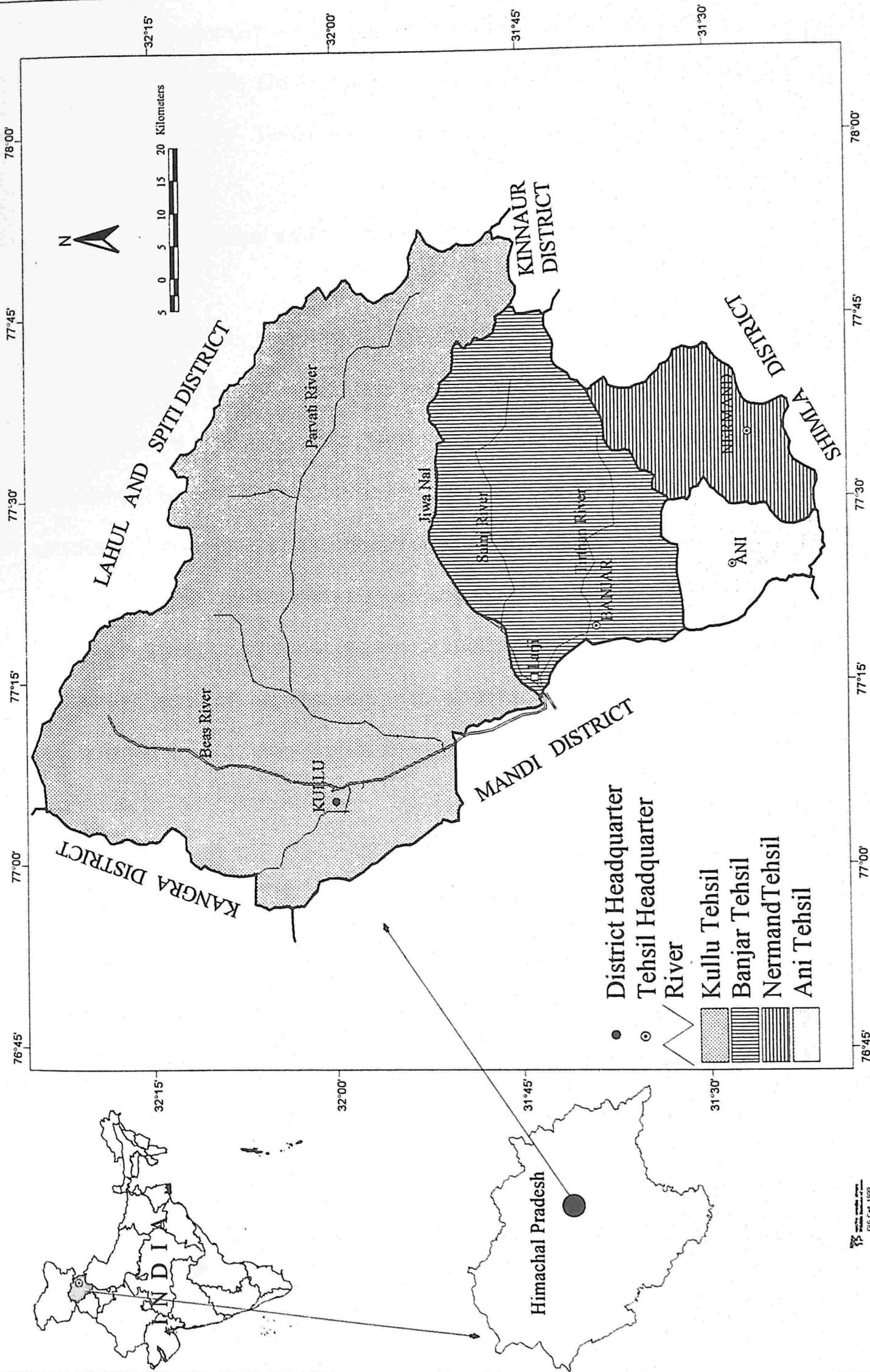
from GHNP has 13 villages ('Phanti' - cluster of hamlets). The major pressure on the GHNP and two WLS comes from these villages. The local residents still claim traditional rights for grazing and collection of medicinal plants in spite recent issue of the final notification. A large part of the GHNP-CA lies in 'Waziri Inner Seraj' (sub-block) of 'Seraj/Banjar Tehsil' (Block), while a small portion falls in sub-block 'Waziri Rupi' of Kullu Tehsil (Fig. 2.2). The GHNP-CA besides supporting livestock residing within the Sainj Sanctuary and the Ecodevelopment Zone has also been receiving pastrolists and grazing sheep and goat flocks from the adjacent cluster of villages in Ani Tehsil. The GHNP-CA forms a large contiguous PA network with the Pin Valley National Park in the east; Rupibhabha Wildlife Sanctuary in the south-east; Khirganga protected forest and Kanawar Wildlife Sanctuary in the north-west. Thus, the GHNP-CA becomes an area of high conservation significance in the region (Fig. 2.1).

The highly varied topography, physiography and past management of the landscape has resulted in diverse ecosystems and floral and faunal species. Since the following Chapter specifically focuses on the landscape and its environment, the physical, biological and socio-economic environments of the study area are dealt in greater detail therein.

2.2 The Reconnaissance

As already stated, the present study was a part of the major FREEP-GHNP Research Project and was initiated after obtaining requisite permission from the Director, GHNP, Kullu for carrying out research work in the GHNP-CA. A rapid

FIG 2.2 - KULLU DISTRICT AND ITS TEHSILS



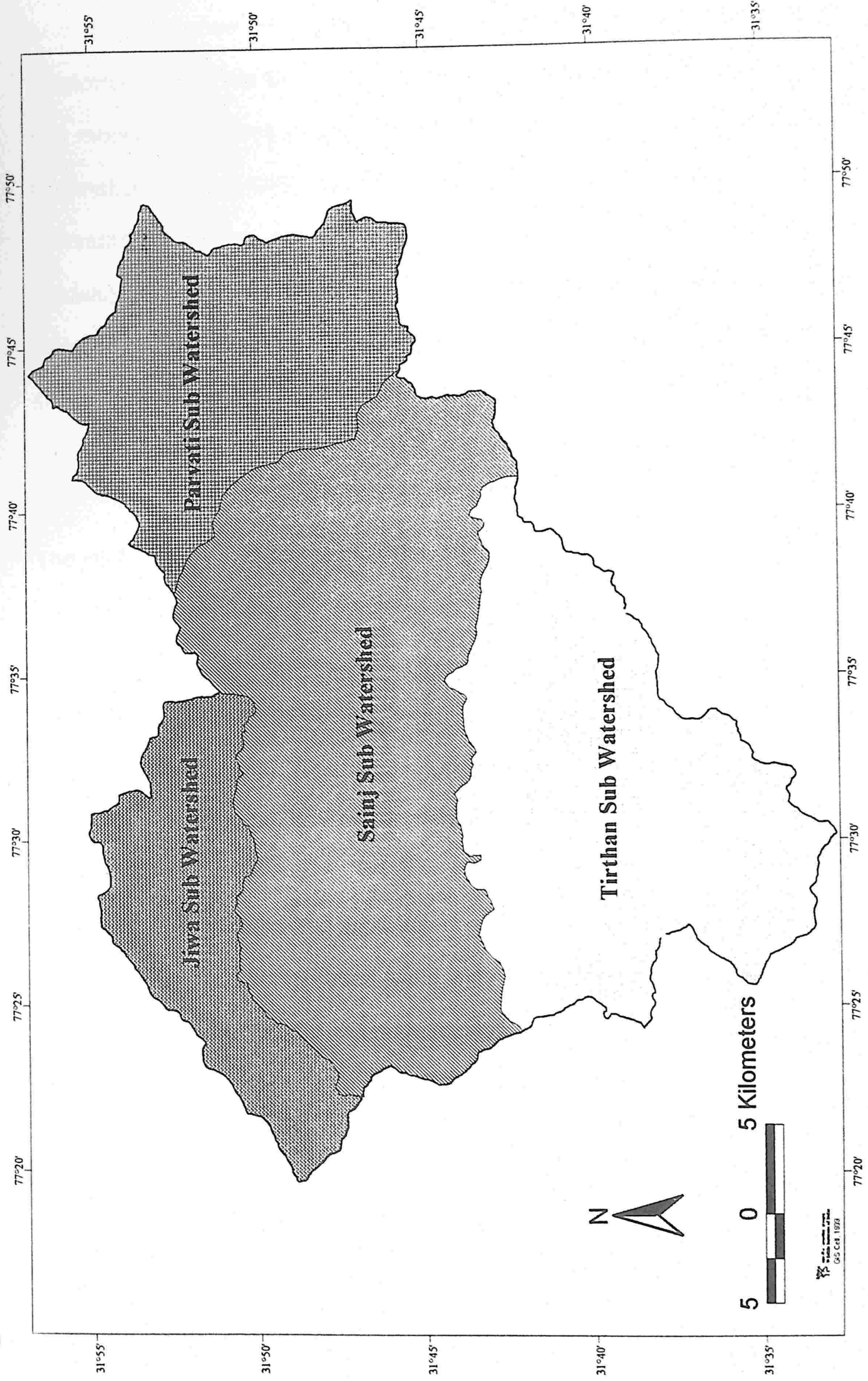
survey in representative field areas across GHNPCA was undertaken during July-December, 1995. On the basis of reconnaissance, the present study was designed in February, 1996 (Mehra and Mathur, 1996).

2.3 The Hierarchical and Landscape Approach

The hierarchical theory suggests that higher level of organisation incorporates and contains the behaviour of lower level (O'Neill *et al.*, 1986; Noss, 1990b). The importance of higher order constraints does not suggest that monitoring and assessment be limited to higher level only (e.g. remote sensing of landscape structure). Lower level in a hierarchy contains the details as species identities and abundance. The hierarchy concept suggests that biodiversity be monitored at multiple levels of organisation, and at multiple spatial and temporal scales. No single level of organisation (e.g. species, population, community) is fundamental and different levels of resolution are appropriate for different questions.

The above hierarchical and landscape approach would thus entail a conceptual framework for identifying species, measurable indicators to monitor and assess the overall status of biodiversity at multiple levels in relation to livestock grazing. The entire study area has been thus, recognised as one large landscape consisting of four sub-watersheds (SWS), namely Tirthan, Sainj, Jiwa and Parvati (Fig.2.3).

Fig. 2.3 - Four Constituent Sub - watersheds in the Great Himalayan National Conservation Area



31°55'

31°50'

31°45'

31°40'

31°35'

77°50'

77°45'

77°40'

77°35'

77°30'

77°25'

77°20'

77°50'

77°45'

77°40'

77°35'

77°30'

77°25'

77°20'



5 0 5 Kilometers



In order to integrate and make an overall assessment of various aspects of livestock grazing in the GHNP, a combination of traditional field assessments and modern techniques *viz.*, application of remote sensing and Geographical Information System (GIS) was used. Among traditional techniques, use of secondary information, questionnaires, interviews (villagers, pastoralists and PA officials), field estimates, inventories and ground quantification of various habitat variables were carried out. The present study thus, focuses on a combined strategy of an extensive study at the landscape level while intensive study at specific identified sites.

The methodology adopted for the following three Chapters on specific themes is described below:

2.4 The Methodology

2.4.1 The Landscape, its Environment and Livestock Grazing

The concepts, principles and approaches related to the Landscape Ecology and Dynamics are increasingly used world wide to address complex conservation issues and management of natural resources. This becomes more pertinent in the case of highly undulating and fragile Himalayan landscape wherein the livestock, wild animals and human use different landscape components/units across the altitudinal gradient or watersheds during various seasons. Likewise, different slope categories and aspects also play an important role in influencing the floral and faunal diversity and their use patterns. Recognising the merit of

these facts, it was considered essential to describe, characterise and assess the landscape and its environs as a first step towards addressing the complex issue of livestock grazing.

2.4.1.1 The Landscape Level Mapping

The entire GHNP was treated as one landscape constituting the catchments of the river Beas and comprising four sub-watersheds (SWS) viz., Tirthan, Sainj, Jiwa and Parvati. The Survey of India (SOI) toposheets no. 53 E/5; 53 E/6; 53 E/9; 53 E/10; 53 E/13; and 53 E/14 at 1:50,000 scale and management maps obtained from the park management, HPFD were mainly used as reference maps. The Indian Remote Sensing (IRS) IB LISS II data, Geocoded false colour composites (FCC) with the standard band combination (band 2, 3 and 4) at 1:50,000 scale with a resolution of 36.25 m for the period: September-October, 1993 obtained from the National Remote Sensing Agency (NRSA), Hyderabad was used for the landscape level mapping, assessment and characterisation. A preliminary field survey was undertaken in Sainj SWS during May-June, 1996 to correlate the image characteristics and ground features using standard visual interpretation techniques (Anon., 1983). An interpretation key based on the image properties and ground feature relationship was developed for FREEP-GHNP Research Project by Naithani and Mathur (1998). The image elements usually considered for interpretation viz., tone, size, slope, shadow association and physiography were taken into account (Tomar, 1998). The interpreted key was modified (Table 2.2) keeping in view the objectives of the present study. Subsequently, during the field study, the desired ground validation work

was undertaken in pre-determined and representative sites. The interpretation key and field knowledge were used to prepare the landuse/forest cover map highlighting different grazing resources. A diagrammatic presentation of the visual interpretation process is given in **Fig 2.4**.

Additional information on the drainage and topography (contours at 120 m interval) were also digitised based on the SOI toposheets in the Geographical Information System (GIS) domain using ARC/INFO package to generate desired maps and better understanding of the landscape features in relation to livestock grazing.

Table 2.2 – The Interpretation Key

A. Interpretation Key for Land Use and Forest Cover Mapping in GHNPCA Using IIRS LISS II Data Band Combination 2 3 and 4 on 1: 50,000 Scale (Source: Naithani and Mathur, 1998)

Sl No	Tone	Texture	Physiography	Elevation (Gaston and Garson, 1992)	Type	Vegetation Association
1	Bright red	Medium to Coarse	Moderate to steep slope of hill	600-1700m.	Sub tropical pine forest, mainly chir pine	Conifer, Chirpine- <i>Pinus roxburghii</i>
2	Brownish red to dark brown	Medium to Coarse	The study area and all aspect with varying density till the beginning of sub-alpine	1500-3300m.	Himalayan moist temperate forest	Mixed conifer, <i>Pinus wallichiana</i> , <i>Abies pindrow</i> , <i>Picea smithiana</i> , <i>Cedrus deodara</i>
3	Red to brownish red to bright red with whitish ting	Medium to Coarse	Gentle to medium slopes with thick soil cover in all study area and nalas	1500-3300m.	Himalayan moist temperate forest	Conifer and broad leaved - <i>Pinus wallichiana</i> , <i>Abies pindrow</i> , <i>Q.leucotrichophora</i> , <i>Q.loribunda</i> , <i>Acer sp.</i> , <i>Aesculus indica</i> , <i>Prunus comuta</i>
4	Various shades of red to brownish red	Medium to Coarse	Gentle to medium slopes and spurs on the ridges, soil cover sufficient	1500-3300m.	Himalayan moist temperate forest	Broad leaved and conifers- Upper story : <i>Q.semecarpifolia</i> , <i>Betula utilis</i> , <i>Abies pindrow</i> , <i>Taxus</i> , <i>Prunus comuta</i> , <i>Acer sp.</i> Under story- <i>Viburnum</i> , <i>Lonicera</i> , <i>Rosa</i> , <i>Sinaruindinaria sp.</i>
5	Bright red to deep red	Medium to Coarse	Along gentle to medium slopes, moist areas, along nalas and village surroundings	1500-3300m.	Himalayan moist temperate forest	Broad leaved Upper story- <i>Q. floribunda</i> , <i>Aesculus indica</i> , <i>Q. leucotrichophora</i> , <i>Betula alnoides</i> , <i>Q. semecarpifolia</i> , <i>Prunus sp.</i> Under story- <i>Rhododendron campanulatum</i> , <i>Bamboo brakes</i> , <i>Viburnum</i> , <i>Berberis sp.</i> , <i>Indigofera</i> , <i>Rosa</i> , <i>Sorbaria sp.</i> and grasses.
6	Light red to brownish red	Medium to Coarse	Along river bed only in low elevated areas of park	Upto 2500m.	Lower temperate grass patches	Grass patches <i>Themada sp.</i> , <i>Apluda sp.</i>

Contd...

Table 2.2 Contd...

SI No	Tone	Texture	Physiography	Elevation (Gaston and Garson, 1992)	Type	Vegetation Association
7	Light pink varying shades of grayish and brownish tinge	Medium to Coarse	Higher to medium slopes and around villages also	1500-3300m.	Himalayan moist temperate forest	Secondary scrub <i>Berberis chitra</i> , <i>Indigofera</i> , <i>Rosa sp.</i> , <i>Pinus wallichiana</i> , <i>Abies</i> , <i>Acer</i> and grasses.
8	Pinkish yellow green tinge	Fine to medium	Top of the ridge portions, spurs and moist sloppy areas	Above 3000m to 3600m.	Dry alpine scrub	<i>Rhododendron campanulatum</i> , <i>Juniper sp.</i> , <i>Rhododendron lepidotum</i> , <i>Rhododendron anthopogon</i> with grasses like <i>Poa sp.</i> and <i>Danthonia cachemyriana</i>
9	Light red yellowish and green tinge	Fine to medium	Generally all types of slopes	1500-3600m.	Sub-alpine and alpine grasslands.	<i>Poa annua</i> , <i>Poa alpina</i> , <i>Agrostis</i> , <i>Danthonia cachemyriana</i>
10	Various shades of red to brownish red	Medium to Coarse	Medium to higher slopes	1500-3300m.	Temperate zone plantation	Mainly conifer: <i>Pinus wallichiana</i> , <i>Abies</i> , Broad leaved: <i>Acer</i> , and grasses.
11	Varying shades of yellowish green with red tinge	Smooth to fine	Steep to moderate slope	1500-3600m. and above	Temperate, sub-alpine and alpine zone.	Exposed rock, cliff
12	Bluish to cyan colour	Smooth to fine	Steep to moderate and gentle slope	1500-3600m. and above	All study area	Land slides
13	Bright to white and light grey colour	Smooth to fine	Between river channels		Along the rivers	Sand bar
14	Dark blue to dark brown	Smooth to fine	All water bodies of the study area, mostly on higher elevated plains	Between 2000-3000m.	Specially on higher reaches	Water bodies
15	White to dirty white	Smooth to fine	Mostly on gentle to medium slope, specially north and north west aspect	Mostly above 3000m	Above snow line and also depend on slope and aspect	Snow

Contd...

Table 2.2 Contd...

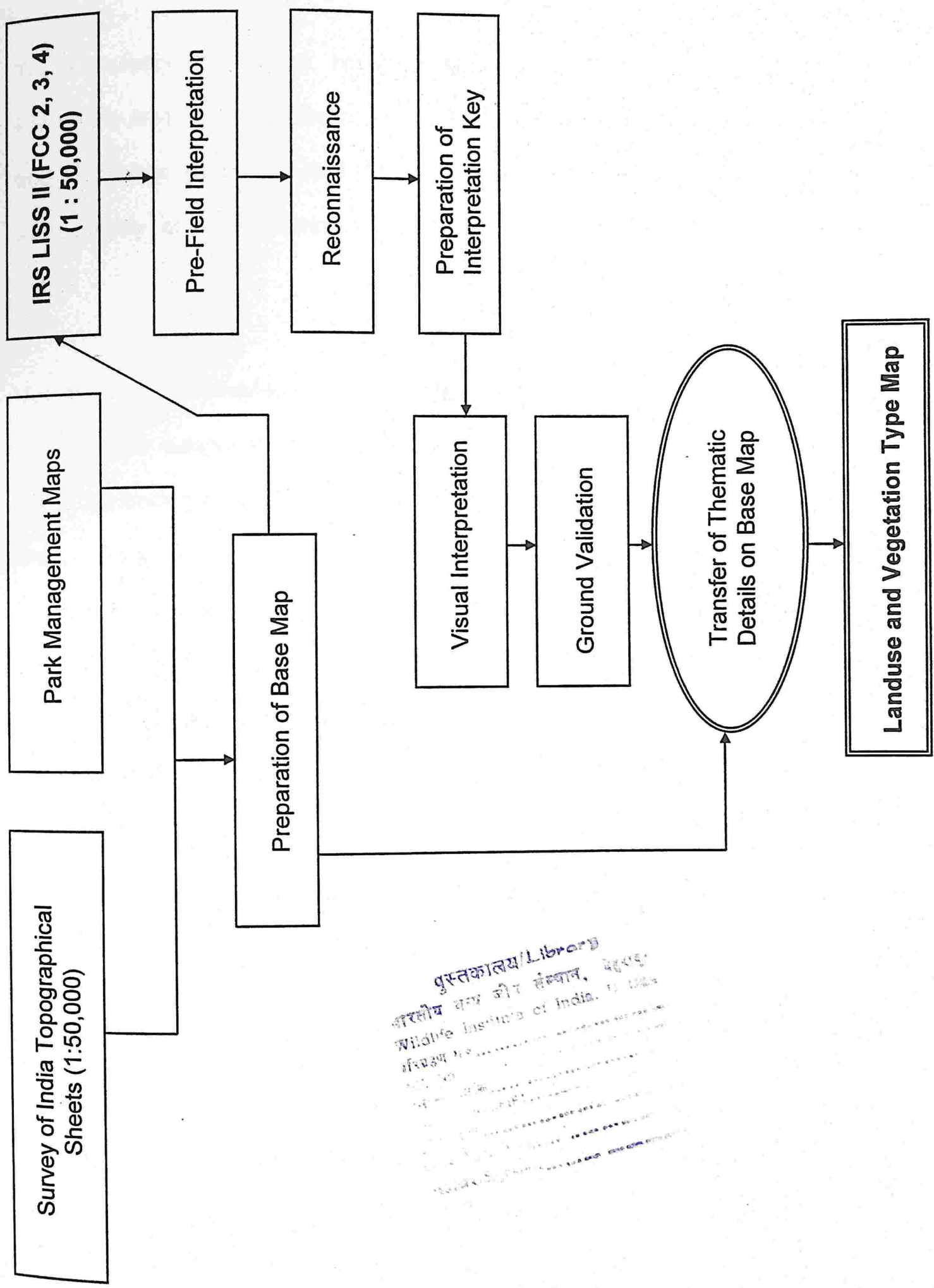
SI No	Tone	Texture	Physiography	Elevation (Gaston and Garson, 1992)	Type	Vegetation Association
16	Grey to dirty grey and white	Medium to Coarse	Mostly on medium to higher slopes in upper reaches	Above 3600m.	Below/above snow line and confined within these zones	Morain
17	White	Fine	Mostly on upper reaches	Above 3600m.	Above morrains	Glacier
18	Dirty brown to gray	Medium to coarse	Mostly at middle and margins of morrain	Above 3600m.	After and within morrain	Morainic lands
19	Various tones of red with dark to light gray and pink	Medium to Coarse	Medium to gentle slopes on south as well as south-east aspect	1300 to 2500m.	Mostly on moist temperate zone	Habitation/Orchards/ Agriculture

B. Modified Key Used for the Present Study Based on Clubbing of Categories

SI. No.	Landuse/Forest Cover Type	Clubbed categories as of original (A) Key (SI. No. as of Table 2A)
1	Closed Forest	1+2+3+4+5+10
2	Open Forest	7
3	Grass Patches	6
4	Dry Alpine Scrub	8
5	Alpine Pastures	9
6	Rocky Slopes/Cliffs	11+12+13
7	Rivers/Lakes	14
8	Permanent Snow	15+17
9	Habitation/Agriculture/Orchards	19
10	Morraines	16+18

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Fig. 2.4.- Schematic Flow Chart For Visual Interpretation of Satellite Images of GHNP/CA



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2.4.1.2 The Landscape Characterisation – Its Environment

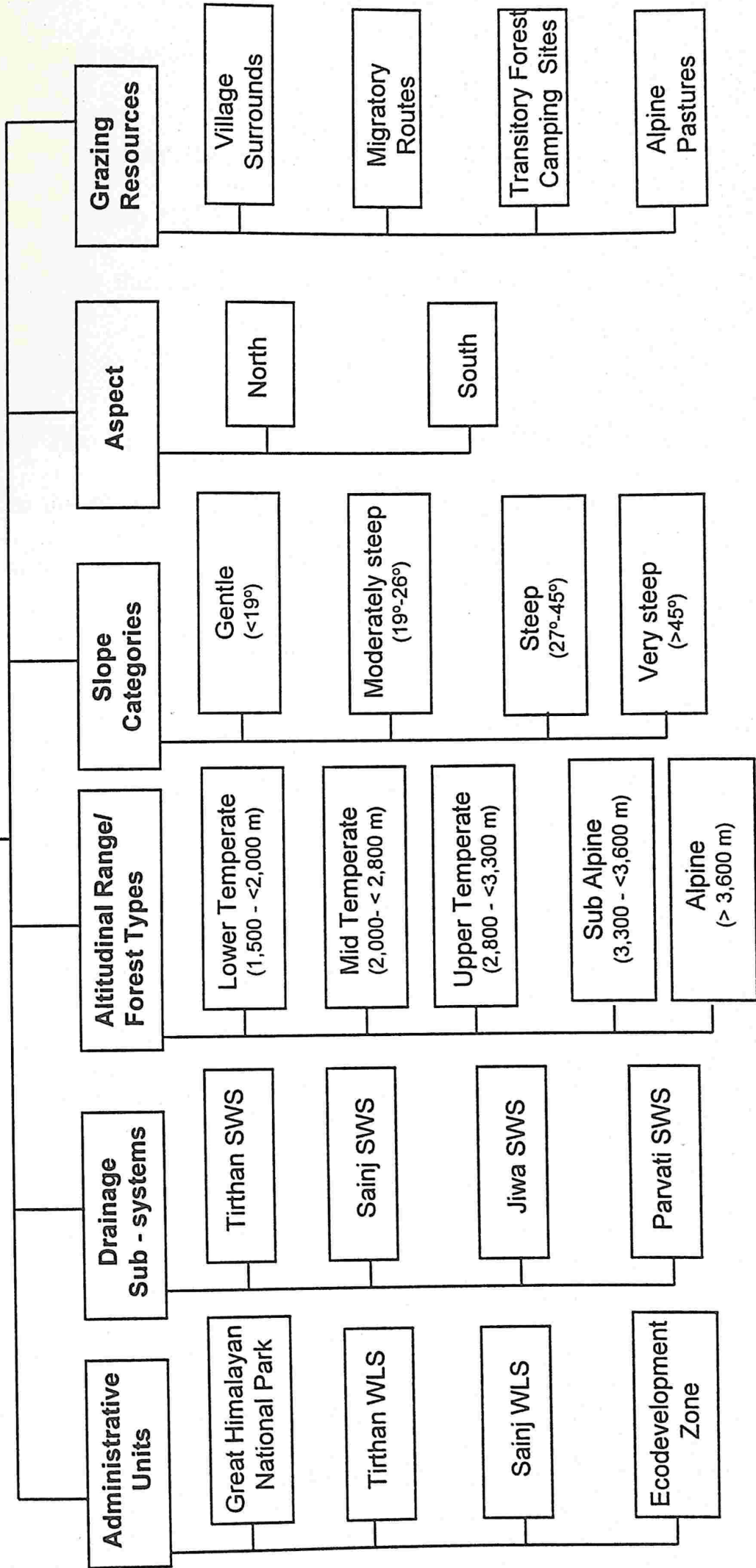
The knowledge of physical, biological, and socio-economic aspects of the immediate environment facilitates better understanding of ecological interactions and dynamics over time and allows effective planning for the long-term sustainability of the environment and management of its resources (Haber 1990).

Varying administrative/legal units of land, drainage sub - systems, altitudinal range, slope categories, aspect and forest types were considered to be the major controlling factors for diversity and resource use patterns in the study area. Thus, the overall environment is characterised adopting a broad landscape stratification approach using these entities. A diagrammatic presentation of the stratification used for various landscape level assessments and characterisation are given in Fig. 2.5. The stratification criteria adopted in the present study is described below:

(a) Administrative Status: The entire GHNPCHA is covered under four administrative units viz., the Great Himalayan National Park, Tirthan Wildlife Sanctuary, Sainj Wildlife Sanctuary, and Ecodevelopment Zone. These units are governed differently by legal provisions under the Wildlife (Protection) Act, 1972.

(b) Drainage Sub-Systems: The GHNPCHA is constituted by four sub-watersheds viz., Tirthan, Sainj, Jiwa and Parvati. They vary in the

GHNPCA



extent, terrain and use pattern. Generally, the resource use is restricted by watershed boundaries.

(c) Slope Categories: Four broad slope categories viz., Gentle ($<19^\circ$), Moderately Steep ($19^\circ - 26^\circ$), Steep ($27^\circ - 45^\circ$) and Very Steep ($>45^\circ$) were used as the varying slope categories directly influence resource use patterns.

(d) Aspect: Two distinct aspects – the north and the south categories were used for the characterisation purpose. The south facing slopes receive more sun light compared to north aspect, resulting into varied structure and composition of vegetation.

(e) Altitudinal Gradient and Forest Types: Five broad forest types corresponding to different altitudinal ranges viz., Lower Temperate (1,500 - $>2,000$ m), Mid Temperate (2,000 - $>2,800$ m), Upper Temperate (2,800 - $>3,300$ m), Sub-Alpine (3,300 - $>3,600$ m) and Alpine ($>3,600$ m) were recognised and used for different field assessments and characterisation as they experience markedly distinct utilisation pattern by livestock, wild animals and human.

2.4.1.3 The Extent and Distribution of Grazing Resources

The seasonal migration is a traditional way of livestock rearing and management in the region. Thus, livestock and dependent graziers spend winter months in village and village surrounds at lower reaches while they migrate to higher reaches during summer and rainy seasons traversing through various

forest/vegetation types. Broadly four types of grazing/fodder resources distinct in their composition, intensity of grazing incidence and seasonal use pattern viz., Village pastures ('Ghasnis') and their surrounds (VS), Migratory routes adopted across different forest types and along ascending altitudinal gradient (MR), Transitory forest camping sites (TFCS) and Alpine pastures (AP) were recognised for various assessments at the landscape and site specific levels. Available information through the SOI toposheets, remote sensing data, forest department records, Settlement report (Anderson, 1886), Indicative plan (Mehta *et al.* 1993) field visits and interviews of pastrolists were used in the identification and mapping of various grazing resources. A list of grazing resources, their extent and distribution according to various stratified categories was an outcome of this component.

2.4.2 Species Diversity, Biotic Pressure and Status of Grazing Resources

Subsequent to the above broad landscape level assessment, the second step focused on field assessments at the site-specific level. Primarily these site-specific assessments aimed to address diversity and use patterns at the species level.

2.4.2.1 The Sampling Strategy

Recognising seasonal area-specific resource use pattern due to various constraints imposed by the terrain and harsh climatic conditions, the sampling strategy for field assessment was appropriately designed. Thus, the summer

(April – June) and monsoon or rainy (July – September) seasons were mainly utilized for field data collection in higher reaches i.e. Alpine pastures, Transitory forest camping sites and Migratory routes, while six month long winter (October – March) season was used for data collection in the Village surrounds. These corresponding seasons being the best time for any type of study in above four sites provided optimum conditions for field assessments related to the structure, composition, and utilization of diverse grazing resources. The upper reaches were inaccessible during winter season due to heavy snow. This was the time when plants in Alpine pastures, Transitory forest camping sites and Migratory routes were covered by snow while livestock concentrated in Village surrounds. At the advent of summer season and melting of snow, plants exhibit their growth phase in higher reaches and majority of plants completed their life cycle before the onset of winter.

In absence of road network in the GHNPCA and rugged terrain, the only means to reach various field sites is tedious and time-consuming tracking. This physical constraint obviously restricts simultaneous visit to various Alpine pastures located in different sub-watersheds. In order to overcome this constraint, it was decided to select the Tirthan SWS as an intensive study area assuming its representativeness to the overall GHNPCA in a larger perspective and also appreciating the fact that: (i) it harbours the maximum number of Alpine pastures; and (ii) it receives maximum number of migratory livestock among four SWS. Further, it is noteworthy to mention here that visit to any Alpine pasture required a minimum tracking of 30-35 km from the last road head. Moreover, inadequate field research infrastructure in terms of

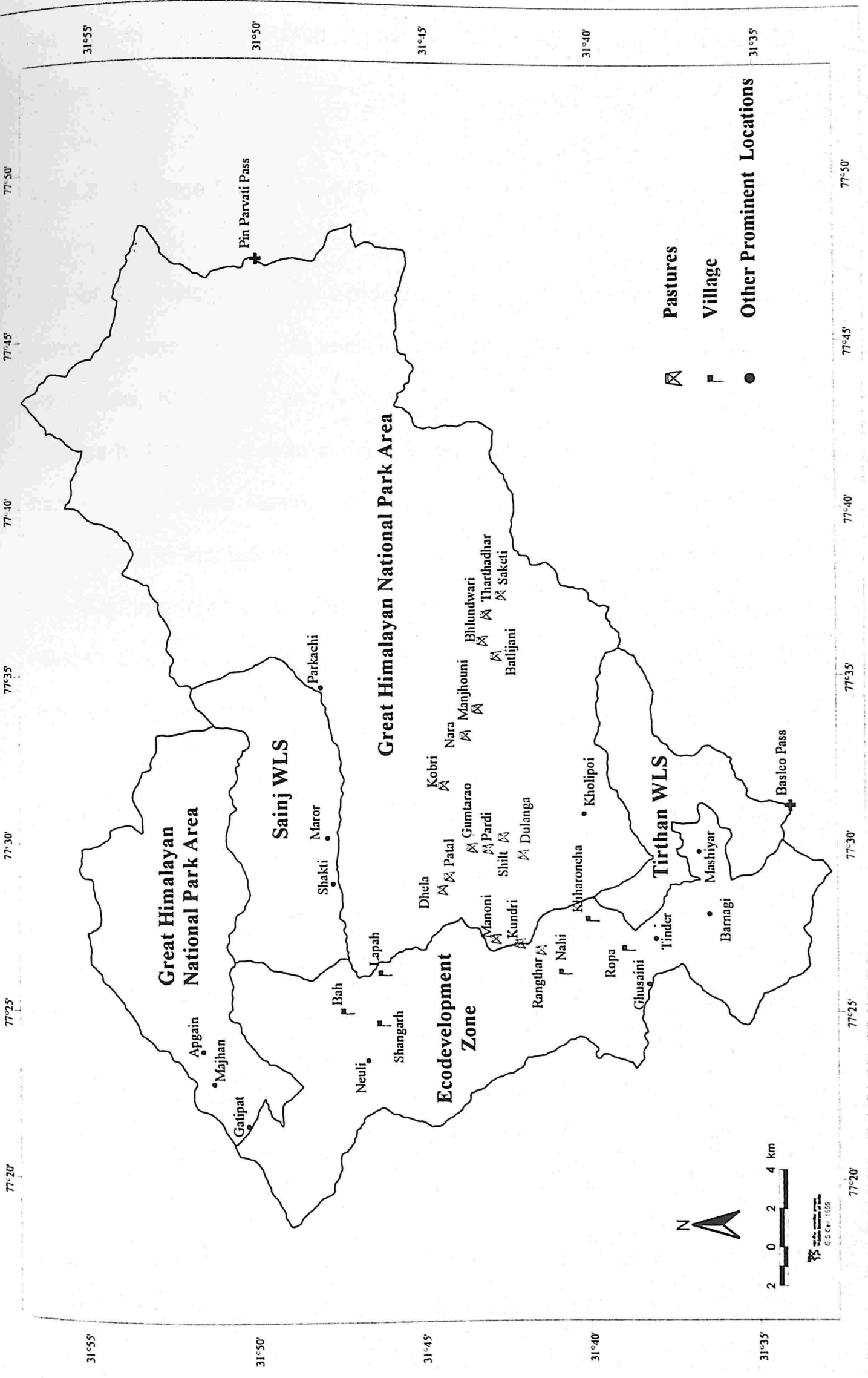
camping sites, basic amenities and treacherous trails due to landslides or missing wooden bridges due to floods posed several additional problems in the smooth conduct of field studies. These constraints called for meticulous planning for field visits, particularly accompanying field support – assistants, camping gears, rations, etc. In spite of these explained field odds, as far as possible due care was taken to cover different intensive study sites under any one category of grazing resource in the same season with minimum difference of days.

2.4.2.2 Intensive Study Sites and Field Assessments

Field assessments pertaining to the structure, composition, species diversity and grazing pressure were carried out separately for the four broad categories of grazing resources (VS, MR, TFCS and AP). Details of selected intensive study sites in each category and methods employed for various quantification are provided below (**Fig.2.6**).

Fieldwork was conducted covering an altitudinal range between 1,300-4,800 m. Field identification of flowering plants was done with the help of regional floras, research papers and reports viz., Collett, 1921; Nair, 1977; Rau, 1975; Polunin and Stainton, 1984; and Aswal and Mahrotra, 1994; Bor, 1960; Uniyal *et al.* 1994. Most of the specimens were collected and preserved at the Herbarium of Wildlife Institute of India following Jain and Rao, 1977. Some of the collected specimens were identified by matching specimens already lodged at the

Fig. 2.0 - Intensive Study Sites For Assessment of Grazing Resources in GINI CA



Herbaria of Forest Research Institute and Botanical Survey of India, Dehra Dun.

2.4.2.3 Village Surrounds (VS)

Out of 125 villages in the Ecodevelopment Zone, six hamlets and their surrounds were selected as intensive study sites (Table 2.3). Three hamlets viz., Ropa, Kharoncha and Nahi in Tirthan SWS and three villages viz., Shangarh, Bah and Lapah in Sainj SWS were selected. Among these six hamlets, four were located on the north aspect whereas Bah and Nahi hamlets were located on the south aspect. These hamlets were further classified into three categories of grazing pressure based on the number of resident livestock viz., high (>750 livestock), moderate (>300 – 750 livestock) and low (>300 livestock).

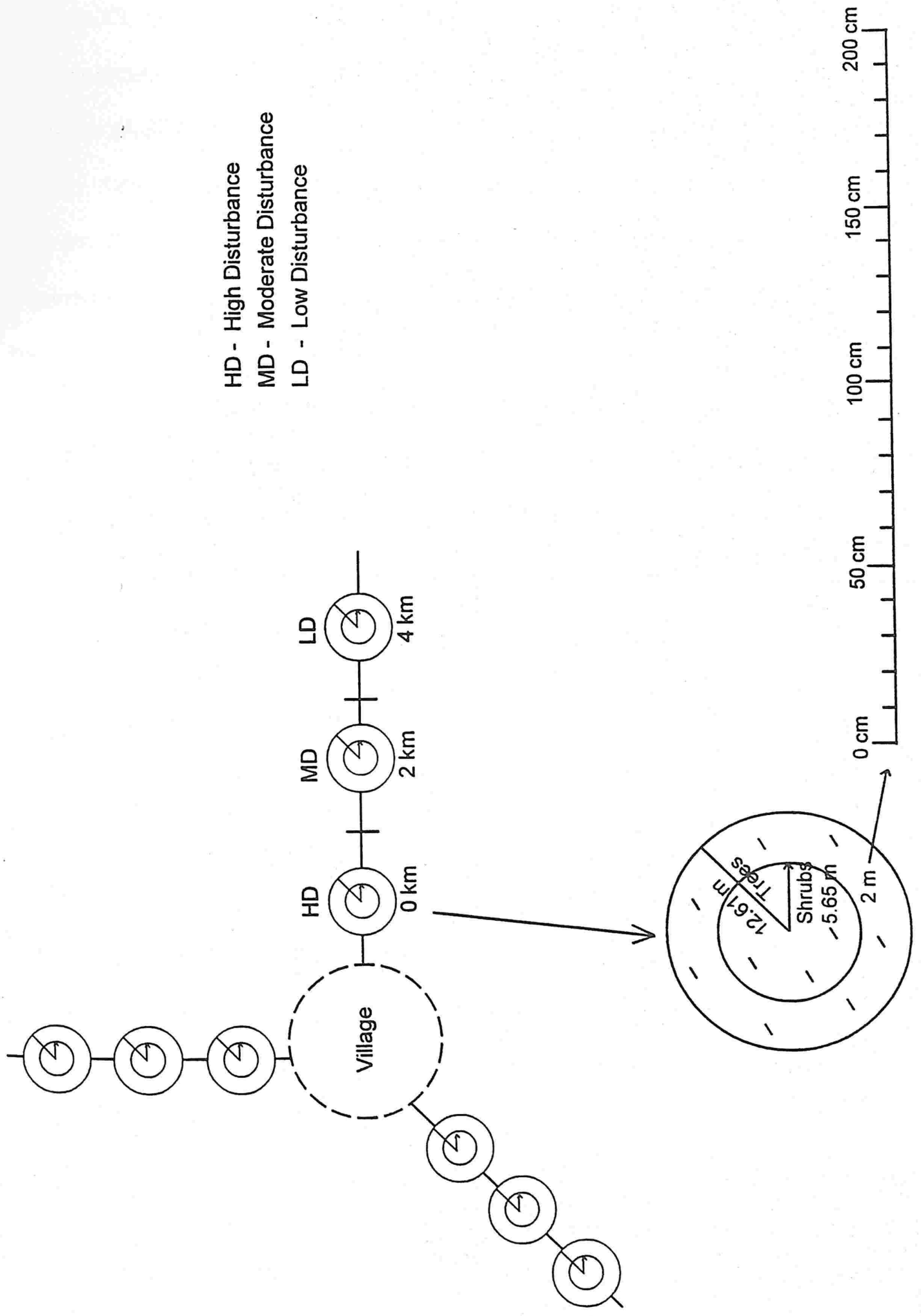
Table 2.3 - Intensive Study Sites under the Category of Village Surrounds (VS)

Sl. No.	Village Surrounds	Sub-watershed	Altitude (m)	Aspect	Grazing Pressure
1	Ropa	Tirthan SWS	1,600	N	Low
2	Kharoncha	Tirthan SWS	1,800	N	High
3	Nahi	Tirthan SWS	1,800	S	Moderate
4	Shangarh	Sainj SWS	2,100	N	High
5	Bah	Sainj SWS	1,800	S	Low
6	Lapah	Sainj SWS	2,200	N	Moderate

Field assessments in selected six village surrounds aimed to assess the diversity of trees, shrubs, and ground cover along biotic pressure in terms of

lopped and girdled trees. Field data on regeneration of tree species was also collected. To achieve this, three radiating transects originating from the outskirts of each selected village in the east, north, and south–west directions were laid. In order to have a complete representation of diversity across altitudinal gradient and disturbance regimes, three circular sample plots of 12.61 m radius (500 sq m) at 0 km, 2 km and 4 km distance using nylon rope were laid on each of the radiating transect (Fig. 2.7). In each plot, tree species, their individuals and girth at breast height (GBH in cm) were recorded. The individuals of tree species with >20 cm GBH and >3m height with a distinct bole were considered as trees. Observations on lopped, girdled and dead trees by species and their individuals were also recorded. Lower girth classes (<20 cm) of same species were considered as regeneration. A nested plot of 5.65 m radius (100 sq m) was demarcated in the above tree plot for assessing shrub diversity using the same centre. The woody species which had GBH < 20 cm, height < 3m and those branching from base of stem were considered as shrubs (Muller – Dombois and Ellenberg, 1974). The species were identified and their numbers of individuals were recorded. The ground cover estimates were carried out in each tree sample plot using a modified point – intercept method on a line of 2 m. Ten random lines (2m) were laid on the ground in 12.61 m radius plot and ground cover categories (Herb, Grass, Rock/Barren, Dung, Weed and Shrub) were recorded as they hit at every 10 cm interval. In all 20 hit values for ground cover on each of the 10 random lines were recorded. Thus, the data obtained in above manner on trees, shrubs and ground cover composition was used for ascertaining the species richness, species diversity and biotic pressure.

Fig. 2.7 - Diagrammatic Representation of Layout of Vegetation Sampling Plots in VS and IFCS



In addition to the above described assessments, two village pastures ('Ghasnis' or hay plots) near village Nahi in Tirthan SWS and village Bah in Sainj SWS, hereafter called as 'Nahi Ghasni' and 'Bah Ghasni', respectively were selected for assessing major constituent grasses and the Above Ground Biomass (AGB) and Below Ground Biomass (BGB) by the Harvest method (Odum, 1960). The vegetation was clipped nearest to the ground in quadrat (50 cm X 50 cm) during September–October, 1997 when grasses have attained maximum height, maturity and ready for harvest by local people for hay purpose. 50 quadrats in each Ghasni were laid. The fresh weight in each case was recorded using a 5-kg field balance. The clipped vegetation was sun-dried and dry weight was recorded until a constant weight was reached. The values of AGB in g/m^2 were calculated. Likewise, 50 monoliths of 25 cm X 25 cm X 25 cm were dug in each of the Ghasnis, roots were first separated manually as far as possible and subsequently by washing with running water using a sieve. Roots were also sun – dried and weighed to determine BGB (g/m^2).

2.4.2.4 Migratory Routes (MR)

Since migratory livestock spends considerable time in traversing from one forest to another forest to reach higher altitudes as well as while descending, a representative migratory route (Ropa – Dhela) in the Tirthan SWS was selected for vegetation assessment. 89 plots at 250 m interval all along migratory route for trees (12.61 m radius) and shrubs (5.65 m radius) as described in the case of village surrounds were laid and observations on tree

and shrub species – their individuals; GBH; lopped, girdled and dead trees and tree regeneration were recorded. As migratory route trails were of narrow width (2-4'), the sample plots were laid in the proximity to the actual 250 m interval distance. The distance was measured by counting calibrated footsteps. :

2.4.2.5 Transitory Forest Camping Sites (TFCS)

The livestock is allowed to rest at fixed locations in different forest openings, hereafter called as Transitory Forest Camping Sites (TFCS) after covering certain distance (8-10 km) while migrating. This facilitates night halts in pre-decided locations by the pastrolists and to establish their temporary camps. The livestock in TFCS gets rest, water, grazing requirement and more protection from wild predators than in forested tracts. In response to such short duration (2 – 3 days) camping, vegetation at each TFCS gets influenced due to trampling, concentrated grazing, manuring and other allied activities. Seven Transitory forest camping sites (Table 2.4) in Tirthan SWS were selected for vegetation assessment. The Table 2.4 provides basic details of each selected site and also the grazing pressure experienced by each pasture. The pressure was assumed considering the actual number of visiting sheep and goats, duration of their stay and overall size of the pasture visited. Broad three categories viz. Low, Moderate sand High grazing pressure were recognized.

Table 2.4 - Details of Selected Transitory Forest Camping Sites for Vegetation Assessment

Sl. No.	TFCS	Sub-watershed	Altitude (m)	Aspect	Size (ha)	No. of Sample Plots for Trees (12.61m)	No. of Quadrats (1X1 m)	Grazing Pressure
1	Dulanga	Tirthan	2,640	South	2	9	-	Moderate
2	Shilt	Tirthan	2,880	South	6	9	-	Low
3	Pardi	Tirthan	3,120	South	5	9	-	Low
4	Rangthar	Tirthan	2,980	South	4	9	-	Low
5	Kundari	Tirthan	3,365	South	5	9	-	Moderate
6	Nara	Tirthan	3,320	South	3	9	75	High
7	Manjhouni	Tirthan	3,450	South	2	9	40	High

All sites were quantified for trees and shrubs as described in the above category of VS. Nine sample plots (12.61 m and 5.65 m radius) on three transects radiating from the centre of each TFCS were laid for tree and shrub level assessments. Two sites viz., Nara and Manjhouni (Sl. No. 6 and 7) were further assessed for herbaceous flora. Quadrats of 1m X 1m were laid for determination of composition and species diversity. The minimum size of the quadrat i.e. 1m X 1m was arrived using vegetation sampling techniques – ‘species-area curve’ as described by Mishra (1968). Similarly, the minimum number of quadrats required for sampling in Nara and Manjhouni TFCS were also worked out. Accordingly, 75 quadrats in Nara and 40 in Manjhouni TFCS were laid. The composition of herbaceous flora and species diversity in two TFCS was compared.

2.4.2.6 Alpine Pastures (AP)

The livestock utilise different Alpine pastures (>3600m) for a substantial duration during summer migration, being the ultimate destinations. Alpine pastures are thus major centres of resource utilization and also varied activities of pastoralists. As stated earlier, plants in AP are short lived and nearly for six months they remain covered under snow. During a short span of 2–3 months of livestock grazing. Alpine pastures are influenced in several ways. In view of this, vegetation and biotic assessments were carried out in nine (9) selected intensive study sites of Alpine pastures. Details of these nine sites and quadrats laid in each of them are given in the **Table 2.5**.

Table 2.5 - Details of Nine Selected Alpine Pastures for Intensive Studies

Sl. No.	Site	Sub-watershed	Altitude (m)	Aspect	Size (sq m)	No of Quadrats (1 X 1 m)	Grazing Pressure
1	Ghumtarao	Tirthan	3,600	S	240	90	Low
2	Patal	Tirthan	3,620	S	200	50	Low
3	Mononi	Tirthan	3,610	S	18	40	High
4	Batlijani	Tirthan	3,630	S	256	80	Low
5	Bhlundwari	Tirthan	3,740	S	375	100	Moderate
6	Tharthadhar	Tirthan	4,000	S	140	40	Moderate
7	Saketi	Tirthan	4,240	N	169	40	High
8	Kobari	Tirthan	4,000	S	188	40	Moderate
9	Dhela	Sainj	3,800	N	406	100	Moderate

As all selected Alpine pastures were devoid of trees and shrubs, only herbaceous layer was quantified. The minimum size and number of quadrats required for sampling in each site were estimated (Mishra, 1968). The uniform size of the quadrat i.e. 1m X 1m was achieved which was used in

The vegetation data was analysed for frequency (F), density (D) and abundance (A). The term abundance and density represent the numerical strength of species in the community. Abundance if considered along with frequency, gives an idea of the distribution pattern of the species while the latter represents the number of individuals per unit area. The density and frequency taken together are of prime importance in determining community structure and have a variety of uses far beyond those of other quantitative values (Mishra, 1968). Values of abundance, and density and per cent frequency for each species were computed using the following formulae:

$$\% \text{ Frequency} = \frac{\text{Number of sample plots in which the species occurred}}{\text{Total number of studied sample plots}} \times 100$$

$$\text{Density} = \frac{\text{Total number of individuals of a species in all plots}}{\text{Total number of studied sample plots}}$$

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all sampled plots}}{\text{Number of sampling plots of occurrence}}$$

In the present study, tree measurements were made in sample plots of 12.61 m radius plot = 500 m², shrubs in 5.65 m radius plot = 100 m² and ground layer in 1 X 1 m plot = 1 m². Tree density values are presented as number of trees/ha.

In addition, in the case of trees in village surrounds, Migratory Routes and Transitory Forest Camping Sites, the abundance (AB), dominance (DO) and Importance Value (I) of each species were calculated by a slightly modified method as described by Zhang and Cao (1995). The formulae used by them for AB, DO and I are given below:

$AB = (N_i/N) * 100$; $DO = (S_i/S) * 100$; $I = AB + DO$, where N_i is the number of individuals in the i th tree species, N is the total number of individuals of all the tree/shrub species in the corresponding replicate plots; S_i is total area (cross-section) at breast height of the trunks of all tree species in the plot. Likewise, dominance in case of each shrub species was also calculated.

Diversity Indices : Diversity of communities can be assessed using 'species richness' (measure of total number of species in a sampling area), species abundance model or evenness (how the abundance data are distributed among the species) and indices based on the proportional abundance of the species. Over the years a number of indices have been proposed for characterizing species richness and evenness. Such indices are termed as richness and evenness indices. For better clarity, these terms/indices and their formulae are explained below :

Species Richness (NO) : The number of species in a community or in a sampling area is referred to as species richness. Margalef (1958) has given an index for species richness:

$$\text{Margalef index } R = \frac{S-1}{\ln(n)}$$

Where S = the total number of species in a community

N = sampling points

'Higher the value of R means greater species richness.'

Species Evenness or Equitability : Evenness refers to how the species abundances (e.g., the number of individuals, biomass, cover etc.) are distributed among the species.

Two prominent diversity indices viz. Simpson's Index (λ) and Shannon's Index (H') are usually used. Whereas:

Diversity Index 1 Simpson Index - $\lambda = \sum_{i=1}^s p_i^2$

Where p_i is the proportional abundance of the i th species, given by

$$P_i = n_i / N' \quad i = 1, 2, 3, \dots, S$$

Where n_i is the number of individuals of i th species and N is the known total number of individuals for all S species in the population. Simpson's Index, which varies from 0 to 1, gives the probability that two individuals drawn at random from a population belong to the same species. Simply stated, if the probability is high that both individuals belong to the same species, then the diversity of community sample is low.

Diversity Index 2. Shannon's Index: H : The Shannon Index (H) has probably been the most widely used index in community ecology. It is based on information theory (Shannon and Weaver, 1949) and is a measure of the average degree of "uncertainty" in predicting to what species an individual chosen at random from a collection of S species and N individuals will belong.

This average uncertainty increases as the number of species increases and as the distribution of individuals among the species becomes even.

The equation for the Shannon function, which uses natural logarithms (ln), is

$$H' = \sum_{i=1}^{S^*} (p_i \ln p_i)$$

Where H' is the average uncertainty per species in a infinite community made up of S^* species with known proportional abundances $p_1, p_2, p_3 \dots \dots \dots, p_s$; S^* and p_i s are population parameters and, in practice, H' is estimated from a sample as

$$H' = \sum_{i=1}^S \left[\left(\frac{n_i}{n} \right) \ln \left(\frac{n_i}{n} \right) \right]$$

Where n_i is the number of individuals belonging to the i th of S species in the sample and n is the total number of individuals in the sample.

“Maximum the value of H' means all S species are represented by the same number of individuals, that is, a perfectly even distribution of abundances”.

Evenness Index (E) : When all species in a sample are equally abundant, it seems intuitive that evenness index should be maximum and decrease towards zero as the relative abundances of the species diverge away from

evenness. Probably the most common evenness index (E_p) is by Pielou (1975) and is referred as Pielou's equitability.

$$E_p = \frac{H'}{\ln(S)} = \frac{\ln(N_1)}{\ln(N_0)}$$

"The maximum E_p value means when all of the species in the sample are perfectly even".

2.4.2.8 Livestock Grazing and Wild Animals

The grazing resources throughout the world are extensively used by livestock and a variety of wild animals. They provide the majority of the nutrients for livestock and essentially all the nutrients for numerous species of large wild herbivores. Similar to elsewhere in the world, in GHNP CA too the organic component of grazing system is a complex of producers, consumers and decomposers that are organized into a food web. The GHNP CA due to its varied topography and altitudinal gradient harbours diverse wild animals representing different taxonomic groups. Since livestock utilizes various grazing resources across the altitudinal gradient during different time of the year, they often come into contact, share grazing resources, interact or compete with wild animals. Recognising the significance of these ecological relationships, and also considering the fact that any study on livestock grazing would remain incomplete without looking in totality. Thus, an attempt was made to generate desired information on prominent wild animals – their

habitats, use pattern and their interactions with livestock using a systematic approach. The secondary information or researches carried out by co-workers under the major project were mainly relied since it was neither desirable nor feasible to assess the distribution, abundance and specific interactions of a diverse wild fauna in GHNPCA, in the present scope of the study. In addition to this, observations on direct sightings, indirect evidences (tracks and trails, dung, calls, feeding signs, etc) were meticulously recorded as and when encountered during the field work in various grazing resource sites. Further, extensive interviews of local people, pastoralists and field staff were carried out and the valuable information provided by them helped in the overall synthesis on understanding of ecological interactions among livestock and wild animals. Field observations on allied activities of accompanying pastoralists to higher altitudes during migration and camping sites were also recorded.

2.4.3 Grazing Practices and its Socio-economics

The livestock rearing and management is an age-old practice and has been one of the main professions of local people in GHNPCA. Hence, livestock has direct relationship with human life style and their socio-economics. Pastoralism has a long history of its influence world over on the society, natural systems and Government policies and has also got influenced vice-versa. Keeping this fact in mind, the present investigations also aimed to assess the historical perspective, legal policies and provisions, socio-economics of dependent communities and their grazing management

practices. A combination of several approaches including literature search (historical documents/reports, scientific research documentation, and official records of the Forest Department and Park management); interviews (local people, pastoralists and field staff); and field visits to selected village sites and grazing routes was used for qualitative and quantitative assessments. These assessments were mainly related to the migration pattern, type of livestock, their number, distribution and socio-economics.

Extensive as well as intensive field visits were undertaken to different sub-watersheds in order to cover representative villages and grazing sites. More than 50 field visits of varying duration ranging from average 3 days to 20 days were made during a 3-year study period. Village clusters in the adjacent 'Ani' Tehsil were also visited. A multiple check strategy was used to get the best possible estimate of total livestock population dependent upon the resources of GHNPCA. Pastoralists were first interviewed individually or in smaller groups at their respective village sites to ascertain their livestock holdings, migratory routes adopted by them and final destinations in Alpine pasture areas. This was followed by the first level cross check by intercepting migratory flocks at the fixed entry/exist points in different sub-watersheds viz. Banjar, Gushaini, Bathad, Neuli, Jiwa, Rola, Sainsar, Lapah, Bah, Shangarh, Pashi, Raila and Mashyar. Livestock in each flock was enumerated and details on their origin, migratory routes adopted and time spent at various grazing resources were recorded. The livestock enumeration was conveniently carried out by strategically selecting narrow wooden bridges across rivers or narrow trail points. After a dialogue with pastoralists in each

group and explaining the purpose of study, herders were usually convinced and they extended full cooperation in enumeration and responding to structured questionnaires. The second or final level check was carried out when these pastrolists with their migratory levels were either camping at the Transitory forest camping sites or Alpine pastures. Above-mentioned field visits also included systematic followings to at least all major and well-known migratory routes in different sub-watersheds. Maximum opportunities were also availed to have formal as well as informal interviews and interactions with field staff of the GHNPCA so as to have better insight on grazing practices and livestock-wildlife-human conflicts.

2.4.4 Livestock Grazing and Conservation Implications

The present study ultimately attempts to provide an insight on the livestock grazing vis-a-vis ecology, socio-economics and conservation of the landscape and its values. The availability of a series of technical reports on various physical, biological, sociological, management and monitoring aspects of GHNPCA by co-workers and national and international consultants under the FREEP-GHNP Research Project at its completion phase on one hand facilitated the overall understanding and synthesis. While on the other hand recent developments due to the final notification of the Great Himalayan National Park and consequent abrupt restrictions on the resource use by local people posed new challenges. Finally, a comparative account on the potential implications and management needs is projected using findings of

the present study, professional knowledge and learnings from elsewhere visualising the following two broad scenarios:

- (i) Regulation of livestock grazing by enforcement of law subsequent to the final notification, and
- (ii) Continuance of current grazing practices.



The Landscape, its Environment and Livestock Grazing

3.1 The Landscape

Landscape can be variously defined. According to Forman and Godron (1981) landscape can be defined as a “kilometers-wide area where a cluster of interacting stands or ecosystem is repeated in similar forms”. In other words, landscape is an area composed of interacting ecosystems that are repeated because of geology, landform, soils, climate, biota, and human influences throughout the area (Kaufmann *et al.* 1994). Landscape is generally of a large size, shape and pattern which is determined by interacting ecosystems. In the Himalayan system, the administrative, legal and social boundaries are usually delineated by the drainage system. Therefore, a landscape in such a situation can be a series of similar and interacting watersheds. To elaborate further, a landscape is constituted by pieces of land or mosaic characterized by their natural attributes, landuse pattern and by the kinds and extent of resource use practices and resultant changes in the physical and biological environments of the system (Sawarkar, 1995).

Ecologists, resource managers, and planners have traditionally ignored interactions among different elements in a landscape (Forman, 1981). However, it has now been realized that conservation efforts can succeed only by acknowledging the relationship between the physical, biological,

ecological, socio-economic, political and administrative imperatives. Thus, the philosophy of maintaining biological diversity rests solely on the art of choosing the appropriate tools and approaches in being able to synergistically combine such combinations. Hence, a regional landscape planning approach demands an integration of ecological evaluation methodologies at hierarchical scales, from the smallest to the successively larger ones such as stand or site, multistand or multipatch and watershed level leading to the landscape level. In another words, an approach integrating assessments at macro (watershed or landscape) as well as micro (stand or site) levels is needed.

In light of the above and as stated in the previous Chapter, the GHNPCA was considered as one landscape. This landscape was assessed for its physical, biological, socio-economic environments while addressing issues relevant to livestock grazing in the region.

3.2 The Results and Discussion

The results on the physical, biological and social environments are presented one by one in the subsequent paragraphs.

3.2.1 Physical Environment

The topographical, geomorphic and climatic attributes constitute the physical environment in the region which leads into spatio-temporal variations in diversity and resource use patterns.

3.2.1.1 The Region

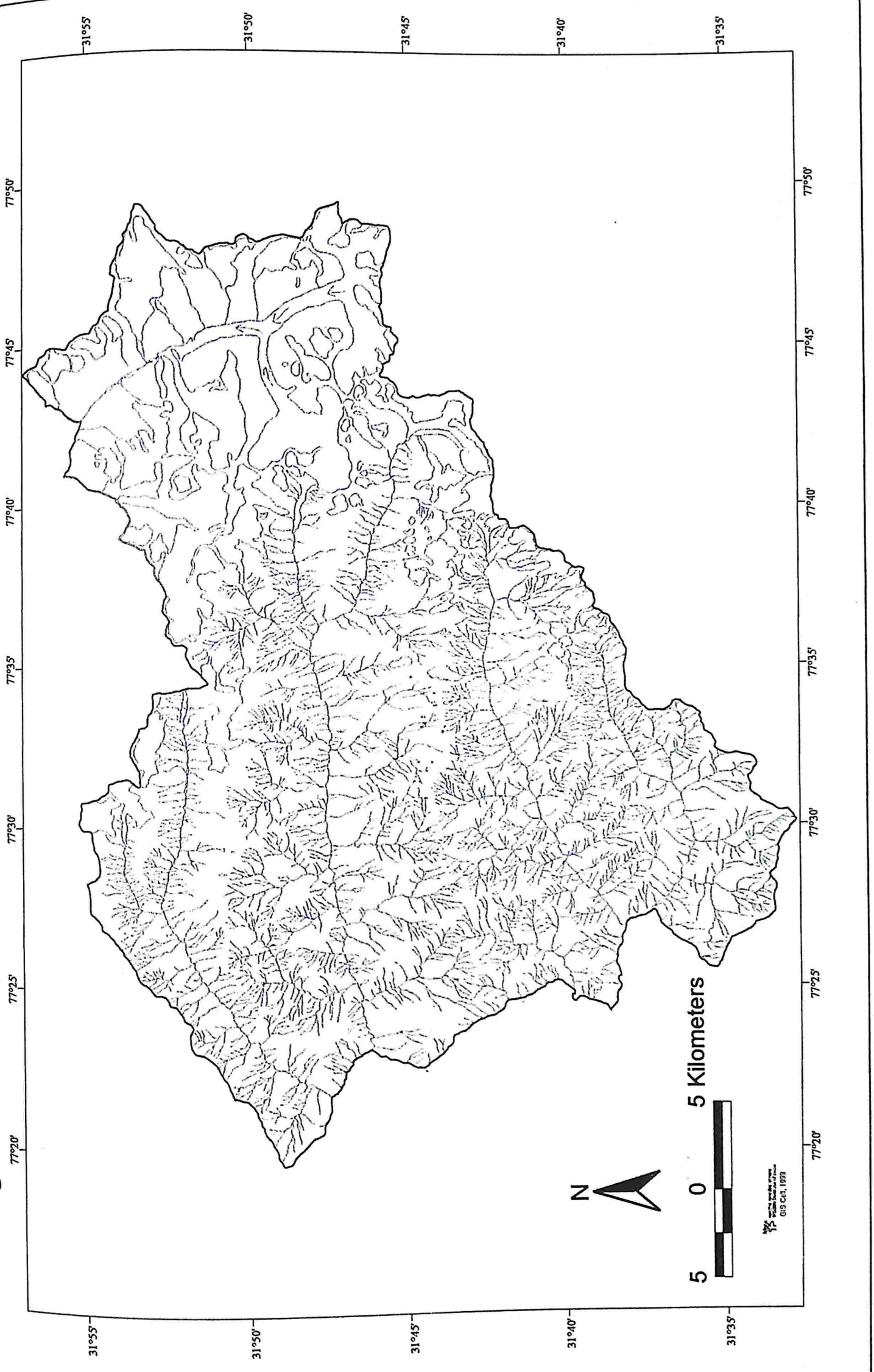
The Himalayas, a unique feature on earth, have been named variously the Abode of Snow, Abode of Gods, Weather-maker of the Indian Sub-continent, the Third Pole and the Weather Tower of Asia (Khoshoo, 1996). The Himalayan mountain range, due to its vertical and horizontal complexities, is probably the most diverse system in the world. Large altitudinal variations between the plains of the Himalayan foothills and highest peaks provide a great variety of natural and man-made ecosystems. Horizontally, the range extends from north to northeast and represents two prominent Indian biogeographic zones viz., Trans-Himalaya and Himalayas and they combinely occupy nearly 10.9% of the country's geographical area (Rodgers and Panwar, 1988).

The compact block of GHNPCHA comprising a National Park, two Wildlife Sanctuaries and an Ecodevelopment Zone encompassing a total area of 1,171 sq km acquires a grater regional conservation importance due to its contiguity with other adjoining PAs and managed forests.

3.2.1.2 Terrain and Sub – Watersheds

The terrain in the landscape is characterized by numerous high ridges (>4,000m), deep gorges and precipitous cliffs, craggy rocks, glaciers and narrow valleys. The perpetually snow bound area in the eastern part occupies 17.08% of the total landscape and drains out four perennial rivers (Fig. 3.1). Thus, the landscape under consideration consists of four sub-

Fig. 3.1 - Drainage Pattern in the Great Himalayan National Park Conservation Area



watersheds. Among four sub-watersheds, the Sainj SWS was the largest and occupied 39.62% area of the landscape while Jiwa SWS was the smallest, covering 12.64% landscape area (Table 3.1).

Table-3.1: Four Sub-watersheds and their area

Sl. No.	Sub-watershed	Area (sq km)	Percentage Area of the landscape
1	Tirthan SWS	330	28.18
2	Sainj SWS	464	39.62
3	Jiwa SWS	148	12.64
4	Parvati SWS	229	19.56
		1171	100

3.2.1.3 Altitude

Landscape is featured by a marked altitudinal gradient ranging from 1,300 m to 6,110 m above mean sea level (Negi, 1996). The minimum altitude is at Seund which is the confluence of Sainj and Jiwa rivers while the maximum in Parvati SWS of an unnamed peak. In general, the altitude increases from west to east. The Ecodevelopment zone is located on the western periphery. Details on the distribution of area in different altitudinal zones are presented in

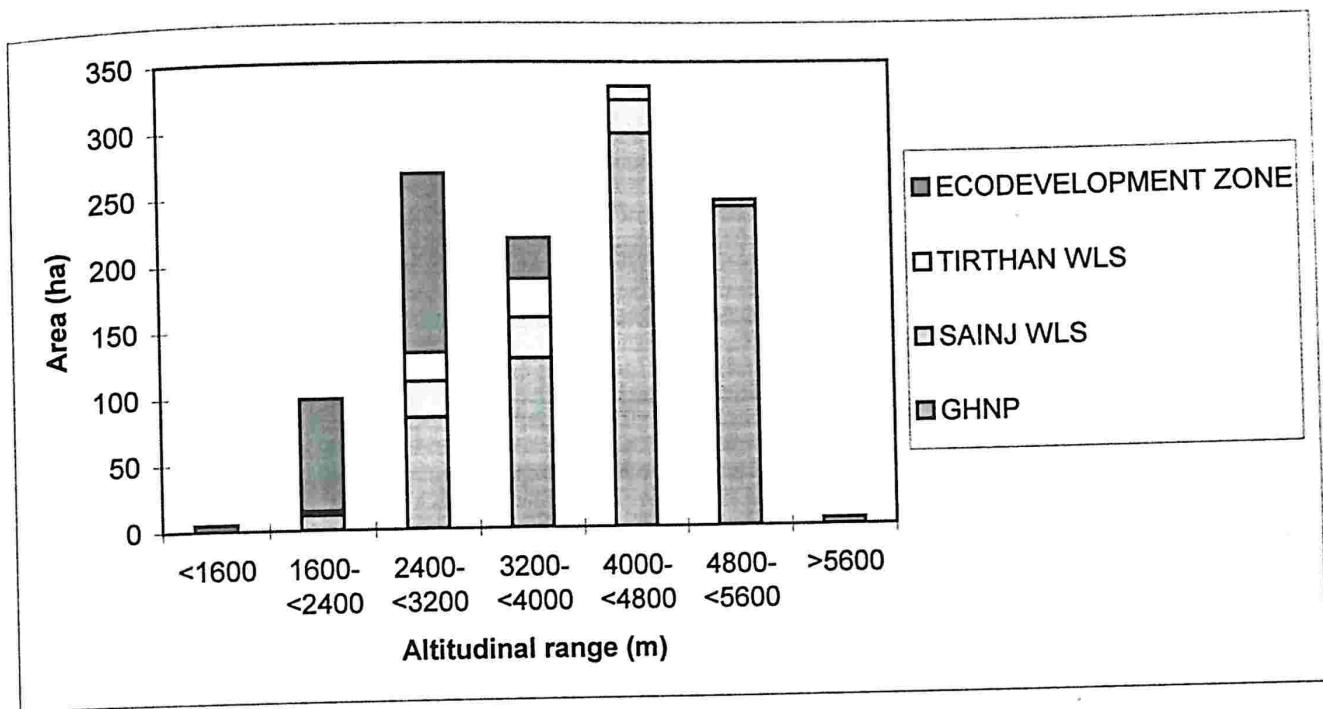
Table 3.2.

Table-3.2 – Landscape area under different altitudinal zones.

Altitudinal zones (m)	<1600	1600-2400	2400-3200	3200-4000	4000-4800	4800-5600	5600-6400
Landscape area (sq km)	5.05	98.58	266.95	217.94	331.94	245.90	4.64
Percentage of landscape	0.4	8.4	22.8	18.6	28.4	21.0	0.4

It is noteworthy that on the one hand altitudinal variation results in diversity of forests and habitats while on the other hand altitude regulates spatio-temporal distribution of human and livestock populations and also their resource use pattern. Bulk of the temperate forests occur in lower altitudes (1,300-3,200 m) while summer grazing areas occur at > 3,200 m. The data on altitudinal variation among four administrative constituents (GHNP, Sainj, Tirthan WLS and EZ) revealed that >87% area of the Ecodevelopment Zone lies below 3,200 m elevation thus harbouring bulk of forest, greatly lacking alpine pastures. On the contrary three PAs had 83.9% of their total area at >3,200 m altitude (**Fig.3.2**), thus possessing disproportionately greater chunk of alpine pasture areas in comparison to the Ecodevelopment zone.

Fig 3.2 – Distribution of Different Altitudinal Zones in the Four Administrative Constituents of the GHNP



3.2.1.4 Slope

Besides altitudinal complexities, the undulating terrain and steep slopes also characterize the landscape. Four slope categories adopted for the present study influence resource use, and management of natural resources in one or the other way. The slope distribution data was analysed in three ways : (i) Sub-watersheds wise, (ii) Administrative unit wise, and (iii) overall GHNP.

3.2.1.4.1 Sub-watersheds: The values of Gentle slopes among four SWS varied from 14% (Tirthan SWS) to 21% (Jiwa SWS). More than 65% area of each SWS was under steep and very steep slopes (Table 3.3).

Table 3.3 – Slope Categories in Various Sub-watersheds (Values in %) of GHNPCA.

Sl. No.	Slope Category	Sub-watersheds				Overall GHNPCA
		Tirthan SWS	Sainj SWS	Jiwa SWS	Parvati SWS	
1	Gentle <19 ⁰	15	14	21	20	16
2	M. Steep 19 ⁰ - 26 ⁰	11	11	13	12	12
3	Steep 27 ⁰ - 45 ⁰	41	37	40	29	37
4	V. Steep > 45 ⁰	33	38	26	39	35

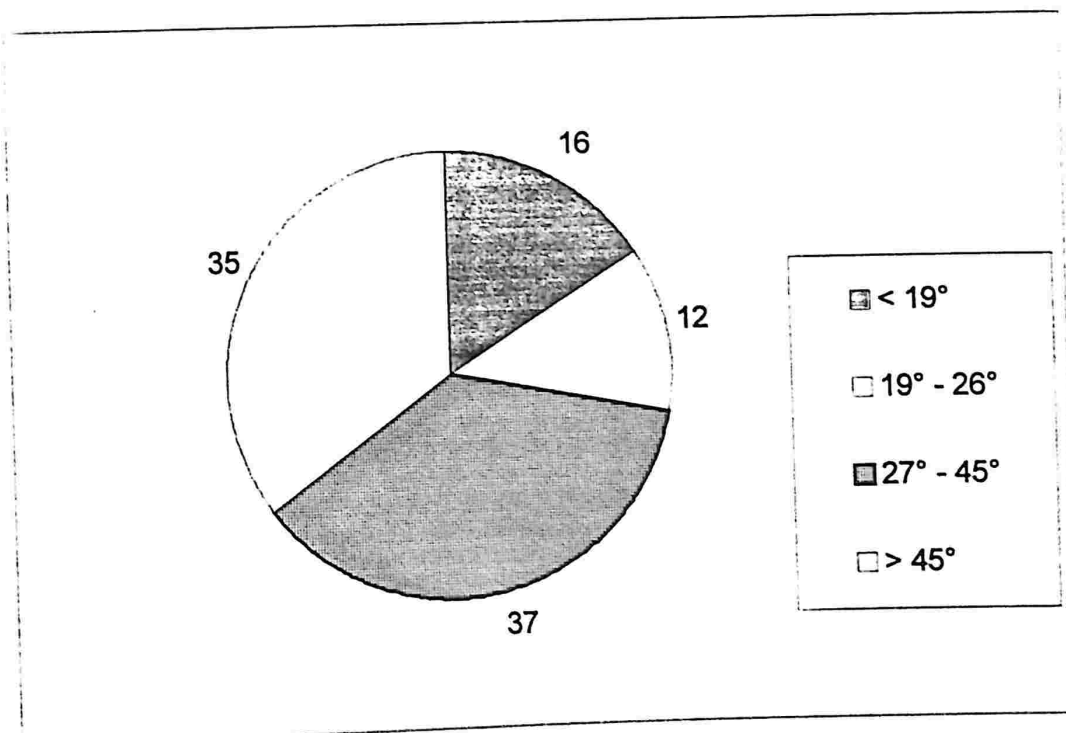
3.2.1.4.2 Administrative Units: Interestingly no marked distinction among four administrative constituents on the basis of slope categories was evident. However, it is worth mentioning here that only a small quantum of land (69 sq km or 5.89% of the total landscape) is just available in the Evodevelopment zone under the Gentle and Moderately Steep slope categories. This means that the entire human population residing in the 125 hamlets of EZ is directly dependent upon this meager land area for agriculture and horticulture purposes (Table 3.4).

Table 3.4 - Slope Categories in various Administrative Units (Area in sq km) of the GHNP

Sl.No.	Slope category	GHNP	Tirthan	Sainj	EZ	Overall GHNP
1	<19°	134	9	9	39	191
2	19°-26°	87	6	12	30	135
3	27°-45°	262	24	51	98	435
4	>45°	282	22	18	88	410
Total		765	61	90	255	1171

3.2.1.4.3 Overall Landscape: Analysis revealed that the entire landscape just possesses 16% land under the Gentle slope while > 70% of the landscape falls under Steep and Very Steep slope categories (Fig. 3.3).

Fig. 3.3 – Characterisation of the Landscape by Slope Categories (Values in %)



3.2.1.5 Climate

The GHNP/PCA experiences three distinct seasons viz., (i) Summer (April to June); (ii) Monsoon or rainy (July to September); and (iii) a six month long spell of winter (October to March). Like several PAs in India, the GHNP and two Sanctuaries also lagged behind in setting up the meteorological observatories at different locations. Data thus available for reference was mainly from two stations viz., Niharni (1,800 m) in the Ecodevelopment zone and Sainj (1,450 m), outside GHNP/PCA. The Public Works Department is maintaining these two meteorological stations. It was only after the commencement of FREEP-GHNP Project, that on the initiatives of research team and support of the park management, three meteorological stations viz., Kharoncha (1,800 m) in Tirthan SWS, Shangarh (2,100 m) in Sainj SWS and Pashi (1,500 m) in Jiwa SWS were established and regular data collection on rainfall and minimum and maximum temperatures on daily basis was carried out. Under the own new initiatives, rainfall and temperature data was also collected at three different locations in higher altitudes whenever such sites were visited and camped. Hence, broad observations based on the available or collected data are highlighted below.

The rainfall and temperature vary across the altitudinal gradient. The rainfall and temperature decreases as one ascends to higher altitudes. The temperature varies from -20°C to 30°C during severe winter months of December-January and peak summer months (May-June), respectively.

Depending upon the variation in altitude, higher reaches were colder than the valleys.

Average rainfall recorded at Niharni and Sainj during the period 1992-94 was 1,178 mm and 1,186 mm, respectively. Nearly 50% of the rainfall is received during the monsoon or rainy season, otherwise main precipitation is in the form of snow during winter. Occasional rains were also recorded during summer and winter months.

Higher reaches sometime experiences snowfall as early as the second fortnight of September. During the course of present study, the earliest snowfall was observed at Tirth in Tirthan SWS on 16 September, 1996 and as late as on 6 June, 1997. Except a few clear days, the upper reaches receive continuous rains throughout the monsoon season which causes over-flowing of river banks leading to land slides and erosion.

Long period of winter prohibits any outdoor activity in the region. Thus, local people have to mainly depend upon the stored resources (grains, fodder and fuelwood, etc.) and economy generated during the non-winter months. Out of that too heavy rains often take a toll of agricultural and horticulture crops. Due to these factors dependence on the livestock rearing for sustenance and also economy increases. Likewise, PA managers feel handicapped in carrying out protection works due to harsh weather conditions and inaccessibility of areas caused by damage of bridle paths and essential wooden bridges for any type of communication.

3.2.1.6 Landuse

In GHNP, as in other parts of the Himachal Pradesh, due to topographical intricacies and harsh climatic conditions, human population is traditionally dependent on forest and pasture resources for their own livelihood and rearing of livestock. Hence, forests and pastures play an integral role in the farming system prevalent in the region. During the post-independence period, the area witnessed increased agricultural activities and thus, a considerable area has been brought under agricultural system for production of grains. Even during recent 2-3 decades a gradual shift towards horticultural and other cash crops was observed.

Land, which is not privately owned, is controlled by the Forest Department or by the Revenue Department. Some revenue lands are classified as Government waste lands which are used by villagers and their grazing animals.

3.2.1.6.1 Overall Landuse Pattern: The landuse pattern obtained for the GHNP using the satellite data of 1993 is presented below in **Table 3.5**.

Table 3.5 – Overall Landuse Pattern in GHNP/CA.

Sl. No.	Landuse Category	Area (sq km)	% of the Landscape
1	Forests	451.9	38.6
2	Grass Patches and Alpine Pastures	274.9	23.5
3	Rivers, Water Bodies and Permanent Snow	205.1	17.5
4	Rocky Slopes/Cliffs and Moraines	212.0	18.1
5	Habitations, Agriculture and Orchards	27.1	2.3
	Total	1,171.0	100.0

Different types of forests constitute the foremost category of landuse on the basis of actual forest area. Broadly two types of forests were recognized viz., Temperate forests and Sub-alpine scrub. Temperate forests occur in the altitudinal range from 1,300 m to < 3,300 m while Sub-alpine scrub or Krummholtz dominated by *Rhododendron* sp. Occur between 3,300 and 3,600 m a.m.s.l. The temperate forests were further divided in two density classes on the bases of canopy cover (%): (i) Closed forest (> 40% canopy cover), and (ii) Open forest (10-40%). The second major landuse type was of the Grass Patches on lower altitudes and Alpine Pastures at > 3,600 m elevation. The area occupied by this category was 274.9 sq km or 23.5% of the landscape. Rivers, water bodies (lakes) and permanent snow occupied 17.5% of the landscape. The Rocky Slopes, Cliffs and Moraines also formed a significant landuse category by occupying 18.1% of the total land area. The village systems comprising habitations, agricultural areas and orchards covered just 27.1 sq km or a meager 2.3% of the entire landscape. The landuse pattern was further analyzed on basis of the administrative units and sub-watersheds.

3.2.1.6.2 Landuse Pattern – Administrative Units: The landuse pattern on the basis of administrative constituents of GHNP/PCA is presented in **Table 3.6**.

Table 3.6 – Landuse Pattern in GHNP/PCA on the Basis of its Administrative Constituents (Area in sq km)

Sl.No.	Landuse Category	Constituents				Overall Landscape
		GHNP	Tirthan	Sainj	EZ	
1	Closed Forest	103.96	34.00	18.00	156.01	311.97
2	Open Forest	4.97	00.00	2.00	15.99	22.96
3	Grass Patches	16.98	1.00	2.00	33.99	53.97
4	Dry Alpine Scrub	85.99	8.99	15.98	5.99	116.95
5	Alpine Pastures	170.98	9.00	33.00	8.01	220.99
6	Rocky Slopes/Cliffs	157.97	7.00	14.99	8.01	187.97
7	Water Bodies	4.05	0.02	0.04	0.99	5.10
8	Permanent Snow	195.00	0.99	3.99	0.00	199.98
9	Habitation/Agriculture/Orchards	1.07	0.00	0.00	26.01	27.08
10	Moraines	24.03	0.00	0.00	0.00	24.03
	Total Area (sq km)	765.00	61.00	90.00	255	1171.00

Significant observations made are highlighted below :

- (a) The Ecodevelopment zone alone possesses more than 50% of the closed and open forests when compared with three other administrative constituents of the GHNP/PCA.

- (b) The bulk (170.98 sq km or 73.37%) of the total Alpine pastures lie in the GHNP area alone while the Ecodevelopment zone possessing the majority livestock of the GHNP had only 8.01 sq km or 3.62% of the Alpine pastures.
- (c) The proportion of Grass patches occurring on lower altitudes was maximum in the case of Ecodevelopment zone, followed by GHNP. The EZ harboured 62.98% of total Grass patches.
- (d) A vast proportion (>17%) of the landscape was under Permanent snow. Further, the vastness of these snow bound areas was evident in the case of GHNP. The GHNP alone harboured 97.51% of the total Permanent snow areas. This way, nearly one-fourth ($\frac{1}{4}$) area of the GHNP was snow covered. In contrast to the GHNP, the EZ was totally devoid of Permanent snow.
- (e) As stated earlier, the Tirthan WLS was free from any human settlement. The Sainj WLS has only meager areas under habitation and their agricultural areas. Strikingly, the dominance of habitations, agriculture and orchards was in the Ecodevelopment zone (Fig 3.4). Thus, 96.04% area under the permanent human use was located in the EZ. The habitations and cultivation areas alone occupied 10.2% of the EZ.

3.2.1.6.3 Landuse Pattern- Sub-watershed Basis: The appraisal of landuse data presented on the basis of Sub-watersheds revealed the following noticeable observations (Table 3.7) :

Fig. 3.4 - Landuse and Forest Cover of Great Himalayan National Park Conservation Area

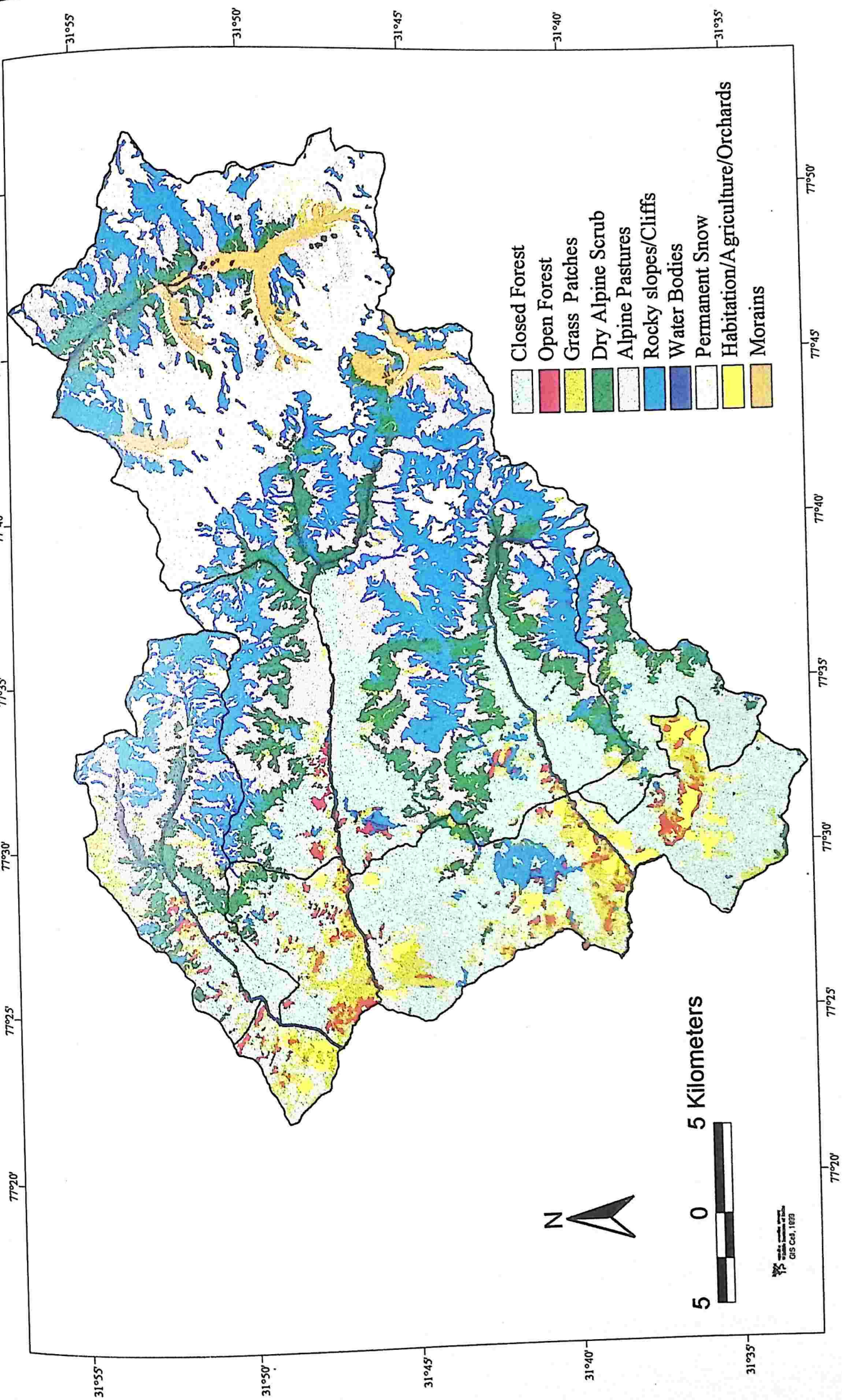


Table 3.7 – Landuse Pattern on the Basis of Sub-watersheds (Values in % of SWS area)

Sl No.	Landuse Category	Sub-watersheds				Overall Landscape
		Tirthan	Sainj	Jiwa	Parvati	
1	Closed Forest	44.21	26.93	24.22	0.00	26.64
2	Open Forest	2.97	1.91	2.44	0.00	1.96
3	Grass Patches	6.13	4.22	8.66	0.36	4.61
4	Dry Alpine Scrub	10.90	10.29	9.70	8.51	9.99
5	Alpine Pastures	13.13	21.49	28.61	16.12	18.87
6	Rocky Slopes/Cliffs	13.99	17.30	16.36	17.10	16.05
7	Water Bodies	0.57	0.41	0.54	0.41	0.46
8	Permanent Snow	3.25	14.48	6.93	50.03	17.08
9	Habitation/Agriculture/Orchards	4.91	1.31	2.25	0.00	2.31
10	Moraines	0.00	1.59	0.00	7.56	2.05

- (a) By and large, each SWS had a resembling landuse pattern as of the entire landscape, except some obvious distinctions with regard to the categories of closed and open forests, Permanent snow and settlement areas.
- (b) The Tirthan SWS on the one hand disproportionately possessed the bulk of the closed and open forests among four sub-watersheds. While on the other hand Parvati SWS was completely deficient in having any type of forest.
- (c) Four sub-watersheds were not uniform with regard to distribution of Alpine pastures. The Sainj SWS possessed maximum area of Alpine pastures (99.71 sq km or 44.86% of total Alpine pastures). However,

while comparing percentage figures for Alpine pastures in relation to the respective areas of each SWS, it was Jiwa SWS which obtained the highest value i.e. 28.61%.

- (d) A skewed distribution of Permanent snow covered areas was highlighted earlier in favour of the GHNP. Likewise, an inconsistent pattern was noticed among four sub-watersheds. Over 50% of the Parvati SWS was under Permanent snow. Though 16.12% of the Parvati SWS was under Alpine pastures, they were not available to migratory livestock due to its inaccessibility.
- (e) More than 50% of the actual area under the category of habitations and cultivation was lying in Tirthan SWS. The use of forest resources by local people mainly for fodder and grazing by livestock; and diverse habitats by wild animals are directly associated with the distribution of landuse categories as listed in **Tables 3.5 to 3.7**. The close examination makes it amply clear that the four administrative constituents of GHNP/PCA were certainly not consistent with the available forest and pasture resources. Undoubtedly, the situation with regard to the availability of resources and landuse pattern was more analogous across four sub-watersheds.

3.2.1.7 Legal Status

The entire Landscape is covered under two broad legal categories viz., (i) 'Revenue land' comprising villages, hamlets and cultivation areas under private ownership, and (ii) Government owned 'forest lands' comprising

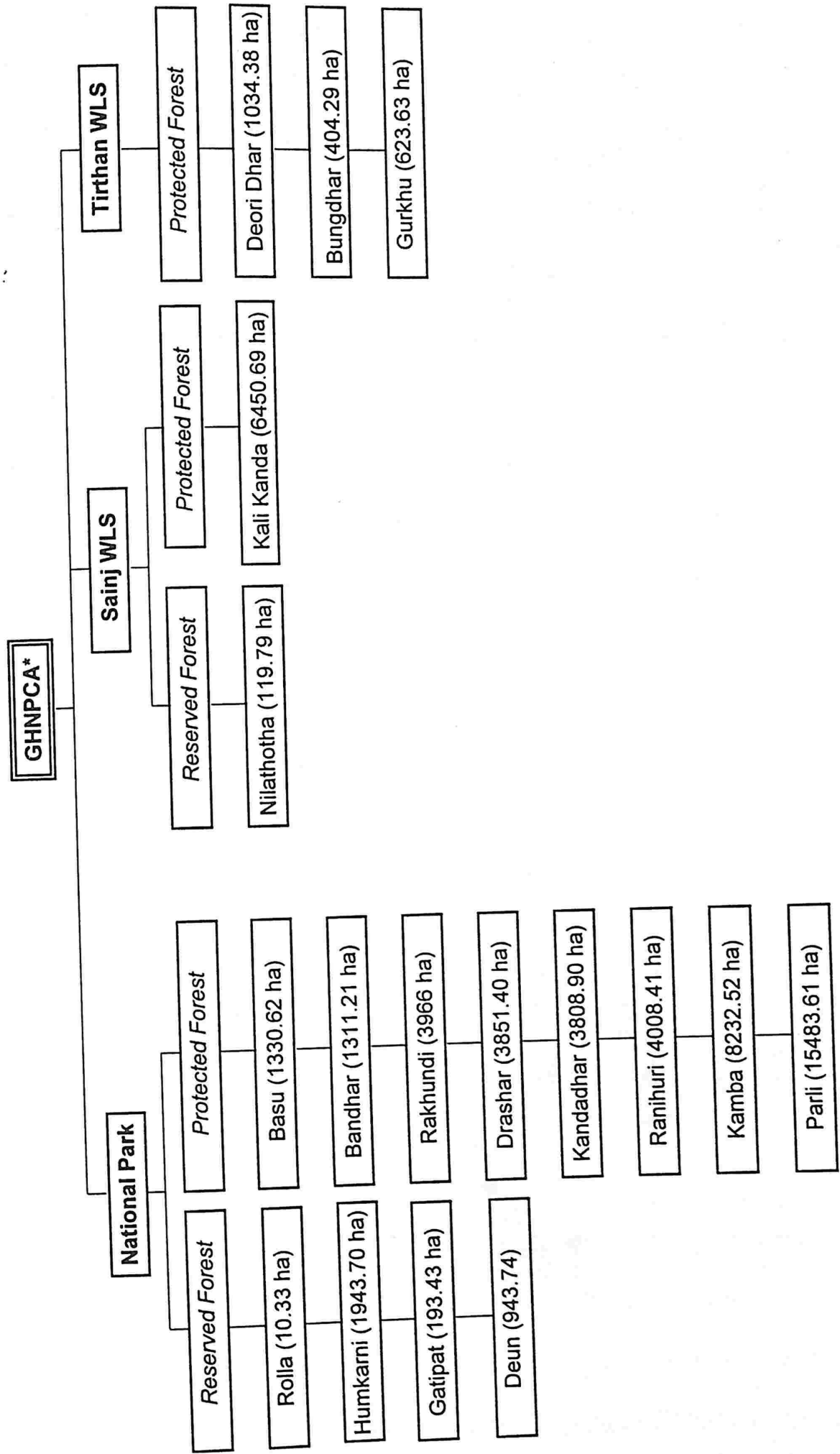
Reserved Forests (RF) or Protected Forests (PF). Protected forests have been further divided into three categories viz., Demarcated PF Class I and Class II forests and undemarcated PF or Class III forests. They differ mainly on the basis of their location, composition, management and rights of their use by local people. A comparative description of forests under these three categories is presented in Table 3.8.

Table 3.8 – A Comparative Description of Different Protected Forests.

Sl. No	Type	Location	Quality of Forest	People Rights	Management
(i)	Demarcated Protected Forests – Class I	Near habitation, usually in lower elevations	Valuable growing forest stock	Less extensive but well defined	High level of management, Traditionally managed on the silvicultural system basis
(ii)	Demarcated Protected Forest – Class II	Comparatively in higher altitudes including alpine areas	Diverse vegetation types including pastures and snow bound areas providing large quantities of timber to local requirement and commercial purposes	Mainly used as summer grazing areas	Moderate level of management
(iii)	Undemarcated Protected Forests – Class III	Varying locations	Comprising wooded areas, grass patches and rocky barren slopes	People meet timber and grazing requirements	Low level management mainly due to poor demarcation and inaccessibility

RFs are better quality forests since they obviously enjoy higher legal status; and they are located in interior areas. The Fig. 3.5 presents distribution of

Fig. 3.5 - Distribution of Forests in GHNP



* Information for the Ecodevelopment zone and PF - Class III could not be accessed.

Reserved and Protected Forests (Class I and II) across the three administrative constituents viz., National Park and two Wildlife Sanctuaries. Information on PFs – Class III could not be accessed. The forests in GHNP were once managed as a part of the Seraj Forest Division. The Tirthan WLS, covering an area 61 sq km was first carved out and declared as 'Sanctuary' through the H.P. Government Notification in 1976. There are no villages inside the Tirthan WLS. The process of creating the Great Himalayan National Park was initiated way back in 1978-80, when the first Himachal Wildlife Project survey was undertaken. Based on the recommendations of the survey report, the first notification of intention to constitute GHNP vide H.P. Government Notification No. 6-16-73-SF-II dated 1 March, 1984 was issued. Since a few hamlets were falling in the initial notified park area and all efforts to relocate them have failed, the area was realigned and a new Sanctuary named as Sainj WLS was carved out. Further, considering the significance of a contiguous area in Parvati valley and additional area was added to the GHNP so as to enlarge the overall area to present 765 sq km vide H.P. Government Notification No.3-6-16-73-SF-II dated 22 April, 1994.

Further, an area extending radially upto 5 km on the western periphery of Tirthan and Sainj WLS as well as GHNP, covering 255 sq km was also demarcated as the 'Ecodevelopment Zone'. Though the Ecodevelopment zone harbours a number of villages, hamlets and cultivation area thus, constituting a bulk of 'revenue land' in spite this holds over 50% of the total forest area of GHNP. As explained earlier in para 2.1 under Chapter 2, the legal formalities for the final declaration of the Great Himalayan National Park

remained pending for almost 15 years. However, it was only on the directives of the Supreme Court of India that the process of settlement was hastened and the final notification was issued in May, 1999 by settling rights of the local people by making a provision of cash compensation worth Rs. 1.5 crore to right holders. More than 50% of the cash compensation was already paid to the affected parties in the Ecodevelopment zone by the time of writing this document. The final award also made a provision of about Rs.7.5 crores for developing pasture lands, forest lands and medicinal plant areas during the period of next five years (*pers. Comm. Park Authorities, GHNP*). As stated by the Park authorities, due procedure in accordance to the Wildlife (Protection) Act, 1972 was followed for settlement. The final notification also resulted into a minor adjustment of 10.6 sq km between GHNP and the EZ. The revised area statistics has already been provided in the **Table 2.1**. Hence, the GHNP/PCA is now constituted by a NP, two WLS and an Ecodevelopment zone covering an area of 1,171 sq km for achieving long term conservation goal.

The GHNP and two WLS are fully under the control of the Director, GHNP, Kullu and being managed as per the provisions of the Wildlife (Protection) Act, 1972. The present EZ is mainly constituted by forests, grass patches ('Ghasnis'), alpine pastures and habitations alongwith their agricultural and orchard lands. Thus, a larger proportion of the EZ is Government owned forest land while the village and their surrounds form revenue area. The forest land is managed under the provisions of the Indian Forest Act, 1927 and the Forest Conservation Act, 1980 and also under the control of the

Director, GHNP. While the revenue areas are under the control of the District Administration. The EZ makes the Buffer zone to three PAs.

The current legal provisions prohibit any type of resource use (grazing and collection of herbs, medicinal plants, etc.) in a National Park while only regulated resource use is permissible in a Wildlife Sanctuary. In such circumstances, the EZ becomes the Multiple Use Zone.

3.2.2 The Biological Environment

The landscape owing to large altitudinal and climatic variations alongwith varying land forms contribute a rich floral and faunal diversity. Prior to the initiation of FREEP-GHNP Research Project, only a general account on the floral and faunal attributes specific to GHNP-CA was available. However, concurrent to the present study, several researches and short term consultancy studies were undertaken on different aspects. Findings of these recent researches were optimally used while synthesizing this section on the landscape. The floral and faunal diversity and its distribution across the landscape is thus described below.

3.2.2.1 Floral Diversity

The GHNP-CA harbours varied forests (38.6%) and Pastures (23.5%). Hence, >60% area of the landscape is under one or the other type of vegetation. Old Forest Working Plans relevant to the area, described the following 14 forest

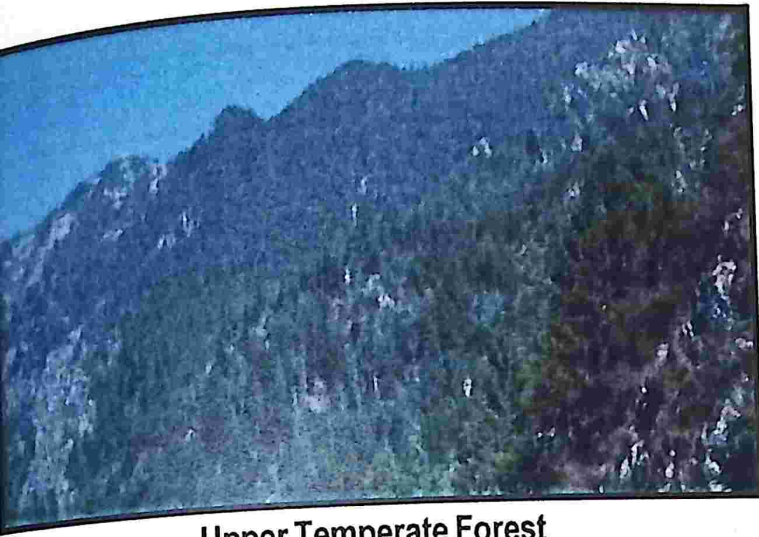
vegetation types as per Champion and Seth (1968) . Plates 1 and 2 depicts different temperate forests, sub-alpine and alpine pastures.

1. Ban Oak (*Quercus* sp.) Forest 12/C1(a)
2. Moist Deodar Forest 12/c1 (c)
3. Western Mixed Coniferous Forest 12/c1(d)
4. Moist Temperate Deciduous Forest 12/C1(e)
5. Kharsu Oak Forest 12/C2(a)
6. Western Himalayan Upper Oak – Fir Forest 12/C2(b)
7. Montane Bamboo Brakes 12/DS1
8. Himalayan Temperate Parklands 12/DS2
9. Himalayan Temperate Pastures 12/DS3
10. Western Himalayan Sub-Alpine Fir Forest 14/C1(a)
11. Sub-Alpine Pastures 14/DS1
12. Birch/*Rhododendron* Scrub Forest 15/C1
13. Deciduous Alpine Scrub 15/C2
14. Alpine Pastures 15/C3

The *Aesculus indica*, *Juglans regia*, *Prunus comuta*, *Acer* sp., *Betula alnoids*, *Betula utilis*, *Populus ciliata*, *Salix wallichiana*, *Fraxinus* sp., *Quercus leucotrichophora*, *Q.floribunda*, *Q.semecarpifolia*, *Celtis tetrandra* formed the broad leaved species whereas *Cedrus deodar*, *Pinus wallichiana*, *Abies pindrow*, *Picea smithiana*, *Taxus baccata*, *Pinus roxburghii*, etc., were among the prominent conifers. Kharsu oak (*Quercus semecarpifolia*) occur in large extensive pure patches in the upper temperate zones whereas *Abies pindrow*

Plate - 1

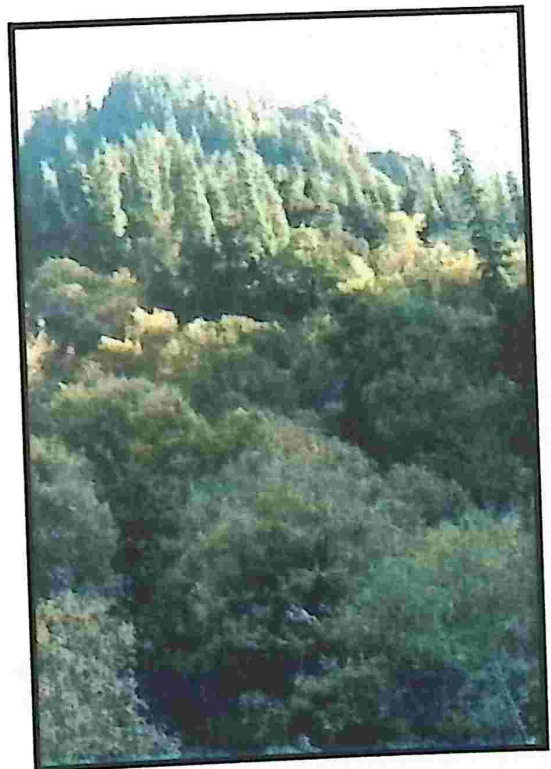
Different Temperate Forests



Upper Temperate Forest



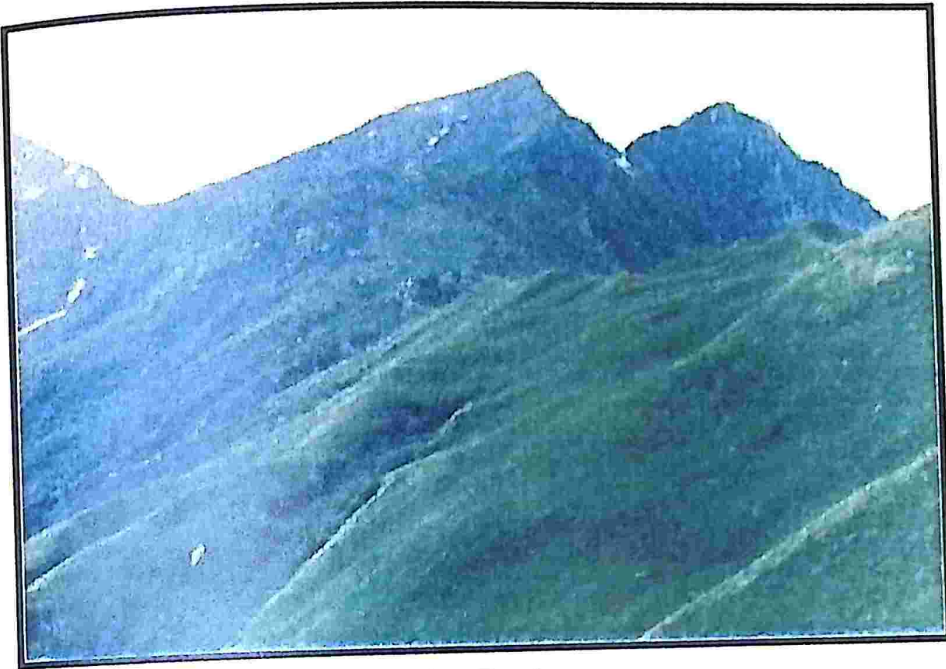
Middle Temperate Conifer Forest



Lower Temperate Mixed Broad Leaved Forest

Plate - 2

Sub-Alpine and Alpine Pastures



Alpine Pastures



Transition Sub-alpine to Alpine

and *Pinus wallichiana* in the lower reaches than Kharsu oak which forms the sub-alpine forest reaching to the timber line. The riverine forests are dominated by the species of *Salix*, *Populus*, *Aesculus*, and *Prunus*. The Himalayan bamboo *Thamnocalamus spathiflorus* and *Sinarundinaria falcata* are usually found in moist slopes more in the northern aspect than in southern aspect. The major shrub species were the *Indigofera*, *Viburnum*, *Sarcococca*, *Berberis*, *Rosa* and in the higher altitudes the *Juniperus* and the *Rhododendron* form patches. The herb layer in the alpine areas is composed of many commercially important medicinal and aromatic plants like *Picrorhiza kurrooa*, *Dactylorhiza hatagirea*, *Aconitum heterophyllum*, *Jurinea macrocephala* and *Nardostachys grandiflora* along with colourful species like the *Potentilla*, *Gagea*, *Geranium* and *Meconopsis*.

Gaston *et al.* (1981) assessed distribution of large mammals and birds in GHNPCA on the basis of five broad vegetation categories. These are described below:

- Sub-tropical pine forests characterised by Chir pine (*Pinus rhoburghii*) between 600 – 1,700 m.
- Himalayan moist temperate forests characterised by both conifers and broad-leaved species between 1,500 – 3,600 m.
- Sub-alpine forests dominated by birch (*Betula* sp.) and fir (*Abies* sp.) between 3,000 – 3,400 m.

- Moist sub-alpine scrub characterised by *Rhododendron* species between 3,000 – 3,500 m.
- Dry alpine scrub characterised by Junipers (*Juniperus* sp.) between 3,400 – 3,800 m.

Singh and Rawat (1999) carried out systematic floristic surveys concurrently across GHNPCA during 1995 – 1999 in different forests and pastures in three seasons. A total of 832 plant species belonging to 128 families and 427 genera of higher plants were recorded. Habit wise distribution included 69 tree, 113 shrub, 493 herb, 96 grass and 27 ferns and 8 climber species. This represented nearly 26% flora of Himachal Pradesh. Further, an ethnobotanical survey undertaken by them revealed that local people use more than 250 plant species for various purposes. A number of species were recognised as locally threatened due to heavy exploitation, or rare due to their ecological and phytogeographical reasons. 15 species recorded in GHNPCA have been listed in the Red Data Book of Indian Plant (Nayer and Sastry, 1987). Singh and Rawat (1999) further described vegetation of GHNPCA into 11 physiognomic types that correspond to nearly 25 categories of Champion and Seth (1968). Thus, a detailed account on the floristics, species diversity, vegetation structure and composition, ethnobotany and conservation priorities for GHNPCA has been made available by them for the first time.

During the present study, it was noticed that the Himalayan Temperate forests, characterised by both conifers and broad-leaved species between 1,500-3,600m, dominate the landscape. Only two species of bamboo viz., *Sinarundinaria falcata* and *Thamnocalamus spathiflora* occur in GHNP. Both the species are important since they form important wildlife habitat as well as heavily used by local people for making baskets ('Kilta').

It was also recorded that opportunistic plants viz., *Rumex*, *Polygonum*, *Impatiens*, *Girardinia*, etc. dominated ground cover in disturbed areas. *Themeda triandra*, *Heteropogon contortus*, *Andropogon lanceolatus*, *Carex* sp., *Apluda* sp. were prominent grass and sedge species in grass patches ('Ghasnis') in village surrounds. *Poa* sp., *Danthonia* sp. and *Phleum* sp. and *Carex* sp. were dominant among grasses and sedges in Alpine pastures. Lower plants viz., Bryophytes and Lichens in GHNP have been studied by Karunakaran and Singh (*pers. comm.*) and Upreti (1999), respectively. So far, 150 species of Bryophytes and 192 species of Lichens have been identified and documented by them, respectively.

Lichens are the unique group of plants that consists of two unrelated components i.e. fungi and algae living in a close symbiotic association. The peculiar association enables these plants to exploit a wide range of habitats. Recent study on lichens in GHNP by Upreti (1999) disclosed a diversity of 192 lichen species belonging to 15 genera and 31 families. The Tirthan SWS and Jiwa SWS exhibit high diversity of 101 and 100 species, respectively. In contrast, the Sainj SWS represented 67 species only. The Shilt, Dhela and

Gatipat have maximum species of lichens represented by 42, 40 and 34, respectively. Availability of several exposed rocks in alpine pastures provided opportunity to *Saxicolous* (rock inhabiting) species to grow. High diversity as of 40 *Saxicolous* species was recorded. The upper temperate forests (2,500-3,000 m) exhibit the highest diversity of lichens in GHNPCA. The *Corticolous* lichens (bark inhabiting) represented 149 species. Orchard species *viz.*, *Prunus*, *Pyrus* sp. and *Juglans* sp. on lower altitudes while tree species belonging to genera *Aesculus*, *Betula*, *Celtis*, *Quercus*, *Rhododendron* and conifers were preferred host plants of lichens in GHNPCA. *Quercus semecarpifolia* tree harboured >30 species. *Q. semecarpifolia* growing in different sub-watersheds exhibit a different pattern of species diversity, being higher in Tirthan and Sainj while least for Jiwa SWS. Common lichens in GHNPCA included *Acarospora fusca*, *Aspicilia almorensis*, *Bacidia millegrana*, *Caloplaca pindarensis*, *Leptogium pedicellatum*, *Lobaria retigera*, *Ramalina sinensis*, *Usnea longissima* and *U.orientalis*. A major trade in lichens for the purpose of making spices, medicines and dyes was is prevalent in the area. During the present investigations also, the harvest of lichens particularly by heavy lopping of *Quercus semecarpifolia* was witnessed.

3.2.2.2 Faunal Diversity

Noticeable variations in altitudes, aspects, slopes, valleys, ridges, peaks, forests, pastures at the macro or landscape level have already been highlighted. The typical terrain of GHNPCA was also rich in diverse

microhabitat elements. A variety of unique and special habitats across the landscape provide additional value. The micro habitat elements of the geomorphic origin i.e. 'unique habitats' viz., rocky outcrops, cliffs, overhangs, caves/dens and bouldery stratum were some of the prominent features across different sub-watersheds. Likewise, micro habitat elements of the biological origin or 'special habitats' viz., numerous streams of different orders/riparian areas, lakes, grass patches, krummholtz (sub-alpine scrub), sacred groves (local 'Devta' or deity sites), bamboo dominated localized patches, down wood, snags, den trees, old growth stands are some outstanding endowment of the nature to the landscape. Obviously, above described macro and microhabitat elements contributed a spectacular, rich and diverse fauna. Prior to the present study and other concurrent researches under the major FREEP-GHNP Research Project, very little information was available on the faunal diversity in the area. However, significant contribution was made by Gaston (1980), Gaston *et al.* (1981, 1983 and 1993); Gaston and Garson (1992), based on several field surveys undertaken by them under the foremost Himachal Wildlife Project. They present a general account of the types, extent and quality on forests and distribution of large mammals and pheasants in different administrative constituents and sub-watersheds.

Subsequent to the above and concurrent to the present study, systematic field surveys and detailed studies on different faunal groups undertaken in GHNP/PCA are described below:

A. Vertebrates		
	Mammals – Large mammals and a special focus on Mountain Ungulates	Vinod and Sathyakumar (1999); Vinod (1997 and 1999); Gaston (1998)
	Birds – Focus on Pheasants	Ramesh <i>et al</i> (1999)
	Herpetofauna	Dutta (1999)
B. Invertebrates		
	Annelids	Julka (1999)
	Molluscs	Julka (1999)
	Insects	Uniyal and Mathur (1998); Uniyal and Mehra (1996); and Uniyal and Singh (1996)

A gist on patterns of diversity, status and distribution of above faunal groups is presented one by one in the following paragraphs:

3.2.2.2.1 Mammals: Thirty one (31) mammalian species, representing six orders *viz.*, Primates (2 species), Carnivora (12 species), Artiodactyla (7 species), Insectivora (3 species), Rodentia (6 species) and Lagomorpha (1 species) have been documented so far for the entire area. Primates were represented by *Rhesus macaque (Macaca mulatta)* and common langur (*Presbytis entellus*). These two primates were widely distributed across the temperate forests (1,440 – 3,420 m). The obvious absence in the Alpine pastures was noticed. Both the primate species preferred broad-leaved forests and village surrounds, mostly feeding on *Aesculus indica*, *Juglans regia* and agricultural crop – *Zea mays* and fruits in orchards. Among Carnivora, 12 species recorded so far are: Common leopard (*Panthera pardus*), Snow leopard (*Uncia uncia*), Asiatic black bear (*Ursus thibetanus*),

Himalayan Brown bear (*Ursus arctos*), Jackal (*Canis aureus*), Red fox (*Vulpes vulpes*), Wolf (*Canis lupus*), Leopard cat (*Felix bengalensis*), Jungle cat (*Felis chaus*), Yellow Throated marten (*Martes flavigula*), Himalayan weasel (*Mustela sibirica*) and Himalayan Palm civet (*Paguma larvata*). Four of these viz., snow leopard, Himalayan Brown Bear, Himalayan Weasel and Red fox are predominantly preferred higher altitudes (> 3,300 m) i.e. sub-alpine and alpine zones. Only one sighting record in the case of snow leopard by Vinod (1999) has been documented. On the contrary, common leopard, Asiatic Black Bear, Himalayan Brown Bear, Jackal and Red Fox were frequently sighted during this study. Yellow-throated marten was usually sighted in pairs, near streams and grass patches across different sub-watersheds. Usually the frequent sightings were between 1,400 to 2,800 m elevations.

Seven species belonging to the Order Artiodactyla or ungulates viz., Grey Goral (*Nemorhaedus goral*), Himalayan Musk Deer (*Moschus chrysogaster*), Himalayan Tahr (*Hemitragus jemlahicus*), Serow (*Nemorhaedus sumatraensis*), Barking deer (*Muntiacus muntjak*), Blue Sheep or Bharal (*Pseudois nayaur*), and Asiatic Ibex (*Capra ibex*) have been listed for GHNPCA by Gaston *et al.* (1981) and Vinod and Sathyakumar (1999). During the present study goral were frequently sighted. The species was widely distributed from 1,600 m to 3,000 m. Usually sightings were on southern grassy slopes and in and around the Transitory forest camping sites. The Himalayan Tahr preferred steep, rocky slopes at altitudes ranging from 2,600 - > 4,000 m. On the contrary direct sightings of the Himalayan Tahr were low. Himalayan Tahr as a solitary to five individuals in a group were sighted near

Gumatrao, Kobari, Dhela, Majhouni, Manoni, Apgain, Gatipat during September-October and June-July. The musk deer being a territorial animal was mainly seen in sub-alpine scrub dominated by *Rhododendron campanulatum* or Krummholtz while foraging was observed in alpine pastures. Sightings of Musk deer in Gumatrao, Kobri, Dhela and Patal were made during the intensive field assessments in sub-alpine and alpine pasture areas. Blue sheep as an animal of alpine pastures and scree slopes and precipitous cliffs at altitudinal range of 3,800 – 4,700 m were sighted on six different occasions during the course of present investigations. The group size varied from 8 to 40 individuals. Majority of these sightings were over Bhlundwari area and Tarthadhar in Tirthan SWS. At least on two occasions Blue sheep were sighted while they were licking on salt licks left behind by pastrolists. These sightings were made in the second half of September month, once pastrolists have vacated pasture areas after intense use. As such Blue sheep were not sighted in alpine pastures while the migratory livestock was present in those pastures. The Barking deer, an inhabitant of middle to upper temperate forests was rarely sighted. Serow, an animal of mid to upper temperate forests though reported in GHNPCA was never sighted during the study period. Likewise, not a single sighting of the Himalayan ibex was recorded during the 3 year field work though the GHNPCA provides a potential habitat.

Six species belonging to orders Rodentia and Lagomorpha viz., House mouse (*Mus musculus*), Common Giant Flying Squirrel (*Hylopete fimbriatus*), Royle's vole (*Alticola roylei*), Indian Porcupine (*Hysterix indica*), Hodgson's Porcupine

(*Hystrix hodsoni*), and Himalayan Mouse Hare – Pika (*Ochotono roylei*) have been documented so far. The Himalayan mouse hare was frequently sighted. This species was sighted only in alpine pastures having predominance of boulders. The maximum sightings were at Kobri, followed by Tarthadhar i.e. >4,000m elevation. Usually these sightings were in afternoons. 11 sightings of Common giant flying squirrel on trees of *Aesculus indica* and *Quercus semecarpifolia* were recorded during the present study. Only one direct sighting of Indian Procupine near Tinder village in Tirthan SWS was made. However, quills of these species as indirect evidence were very frequently seen around village surrounds.

Among above described 31 mammalian species, 11 have been listed as Schedule I species, and 9 as Schedule II species under the Wildlife (Protection) Act, 1972.

3.2.2.2.2 Avifauna: Gaston et al. (1993) documented 183 bird species in GHNP including 132 passerines and 51 non-passerines. They also concluded that the Park supports a substantial proportion of all the species occurring within its altitudinal range in the Western Himalayas. At least 50 species are summer visitors to the Park. Two raptors – Himalayan Griffon (*Gyps himalayensis*) and Lammergier (*Gypaetus barbatus*) are common in the GHNPCA. The GHNPCA is well known for supporting a viable population of many endemic Western Himalayan pheasants, particularly the endangered Western tragopan (*Tragopan melanocephalus*). Other four species of pheasants reported from GHNPCA are: Cheer pheasant (*Catreus wallichii*),

Himalayan monal (*Lopophorus impejanus*), Koklas (*Pucrasia macrolopha*) and Kalij (*Lophura leucomelana*). Ramesh *et al* (1999) have provided details on the altitudinal and seasonal distribution of five pheasants in GHNP. Kalij pheasant occurs in the lower temperate broad-leaved forests with sufficient undergrowth, while Koklass pheasant primarily occur in the upper temperate broad leaved and conifer forests. The Himalayan monal prefers extensive range of habitats and altitudinal distribution. The Western tragopan occurs between 2,600-3,200 m elevations, hence they utilize mainly the broad leaved conifer, mixed conifers and Kharsu oak (*Quercus semicarpifolia*) forests. The cheer pheasant is rarely sighted. However, a few sightings were made in the broad-leaved conifer forests. The distribution pattern of five pheasants illustrates utilization of different forest types located in middle altitudinal range. A Western tragopan was successfully captured for the first time by the Wildlife Institute of India's research team and released after installation of radio-transmitter. Data on the seasonal movement and habitat use is being collected.

3.2.2.2.3 Herpetofauna: Field surveys for the assessment of diversity, distribution and status of herpetofauna (reptiles and amphibians) across different sub-watersheds were undertaken for the first time under the major project. A list of 12 species has been provided by Dutta (1999). The Himalayan Pit Viper (*Agkistrodon himalayanus*) was frequently sighted, especially during the rainy season. During one field trip of 18 days (Rolla to Saketi), as many as nine Himalayan pit vipers were sighted. Other common reptiles sighted were Indian rat snake (*Ptyas mucosus*), Kashmir rock agama

(*Laudakia tuberculata*) and Himalayan ground skink (*Scincella himalayanus*).

Rat snakes were sighted during May-June and August-September.

3.2.2.2.4 Annelids and Molluscs: The earthworm fauna (annelids) in GHNPCA is represented by 11 species, comprising about 25% of diversity recorded in Himachal Pradesh. Of these, 4 species are native and 7 are exotic. High earthworm diversity in the area was recorded. It was mainly due to the availability of diversity of habitats viz., moist forests with thick layer of litter, animal dung, rotten logs, bouldery stratum and bark of standing trees, etc. Two new species of the genus *Plutellus* were recorded and identified from the GHNPCA (Julka, 1999). The study by Julka (1999) has also highlighted that native species are usually found under natural vegetation while introduced exotics predominate cleared areas for cultivation, plant nurseries and in dung heaps near cow sheds. An inventory of molluscs in GHNPCA yielded a list of 14 species. The reason for poor diversity of aquatic molluscs was accounted for the absence of stagnant water bodies. Of 14 species recorded, 10 were terrestrial and 2 aquatic.

3.2.2.2.5 Insects: The recent study on insects belonging to six selected orders viz., Coleoptera, Hymenoptera, Diptera, Hemiptera, Odonata and Lepidoptera revealed a diversity of 37 families, 108 genera and 127 species among specimens identified (Uniyal and Mathur, 1998). The order Lepidoptera (butterflies and moths) represented higher diversity in terms of 55 genera and 61 species among the six orders studied. The order Coleoptera (beetles) had 41 genus and 47 species. Studied six orders were arranged in

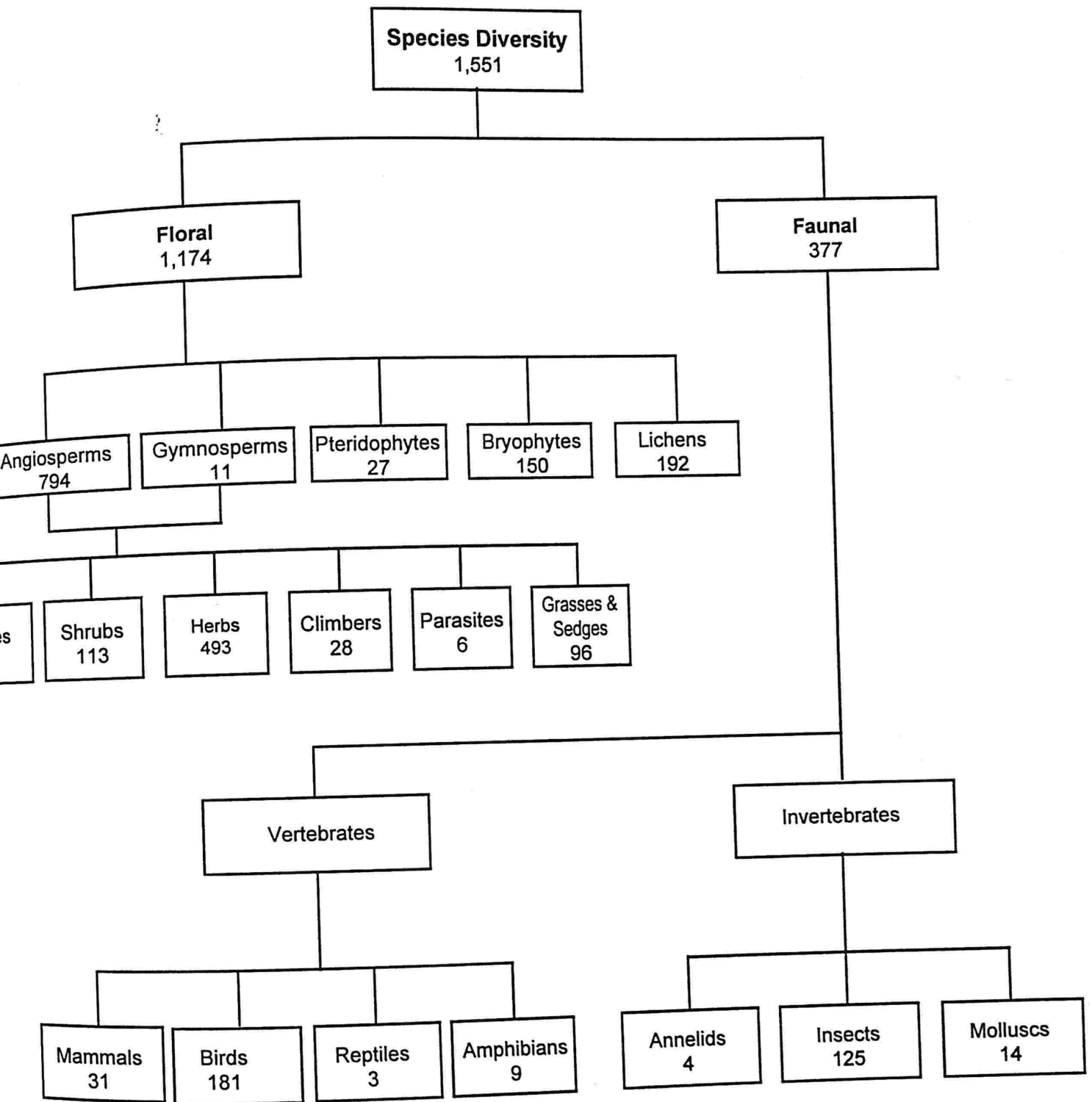
a descending diversity sequences as: Lepidoptera – Coleoptera – Hymenoptera – Odonata – Hemiptera – and Diptera. Out of 37 families recorded, seven families were widely distributed (1,500 - > 3,500 m) while seven other families had a narrow distribution (1,500-2,000 m). Out of 14 families recorded, of the order Coleoptera (beetles) maximum representation of species was recorded in the family Scarabacidae (dung beetle). As the name suggests, members of this family mostly feed on dung of various large herbivores which they roll into convenient – sized ball, bury them in underground chambers and feed at leisure. Apparently, there seems to be a positive correlation between livestock grazing and diversity of dung beetles. This requires further confirmation and monitoring. Uniyal and Mathur, (1998) revealed that among the 13 families, of the order Lepidoptera recorded, three prominent families were viz., Nymphalidae, Pieridae and Papilionidae. Significantly only these three families representing maximum diversity were recorded from alpine pastures. It is therefore, presumed that any deleterious effect on alpine pastures may influence the diversity of these three insect families.

The figure provides a summary of floral and faunal diversity so far documented in the case of GHNPCA (Fig. 3.6).

3.2.3 The Social Environment

Mountainous landscapes are of paramount importance for the biosphere and humanity. Since time immemorial, man has colonised and exploited natural

Fig. 3.6 - Summary of Floral and Faunal Diversity in GHNPCA



high altitude ecosystems for himself and his livestock. The landscape under consideration is no exception. Diverse ecosystems, man and his livestock have co-evolved and are thus, intimately tied as a complex fabric. In this context, it becomes important to examine and understand the social conditions of the local people, particularly of pastoralists, historical development, perceptions and attitudes.

The synthesis on the social environment of local people and pastoralists presented below is largely based on the assessments made in field and villages as per the methodology described in the previous Chapter, however, supplemented by findings of co-workers.

Tucker (1997) has provided a comprehensive account of the historical development of human impacts on the GHNPCA while Nangia *et al.* (1999) have dwelt upon the socio-economic conditions of resource dependent people. Baviskar (1998) has presented an overview on resource use practices, perceptions, resource conflicts and their negotiation based on an intensive micro-study in Sharan and Lapah villages in Sainj SWS.

3.2.3.1 The Historical Perceptive

The historical development in the area was understood for three broad eras :
(i) Pre-colonial Kingdoms, (ii) Colonial System, and (iii) Post-Independence Period.

During the Pre-colonial kingdoms, people were asked to pay taxes, provide labour and various produces and products to rulers in return for rights of access to various resources. This era was followed by an administrative system under the British colonial regime wherein linkages between the State and people were meticulously codified in terms of 'duties' and 'rights'. This colonial phase was more or less bureaucratic as well as hierarchial wherein the policy decisions were always by the top. The best aspect of the British regime was that details of various rights to land and other natural resources viz., right of way, collection of forest produces, livestock grazing, etc. were well documented and because of this people felt more secure. The Post-independence Period witnessed a sea change. This period was greatly influenced by increasing demands and market forces. However, this was not true in the case of pastoralism. The age-old practice of seasonal transhumance pastoralism and their life style largely remained unaffected in spite of major changes in different ruling regimes, new technologies and overall development.

3.2.3.2 The Social System

The social and land tenure systems in the area follow a strict caste centered approach. The caste system has thus influenced the social structure, work distribution and resource use. In general, people are social and simple. People are highly religious and follow 'Hinduism'. Each village is having its own 'Devta' or local deity. People have strong faith in 'Devta' and 'Devta' becomes part and parcel of all rituals, ceremonies, fairs, and conflict

resolution mechanisms. Thus, the entire village community is tied up with this village level social institution. In comparison to several other areas in the country, by and large the area has remained backward. There is a high level of illiteracy among men and women folks. Most of the villages in GHNPCA still lack access through proper road network. Except small-scale handloom industries, the area is devoid of any other type of industry. The area followed to continue the old legacy specifically with regard to rights and concessions extended during the colonial period. At the same time, people faced new challenges on the account of abrupt changes in policies, law, rapid developmental activities, market forces, greater politicisation and exposure to the outer world. This way, the natural resource, its dependents and administrators all got affected. Today, the local people have become victims of uncertainties, insecure rights and growing conflicts.

3.2.3.3 The People and their Life Styles

Human settlements in the region came into existence well over 2,000 years ago in the form of small mountain villages (Ohri, 1980 and Tucker, 1997). Villagers adopted agriculture and pastoralism as their main professions. The available literature revealed that the agricultural practices in the region has undergone drastic changes over the past several decades with the advent of modern technologies. The Government took a lead in providing electricity to each household and drinking water facility. The major development and prosperity brought in the area is due to a major shift from cereal crops to cash crops and finally to horticulture. In general, two crops per annum viz., 'Kharif

during rainy season and 'Rabi' during winter are harvested. The maize (*Zea mays*) occupies about $\frac{1}{4}$ area under of the Kharif crops, followed by Sariyara (*Amaranthus hybridus*) covering nearly 15%. Rajma (*Phaseolus sativus*) is grown in about 10% area as a major pulse crop during Kharif. Wheat (*Triticum aestivum*) is grown as the major Rabi crop which covers > 30% of the agricultural area. Rice (*Oryza sativa*) was the second major crop during Rabi, grown in about > 15% area. More than 12 different crops are grown during Kharif season while only 3 crops (wheat, rice, mustard) are cultivated as Rabi crops (Nangia *et al.* 1999).

More than 70% of households had a mixed economy i.e. a combination of agriculture, horticulture and animal husbandry. Nearly 10% households had their income from agriculture and collection of medicinal plants. Rest 20% households got their incomes mainly by specialised occupations or Government service. Majority of the households keep some type of livestock. The type and number vary among different households. Details are presented in Chapter 5. In general, atleast 5-10 sheep and goat with majority of households is a common feature. The overall number of sheep and goat are nearly equal, precisely sheep is slightly on the higher side.

Nearly 1/3rd of the total population was economically weak i.e. less than Rs.5,000/- cash income per annum. Another 1/3rd fall under low income group (Rs.6,000 – Rs. 10,000/- per annum). Likewise, rest one-third constituted the high income group having cash income of > Rs.11,000/- per

Plate - 3

Biotic Pressure



Girdling of Oak Tree



Timber Dependence for House Construction

annum (Nangia *et al.* 1999). This high income group also included a small proportion (7%) of wealthy people. In recent years, the local economy has been further strengthened by a growing trade in herbs and medicinal plants. In spite development and changes brought in, the overall life style of the local population is still dependent upon forest resources. Till recent months, people have enjoyed various rights and concessions for utilising forest and grazing resources in GHNP. The final declaration of GHNP in recent months has resulted into withdrawal of such privileges enjoyed by local people over past 100 years or so.

The land is still ploughed by bullock, though a number of households keep a small number of cows for milk but they are never taken to the alpine pastures during summer migration. A substantial number of sheep and goat are owned by most of the households and their number per household increases with the higher location of villages. People seldomly own buffalo for religious reasons, thus sheep and goat form a bulk of the livestock population in GHNPCA. Most of these sheep and goat are taken to the alpine pastures for summer grazing, apart from this a substantial number of sheep and goat from the proximate neighbourhood and 'Ani' Tehsil visit GHNPCA during summer and monsoon months and utilize various grazing resources. The houses and livestock sheds are mainly made of wood (**Plate 3**). People generously use wood of *Abies pindrow*, *Cedrus deodar*, *Pinus wallichiana* and *Picea smithiana*. A certain amount of wood under old norms of rights and concessions is availed from the Forest Department. However, people use much more wood than is usually provided. Special wooden structures for

storage of food grains and fodder are also constructed so as to use those during harsh winter months (**Plate 4**). Villages are mostly scattered in the lower temperate forest or EZ.

The distribution of villages in different administrative constituent units across the landscape and their human population are presented in **Table 3.9**. The various administrative units in a Revenue District can be arranged in an ascending order as: household (family) → hamlets (a sub-village) → 'Phanti' (a revenue village) → 'Kothi' (a cluster of villages) → 'Waziri' (Sub-Tehsil) → 'Tehsil' (a revenue sub-block) → Block → District.

There is no village in the finally notified National Park (GHNP) and Tirthan WLS. The Sainj WLS possesses two tiny hamlets viz., Shakti and Maror forming a part of Garapali Phanti or revenue village. The Ecodevelopment zone harbours remaining 125 hamlets under 13 revenue villages. As per the District Census figures, there were 2,313 families (households) constituting a total human population of 13,145 persons. As such the administrative distribution of villages was irrespective of sub-watersheds. However, the further analysis of population data presented in **Table 3.9** revealed that among four SWS, the maximum households (1033) having human population of 6,073 was in Tirthan SWS, followed by 768 households with 4,250 persons in Sainj SWS while the minimum population (2,822) lived in Jiwa SWS. The fourth SWS i.e. Parvati SWS was devoid of any human settlement (**Table 3.10**). **Plate 5** depicts village surrounds in the GHNP/PCA.

Plate - 4

Fodder Collection and Storage



Crop Residue



Hay from 'Ghasnis'

Plate - 5

Village Surrounds



Terrace Cultivation



Disturbed Forest



A Typical House

Table 3.9 – Distribution of Villages and Human Population in GHNPCHA

Sl. No.	Waziri	Kothi	Phanti	No.of Hamlets	No.of Households	Total Population
1	Rupi	Balhan	Railla	19	512	2822
		Sainsher	Sainshar	29	302	1606
			Garaparli	7	116	592
2	Inner Seraj	Banogi	Suchen	5	202	1212
		Sangarh	Shangarh	14	111	618
			Lapah	4	37	222
		Palach	Kalwari	2	43	252
			Srikot	7	78	417
		Sarchi	Shilli	4	137	812
		Nohanda	Pekhri	16	187	1098
			Tinder	6	123	677
		Tung	Chipni	6	245	1537
			Mashyar	8	220	1280
	Total	8	13	127	2313	13145

Table 3.10 – Distribution of Population Among Four Sub-watersheds

Sl.No.	Sub-watershed	Households	Human Population
1	Tirthan SWS	1,033	6,073
2	Sainj	768	4,250
3	Jiwa SWS	512	2,822
4	Parvati SWS	-	-
	Total	2,313	13,145

Males constituted 51.96% of the total human population. The male : female ratio was 1:0.92. The Schedule Castes and Schedule Tribes together constituted 29.64% of the total human population. Noticeably, only 16.63% of the female population was literate while 58.09% male population was illiterate.

The overall literacy rate was just 30.30%, much below than the average national literacy level.

The main diet is composed of cereals (wheat, maize and rice), pulses and vegetables. People prefer non-vegetarian diets, mainly of sheep and goat mutton on special occasions. Poultry farming in GHNPCHA is uncommon. Hence, people are dependent upon nearby markets for chicken and eggs. Green vegetables (Spinach, Lettuce, Brinjal, Cucumber, Tomato, Chillies, Cabbage, Cauliflower) and potato are grown mainly for self-consumption. Milk production is as such low. However, they obtain sufficient milk production for self-consumption and also for making 'Ghee' (Purified butter) and curd. People also consume walnut (*Juglans regia*) as dry fruit. Fruits viz., apple and peaches are also dried for use during winters. Apple, Plum and Peaches are grown extensively in orchards. Most of the households own some quantity of fruit trees in orchards. The sizes of these orchards vary with the economic status of family. The landholdings varied from 5 to 50 'bighas' (Nangia *et al.*, 1999). Five bighas make an 'Acre' (1 ha = 2.5 Acres). Nearly 10% household possessed >5 bighas. 36% household had >30 bighas. Otherwise, an average holding was about 15-20 bighas.

Despite varying castes, land holdings, literacy, occupations, income groups among villagers of GHNPCHA, the role of livestock in the life style and livelihood of the majority of the population remains of paramount importance. While habitations, farm land, forests, grazing areas and markets are static in nature but the only mobile component across the entire landscape is a

pastrolist or his livestock. Thus, pastrolism becomes the hub or a linking factor for the different components.

By and large, the age old traditional ways of specialised seasonal resource use, mixed economy and simple life style had provided self – sufficiency to the local population. However, with the every passing day the complexity of problems mainly on the account of: (i) increasing human population, growing demands influence of market forces, conflicts, uncertainties; (ii) faulty land use practices; (iii) curtailment of seasonal spatial resource use; and (iv) over-burdening of limited and depleted available resources has already started disrupting the traditional sustainable ways and leaving permanent scars. Realising this tenet concerning doubtful sustainability of natural resources and self sufficiency of local people, the Government of Himachal Pradesh with the external aided funding had initiated a major 5-year Project for the conservation of biodiversity in GHNPCA adopting an ecodevelopment approach. Thus, in past 4-5 years, by adopting a participatory approach involving all stakeholders and formation of Village Ecodevelopment Committees (VDCs) a modest beginning has been made in the right direction. The success ultimately depends on the greater participation and sincerity at all levels.

3.2.4 Cross Linkages and Spatial Distribution of Resources

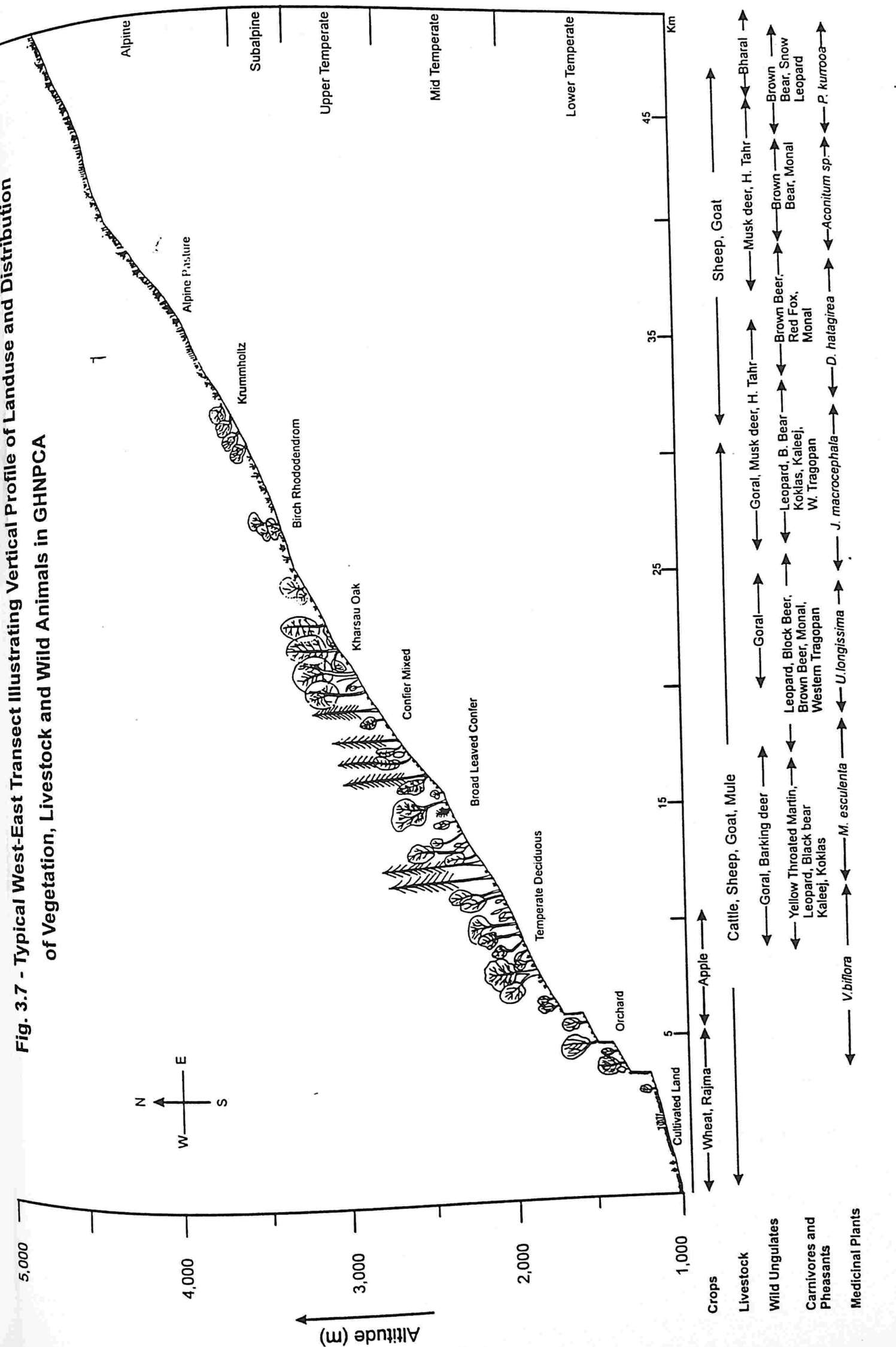
The foregoing results and discussion have broadly described physical, biological and social environment across the landscape and its linkages with

pastoralism. However, for a better understanding different sectoral linkages (agriculture, forests, wild animals and livestock) and a spatial distribution of various resources and their users are depicted in Fig. 3.7. The typical west-east transect across altitudinal gradient in a sub-watershed illustrates that habitations, agriculture and horticulture was mainly confined to lower elevations comparing with prominent wild ungulates, carnivores, pheasants and highly demanded medicinal herbs, livestock (sheep and goat) had widest spatial distribution across the gradient of altitude and different forest types. Each of the six major plants (*Viola serpens*, *V. odorata*, *Morchella esculenta*, *Usnea longissima*, *Jurinea macrocephala*, *Dactylorhiza hatagirea*, *Aconitum heterophyllum*, *Picrorhiza kurrooa*) being harvested for meeting increasing market demands showed narrow niche. The vastness of the landscape in terms of its span and altitudinal variation has thus provided a bounty of variety and variability of ecosystems, habitats, and species and their interactions.

3.2.5 The Grazing Resources

The above analysis has shown that the practice of pastoralism in GHNP is semi-nomadic and livestock therefore, traverses widest altitudinal range during three seasons and utilize different grazing resources. The reconnaissance prior to the present intensive study was able to reveal four types of grazing resources viz., (i) the village pastures ('Ghasnis') and their surrounds (VS), (ii) Forest resources across migratory routes (MR), (iii) Transitory forest camping sites (TCFS) and (iv) Alpine Pastures (AP).

Fig. 3.7 - Typical West-East Transect Illustrating Vertical Profile of Landuse and Distribution of Vegetation, Livestock and Wild Animals in GHNPCA

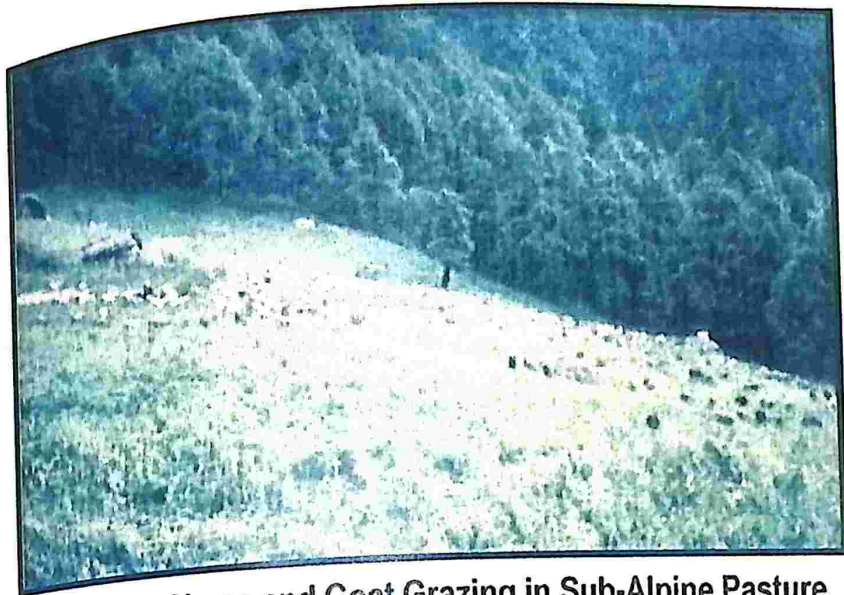


3.2.5.1 Village Pastures : The village pastures ('Ghasnis') are grass dominated areas in village surrounds, mostly on the southern aspect. These village pastures either lies in the revenue area of undemarcated Protected Forests – Class III. Generally each revenue village ('Phanti') has got atleast some area of Ghasnis. As already stated, there was lack of available information on the PF – Class III mainly due to undemarcation of such areas (Table 3.8). However, based on the resource mapping and landuse analysis, it was known that the Evodevelopment zone possessed about 34 sq km area under Ghasnis or Grass Patches. Based on field observations, it can also be stated here that the size of Ghasnis ranged from 150–300 ha. Ghasnis are optimally protected for 6-7 months i.e. April-October. This is the time when majority of livestock is away on summer migration except a few stall-fed cows and bullocks. Thus, vegetation in Ghasnis is allowed to fully grow during summer and rainy seasons. This way plants particularly grasses are able to complete their critical part of life cycles. The seed formation, seed dispersal and translocation of food reserves and storage in underground roots or rhizomes take place in the case of perennial grasses. Once grasses have grown, reached their peak production level, matured and dried, they are harvested and stored as hay during October-November. The harvest and storage operations are usually carried out by female members of each household and they complete these operations prior to the set in of severe winter or snowfall. Later, livestock on their return from migration is permitted to graze on the remnants of grass or litter scattered on ground during the harvest operation.

3.2.5.2 Grazing Resources Along Migratory Routes : During upward and downward movement, livestock utilizes ground vegetation in lower temperate, upper temperate, sub-alpine scrub forests. Pastoralists occasionally facilitate grazing by lopping of trees during migration. Likewise, villagers also collect fodder from trees from adjoining forests specially during winter months so as to feed cattle. Details of trees lopped are provided in the Chapter 4. As such, a minimum impact is made on the forested tract during migration. Firstly, the migratory flock uses only narrow selected trails for their movement. Thus, only a small proportion of the forest area is used and affected by the migrating sheep and goat. Secondly, pastoralists usually rush their flock to the specified Transitory forest camping sites (TFCS) so as to reach well before dark and to avoid livestock predation. **Plates 6 and 7** depicts livestock and camping sites in the GHNP. CA.

3.2.5.3 Pastures : Two type of pastures (locally called 'Thatches') depending upon their location in GHNP. CA and origin were recognised. These two broad categories included the : (i) TFCS as forest openings mainly due to biotic activities, and (ii) Alpine pastures (AP) – mainly natural in origin at above 3,600 m altitude. The former is further divided into three types based on altitudinal range and forest types. These three types were : (i) Mid Temperate (MT) – 2,000 to < 2,800 m; (ii) Upper Temperate (UP) – 2,800 to < 3,300 m; and (iii) Sub-Alpine (SA) – 3,300 to < 3,600 m. Alpine pastures in GHNP. CA occur above the natural tree line. In TFCS, the ground vegetation is predominantly herbaceous with short, green and tender shoots. The TFCS

Pastoralists and Livestock



Migratory Sheep and Goat Grazing in Sub-Alpine Pasture



Flock of Sheep and Goat



Livestock Dependence

Plate - 7

Grazing Sites



Livestock Camping Site in the Alpine Pasture



A Transitory Forest Camping Site

are anthropogenic in origin, mainly due to the combine effect of gradual removal of woody vegetation, burning and grazing.

3.2.5.3.1 Listing, Mapping and Distribution of Pastures: Prior to the initiation of present investigations, reliable and systematic baseline information on such pastures (Thatches) across the Landscape of GHNP/CA was not available. Thus, a major effort during the tenure of present study was made to list and map pastures and also to assess their distribution across different forests and sub-watersheds. These pastures are those which were visited by pastrolists and used by their livestock for camping and grazing.

A total of 161 pastures were identified, listed and mapped (**Fig 3.8**) for the entire landscape. These pastures were located at varying altitudes ranging 2,180 m to 4,600 m. Beyond this altitude (4,600m) in most of the cases there was the permanent snowline.

The distributional analysis of 161 pastures those were visited by pastrolists on the basis of administrative units, sub-watersheds and aspects is discussed.

(i) Administrative Units : The **Table 3.11** revealed that 111 or 68.94% pastures were located in GHNP alone. Another 30 or 18.6% pastures were in two other PAs i.e. Tirthan WLS and Sainj WLS. Therefore, only 20 pastures or 12.42% of the total pastures visited by pastrolists were located in the Ecodevelopment zone.

Fig. 3.8 - Distribution of Pastures (Thaches) in the Great Himalayan National Park Conservation Area

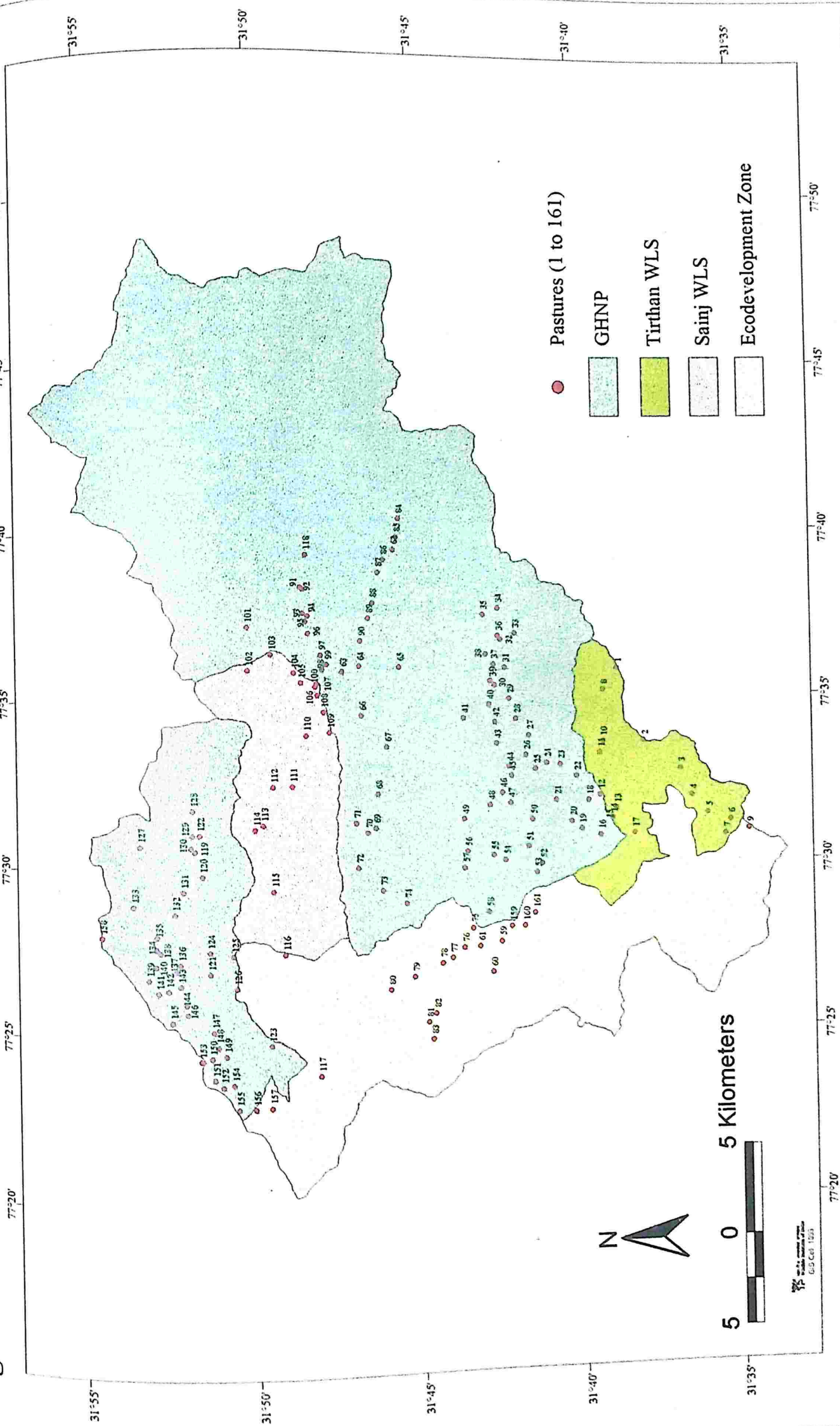


Table 3.11 – Distribution of Pastures by Administrative Units.

Sl.No.	Administrative Unit	No. of Pastures	Percentage of Total Pastures
1	Great Himalayan NP	111	68.94
2	Tirthan WLS	14	8.70
3	Sainj WLS	16	9.94
4	Ecodevelopment zone	20	12.42
Total		161	100.00

(ii) **Sub-watersheds and Aspects :** The data analysis on the distribution of pastures across three sub-watersheds indicated that there was no marked difference in their number in three sub-watersheds. The Tirthan SWS had maximum number i.e. 64 pastures those were visited by pastrolists, followed by 57 in Sainj WLS and the least 40 in Jiwa WLS (Table 3.12). In general, the distribution of pastures was skewed in favour of south aspect (59.63%).

Table 3.12 – Distribution of 161 Pastures across Sub-watersheds and Different Aspects.

Sl. No.		Sub-watersheds						Overall Landscape			
		Tirthan SWS		Sainj SWS		Jiwa SWS		N	S	Total	%of Pastures
Aspect Categories	N	S	N	S	N	S	N				
1	Mid Temperate (2,000-<2,800 m)	3	3	4	2	1	1	8	6	14	8.70
2	Upper Temperate (2,800 - < 3,300 m)	5	12	6	7	1	11	12	30	42	26.09
3	Sub-Alpine (3,300 - < 3,600m)	9	9	5	10	0	6	14	25	39	24.22
4	Alpine (>3,600 m)	17	6	8	15	6	14	31	35	66	40.99
Total		34	30	23	34	8	32	65	96	161	100.00

A list of 161 pastures, their locations and aspect is given in Table 3.13.

Table 3.13 - List of Pastures (Thaches) in the GHNPCA

Sl. No	Sub-watershed	Aspect	Pasture	Altitude (m)	Category
1	Tirthan	N	Dunga	4450	AP
2	Tirthan	N	Mungra Dwari	3870	AP
3	Tirthan	N	Chhadar	3200	UT
4	Tirthan	N	Mandrach	2320	MT
5	Tirthan	N	Bagaris	2430	MT
6	Tirthan	N	Jasu	3210	UT
7	Tirthan	N	Naragi	3080	UT
8	Tirthan	N	Munni Ropa	3780	AP
9	Tirthan	N	Basleo	3400	SA
10	Tirthan	N	Rata Dabar	3760	AP
11	Tirthan	N	Ker	3640	AP
12	Tirthan	N	Bhuj	3680	AP
13	Tirthan	N	Manjnikot	3860	AP
14	Tirthan	N	Badi	2815	UT
15	Tirthan	N	Chhodar	3600	AP
16	Tirthan	N	Mundreur	3360	SA
17	Tirthan	N	Bashel	3580	SA
18	Tirthan	N	Deti	3660	AP
19	Tirthan	N	Shagot	2860	UT
20	Tirthan	N	Khoril Poli	2680	MT
21	Tirthan	N	Chanoni	3340	SA
22	Tirthan	N	Ashurbagh	3790	AP
23	Tirthan	N	Sari	3380	SA
24	Tirthan	N	Phuphu	3440	SA
25	Tirthan	N	Jhatholi	3460	SA
26	Tirthan	N	Dharach	3680	AP
27	Tirthan	N	Bhogara Dunga	3860	AP
28	Tirthan	N	Umblidwari	3800	AP
29	Tirthan	N	Khukhari	3850	AP
30	Tirthan	N	Channi	3560	SA
31	Tirthan	N	Khol	3840	AP
32	Tirthan	N	Bandyog	3640	AP
33	Tirthan	N	Deobani	3800	AP
34	Tirthan	N	Saketi	4240	AP
35	Tirthan	S	Tharthadhar	4000	AP
36	Tirthan	S	Bhlundwari	3740	AP
37	Tirthan	S	Batlijani	3630	AP
38	Tirthan	S	Chang	3590	SA
39	Tirthan	S	Bakretu	3579	SA
40	Tirthan	S	Manjhouni	3450	SA
41	Tirthan	S	Chakrer	3590	SA
42	Tirthan	S	Dwarigarh	3120	UT
43	Tirthan	S	Shankha	3100	UT
44	Tirthan	S	Rakhalti	3000	UT
45	Tirthan	S	Balu	3010	UT
46	Tirthan	S	Hara	3290	UT
47	Tirthan	S	Nara	3320	SA
48	Tirthan	S	Nara	4000	AP
49	Tirthan	S	Kobri	3950	AP
49	Tirthan	S	Bharengcha	2320	MT
50	Tirthan	S	Chalocha		

Contd...

Table 3.13 Contd...

Sl. No	Sub-watershed	Aspect	Pasture	Altitude (m)	Category
51	Tirthan	S	Gharani	2560	MT
52	Tirthan	S	Dulanga	2640	MT
53	Tirthan	S	Shilt	2880	UT
54	Tirthan	S	Pardi	3120	UT
55	Tirthan	S	Bhujdwari	3210	UT
56	Tirthan	S	Ghumtaroa	3590	SA
57	Tirthan	S	Patal	3620	AP
58	Tirthan	S	Manoni	3590	SA
59	Tirthan	S	Kolchi	3210	UT
60	Tirthan	S	Palni	2820	UT
61	Tirthan	S	Gurat	3010	UT
62	Sainj	N	Shili Danswari	3920	AP
63	Sainj	N	Dotla	3620	AP
64	Sainj	N	Niari Naina	3680	AP
65	Sainj	N	Nala Tapra	3880	AP
66	Sainj	N	Mati Naina	3440	SA
67	Sainj	N	Charkera	3720	AP
68	Sainj	N	Kili	3840	AP
69	Sainj	N	Kamba	3760	AP
70	Sainj	N	Tunda Bhuj	3400	SA
71	Sainj	N	Dudla	3120	UT
72	Sainj	N	Humkharni	2800	UT
73	Sainj	N	Manjhan Galu	3300	SA
74	Sainj	N	Dhela	3800	AP
75	Sainj	N	Pitta	3560	SA
76	Sainj	N	Shungcha	3550	SA
77	Sainj	N	Ukkhal	3400	SA
78	Sainj	N	Duggi	3260	UT
79	Sainj	N	Raj Thatti	3205	UT
80	Sainj	N	Sarah	3080	UT
81	Sainj	N	Thati	2200	MT
82	Sainj	N	Thini	2180	MT
83	Sainj	N	Jagnahu	2615	MT
84	Sainj	N	Kharu	2600	MT
85	Sainj	S	Munda Tapra	3990	AP
86	Sainj	S	Manj Ka Tapra	3950	AP
87	Sainj	S	Rati Dwari	3880	AP
88	Sainj	S	Indra	3790	AP
89	Sainj	S	Ral	3510	SA
90	Sainj	S	Jaola	3440	SA
91	Sainj	S	Palta	3340	SA
92	Sainj	S	Rakti Tapra	3640	AP
93	Sainj	S	Ghughumua	3680	AP
94	Sainj	S	Joara(l)	3550	SA
95	Sainj	S	Rahni	3520	SA
96	Sainj	S	Jauvia	3360	SA
97	Sainj	S	Majhaun	3200	UT
98	Sainj	S	Avni	3080	UT
99	Sainj	S	Raktikhoh	3100	UT
100	Sainj	S	Parkachi	3060	UT

Contd...

Table 3.13 Contd...

Sl. No	Sub-Watershed	Aspect	Pasture	Altitude (m)	Category
101	Sainj	S	Mathaun	4100	AP
102	Sainj	S	Jaraun	3860	AP
103	Sainj	S	Joara(li)	3600	AP
104	Sainj	S	Rati Nari	3360	SA
105	Sainj	S	Saltu	3320	SA
106	Sainj	S	Kaili	3000	UT
107	Sainj	S	Chyas	2970	UT
108	Sainj	S	Baramchuli	2860	UT
109	Sainj	S	Karceher	2720	MT
110	Sainj	S	Thumri	3740	AP
111	Sainj	S	Galu	3530	SA
112	Sainj	S	Garwari	3940	AP
113	Sainj	S	Dudi Chan	3860	AP
114	Sainj	S	Bahli	3880	AP
115	Sainj	S	Theiru	3540	SA
116	Sainj	S	Socha	3600	AP
117	Sainj	S	Murli	2760	MT
118	Sainj	S	Rakti Sar	3880	AP
119	Jiwa	N	Dishari	3680	AP
120	Jiwa	N	Paniharu	3800	AP
121	Jiwa	N	Silirari	3280	UT
122	Jiwa	N	Khutar Ka Ban1	3750	AP
123	Jiwa	N	Deun	2200	MT
124	Jiwa	N	Radhauni	3860	AP
125	Jiwa	N	Barohi	4335	AP
126	Jiwa	N	Kandi	3627	AP
127	Jiwa	S	Khutar Ka Ban2	4360	AP
128	Jiwa	S	Ranka	3820	AP
129	Jiwa	S	Ratichho	3760	AP
130	Jiwa	S	Talyaharu	3700	AP
131	Jiwa	S	Bagri	3800	AP
132	Jiwa	S	Changar	3580	SA
133	Jiwa	S	Lahli Bati	3920	AP
134	Jiwa	S	Mili Dwar	3600	AP
135	Jiwa	S	Duara	3200	UT
136	Jiwa	S	Ukhal Patthar	2920	UT
137	Jiwa	S	Majhan	3400	SA
138	Jiwa	S	Gara Daura	3450	SA
139	Jiwa	S	Shililuari	4280	AP
140	Jiwa	S	Rati Thati	4033	AP
141	Jiwa	S	Rohni	4000	AP
142	Jiwa	S	Khanersu	3960	AP
143	Jiwa	S	Hari	3360	SA
144	Jiwa	S	Athadug	3000	UT
145	Jiwa	S	Biraghmar	3600	AP
146	Jiwa	S	Bira	3500	SA
147	Jiwa	S	Appgain	2840	UT
148	Jiwa	S	Jubkutan	3000	UT
149	Jiwa	S	Bakarchuna	2900	UT
150	Jiwa	S	Becha	3480	SA

Contd....

Table 3.13 Contd...

Sl. No	Sub-Watershed	Aspect	Pasture	Altitude (m)	Category
151	Jiwa	S	Dwara	3200	UT
152	Jiwa	S	Morgain	3200	UT
153	Jiwa	S	Drasher	3800	AP
154	Jiwa	S	Ligan	3000	UT
155	Jiwa	S	Shilphar	3200	UT
156	Jiwa	S	Bhakhilchin	2800	UT
157	Jiwa	S	Chhogad	2200	MT
158	Jiwa	S	Phagchi	4600	AP
159	Tirthan	S	Kundari	3365	SA
160	Tirthan	S	Dashmani	3100	UT
161	Tirthan	S	Rangthar	2980	UT

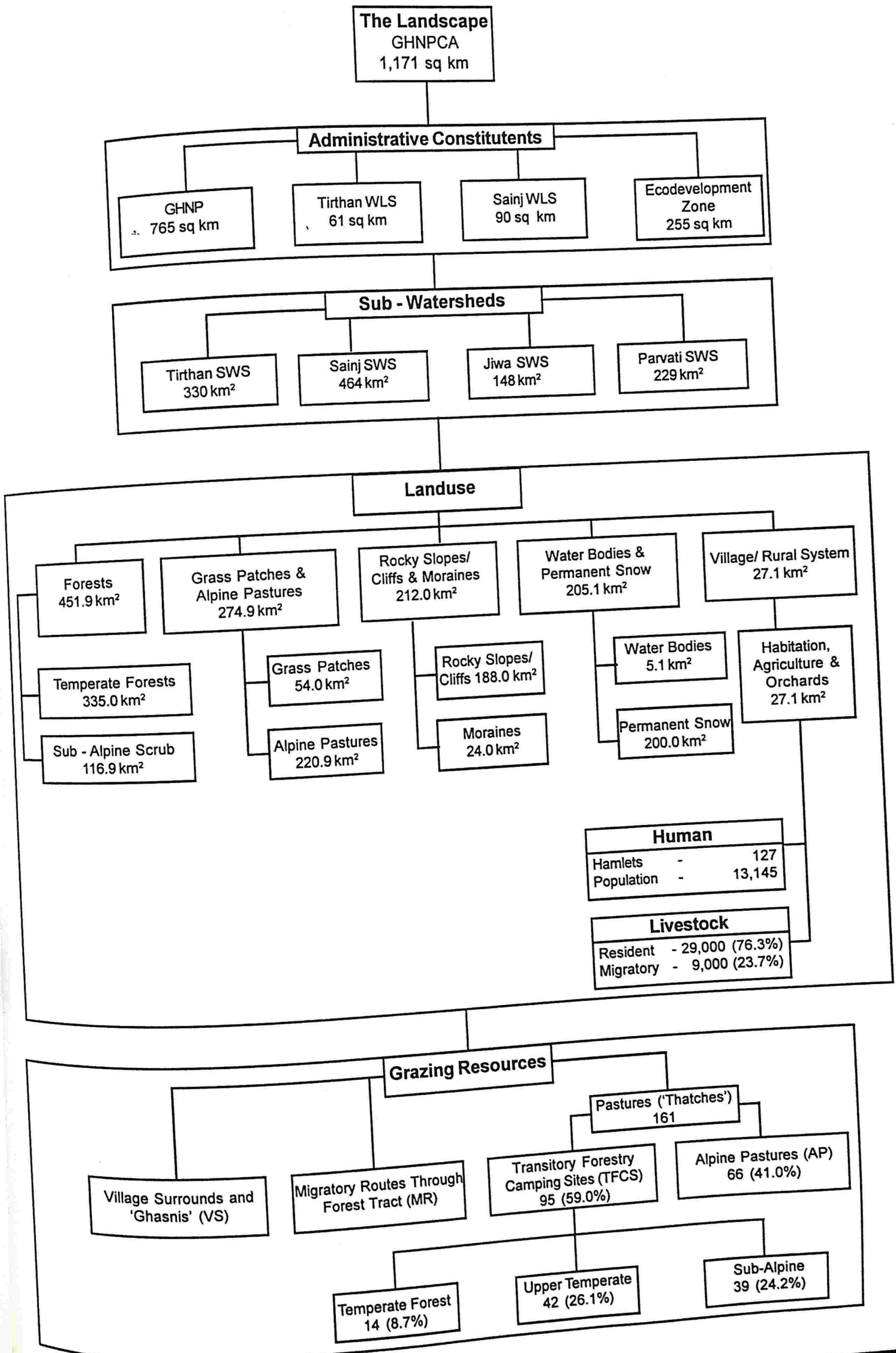
* - Sl No. 1 to 161 of pastures as shown on Fig 3.6

MT - Mid Temperate
 UT - Upper Temperate
 SA - Sub- Alpine
 AP - Alpine Pastures

3.2.6 Conclusion

- (i) Nature has endowed the landscape with a spectacular diversity of land forms, habitats and floral and faunal species. The altitude was a decisive factor for resultant diversity and resource use pattern. Despite agriculture including horticulture being the main profession in the GHNPCA, pastrolism still remained the central point of traditions, life style, activities, economy, self sufficiency, sectoral linkages, (pastures – forests – agriculture – household – market), and overall influence. The landscape, its constituent administrative units and sub-watersheds, landuse and grazing resources are summarized in Fig 3.9.
- (2) The land and the people have witnessed different periods of governance, shift in policies, development and exposure to the outer world. Despite this, the landscape persisted to be rich in diversity while

Fig. 3.9 - The Landscape, Landuse and Grazing Resources



people continued to be simple and followed the traditional ways of living, especially in the case of pastoralism.

- (3) A well defined seasonal as well as highly spatial distributed resource use strategy adopted by people, livestock and wild animals was an insurance for sustainability and a device for lesser conflicts. This well established system of sustainability in spite difficult terrain and harsh climate is gradually getting perturbed due to abrupt changes brought in agricultural and livestock grazing practices, policies and increasing market influences.
- (4) In a high altitude landscape, typical as that of the GHNP, the use of watershed approach seems to be the best option for delineation, demarcation, administration and distribution of natural resources, their use and management.
-

Species Diversity, Biotic Pressure and Status of Grazing Resources

4.1 Spatial Heterogeneity and Species Diversity

Landscapes are not merely unique, in structure, composition and spatial pattern. They are also dynamic (Wiens, 1994; Morris, 1987; and Andren *et al.*, 1997). The spatial heterogeneity of the landscape, as well as any change brought in them by natural or man-made processes, influence the distribution, abundance and dynamics of constituent species. Many conservationists agree that time is running out for conserving the variety of plants and animals that make up the tapestry of life. A central concern of landscape ecology is to account for the distribution and local abundance of species inhabiting a mosaic of habitat patches.

Human activities have become so pervasive that they hardly leave any landscape intact. Thus, there is an increasing concern about the ability of land managers to maintain the native diversity or tapestry of life. The success of a species in a community or habitat mosaic depends on the prevalence of its habitat requirements there (realized niches), the degree of its exploitation (biotic pressure), and its population level (abundance).

4.2 The Results and Discussion

The spatial heterogeneity of the landscape under consideration i.e. GHNPCA has already been described. The long history of natural processes (earthquakes, glacier movement, avalanche, landslides, floods and fire) and human activities for himself or his domesticated animals, especially in terms of an age old practice of pastrolism has also been illustrated. The grazing resources – their types, extent and distribution have also been dwelt upon. Hence, in the present Chapter, species diversity, biotic pressure and status of investigated grazing sites are discussed. Results on four type of grazing resources are presented below one by one.

4.3 Village Surrounds (VS)

Six intensive study sites *viz.*, Ropa, Kharoncha and Nahi in Tirthan SWS while Shangarh, Bah and Lapah in Sainj SWS under the category of VS were selected for the assessment of tree and shrub diversity and ground cover (Table 2.3).

4.3.1 Tree Diversity

4.3.1.1 Overall Village Surrounds: Thirty four (34) different tree species were listed in the six intensively studied Village surrounds through data collection in 54 plots (6 VS x 9 plots) of 500 m² each (Table 4.1). Prominent tree species recorded were: *Pinus wallichiana*, *Cedrus deodara* and *Quercus semecarpifolia*. Values of tree density ranged from 0.37 trees/ha to 19.63

tree/ha. The highest value of tree density i.e. 19.63 tree/ha was recorded in the case of *Pinus wallichiana*, being one of the important timber species used in house construction. Out of 34 species recorded, five species viz., *P. wallichiana*, *C. deodara*, *Q. semecarpifolia*, *Rhododendron arboreum* and *Picea smithiana* alone constituted 45.4% of the total tree density in VS. Three species of the genus *Quercus* (Oak) viz., *Q. semecarpifolia* (Kharsu), *Q. leucotrichophora* (Ban) and *Q. floribunda* (Moru) were recorded in VS. These three species together provide the bulk of fodder collected by pastrolists. Three species of Oak constituted 16.2% of the total trees occurred in VS. The *Taxus baccata*, from which 'Taxol' an important drug for the cure of cancer is extracted occurred in a low density of 2.59 tree/ha. Despite such a valuable tree, the species was heavily lopped for bedding material of livestock. The values of abundance for 34 tree species recorded in six Village surrounds varied from 0.28 to 15.06. The *Pinus wallichiana* obtained maximum value of abundance.

Table 4.1 - Village Surrounds (VS) - Overall, 'Tree' : Density and Abundance Values

SI No.	Tree species	No. of Individuals	Density (tree/ha)	Abundance
1	<i>Pinus wallichiana</i>	53	19.63	15.06
2	<i>Cedrus deodara</i>	37	13.70	10.51
3	<i>Quercus semecarpifolia</i>	29	10.74	8.24
4	<i>Rhododendron arboreum</i>	21	7.78	5.97
5	<i>Picea smithiana</i>	23	8.52	6.53
6	<i>Quercus leucotrichophora</i>	19	7.04	5.40
7	<i>Pinus roxburghii</i>	18	6.67	5.11
8	<i>Aesculus indica</i>	13	4.81	3.69
9	<i>Betula alnoides</i>	13	4.81	3.69
10	<i>Alnus nitida</i>	12	4.44	3.41

Contd...

Table 4.1 Contd...

SI No.	Tree species	No. of Individuals	Density (tree/ha)	Abundance
11	<i>Celtis tetrandra</i>	12	4.44	3.41
12	<i>Toona serrata</i>	10	3.70	2.84
13	<i>Benthimidia capitata</i>	9	3.33	2.56
14	<i>Prunus cornuta</i>	9	3.33	2.56
15	<i>Pyrus pashia</i>	9	3.33	2.56
16	<i>Quercus floribunda</i>	9	3.33	2.56
17	<i>Taxus baccata</i>	8	2.96	2.27
18	<i>Abies pindrow</i>	7	2.59	1.99
19	<i>Populus ciliata</i>	7	2.59	1.99
20	<i>Ulmus wallichiana</i>	7	2.59	1.99
21	<i>Acer caesium</i>	4	1.48	1.14
22	<i>Juglans regia</i>	4	1.48	1.14
23	<i>Lyonia ovalifolia</i>	3	1.11	0.85
24	<i>Rhus semialata</i>	3	1.11	0.85
25	<i>Rhus wallichii</i>	3	1.11	0.85
26	<i>Corylus jacquemontii</i>	2	0.74	0.57
27	<i>Acer pictum</i>	1	0.37	0.28
28	<i>Albizia julibrissin</i>	1	0.37	0.28
29	<i>Carpinus viminea</i>	1	0.37	0.28
30	<i>Ficus pamata</i>	1	0.37	0.28
31	<i>Ilex dipyrena</i>	1	0.37	0.28
32	<i>Persia odoratissima</i>	1	0.37	0.28
33	<i>Pistacia intrgerrima</i>	1	0.37	0.28
34	<i>Robinia pseudoacacia</i>	1	0.37	0.28
	Total	352	130.37	100.00

4.3.1.2 Individual Village Surround

The vegetation assessment in six selected Village surrounds was carried out along three radiating transects at 0 km, 2 km and 4 km distance from the outskirts of each village presuming a corresponding high, moderate and low biotic disturbance levels, with increasing distance, respectively. Details of tree species recorded, their density, basal area (sq km), abundance, dominance and Important value (I) in case of each select site of VS and three levels of biotic disturbance are presented in Table 4.2.

Table 4.2 - Village Surrounds (VS) – Each Village, Trees : Density, Basal Area, Abundance (AB), Dominance (DO) and Importance Value (I)

1. Village Surround - Ropa, Tirthan SWS

A. Biotic Pressure - High (0 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Ropa	<i>Ficus pamata</i>	6.7	0.1	5.0	8.6	13.6
2	Ropa	<i>Pinus wallichiana</i>	93.3	0.9	70.0	59.5	129.5
3	Ropa	<i>Pyrus pashia</i>	6.7	0.2	5.0	12.8	17.8
4	Ropa	<i>Rhus wallichii</i>	6.7	0.0	5.0	1.4	6.4
5	Ropa	<i>Toona serrata</i>	20.0	0.3	15.0	17.7	32.7

B. Biotic Pressure – Moderate (2 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Ropa	<i>Albizia julibrissin</i>	6.7	0.1	7.1	2.5	9.7
2	Ropa	<i>Alnus nitida</i>	13.3	0.3	14.3	13.0	27.3
3	Ropa	<i>Benthimidia capitata</i>	6.7	0.1	7.1	2.7	9.9
4	Ropa	<i>Pinus wallichiana</i>	13.3	1.0	14.3	47.5	61.8
5	Ropa	<i>Pistacia intrgerrima</i>	6.7	0.0	7.1	1.4	8.6
6	Ropa	<i>Pyrus pashia</i>	6.7	0.0	7.1	1.1	8.2
7	Ropa	<i>Rhus semialata</i>	20.0	0.2	21.4	10.1	31.5
8	Ropa	<i>Robinia pseudoacacia</i>	6.7	0.0	7.1	1.6	8.7
9	Ropa	<i>Toona serrata</i>	13.3	0.4	14.3	20.0	34.3

C. Biotic Pressure - Low (4 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Ropa	<i>Alnus nitida</i>	13.3	0.3	11.1	15.6	26.7
2	Ropa	<i>Benthimidia capitata</i>	26.7	0.5	22.2	29.2	51.4
3	Ropa	<i>Persia odoratissima</i>	6.7	0.0	5.6	1.3	6.8
4	Ropa	<i>Pinus wallichiana</i>	40.0	0.8	33.3	41.4	74.7
5	Ropa	<i>Pyrus pashia</i>	6.7	0.1	5.6	6.4	11.9
6	Ropa	<i>Rhododendron arboreum</i>	26.7	0.1	22.2	6.2	28.4

2. Village Surround - Kharoncha, Tirthan SWS

A. Biotic Pressure - High (0 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Kharoncha	<i>Aesculus indica</i>	6.7	1.6	12.5	65.4	77.9
2	Kharoncha	<i>Celtis tetrandra</i>	6.7	0.0	12.5	1.2	13.7
3	Kharoncha	<i>Quercus leucotricophora</i>	26.7	0.6	50.0	22.7	72.7
4	Kharoncha	<i>Ulmus wallichiana</i>	13.3	0.3	25.0	10.7	35.7

Contd...

Table 4.2 Contd....

B. Biotic Pressure - Moderate (2 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Kharoncha	<i>Acer caesium</i>	6.7	0.1	6.7	1.6	8.3
2	Kharoncha	<i>Acer pictum</i>	6.7	0.0	6.7	0.7	7.4
3	Kharoncha	<i>Aesculus indica</i>	6.7	1.8	6.7	43.3	49.9
4	Kharoncha	<i>Benthimidia capitata</i>	6.7	0.1	6.7	2.1	8.7
5	Kharoncha	<i>Celtis tetrandra</i>	13.3	0.1	13.3	1.4	14.7
6	Kharoncha	<i>Ilex dipyrena</i>	6.7	0.1	6.7	1.3	8.0
7	Kharoncha	<i>Juglans regia</i>	6.7	0.3	6.7	7.1	13.8
8	Kharoncha	<i>Lyonia ovalifolia</i>	6.7	0.1	6.7	2.7	9.4
9	Kharoncha	<i>Quercus floribunda</i>	6.7	0.5	6.7	10.9	17.6
10	Kharoncha	<i>Quercus leucotricophora</i>	33.3	1.2	33.3	28.9	62.3

C. Biotic Pressure - Low (4 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Kharoncha	<i>Aesculus indica</i>	6.7	0.5	6.7	19.9	26.6
2	Kharoncha	<i>Benthimidia capitata</i>	20.0	0.2	20.0	6.6	26.6
3	Kharoncha	<i>Betula alnoides</i>	6.7	0.3	6.7	11.3	18.0
4	Kharoncha	<i>Carpinus viminea</i>	6.7	0.1	6.7	2.4	9.1
5	Kharoncha	<i>Pecia smithiana</i>	20.0	1.0	20.0	42.1	62.1
6	Kharoncha	<i>Quercus floribunda</i>	13.3	0.0	13.3	1.6	14.9
7	Kharoncha	<i>Rhododendron arboreum</i>	13.3	0.3	13.3	11.0	24.3
8	Kharoncha	<i>Rhus wallichii</i>	6.7	0.1	6.7	2.4	9.1
9	Kharoncha	<i>Toona serrata</i>	6.7	0.1	6.7	2.7	9.4

3. Village Surround - Nahi, Tirthan SWS

A. Biotic Pressure - High (0 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Nahi	<i>Cedrus deodara</i>	13.3	0.5	28.6	23.3	51.8
2	Nahi	<i>Picea smithiana</i>	13.3	0.7	28.6	31.4	59.9
3	Nahi	<i>Quercus leucotrichophora</i>	6.7	0.7	14.3	30.6	44.9
4	Nahi	<i>Quercus semecarpifolia</i>	6.7	0.3	14.3	13.1	27.4
5	Nahi	<i>Rhododendron arboreum</i>	6.7	0.0	14.3	1.7	16.0

B. Biotic Pressure - Moderate (2 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Nahi	<i>Juglans regia</i>	13.3	0.5	7.4	9.1	16.5
2	Nahi	<i>Pinus wallichiana</i>	33.3	1.0	18.5	19.3	37.8
3	Nahi	<i>Quercus semecarpifolia</i>	93.3	3.6	51.9	66.9	118.8
4	Nahi	<i>Rhododendron arboreum</i>	40.0	0.3	22.2	4.7	26.9

Contd...

Table 4.2 Contd...

C. Biotic Pressure - Low (4 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Nahi	<i>Abies pindrow</i>	26.7	0.8	12.9	15.3	28.2
2	Nahi	<i>Pinus wallichiana</i>	20.0	0.5	9.7	10.0	19.7
3	Nahi	<i>Quercus leucotrichophora</i>	13.3	0.5	6.5	9.3	15.8
4	Nahi	<i>Quercus semecarpifolia</i>	93.3	2.6	45.2	48.6	93.8
5	Nahi	<i>Rhododendron arboreum</i>	20.0	0.2	9.7	3.7	13.4
6	Nahi	<i>Taxus baccata</i>	33.3	0.7	16.1	13.1	29.2

4. Village Surround - Nahi, Sainj SWS

A. Biotic Pressure - High (0 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Shangarh	<i>Aesculus indica</i>	6.7	3.2	5.3	36.5	41.7
2	Shangarh	<i>Cedrus deodara</i>	33.3	1.6	26.3	17.9	44.2
3	Shangarh	<i>Pinus roxburghii</i>	20.0	1.3	15.8	14.5	30.2
4	Shangarh	<i>Pinus wallichiana</i>	20.0	1.6	15.8	18.6	34.4
5	Shangarh	<i>Pyrus pashia</i>	6.7	0.0	5.3	0.2	5.4
6	Shangarh	<i>Quercus floribunda</i>	20.0	0.9	15.8	10.0	25.8
7	Shangarh	<i>Rhododendron arboreum</i>	6.7	0.0	5.3	0.3	5.6
8	Shangarh	<i>Toona serrata</i>	13.3	0.2	10.5	2.1	12.7

B. Biotic Pressure - Moderate (2 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Shangarh	<i>Cedrus deodara</i>	53.3	0.8	25.0	15.7	40.7
2	Shangarh	<i>Lyonia ovalifolia</i>	13.3	0.1	6.3	2.4	8.7
3	Shangarh	<i>Picea smithiana</i>	53.3	0.8	25.0	15.5	40.5
4	Shangarh	<i>Pinus roxburghii</i>	53.3	1.8	25.0	35.8	60.8
5	Shangarh	<i>Pinus wallichiana</i>	33.3	1.5	15.6	30.1	45.7
6	Shangarh	<i>Pyrus pashia</i>	6.7	0.0	3.1	0.5	3.6

C. Biotic Pressure - Low (4 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Shangarh	<i>Cedrus deodara</i>	113.3	2.9	48.6	39.2	87.7
2	Shangarh	<i>Picea smithiana</i>	53.3	1.8	22.9	24.3	47.2
3	Shangarh	<i>Pinus roxburghii</i>	46.7	1.4	20.0	19.4	39.4
4	Shangarh	<i>Pinus wallichiana</i>	20.0	1.3	8.6	17.1	25.7

Contd...

Table 4.2 Contd...

5. Village Surround - Bah, Sainj SWS
A. Biotic Pressure - High (0 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Bah	<i>Alnus nitida</i>	20.0	4.2	27.3	14.2	41.4
2	Bah	<i>Betula alnoides</i>	20.0	13.2	27.3	44.3	71.6
3	Bah	<i>Populus ciliata</i>	20.0	2.2	27.3	7.5	34.8
4	Bah	<i>Quercus leucotrichophora</i>	13.3	10.1	18.2	34.0	52.2

B. Biotic Pressure - Moderate (2 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Bah	<i>Acer caesium</i>	13.3	1.7	12.5	3.2	15.7
2	Bah	<i>Aesculus indica</i>	26.7	35.7	25.0	69.7	94.7
3	Bah	<i>Alnus nitida</i>	13.3	2.1	12.5	4.1	16.6
4	Bah	<i>Betula alnoides</i>	6.7	3.0	6.3	5.9	12.1
5	Bah	<i>Celtis tetrandra</i>	13.3	1.6	12.5	3.2	15.7
6	Bah	<i>Quercus leucotrichophora</i>	13.3	4.6	12.5	9.0	21.5
7	Bah	<i>Rhododendron arboreum</i>	13.3	1.1	12.5	2.2	14.7
8	Bah	<i>Ulmus wallichiana</i>	6.7	1.4	6.3	2.8	9.0

C. Biotic Pressure - Low (4 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Bah	<i>Aesculus indica</i>	20.0	24.2	14.3	37.1	51.4
2	Bah	<i>Alnus nitida</i>	20.0	4.2	14.3	6.5	20.8
3	Bah	<i>Betula alnoides</i>	20.0	11.8	14.3	18.0	32.3
4	Bah	<i>Celtis tetrandra</i>	6.7	0.9	4.8	1.3	6.1
5	Bah	<i>Populus ciliata</i>	26.7	8.5	19.0	13.0	32.0
6	Bah	<i>Quercus leucotrichophora</i>	20.0	12.9	14.3	19.7	34.0
7	Bah	<i>Rhododendron arboreum</i>	13.3	1.1	9.5	1.7	11.3
8	Bah	<i>Toona serrata</i>	13.3	1.7	9.5	2.6	12.1

6. Village Surround - Lapah, Sainj SWS
A. Biotic Pressure - High (0 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Lapah	<i>Aesculus indica</i>	13.3	1.6	11.1	29.8	40.9
2	Lapah	<i>Celtis tetrandra</i>	20.0	0.3	16.7	5.3	22.0
3	Lapah	<i>Juglans regia</i>	6.7	0.2	5.6	3.2	8.8
4	Lapah	<i>Picea smithiana</i>	6.7	1.0	5.6	18.1	23.6
5	Lapah	<i>Pinus wallichiana</i>	20.0	1.5	16.7	28.6	45.3
6	Lapah	<i>Prunus cornuta</i>	6.7	0.2	5.6	3.1	8.7
7	Lapah	<i>Pyrus pashia</i>	26.7	0.2	22.2	4.6	26.8
8	Lapah	<i>Taxus baccata</i>	13.3	0.2	11.1	3.1	14.2
9	Lapah	<i>Ulmus wallichiana</i>	6.7	0.2	5.6	4.2	9.7

Contd...

Table 4.2 Contd...

B. Biotic Pressure - Moderate (2 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Lapah	<i>Betula alnoides</i>	20.0	0.4	13.6	6.3	20.0
2	Lapah	<i>Cedrus deodara</i>	33.3	4.2	22.7	62.1	84.9
3	Lapah	<i>Pinus wallichiana</i>	26.7	1.2	18.2	18.4	36.6
4	Lapah	<i>Prunus cornuta</i>	40.0	0.5	27.3	7.5	34.8
5	Lapah	<i>Rhus wallichii</i>	6.7	0.0	4.5	0.3	4.9
6	Lapah	<i>Taxus baccata</i>	6.7	0.1	4.5	1.9	6.5
7	Lapah	<i>Ulmus wallichiana</i>	13.3	0.2	9.1	3.3	12.4

C. Biotic Pressure - Low (4 km distance)

SI No	VS	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	Lapah	<i>Abies pindrow</i>	20.0	0.9	13.0	14.1	27.1
2	Lapah	<i>Acer caesium</i>	6.7	0.2	4.3	2.9	7.3
3	Lapah	<i>Betula alnoides</i>	13.3	0.2	8.7	2.4	11.1
4	Lapah	<i>Celtis tetrandra</i>	20.0	0.1	13.0	1.5	14.5
5	Lapah	<i>Corylus jacquemontii</i>	13.3	0.5	8.7	7.8	16.5
6	Lapah	<i>Picea smithiana</i>	6.7	1.7	4.3	26.7	31.0
7	Lapah	<i>Pinus wallichiana</i>	33.3	2.0	21.7	30.3	52.0
8	Lapah	<i>Prunus cornuta</i>	13.3	0.2	8.7	3.5	12.2
9	Lapah	<i>Quercus floribunda</i>	20.0	0.5	13.0	7.9	20.9
10	Lapah	<i>Ulmus wallichiana</i>	6.7	0.2	4.3	3.0	7.4

(A) Tree Diversity: A comparison of data on species in six VS revealed that the highest number of tree species recorded, being 10 was in the case of Kharoncha VS with low disturbance (4 km) as well as in Lapah VS with moderate level disturbance (Table 4.3).

**Table 4.3 – A Comparison of Tree Species in Six Village Surrounds
(Values in Number)**

Sl. No.	Village Surrounds	Sub-waterhshed	Disturbance Level		
			High (0 km)	Moderate (2 km)	Low (4 km)
1	Ropa	Tirthan SWS	5	9	6
2	Kharoncha	Tirthan SWS	4	10	9
3	Nahi	Tirthan SWS	5	4	6
4	Shangarh	Sainj SWS	8	6	4
5	Bah	Sainj SWS	4	8	8
6	Lapah	Sainj SWS	9	7	10

(B) Tree Density: The values of tree density among six Village surrounds and across three different levels of biotic disturbance ranged from 53.33 tree/ha to 233.33 trees/ha (Table 4.4). The maximum tree density (233.33 tree/ha) was recorded in Shangarh VS with low level disturbance i.e. 4 km distance from the village.

Among six VS, the highest tree density, being 113.33 tree/ha was recorded for *Cedrus deodara* in the case of low disturbance area of Shangarh, Sainj SWS. This was followed by *Quercus semecarpifolia* (99.33 tree/ha) in low disturbance area of Nahi VS and *Pinus wallichiana* (99.33 tree/ha) in high disturbance area of Ropa VS.

**Table 4.4 - A Comparison of Tree Density in Six Village Surrounds
(Values in tree/ha)**

Sl.No.	Village Surrounds	Sub-watershed	Disturbance Level		
			High (0 km)	Moderate (2 km)	Low (4 km)
1	Ropa	Tirthan	133.33	93.33	120.00
2	Kharoncha	Thirthan	53.3	100.00	100.00
3	Nahi	Tirthan	46.67	180.00	206.67
4	Shangarh	Sainj	126.67	213.33	233.33
5	Bah	Sainj	73.33	106.67	140.00
6	Lapah	Sainj	120.00	146.67	153.33

Noticeably, amongst three disturbance zones, higher values of tree density were recorded in low disturbance area (4 km distance) in all cases except for Ropa VS.

(C) Basal Area: The cumulative values of basal area for different trees in six VS ranged from 1.44 sq m to 65.36 sq m (Table 4.5). The highest cumulative value of basal area (65.36 sq m) was recorded in low disturbance zone of Bah VS while the lowest value of 1.44 sq m was recorded in high disturbance zone of Ropa village. In general, tree species viz., *Aesculus indica*, *Betula alnoides* and *Quercus leucotrichophora* occupied higher basal area. On comparing the three disturbance zones on the basis of cumulative values of basal area for six VS, it was revealed that the high disturbance zone obtained the lowest value (49.87 sq m) while the low disturbance zone obtained the highest cumulative value of basal area (88.86 sq m). This indicates that the total basal area of all trees in the proximity of VS reduces to more than half.

Table 4.5 - A Comparison of Basal Area in Six Village Surrounds (Values in sq/m)

Sl.No.	Village Surrounds	Sub-watershed	Disturbance Level		
			High (0 km)	Moderate (2 km)	Low (4 km)
1	Ropa	Tirthan	1.44	2.11	1.86
2	Kharoncha	Thirthan	2.48	4.24	2.40
3	Nahi	Tirthan	2.13	5.39	5.34
4	Shangarh	Sainj	8.74	5.0	7.34
5	Bah	Sainj	29.72	51.27	65.36
6	Lapah	Sainj	5.36	6.68	6.56
Total			49.87	74.69	88.86

(D) Importance Value: The Importance Value (I) for different tree species in six VS ranged from 3.59 (*Pyrus phasia*) to 129.50 (*Pinus wallichiana*). Tree species viz., *Pinus wallichiana*, *Cedrus deodara*, *Aesculus indica* and *Quercus semecarpifolia* usually obtained higher estimates of the Importance Value. No marked influence of different disturbance zone was observed with regard to the Important Value of various tree species.

(E) Affected Trees and Regeneration Status: The % values for lopped, girdled, and dead and dying trees were determined for six Village surrounds and across three different disturbance zones.

The values of lopped trees in six VS and across three disturbance zones varied from 0 to 57.14% of the total trees recorded in the corresponding disturbance category/VS (Table 4.6). Maximum trees (57.14%) in Nahi VS

within high disturbance were found lopped, followed by 46.67% in moderate disturbance zone of Kharoncha VS. In all cases, in their farthest areas (4 km) from village outskirts the proportion of lopped trees was either almost absent or minimal. The values of percentage lopped trees in case of at least three VS under the category of moderate level of disturbance were highest even in comparison to their corresponding high disturbance zone. This situation was comparable with overall low tree density in those corresponding VS. Comparing the proportion of lopped trees among six VS irrespective of different disturbance regimes, it was found that values varied from 13.85% (Nahi VS) to 26.32% (Kharoncha VS). This range illustrates that nearly 1/5 trees in VS were impacted just by lopping alone. In general, trees were lopped either for fodder or fuelwood.

Table 4.6 - Lopped Trees in Village Surrounds (Values in %)

SI No.	Village Surrounds	Sub-watershed	Disturbance Level			
			High (0 km)	Moderate (02 km)	Low (04 km)	Overall VS
1	Ropa	Tirthan	20.0	28.5	5.50	17.3
2	Kharoncha	Tirthan	37.5	46.6	0.0	26.3
3	Nahi	Tirthan	57.1	18.5	0.0	13.8
4	Shangarh	Sainj	21.0	25.0	0.0	13.9
5	Bah	Sainj	36.3	25.0	0.0	16.6
6	Lapah	Sainj	11.1	31.8	4.3	15.8

Trees were also found to be damaged by girdling. People girdle trees in order to create more openings so as to either expand cultivation areas or enhance foraging for livestock. The data collected on girdled trees in six VS across three disturbance regimes is presented in Table 4.7. In several instances,

there was no girdling while in a few cases, values to the extent of 15% girdled trees as in the case of Ropa VS were recorded. Girdling of trees was completely absent in low disturbance zone in each case. However, while comparing the overall proportion of girdled trees in six VS, the highest value of 5.7% girdled trees was recorded in the case of Ropa VS. In contrast, Bah VS did not had a single case of girdling.

Table 4.7 - Girdled Trees in Village Surrounds (Values in %)

Sl. No.	Village Surrounds	Sub-watershed	Disturbance Level			
			High (0 km)	Moderate (02 km)	Low (04 km)	Overall VS
1	Ropa	Tirthan	15.0	0.0	0	5.7
2	Kharoncha	Tirthan	0.0	6.6	0	2.6
3	Nahi	Tirthan	0.0	7.4	0	3.0
4	Shangarh	Sainj	0.0	6.2	0	4.6
5	Bah	Sainj	10.53	0.0	0	0.0
6	Lapah	Sainj	0.0	4.5	0	1.5

Based on field assessments in six VS, it can be inferred that trees were impacted to the extent of 3-4% just by girdling alone. Simultaneously data on dead trees was also collected. Except in a few cases, the proportion of dead trees was almost nil. The highest % value of dead trees was recorded in the case of Ropa (16.6%) VS. Comparing the proportion of dead trees among six VS, the highest value, being 11.5% was recorded in the case of Ropa VS, followed by 6.9% of dead trees in Shangarh VS. As could be expected, the values of dead trees were almost resembling to girdled trees in corresponding VS or disturbance regime (Table 4.8). Usually trees species viz., *Cedrus deodara*, *Pinus wallichiana*, *Abies pindrow*, *Picea smithiana* were girdled and

also found dead. In majority cases, local people ultimately utilized dead trees for fuel wood purpose.

Table 4.8 - Dead Trees in Six Village Surrounds (Values in %)

Sl. No.	Village Surrounds	Sub-watershed	Disturbance Level			
			High (0 km)	Moderate (02 km)	Low (04 km)	Overall VS
1	Ropa	Tirthan	15.0	0.0	16.6	11.5
2	Kharoncha	Tirthan	0.0	0.0	6.6	2.6
3	Nahi	Tirthan	0.0	11.1	0.0	4.6
4	Shangarh	Sainj	10.5	12.5	0.0	6.9
5	Bah	Sainj	0.0	0.0	0.0	0.0
6	Lapah	Sainj	0.0	4.5	0.0	1.5

As stated earlier in the Chapter on the Study Area and Approach, lower girth classes i.e. < 20 cm in case of tree species were treated as regeneration. Thus, field data on tree regeneration including seedlings and saplings (i.e. <20 GBH) was collected in six VS and across three disturbance regimes and presented here as number of individuals/ha (Table 4.9). The regeneration values among six VS and across three disturbance levels ranged from 0 to 773.0 individuals/ha. In all VS, lower values were recorded in the case of high disturbance zone i.e. close to village periphery. Thus, in general, tree regeneration close to village proximity was poor. Three sites of VS viz., Ropa Kharoncha and Nahi had their highest values of regeneration in low level disturbance. This can be accounted for low biotic pressure and favourable conditions for tree regeneration. However, in the case of Shangarh, Bah and Lapah VS in Sainj SWS, data on tree regeneration revealed that the highest values were recorded in the case of moderate biotic disturbance zone. In

these sites, forests were mainly conifers. Probably a moderate level of disturbance might be facilitating tree regeneration. However, this needs further investigation. Comparatively, lower tree regeneration values irrespective of different disturbance zone were obtained in case of Kharoncha, Bah and Ropa VS while Nahi and Shangarh VS had higher values of tree regeneration.

Table 4.9 - Tree Regeneration in Six Village Surrounds (Values in number of individuals/ha)

Sl. No.	Village Surrounds	Sub-watershed	Disturbance Level			Overall VS
			High (0 km)	Moderate (2 km)	Low (4 km)	
1	Ropa	Tirthan	20.0	26.6	133.3	60.0
2	Kharoncha	Tirthan	0.0	33.3	93.3	42.2
3	Nahi	Tirthan	26.6	253.3	340.0	206.6
4	Shangarh	Sainj	100.0	773.3	493.3	455.5
5	Bah	Sainj	13.3	73.3	40.0	42.2
6	Lapah	Sainj	0.0	260.0	240.0	166.6

4.3.2 Shrub Diversity

The appraisal of data on shrub diversity in six VS and across three disturbance levels yielded a list of 40 shrub species (Table 4.10). The values of shrub density varied from 1.85 to 488.8 shrub/ha. The highest value, being 488.8 shrub/ha was recorded in the case of *Sarcococca hookerana*, followed by *Sinarundinaria falcata* (487.0 shrub/ha). All 40 shrub species together provided a total shrub density of 2,577.7 shrub/ha in the category of Village surrounds. In terms of abundance values, dominant shrubs were: *Sarcococca*

hookerana, *Sinarundinaria falcata*, *Thamnocalamus spathiflorus* and *Prinsepia utilis*. Both species of bamboo i.e. *S. falcata* and *T. spathiflorus* make important fodder resource for livestock. Other than these two bamboo species, shrub species viz., *Indigofera* sp., *Desmodium* sp., *Debregeasia* sp., and *Berberis* sp., were preferred fodder species and thus, they were also harvested. Obviously these shrub species were also preferred by livestock while foraging. Both bamboo species provided fodder throughout the year.

Table 4.10 - Overall Shrub Density and Abundance in Village Surrounds (VS)

SI No	Shrub Species	No. of Individuals	Density (Shrub/ha)	Abundance
1	<i>Sarcococca hookerana</i>	264	488.9	19.0
2	<i>Sinarundinaria falcata</i>	263	487.0	18.9
3	<i>Thamnocalamus spathiflorus</i>	136	251.9	9.8
4	<i>Prinsepia utilis</i>	93	172.2	6.7
5	<i>Berberis aristata</i>	75	138.9	5.4
6	<i>Indigofera heterantha</i>	74	137.0	5.3
7	<i>Sorbaria tementosa</i>	72	133.3	5.2
8	<i>Berberis lycium</i>	62	114.8	4.5
9	<i>Desmodium elagans</i>	50	92.6	3.6
10	<i>Berberis chitria</i>	49	90.7	3.5
11	<i>Viburnum nervosum</i>	35	64.8	2.5
12	<i>Rosa webbiana</i>	26	48.1	1.9
13	<i>Elaeagnus umbellata</i>	19	35.2	1.4
14	<i>Rosa sericea</i>	18	33.3	1.3
15	<i>Deutzia staminea</i>	16	29.6	1.1
16	<i>Berberis ceratophylla</i>	14	25.9	1.0
17	<i>Salix denticulata</i>	11	20.4	0.8
18	<i>Lonicera angustifolia</i>	10	18.5	0.7
19	<i>Indigofera atropurpurea</i>	10	18.5	0.7
20	<i>Daphne cannabina</i>	10	18.5	0.7
21	<i>Cotoneaster affinis</i>	9	16.7	0.6
22	<i>Rubus niveus</i>	8	14.8	0.6
23	<i>Viburnum grandiflorum</i>	7	13.0	0.5
24	<i>Ribes orientalis</i>	7	13.0	0.5
25	<i>Cotoneaster baccilaris</i>	7	13.0	0.5
26	<i>Indigofera hirsuta</i>	6	11.1	0.4

Contd...

Table 4.10 Contd...

SI No	Shrub Species	No. of Individuals	Density (Shrub/ha)	Abundance
27	<i>Skimmia laureola</i>	5	9.3	0.4
28	<i>Rosa macrophylla</i>	5	9.3	0.4
29	<i>Jesminum humile</i>	5	9.3	0.4
30	<i>Cotoneaster microphylla</i>	5	9.3	0.4
31	<i>Rosa moschata</i>	4	7.4	0.3
32	<i>Desmodium trifolium</i>	3	5.6	0.2
33	<i>Viburnum cotinifolium</i>	2	3.7	0.1
34	<i>Rubus foliolosus</i>	2	3.7	0.1
35	<i>Rhamnus purpureus</i>	2	3.7	0.1
36	<i>Hedera nepalensis</i>	2	3.7	0.1
37	<i>Debregeasia salicifolia</i>	2	3.7	0.1
38	<i>Berberis asiatica</i>	2	3.7	0.1
39	<i>Rhamnus echinatus</i>	1	1.9	0.1
40	<i>Desmodium multiflorum</i>	1	1.9	0.1
	Total	1392	2577.8	100.0

On comparison of values of shrub density among six VS and across three disturbance zones, the highest value of shrub density, being 3,233 shrub/ha was recorded in the case of *Sarcococca hookerana* (Table 4.11).

Table 4.11 - Shrub Density in Different Village Surrounds at Varying Level of Disturbance (Values in shrub/ha)

1. Village Surrounds - Ropa, Tirthan SWS
A. Biotic Pressure - High (0 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Sinarundinaria falcata</i>	20	666.7
2	<i>Berberis aristata</i>	35	1166.7
3	<i>Cotoneaster baccilaris</i>	3	100.0
4	<i>Daphne cannabina</i>	2	66.7
5	<i>Presepsia utilis</i>	17	566.7
6	<i>Rosa webbiana</i>	2	66.7
7	<i>Sarcococca hookerana</i>	27	900.0
8	<i>Sorbaria tementosa</i>	2	66.7

Contd...

Table 4.11 Contd...

B. Biotic Pressure - Moderate (2 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Sinarundinaria falcata</i>	81	2700.0
2	<i>Thamnocalamus spathiflorus</i>	75	2500.0
3	<i>Berberis asiatica</i>	2	66.7
4	<i>Daphne cannabina</i>	6	200.0
5	<i>Elaeagnus umbellata</i>	2	66.7
6	<i>Prinsepia utilis</i>	3	100.0
7	<i>Sarcococca hookerana</i>	28	933.3

C. Biotic Pressure - Low (4 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Sinarundinaria falcate</i>	57	1900.0
2	<i>Berberis aristata</i>	12	400.0
3	<i>Daphne cannabina</i>	2	66.7
4	<i>Indigofera hirsuta</i>	6	200.0
5	<i>Sarcococca hookerana</i>	16	533.3

2. Village Surrounds - Kharoncha, Tirthan SWS

A. Biotic Pressure - High (0 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Berberis aristata</i>	3	100.0
2	<i>Desmodium trifolium</i>	2	66.7
3	<i>Deutzia strominia</i>	1	33.3
4	<i>Indigofera heterantha</i>	21	700.0
5	<i>Sarcococca hookerana</i>	5	166.7

B. Biotic Pressure - Moderate (2 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Berberis aristata</i>	10	333.3
2	<i>Debregezea salcifolia</i>	1	33.3
3	<i>Desmodium trifolium</i>	1	33.3
4	<i>Indigofera heterantha</i>	16	533.3
5	<i>Prubseoua utilis</i>	5	166.7
6	<i>Sarcococca hookerana</i>	20	666.7
7	<i>Viburnum continifolium</i>	2	66.7

Contd...

Table 4.11 Contd...

C. Biotic Pressure – Low (4 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Berberis aristata</i>	15	500.0
2	<i>Debregesea salcifolia</i>	1	33.3
3	<i>Desmodium elegans</i>	2	66.7
4	<i>Deutzia strominia</i>	1	33.3
5	<i>Indigofera atropurpurea</i>	10	333.3
6	<i>Rhamnus purpureus</i>	1	33.3

3. Village Surrounds - Nahi, Tirthan SWS

A. Biotic Pressure - High (0 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Berberis lycium</i>	22	733.3
2	<i>Desmodium elagans</i>	2	66.7
3	<i>Indigofera heterantha</i>	9	300.0
4	<i>Rosa sericea</i>	3	100.0

B. Biotic Pressure - Moderate (2 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Thamnocalamus spathiflorus</i>	35	1166.7
2	<i>Berberis lycium</i>	9	300.0
3	<i>Desmodium elagans</i>	3	100.0
4	<i>Indigofera heterantha</i>	6	200.0
5	<i>Prinsepia utilis</i>	1	33.3

C. Biotic Pressure - Low (4 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Thamnocalamus spathiflorus</i>	26	866.7
2	<i>Desmodium elagans</i>	6	200.0
3	<i>Ribes orientalis</i>	7	233.3
4	<i>Rosa sericea</i>	3	100.0

4. Village Surrounds – Sangarh, Sainj SWS

A. Biotic Pressure - High (0 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Berberis chitria</i>	16	533.3
2	<i>Berberis lycium</i>	13	433.3
3	<i>Cotoneaster biicillaris</i>	4	133.3

Contd...

Table 4.11 Contd...

SI No	Shrub Sp	No.	Density (shrub/ha)
4	<i>Cotoneaster microphylla</i>	5	166.7
5	<i>Desmodium elagans</i>	5	166.7
6	<i>Desmodium multiflorum</i>	1	33.3
7	<i>Elaeagnus umbellata</i>	3	100.0
8	<i>Indigofera heterantha</i>	6	200.0
9	<i>Lonicera angustifolia</i>	8	266.7
10	<i>Prinsepia utilis</i>	9	300.0
11	<i>Rhamnus purpureus</i>	1	33.3
12	<i>Viburnum nervosum</i>	14	466.7

B. Biotic Pressure - Moderate (2 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Berberis chitria</i>	19	633.3
2	<i>Berberis lycium</i>	7	233.3
3	<i>Desmodium elagans</i>	6	200.0
4	<i>Elaeagnus umbellata</i>	2	66.7
5	<i>Indigofera heterantha</i>	3	100.0
6	<i>Jusminum humile</i>	1	33.3
7	<i>Lonicera angustifolia</i>	1	33.3
8	<i>Rhamnus echinatus</i>	1	33.3
9	<i>Rosa moschata</i>	4	133.3
10	<i>Rosa sericea</i>	3	100.0
11	<i>Rubus foliolosus</i>	2	66.7

C. Biotic Pressure - Low (4 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Berberis chitria</i>	14	466.7
2	<i>Berberis lycium</i>	11	366.7
3	<i>Elaeagnus umbellata</i>	1	33.3
4	<i>Hedera nepalensis</i>	1	33.3
5	<i>Jesminum humile</i>	4	133.3
6	<i>Lonicera angustifolia</i>	1	33.3

5. Village Surrounds – Bah, Sainj SWS

A. Biotic Pressure – High (0 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Berberis ceratophylla</i>	4	133.3
2	<i>Cotoneaster affinis</i>	9	300.0
3	<i>Prinsepia utilis</i>	54	1800.0
4	<i>Rosa webbiana</i>	5	166.7
5	<i>Sarcococca hookerana</i>	17	566.7
6	<i>Sorbaria tomentosa</i>	23	766.7

Contd...

Table 4.11 Contd...

B. Biotic Pressure - Moderate (2 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Sinarundinaria falcata</i>	41	1366.7
2	<i>Rosa webbiana</i>	17	566.7
3	<i>Sorbaria tomentosa</i>	10	333.3

C. Biotic Pressure - Low (4 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Sinarundinaria falcata</i>	64	2133.3
2	<i>Berberis ceratophylla</i>	10	333.3
3	<i>Desmodium elegans</i>	3	100.0
4	<i>Prinsepia utilis</i>	4	133.3
5	<i>Rosa macrophylla</i>	5	166.7
6	<i>Sarcococca hookerana</i>	54	1800.0
7	<i>Sorbaria tomentosa</i>	22	733.3

6. Village Surrounds – Lapah, Sainj SWS

A. Biotic Pressure - High (0 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Deutzia staminea</i>	3	100.0
2	<i>Elaeagnus umbellata</i>	11	366.7
3	<i>Indigofera heterantha</i>	5	166.7
4	<i>Rubus niveus</i>	3	100.0
5	<i>Sarcococca hookerana</i>	97	3233.3

B. Biotic Pressure - Moderate (2 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Desmodium elagans</i>	11	366.7
2	<i>Deutzia staminea</i>	7	233.3
3	<i>Rosa sericea</i>	9	300.0
4	<i>Skimmia laureola</i>	5	166.7
5	<i>Sorbaria tomentosa</i>	8	266.7
6	<i>Viburnum nervosum</i>	14	466.7

C. Biotic Pressure - Low (4 km distance)

SI No	Shrub Sp	No.	Density (shrub/ha)
1	<i>Desmodium elagans</i>	12	400.0
2	<i>Deutzia staminea</i>	4	133.3
3	<i>Indigofera heterantha</i>	8	266.7
4	<i>Rosa webbiana</i>	2	66.7
5	<i>Rubus niveus</i>	5	166.7
6	<i>Salix denticulata</i>	11	366.7
7	<i>Sorbaria tomentosa</i>	7	233.3
8	<i>Viburnum nervosum</i>	7	233.3
9	<i>Viburnum grandiflorum</i>	7	233.3

On comparison of values of shrub densities among six VS and three disturbance zones, no discernible pattern was observed (Table 4.12).

Table 4.12 – A comparison of Shrub Density in Six Village Surrounds Across Three Disturbance Zones (Values in shrub/ha)

Sl.No.	Village Surrounds	Sub-waterhshed	Disturbance Zone		
			Low (0 km)	Moderate (2 km)	High (4 km)
1	Ropa	Tirthan	3,600.0	6,566.6	3,100.0
2	Kharoncha	Tirthan	1,066.6	1,833.3	1,000.0
3	Nahi	Tirthan	1,200.0	1,800.0	1,400.0
4	Shangarh	Sainj	2,833.3	1,633.3	1,100.0
5	Bah	Sainj	3,733.3	2,266.6	5,400.0
6	Lapah	Sainj	3,966.6	1,800.0	2,100.0

4.3.3 Ground Cover

Field data on the composition of ground cover representing proportions of grass, herb, shrub, rock, weed and livestock dung based on hit values on line transects laid in six VS and across three disturbance zones was collected and percentage values for each constituent, VS and disturbance zone are presented in Table 4.13. The analysis revealed that in general, the values of livestock dung and proportion of weed plants declined on moving away from the VS or high disturbance zone to low disturbance zone. While, as expected and as a general pattern, % values of herb, shrub and grass were higher in moderate and low disturbance zones. Otherwise, more or less the same pattern for each constituent (herb, grass, shrub, etc.) was obtained, except a few exceptions. The data analysis on ground cover by combining the actual corresponding field values revealed that: (i) rocks and barren ground alone occupied the first $\frac{1}{4}$ part of the ground i.e. 28.5%; (ii) herb layer covered the second $\frac{1}{4}$ part of the ground i.e. 25.8%, (iii) grass and shrub layers occupied

nearly the third $\frac{1}{4}$ part of the ground i.e. 22%; and (iv) livestock dung and weed plants covered the last $\frac{1}{4}$ part of the ground i.e. 23.5% (Fig. 4.1).

Table 4.13 - Ground Cover Percentage around Village Surrounds at Varying Level of Disturbance

Sl. No.	Constituents	Disturbance Level			Overall VS
		High	Moderate	Low	
A. Ropa					
1.	Dung	23.50	7.83	0.00	10.44
2.	Grass	10.50	6.50	12.17	9.72
3.	Herb	9.33	24.17	32.83	22.11
4.	Rock	28.33	28.83	32.50	29.89
5.	Shrub	14.33	19.67	15.33	16.44
6.	Weed	14.00	13.00	7.17	11.39
B. Kharoncha					
1.	Dung	13.50	10.50	0.00	8.00
2.	Grass	16.83	6.33	15.00	12.72
3.	Herb	21.33	26.67	39.67	29.22
4.	Rock	18.33	29.17	27.17	24.89
5.	Shrub	8.17	12.17	6.83	9.06
6.	Weed	21.83	15.17	11.33	16.11
C. Nahi					
1.	Dung	21.00	7.17	0.00	9.39
2.	Grass	8.50	7.33	12.17	9.33
3.	Herb	19.00	26.00	41.17	28.72
4.	Rock	22.33	34.67	26.50	27.83
5.	Shrub	11.17	11.33	8.17	10.22
6.	Weed	18.00	13.50	12.00	14.50
D. Shangarh					
1.	Dung	22.00	13.17	0.00	11.72
2.	Grass	7.00	9.17	14.00	10.06
3.	Herb	15.50	20.00	33.00	22.83
4.	Rock	27.83	37.33	38.67	34.61
5.	Shrub	13.33	11.33	8.67	11.11
6.	Weed	14.33	9.00	5.67	9.67
E. Bah					
1.	Dung	15.33	10.67	0.00	8.67
2.	Grass	10.50	7.50	10.67	9.56
3.	Herb	23.00	23.83	40.83	29.22
4.	Rock	14.50	33.50	25.83	24.61
5.	Shrub	8.83	10.33	16.67	11.94
6.	Weed	27.83	14.17	6.00	16.00

Contd...

Table 4.13 Contd...

Sl. No.	Constituents	Disturbance Level			Overall VS
		High	Moderate	Low	
F. Lapah					
1.	Dung	19.83	9.33	0.00	9.72
2.	Grass	11.50	8.67	14.50	11.56
3.	Herb	14.17	21.33	34.00	23.17
4.	Rock	24.50	39.17	24.50	29.39
5.	Shrub	5.83	10.50	15.33	10.56
6.	Weed	24.17	11.00	11.67	15.61
Overall Six Village Surrounds					
1.	Dung	19.19	9.78	0.00	9.66
2.	Grass	10.81	7.58	13.08	10.49
3.	Herb	17.06	23.67	36.92	25.88
4.	Rock	22.64	33.78	29.19	28.54
5.	Shrub	10.28	12.56	11.83	11.56
6.	Weed	20.03	12.64	8.97	13.88

Fig. 4.1 - Ground Cover Constituents in the Six Village Surrounds

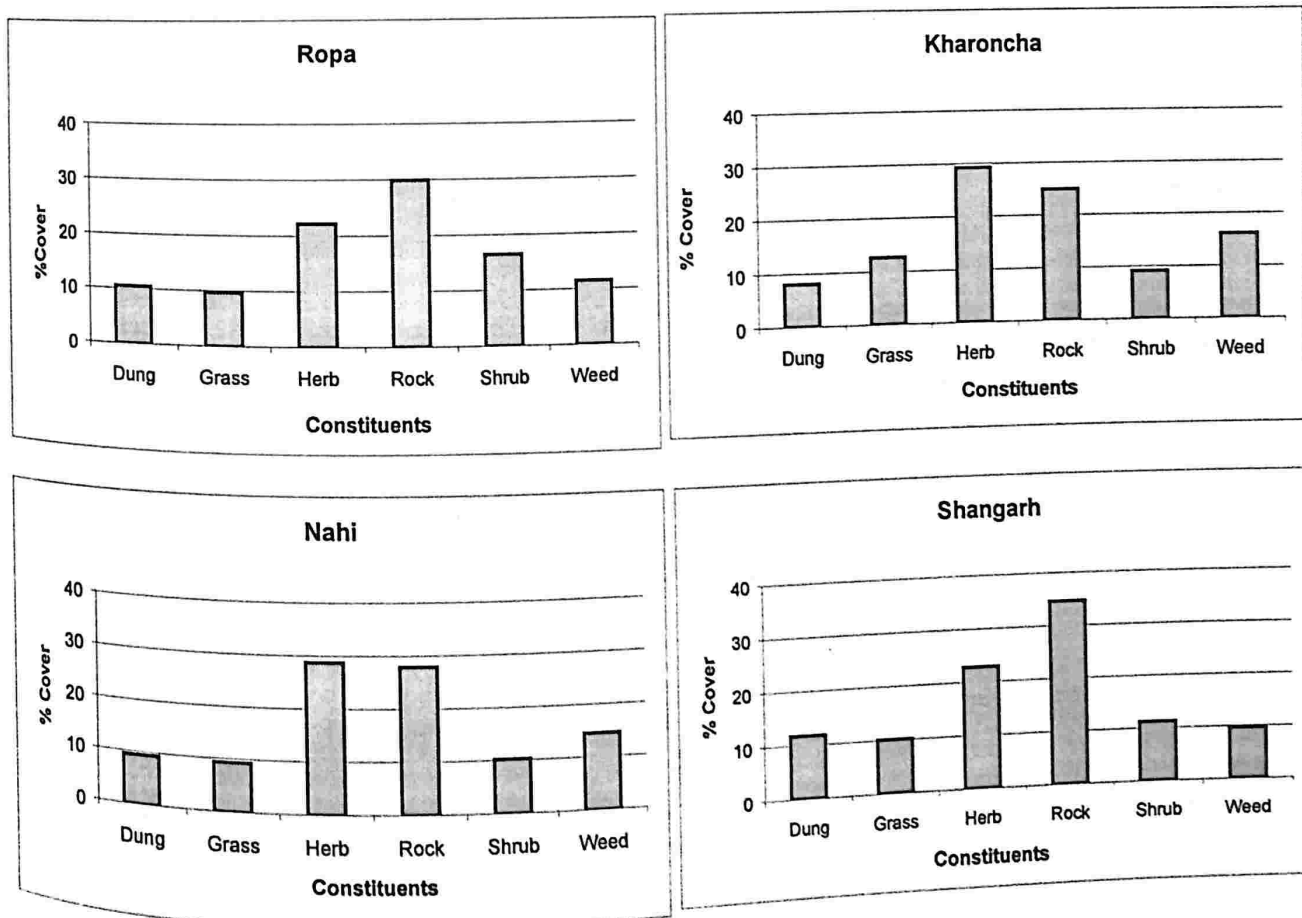
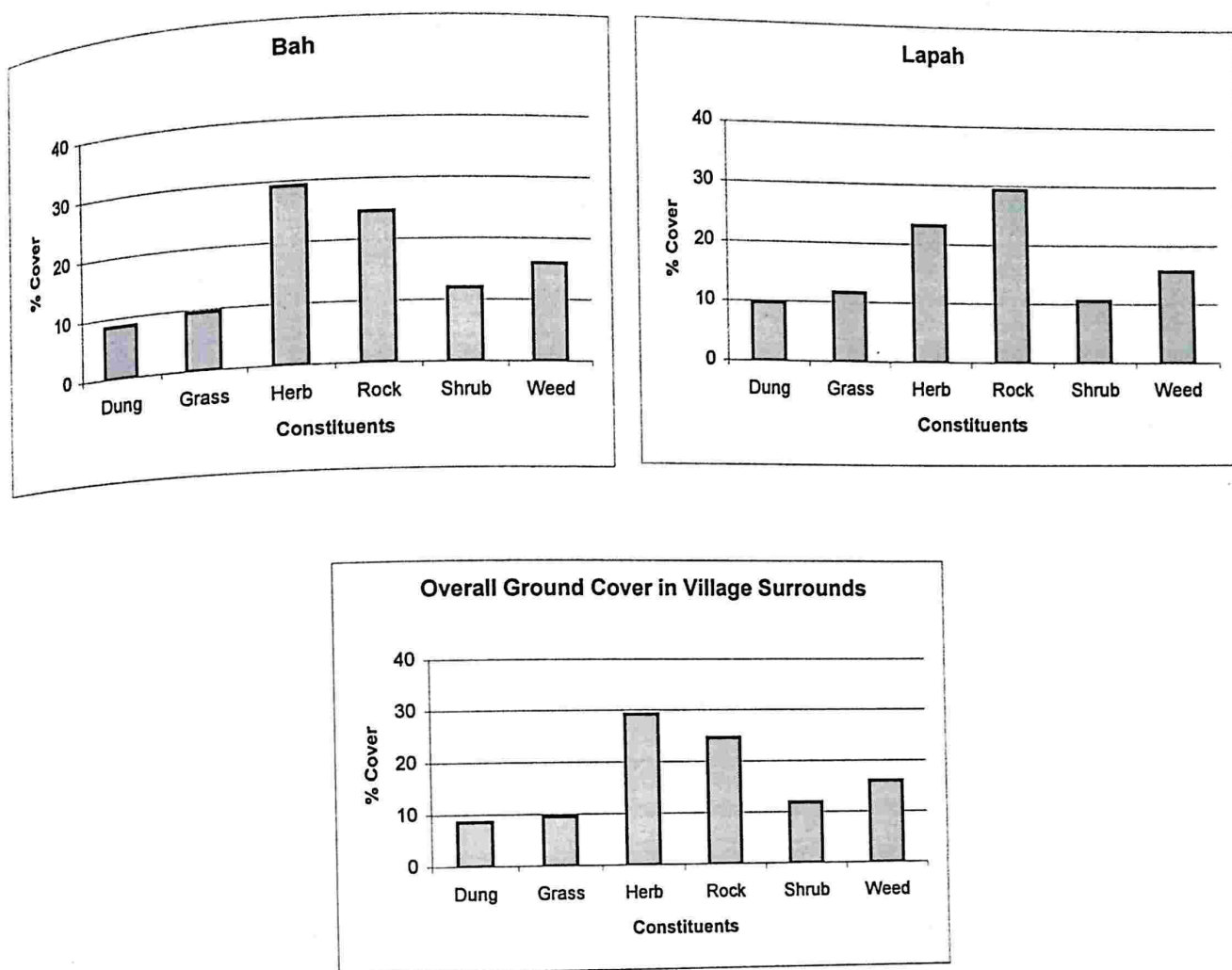


Fig. 4.1 Contd...



4.3.4 Village Pastures ('Ghasnis')

Other than summer migration to alpine pastures, livestock spend nearly 6 months in respective villages. During this period, livestock either utilizes the Village surrounds for grazing or remain indoor during snow period. The condition of each Village surrounds in terms of vegetation diversity, and biotic pressure has already been described in the foregoing text. In addition, each village has got grass hay plot ('Ghasni') which is largely protected and minimally utilized by livestock directly. Grass is usually protected in the growing season and harvested in September-October. The principal

perennial species of grass and sedges characterizing these village pastures ('Ghasnis') are listed in Table 4.14.

Table 4.14 - Grass and Sedge Species in Village Pastures ('Ghasnis')

Sl.No..	Species
A.	Principal Perennial Characterizing Species
1	<i>Themeda anathera</i>
2	<i>Themeda triandra</i>
3	<i>Heteropogon contortus</i>
B.	Associated Perennial Species Contributing more than 10 per cent to the Composition
1	<i>Apluda mutica</i>
2	<i>Andropogon munroi</i>
3	<i>Chrysopogon echinulatus</i>
C.	Other Perennial/annual species present in the community, but contributing less than 10 per cent
1	<i>Arundinella setosa</i>
2	<i>Pennisetum flaccidum</i>
3	<i>Microstegium nudum</i>
4	<i>Carex foliosa</i>
5	<i>Carex nubigena</i>

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The 'Ghasnis' in the GHNPFA fall under the category of 'Themeda - Arundinella type' as per the types of grass covers described by Dabadghao and Shankarnarayan (1973). *Themada anathera* was the dominant species in majority of the Ghasnis. The bulk of the grass density, plant cover and biomass was contributed by *T. anathera*. With the decreasing level of protection, increased grazing and burning pressures, the *T. anathera* dominated grass community in 'Ghasnis' was replaced by *Chrysopogon* sp. and *Apluda mutica*. With intense pressure of grazing and burning at this stage, grass community was further replaced by *Heteropogon contortus* dominated community. The aspect also played a major role in distribution and

abundance of different grass species. Usually the south facing slopes were drier.

The Above Ground Biomass (AGB) and Below Ground Biomass (BGB) were determined for the Nahi Ghasni in Tirthan SWS and Bah Ghasni in Sainj SWS. In all, 50 quadrats were laid in each case for AGB and equal number of monoliths for BGB. The results are summarized in the following tabular statement:

Sr. No.	Parameter	'Ghasnis' – Village Pastures			
		Nahi Ghasni, Tirthan SWS		Bah Ghasni Sainj SWS	
		AGB	BGB	AGB	BGB
1.	No. of quadrats/ Monoliths	50	50	50	50
2.	Range (g/m ²)	1,760	3,310	1,570	3,305
3.	Mean Value	545.5 ± 324.5	1,057.9 ± 647.6	510.0 ± 348.1	994.6 ± 740.0

The higher value of AGB, being 545.5 ± 324.5 g/m² was obtained in Nahi Ghasni. As such two 'Ghasnis' were more or less same with regard to the values of AGB and BGB. Almost double value of BGB was recorded than AGB in each case. The Nahi Ghasni registered higher BGB value. The interesting part of the data analysis was high values of standard deviation indicating large variations among different sample plots laid within a site. This was mainly due to large variations within site on the account of topography, soil depth, soil moisture and resultant grass growth.

4.4 Migratory Routes (MR)

During upward and downward migration, livestock traverses through different temperate forests, sub-alpine scrub and alpine pastures. In one way, any typical traditionally used migratory route more or less represents same features as well as a cross section of the entire landscape. Recognising this fact, data on tree and shrub diversity, affected trees and tree regeneration was collected and results based on such analysis are presented below. The data presented here is based on 89 plots those were laid all along the selected migratory route from Ropa to Dhela. The route begun in Tirthan SWS and the upper most destination was Dhela alpine pasture in Sainj SWS.

4.4.1 Tree Diversity

Altogether 36 tree species were recorded along the selected migratory route (Table 4.15). These represented 52.1% of the total tree diversity of 69 species recorded by Singh and Rawat (1999) in the GHNP. Species those were highly localized or uncommon were not represented. As in the case of VS, three species of Oak (*Quercus* sp.) were recorded. The fourth species i.e. *Quercus glauca* was not recorded as the species has a narrow distribution (1,500 – 2,500 m).

Out of 36 tree species recorded along the MR, 28 species were common to the tree list as of Village surrounds. Rest 8 species viz., *Acer villosum*, *Cornus macrophylla*, *Rhus saccideania*, *Prunus cerassoides*, *Acer*

acuminatus, *Salix wallichiana*, *Morus himalayana* and *Meliosma dillinaefolia* were not represented in studied six Village surrounds.

Table 4.15 - Tree Species recorded in One Transect of Migratory Route

No. of Sample Plots (n) = 89

SI No.	Tree Species	No. of Individuals	Density (Tree/ha)	Abundance
1	<i>Quercus semecarpifloia</i>	66	14.8	19.2
2	<i>Pinus wallichiana</i>	40	9.0	11.7
3	<i>Celtis tetrandra</i>	32	7.2	9.3
4	<i>Cedrus deodara</i>	18	4.0	5.2
5	<i>Rhus semialata</i>	16	3.6	4.7
6	<i>Acer villosum</i>	16	3.6	4.7
7	<i>Rhododendron arboreum</i>	14	3.1	4.1
8	<i>Betula alnoides</i>	13	2.9	3.8
9	<i>Quercus leucotricophora</i>	12	2.7	3.5
10	<i>Ulmus wallichiana</i>	11	2.5	3.2
11	<i>Cornus macrophylla</i>	11	2.5	3.2
12	<i>Prunus cornuta</i>	10	2.2	2.9
13	<i>Picea smithiana</i>	9	2.0	2.6
14	<i>Aesculus indica</i>	9	2.0	2.6
15	<i>Benthimidia capitata</i>	7	1.6	2.0
16	<i>Toona serrata</i>	6	1.3	1.7
17	<i>Quercus floribunda</i>	6	1.3	1.7
18	<i>Pyrus pashia</i>	6	1.3	1.7
19	<i>Alnus nitida</i>	5	1.1	1.5
20	<i>Abies pindrow</i>	5	1.1	1.5
21	<i>Rhus wallichii</i>	4	0.9	1.2
22	<i>Acer caesium</i>	4	0.9	1.2
23	<i>Lyonia ovalifolia</i>	3	0.7	0.9
24	<i>Juglans regia</i>	3	0.7	0.9
25	<i>Rhus saccideania</i>	2	0.4	0.6
26	<i>Prunus cerassoides</i>	2	0.4	0.6
27	<i>Ilex dipyrena</i>	2	0.4	0.6
28	<i>Acer pictum</i>	2	0.4	0.6
29	<i>Acer acuminatus</i>	2	0.4	0.6
30	<i>Salix wallichiana</i>	1	0.2	0.3
31	<i>Robinia pseudoacacia</i>	1	0.2	0.3
32	<i>Pistacia intrgerrima</i>	1	0.2	0.3
33	<i>Persia odoratissima</i>	1	0.2	0.3
34	<i>Morus himalayana</i>	1	0.2	0.3
35	<i>Meliosma dillinaefolia</i>	1	0.2	0.3
36	<i>Ficus pamata</i>	1	0.2	0.3

4.4.2 Tree Density

The density values of 36 tree species ranged from 0.22 tree/ha to 14.83 tree/ha. Tree species viz., *Quercus semecarpifolia*, *Pinus wallichiana*, *Celtis tetrandra* and *Cedrus deodara* obtained comparatively higher values. *Q. semecarpifolia* registered highest tree density, being 14.83 tree/ha. An overall density value of 77.08 tree/ha for all 36 recorded tree species was determined. The value of overall tree density was nearly half in case of MR than that of VS. This low value of tree density can be explained on the basis of fact that about 31% present sample plots came in tree less zone or alpine pastures. Thus, the density value of 77.08 tree/ha can be considered appropriate for the entire landscape where there was a mosaic of habitats constituted by forests, alpine pastures, barren rocks, snow, etc.

4.4.3 Affected Trees

The percentage values of lopped, girdled and dead trees were also worked out across the Migratory route as presented in the case of VS. Of the total trees enumerated in 89 plots along the selected migratory route, only 11% were found lopped, 1.7% girdled and 7.0% dead. The details of damaged trees along the selected migratory route (MR) are given in the following tabular statement.

Sl.No.	Category of Affected Trees	Value (%)
1	Lopped Trees	11.0
2	Girdled Trees	1.7
3	Dead Trees	7.0

4.4.4 Regeneration and Girth Class Distribution

An overall tree regeneration of 61.3 individual/ha was determined for the MR. The data on girth for four principal timber species viz., *Cedrus deodara*, *Picea smithiana*, *Pinus wallichiana*, and *Abies pindrow* and four pre-dominant fodder species viz., *Quercus semecarpifolia*, *Q. leucotrichophora*, *Q. floribunda* and *Ulmus wallichiana* was used to determine the girth class distribution. Fig 4.2 and 4.3 thus, illustrate girth class distribution for selected four timber and four fodder species, respectively. Varying patterns of girth class distribution were observed. A fair distribution towards normal pattern was observed in the case of timber species viz., *P. wallichiana*, *Cedrus deodara* and *Picea smithiana*. The recruitment and some of the intermediate girth classes were missing in the case of *Abies pindrow*. This erratic distribution to some extent can be explained on the account of low occurrence of this species in the overall sampling. In case of four selected fodder species, *Quercus semecarpifolia* (Kharsu oak) being widely distributed and most preferred fodder species showed a normal girth class distribution. The *Q. leucotrichophora* (Ban oak) and *Ulmus wallichiana* lacked adequate proportion of early as well as later classes of girth. While in the case of *Q. floribunda* (Moru oak) again, the intermediate to upper girth classes were almost absent. Even in this case, the

absence or erratic distribution could be attributed to lesser representation of this species in the overall tree sampling. Lower girth classes were almost absent in the case of *Ulmus wallichiana*. It is noteworthy to mention here that leaves of the four principal timber species are also being used for bedding material of livestock. In general, it can be inferred that most of the selected eight species have depicted more or less a 'fair' situation with regard to the girth class distribution. However, a need for closer examination and management is felt so as to ensure a normal girth class distribution in each case.

4.4.5 Shrub Diversity and Density

Assessment of shrub data in 89 plots (5.65 m radius or 100 m²) provided a list of 49 shrub species for the selected Migratory route (Table 4.16). The overall shrub diversity of 2,051.6 shrub/ha was determined. Predominant shrubs were: *Sinarundinaria falcate*, *Sarcococca hookerana*, *Thamnocalamus spathiflorus*, *Rhododendron campanulatum*, *R. lepidotum* and *R. anthopogon*. The highest shrub density other than two bamboo species, being 217.9 shrub/ha was observed in the case of *Sarcococca hookerana*, followed by *R. campanulatum*. Abundance values for 49 shrub species ranged from 0.05 to 20.54.

Fig. 4.2 -

Girth Class (values in cm) Distribution of Some Principal Timber Species

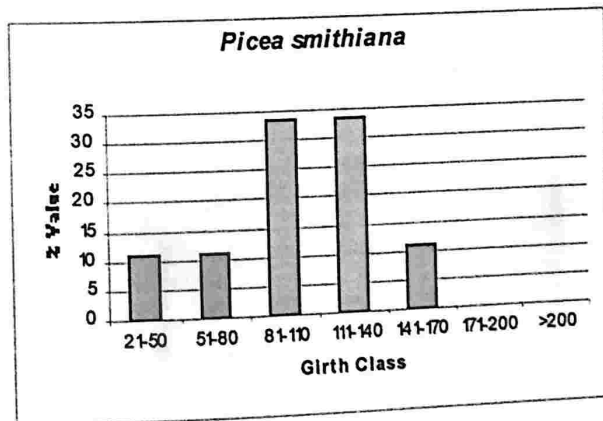
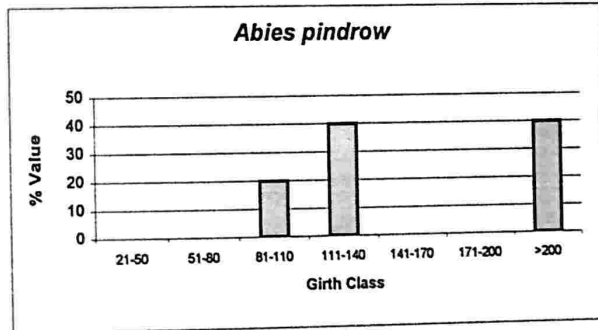
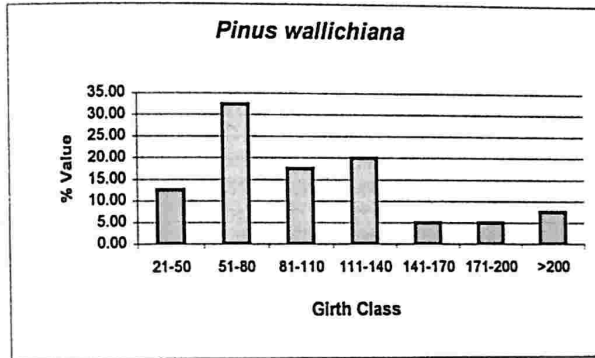
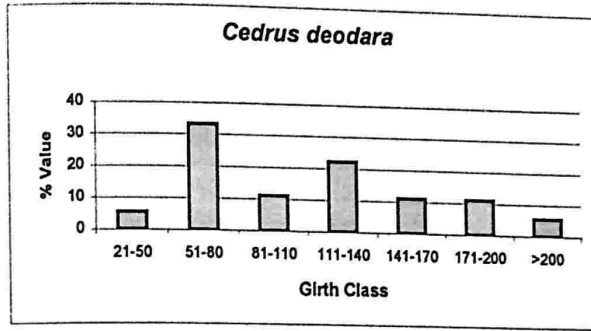


Fig. 4.3 - Girth Class (values in cm) Distribution of Some Prominent Fodder Species

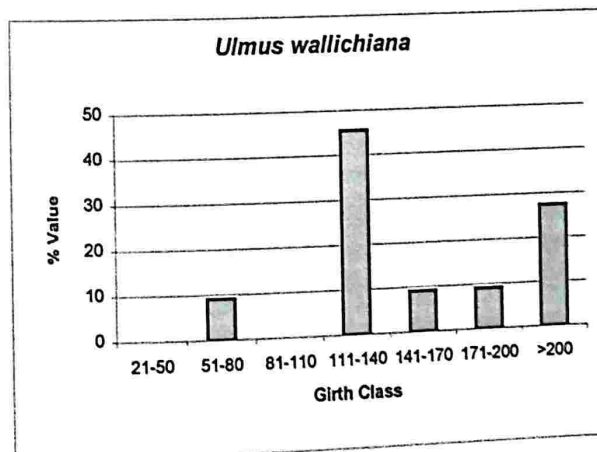
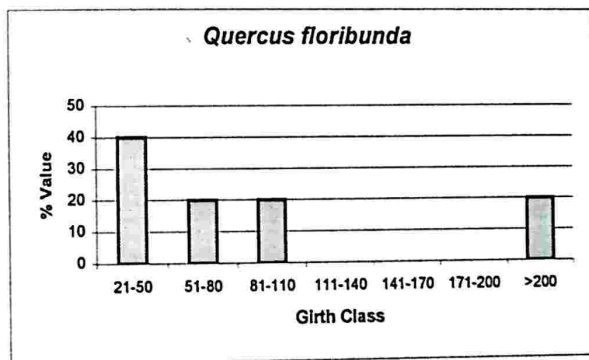
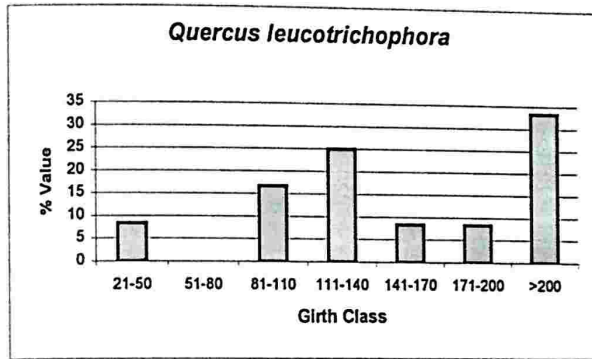
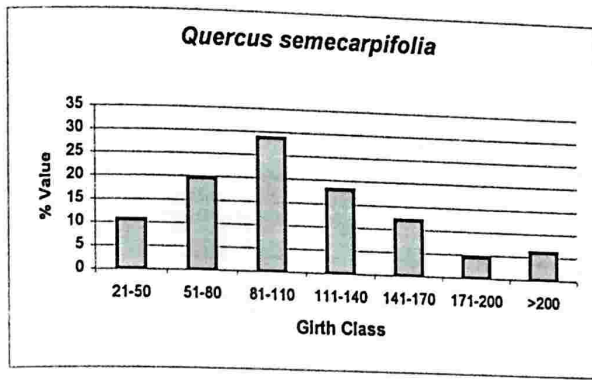


Table 4.16 - Shrub Diversity Along Migratory Route

No. of Sample Plots (n = 89)

Sl No.	Shrub Species	No of individuals	Density (shrub/ha)	Abundance
1	<i>Sinarundinaria falcata</i>	375	421.3	20.5
2	<i>Sarcococca hookerana</i>	194	218.0	10.6
3	<i>Thamnocalamus spathiflorus</i>	168	188.8	9.2
4	<i>Rhododendron campanulatum</i>	128	143.8	7.0
5	<i>Rhododendron lepidotum</i>	118	132.6	6.5
6	<i>Rhododendron anthopogon</i>	105	118.0	5.8
7	<i>Indigofera heterantha</i>	97	109.0	5.3
8	<i>Berberis aristata</i>	83	93.3	4.5
9	<i>Ribes orientales</i>	80	89.9	4.4
10	<i>Prinsepia utilis</i>	64	71.9	3.5
11	<i>Juniperus communis</i>	62	69.7	3.4
12	<i>Rosa webbiana</i>	46	51.7	2.5
13	<i>Indigofera pulchella</i>	39	43.8	2.1
14	<i>Desmodium elegans</i>	35	39.3	1.9
15	<i>Rosa sericea</i>	28	31.5	1.5
16	<i>Berberis asiatica</i>	25	28.1	1.4
17	<i>Sorbaria tomentosa</i>	23	25.8	1.3
18	<i>Cassiope fastigata</i>	10	11.2	0.5
19	<i>Cotoneaster microphylla</i>	20	22.4	1.0
20	<i>Daphne papyracea</i>	10	11.2	0.5
21	<i>Indigofera atropurpurea</i>	10	11.2	0.5
22	<i>Berberis jaeschkeana</i>	8	9.0	0.4
23	<i>Jasminum humile</i>	8	9.0	0.4
24	<i>Viburnum cotinifolium</i>	8	9.0	0.4
25	<i>Viburnum nervosum</i>	8	9.0	0.4
26	<i>Desmodium multiflorum</i>	7	7.9	0.4
27	<i>Juniperus pseudosabina</i>	7	7.9	0.4
28	<i>Lonicera purpurensence</i>	7	7.9	0.4
29	<i>Berberis chitria</i>	5	5.6	0.3
30	<i>Lonicera angustifolia</i>	5	5.6	0.3
31	<i>Salix elegans</i>	5	5.6	0.3
32	<i>Rhamnus purpureus</i>	4	4.5	0.2
33	<i>Berberis lycium</i>	3	3.4	0.2
34	<i>Cotoneaster acuminatus</i>	3	3.4	0.2
35	<i>Cotoneaster affinis</i>	3	3.4	0.2
36	<i>Sorbus lanata</i>	3	3.4	0.2
37	<i>Syringa emodi</i>	3	3.4	0.2
38	<i>Buddleja asiatica</i>	2	2.2	0.1
39	<i>Buddleja crispa</i>	2	2.2	0.1
40	<i>Cotoneaster bacillaris</i>	2	2.2	0.1
41	<i>Debregeasia salcifolia</i>	2	2.2	0.1
42	<i>Elaeagnus parviflora</i>	2	2.2	0.1
43	<i>Rosa macrophalla</i>	2	2.2	0.1
44	<i>Viburnum grandiflorum</i>	2	2.2	0.1
45	<i>Coraria nepalensis</i>	1	1.1	0.1
46	<i>Deutzia strominia</i>	1	1.1	0.1
47	<i>Lonicera angustifolium</i>	1	1.1	0.1
48	<i>Picrasma quassioides</i>	1	1.1	0.1
49	<i>Ribes himalense</i>	1	1.1	0.1
Overall Total		1,826	2,051.6	100.0

4.5 Transitory Forest Camping Sites (TFCS)

The species diversity and assessment of biotic pressure in two types of grazing resources viz., Village surrounds (VS) and Migratory Routes (MR) have already been discussed. The Transitory Forest Camping Sites (TFCS) constituted the third distinct and important set of grazing resource. The results on the species diversity and biotic pressure based on seven intensively studied TFCS and 9 sample plots (Trees – 500 m², Shrubs – 100 m²) laid in each are discussed below. The herbaceous layer was assessed only in two of these nine sites using 1m x 1m quadrats.

4.5.1 Trees

4.5.1.1 Tree Diversity: Values of overall tree diversity for TFCS based on seven sites and tree diversity for each site are described below:

4.5.1.1.1 Overall Tree Diversity and Tree Density: Twenty one (21) tree species were recorded in TFCS. A total density of 151.7 tree/ha was obtained. The *Quercus semecarpifolia* (Kharsu Oak) was the principal characteristic species based on its highest values, being 50 for abundance and 75.9 tree/ha for tree density. Other prominent species were: *Cedrus deodara*, *Pinus wallichiana* and *Rhododendron arboreum*. These three species and *Q. semecarpifolia* together contributed nearly 75% of the overall tree density in TFCS (Table 4.17).

Table 4.17 - Species Diversity, Density and Abundance of Trees in Seven Selected Transitory Forest Camping Sites (TFCS)

Sl No.	Tree species	No. of Individuals	Density (tree/ha)	Abundance
1	<i>Quercus semecarpifolia</i>	239	75.9	50.0
2	<i>Cedrus deodara</i>	47	14.9	9.8
3	<i>Pinus wallichiana</i>	41	13.0	8.6
4	<i>Rhododendron arboreum</i>	29	9.2	6.1
5	<i>Acer villosum</i>	21	6.7	4.4
6	<i>Picea smithiana</i>	18	5.7	3.8
7	<i>Abies pindrow</i>	16	5.1	3.3
8	<i>Betula utilis</i>	12	3.8	2.5
9	<i>Prunus cornuta</i>	11	3.5	2.3
10	<i>Toona serrata</i>	8	2.5	1.7
11	<i>Betula alnoides</i>	6	1.9	1.3
12	<i>Taxus baccata</i>	5	1.6	1.0
13	<i>Ulmus wallichiana</i>	5	1.6	1.0
14	<i>Acer caesium</i>	4	1.3	0.8
15	<i>Celtis tetrandra</i>	4	1.3	0.8
16	<i>Alnus nitida</i>	3	1.0	0.6
17	<i>Juglans regia</i>	3	1.0	0.6
18	<i>Acer acuminatum</i>	2	0.6	0.4
19	<i>Aesculus indica</i>	2	0.6	0.4
20	<i>Rhus wallichii</i>	1	0.3	0.2
21	<i>Sorbus lanata</i>	1	0.3	0.2
Total		478	151.7	100

4.5.1.1.2 Individual TFCS: Detailed assessments were made in seven sites viz., Dulanga, Shilt, Pardi, Rangthar, Kundari, Nara and Manjhouni (Table 4.18).

Table 4.18 - Species Diversity, Density, Basal Area (BA), Abundance (AB), Dominance (DO) and Importance Value (I) of Trees in Seven TFCS and Across Three Disturbance Regimes

1. TFCS - Dulanga

A. Biotic Pressure - High (0 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Acer caesium</i>	13.3	0.1	5.6	2.9	8.5
2	<i>Acer villosum</i>	120.0	0.6	50.0	24.9	74.9
3	<i>Cedrus deodara</i>	20.0	0.4	8.3	16.5	24.8
4	<i>Juglans regia</i>	6.7	0.0	2.8	1.2	4.0
5	<i>Picea smithiana</i>	13.3	0.2	5.6	9.6	15.2
6	<i>Pinus wallichiana</i>	26.7	1.1	11.1	41.4	52.5
7	<i>Rhododendron arboreum</i>	40.0	0.1	16.7	3.5	20.2

B. Biotic Pressure - Moderate (2 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Cedrus deodara</i>	60.0	1.1	31.0	33.5	64.6
2	<i>Celtis tetrandra</i>	13.3	0.0	6.9	1.0	7.9
3	<i>Pinus wallichiana</i>	80.0	1.2	41.4	34.8	76.2
4	<i>Rhododendron arboreum</i>	20.0	0.0	10.3	1.1	11.4
5	<i>Ulmus wallichiana</i>	20.0	1.0	10.3	29.4	39.8

C. Biotic Pressure - Low (4 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Betula alnoides</i>	6.7	0.0	3.7	1.1	4.8
2	<i>Cedrus deodara</i>	66.7	1.3	37.0	42.8	79.8
3	<i>Celtis tetrandra</i>	13.3	0.0	7.4	0.8	8.2
4	<i>Juglans regia</i>	6.7	0.2	3.7	6.5	10.2
5	<i>Picea smithiana</i>	40.0	0.6	22.2	20.5	42.7
6	<i>Pinus wallichiana</i>	13.3	0.5	7.4	14.7	22.1
7	<i>Rhododendron arboreum</i>	13.3	0.0	7.4	1.1	8.5
8	<i>Rhus wallichiana</i>	6.7	0.1	3.7	3.5	7.2
9	<i>Ulmus wallichiana</i>	13.3	0.3	7.4	9.1	16.5

2. TFCS - Shilt

A. Biotic Pressure - High (0 km distance)

SI No	Tree species	Density (trees/ha)	BA (sq m)	AB	DO	I
1	<i>Cedrus deodara</i>	26.7	0.5	18.2	17.4	35.6
2	<i>Pinus wallichiana</i>	66.7	2.0	45.5	65.9	111.3
3	<i>Prunus cornuta</i>	13.3	0.2	9.1	7.5	16.6
4	<i>Rhododendron arboreum</i>	40.0	0.3	27.3	9.4	36.6

Contd...

Table 4.18 Contd...

2. TFCS - Shilt

B. Biotic Pressure - Moderate (2 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Cedrus deodara</i>	40.0	0.2	26.1	8.8	34.9
2	<i>Picea smithiana</i>	26.7	0.4	17.4	14.7	32.1
3	<i>Pinus wallichiana</i>	20.0	0.3	13.0	13.6	26.6
4	<i>Quercus semecarpifolia</i>	66.7	1.5	43.5	63.0	106.5

C. Biotic Pressure - Low (4 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Abies pindrow</i>	6.7	0.1	3.0	2.2	5.2
2	<i>Cedrus deodara</i>	20.0	0.9	9.1	16.9	26.0
3	<i>Pinus wallichiana</i>	46.7	0.7	21.2	13.3	34.5
4	<i>Quercus semecarpifolia</i>	126.7	3.5	57.6	66.9	124.5
5	<i>Rhododendron arboreum</i>	20.0	0.0	9.1	0.7	9.8

3. TFCS - Pardi

A. Biotic Pressure - High (0 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Prunus cornuta</i>	13.3	0.2	28.6	25.5	54.1
2	<i>Quercus semecarpifolia</i>	33.3	0.6	71.4	74.3	145.7

B. Biotic Pressure - Moderate (2 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Abies pindrow</i>	26.7	1.3	20.0	30.0	50.0
2	<i>Acer acumintum</i>	6.7	0.0	5.0	0.7	5.7
3	<i>Acer caesium</i>	6.7	0.0	5.0	0.5	5.5
4	<i>Acer villosum</i>	20.0	0.1	15.0	2.6	17.6
5	<i>Prunus cornuta</i>	20.0	2.2	15.0	50.8	65.8
6	<i>Quercus semecarpifolia</i>	53.3	0.7	40.0	15.3	55.3

C. Biotic Pressure - Low (4 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Acer acuminatum</i>	6.7	0.1	5.3	6.4	11.7
2	<i>Betula utilis</i>	20.0	0.2	15.8	9.8	25.6
3	<i>Quercus semecarpifolia</i>	100.0	1.5	78.9	84.0	162.9

Contd...

Table 4.18 Contd...

4. TFCS - Pardi

A. Biotic Pressure - High (0 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Pinus wallichiana</i>	20.0	0.7	16.7	20.9	37.6
2	<i>Quercus semecarpifolia</i>	100.0	2.6	83.3	79.0	162.3

B. Biotic Pressure - Moderate (2 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Cedrus deodara</i>	46.7	2.2	31.8	45.0	76.8
2	<i>Juglans regia</i>	6.7	0.1	4.5	1.4	6.0
3	<i>Picea smithiana</i>	13.3	0.6	9.1	12.3	21.4
4	<i>Quercus semecarpifolia</i>	80.0	2.0	54.5	41.2	95.7

C. Biotic Pressure - Low (4 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Abies pindrow</i>	13.3	0.3	6.9	6.9	13.8
2	<i>Aesculus indica</i>	13.3	0.6	6.9	12.8	19.7
3	<i>Cedrus deodara</i>	33.3	1.0	17.2	22.2	39.4
4	<i>Picea smithiana</i>	13.3	0.9	6.9	20.2	27.1
5	<i>Quercus semecarpifolia</i>	53.3	1.0	27.6	21.6	49.2
6	<i>Rhododendron arboreum</i>	46.7	0.2	24.1	5.4	29.5
7	<i>Taxus baccata</i>	20.0	0.5	10.3	11.0	21.4

5. TFCS - Kundari

A. Biotic Pressure - High (0 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Quercus semecarpifolia</i>	86.7	1.4	100.0	99.8	199.8

B. Biotic Pressure - Moderate (2 km distance)

SI No	Tree species	Density (trees/ha)	BA (sq m)	AB	DO	I
1	<i>Quercus semecarpifolia</i>	173.3	3.4	92.9	90.3	183.1
2	<i>Toona serrata</i>	13.3	0.4	7.1	9.8	16.9

C. Biotic Pressure - Low (4 km distance)

SI No	Tree species	Density (trees/ha)	BA (sq m)	Ab	DO	IV
1	<i>Quercus semecarpifolia</i>	106.7	3.0	80.0	81.5	161.5
2	<i>Rhododendron arboreum</i>	13.3	0.1	10.0	3.1	13.1
3	<i>Taxus baccata</i>	13.3	0.6	10.0	15.5	25.5

Contd...

Table 4.18 Contd...

6. TFCS - Nara

A. Biotic Pressure - High (0 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Picea smithiana</i>	13.3	1.3	9.1	30.0	39.1
2	<i>Quercus semecarpifolia</i>	133.3	3.0	90.9	70.1	161.0

B. Biotic Pressure - Moderate (2 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Abies pindrow</i>	20.0	1.3	10.3	14.0	24.3
2	<i>Acer caesium</i>	6.7	0.1	3.4	1.4	4.8
3	<i>Quercus semecarpifolia</i>	126.7	6.8	65.5	73.6	139.1
4	<i>Toona serrata</i>	40.0	1.0	20.7	11.1	31.8

C. Biotic Pressure - Low (4 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Abies pindrow</i>	40.0	1.3	19.4	18.6	37.9
2	<i>Quercus semecarpifolia</i>	166.7	5.6	80.6	81.4	162.1

7. TFCS - Majhouni

A. Biotic Pressure - High (0 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Alnus nitida</i>	20.0	0.5	25.0	23.2	48.2
2	<i>Betula alnoides</i>	33.3	0.9	41.7	46.3	88.0
3	<i>Betula utilis</i>	26.7	0.6	33.3	30.6	64.0

B. Biotic Pressure - Moderate (2 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Betula utilis</i>	20.0	0.2	15.8	4.8	20.6
2	<i>Prunus cornuta</i>	13.3	0.4	10.5	10.9	21.4
3	<i>Quercus semecarpifolia</i>	93.3	3.2	73.7	84.4	158.1

C. Biotic Pressure - Low (4 km distance)

SI No	Tree species	Density (tree/ha)	BA (sq m)	AB	DO	I
1	<i>Betula utilis</i>	13.3	0.1	10.5	3.2	13.7
2	<i>Prunus cornuta</i>	13.3	0.4	10.5	7.9	18.4
3	<i>Quercus semecarpifolia</i>	93.3	4.0	73.7	88.2	161.9
4	<i>Sorbus lanata</i>	6.7	0.0	5.3	0.8	6.1

A comparative account of tree diversity among seven 'Thatches' – Pastures or TFCS and across three regimes of biotic pressure are provided in Table 4.19.

A comparison of data on tree species in seven TFCS revealed a variation ranging from just one species to nine species. As such no marked pattern was observed while comparing seven TFCS and three disturbance regimes. However, the highest number of tree species, being 9 was recorded in the case of Dulanga TFCS with low disturbance zone.

Table 4.19 - A comparison of Tree Species in Seven TFCS (Values in Number)

SI.No.	TFCS	Sub-watershed	Disturbance Level		
			Low (0 km)	Moderate (2 km)	High (4 km)
1	Dulanga	Tirthan	7	5	9
2	Shilt	Tirthan	4	4	5
3	Pardi	Tirthan	2	6	3
4	Rangthar	Tirthan	2	4	7
5	Kundari	Tirthan	1	2	3
6	Nara	Tirthan	3	4	2
7	Manjhouni	Tirthan	3	3	4

Quercus semecarpifolia was conspicuously absent in and around Dulanga TFCS, otherwise, this species was present in almost all other cases. Likewise, *Cedrus deodara* was not recorded in Pardi, Nara and Manjouni TFCS. The *Ulmus wallichiana*, a preferred fodder tree was recorded only in Dulanga TFCS.

4.5.1.2 Tree Density: The values of tree density among seven TFCS and three different levels of biotic disturbance varied from 80 tree/ha to 240 tree/ha. In general, values of tree density in the high disturbance zone were lowest in comparison to moderate and low level disturbance zones, except in the case of Dulanga TFCS (Table 4.20). More or less density values of individual species were comparable as that of Village surrounds. The *Q. semecarpifolia* in general obtained higher values of tree density in most of the cases.

Table 4.20 - A comparison of Tree Density in Seven TFCS (Values in tree/ha)

SI.No.	TFCS	Sub-watershed	Disturbance Level		
			Low (0 km)	Moderate (2 km)	High (4 km)
1	Dulanga	Tirthan	240.0	193.3	180.0
2	Shilt	Tirthan	146.6	153.3	220.0
3	Pardi	Tirthan	46.6	133.3	126.6
4	Rangthar	Tirthan	120.0	146.6	193.3
5	Kundari	Tirthan	86.6	186.6	133.3
6	Nara	Tirthan	146.6	193.3	206.6
7	Manjhouni	Tirthan	80.0	126.6	126.7

4.5.1.3 Basal Area: The cumulative values of basal area for constituent tree species in seven TFCS and each category of disturbance regime ranged from 0.77 sq m to 9.23 sq m (Table 4.21). The highest cumulative value of basal area (9.23 sq m) was recorded in the case of Nara TFCS with moderate level disturbance while the lowest value, being 0.77 sq m was obtained in the case of Pardi TFCS with high biotic disturbance. The *Q. semecarpifolia* was

the principal tree species in majority of the cases which occupied higher basal area. On comparison of the three disturbance zones on the basis of cumulative values of all tree species and average of seven TFCS under any one category of biotic disturbance, the lowest value, being 2.47 sq m was obtained in the case of high disturbance zone while moderate zone had the highest value of basal area i.e. 4.53 sq m.

Table 4.21 - A comparison of Tree Basal Area in Seven TFCS (Values in sq m)

Sl.No.	TFCS	Sub-watershed	Disturbance Level		
			Low (0 km)	Moderate (2 km)	High (4 km)
1	Dulanga	Tirthan	2.55	3.32	3.14
2	Shilt	Tirthan	3.00	2.40	5.30
3	Pardi	Tirthan	0.77	4.39	1.79
4	Rangthar	Tirthan	3.29	4.81	4.63
5	Kundari	Tirthan	1.39	3.75	3.72
6	Nara	Tirthan	4.28	9.23	6.86
7	Manjhouni	Tirthan	2.04	3.80	4.57
Average Basal Area			2.47	4.53	4.29

4.5.1.4 Importance Value: The Importance Values (I) for different tree species in seven TFCS ranged from 3.98 to 199.84. In majority of the cases, it was *Quercus semecarpifolia* which received highest score of the Importance Value. Other species those obtained higher ratings of the Important value were: *Acer villosum*, *Cedrus deodara*, *Pinus wallichiana*, *Prunus comuta* and *Betula alnoides*. No distinct pattern was observed with regard to the different biotic zones.

4.5.1.5 Affected Trees and Regeneration Status: The proportion of affected trees by lopping, girdling and dead trees was also worked out in each case of TFCS and across different disturbance zones.

(a) **Lopped Trees:** The values of lopped trees among seven TFCS and across three disturbance zones ranged from as low as 0% to 69.2% (Table 4.22). In general, the highest value was recorded in high disturbance zone in each case except one or two exceptions. Rangthar, Nara and Kundari TFCS were most affected TFCS among the seven intensively studied sites. In contrast, except in the case of Dulanga and Shilt TFCS, lopped trees were not found in the Low disturbance zone. These exceptions of lopped trees in low zone can be explained on the account of the proximity of Dhar hamlet to Dulanga TFCS and lopping of *Q. semecarpifolia* for collection of lichens (*Usnea longissima*). On comparison of overall data on lopped trees for each TFCS irrespective of disturbance zone, data analysis revealed that Manjhouni and Pardi TFCS were least affected by lopping. The interior location of these two TFCS and a considerable distance from any habitation make these two sites safe. It was observed that even plant collectors avoid collecting lichens from far off sites.

Table 4.22 - Lopped Trees in Seven TFCS (Values in %)

Sl. No.	TFCS	Sub-watershed	Disturbance Level			
			High (0 km)	Moderate (02 km)	Low (04 km)	Overall TFCS
1	Dulanga	Tirthan	11.1	10.3	11.1	10.8
2	Shilt	Tirthan	13.6	21.7	6.06	12.8
3	Pardi	Tirthan	14.2	0.0	0.0	2.1
4	Rangthar	Tirthan	66.6	22.7	0.0	24.6
5	Kundari	Tirthan	69.2	32.1	0.0	29.5
6	Nara	Tirthan	50.0	31.0	0.0	24.3
7	Manjhouni	Tirthan	8.33	0.0	0.0	2.0
Overall			31.5	18.2	2.8	16.1

A comparison of lopped trees across three disturbance zones revealed that the high disturbance zone had the highest proportion of lopped trees (31.5%) while the low disturbance zone irrespective of seven TFCS had the lowest percentage of lopped trees (2.8%).

(b) Girdled Trees: Some level of tree girdling was observed in each of the TFCS. The values of per cent girdled trees among seven sites and across three disturbance zones varied from 0 to 15.3% (Table 4.23). The highest percentage of girdled trees were recorded in Kundari TFCS with high disturbance regime. Except Manjhouni TFCS, all rest six TFCS had no sign of tree girdling in their corresponding low disturbance zone. This typical situation in Manjhouni can be corroborated to the fact that the location of this TFCS is comparatively closer to the sub-alpine scrub and alpine pasture areas. There was no proper shelter for pastrolists and it was thus, observed that pastrolists indulged in girdling of trees so as to ensure the availability of

dry fuelwood. The overall per cent value of girdled trees irrespective of any of the TFCS was just 3.5%.

Table 4.23 - Proportion of Girdled Trees in Seven TFCS (Values in %)

Sl. No.	TFCS	Sub-watershed	Disturbance Level			
			High	Moderate	Low	Overall TFCS
1	Dulanga	Tirthan	0.0	10.3	0.0	3.2
2	Shilt	Tirthan	0.0	8.7	0.0	2.5
3	Pardi	Tirthan	0.0	10.0	0.0	4.3
4	Rangthar	Tirthan	11.1	0.0	0.0	2.9
5	Kundari	Tirthan	15.3	3.5	0.0	4.9
6	Nara	Tirthan	0.0	6.9	0.0	2.4
7	Manjhouni	Tirthan	8.3	0.0	10.5	6.0
Overall			3.8	5.8	1.1	3.5

(c) **Dead Trees:** The proportion of dead trees among seven intensively studied TFCS and across three disturbance zones ranged from 0 to 22.7% (Table 4.24). In general, the high disturbance zone in each case had the highest proportion of dead trees, except in Manjhouni TFCS wherein the maximum dead trees were recorded in the low disturbance level. This exception was mainly for the specific reason already stated that the low disturbance zone of Manjhouni TFCS was closer to the alpine pasture area and visitors (pastoralists, herb collectors and others) cater to their fuelwood requirement from this low disturbance zone of TFCS during their longer duration camping in alpine areas. The overall per cent value of dead trees among seven TFCS and across three disturbance zones was 8.3%. A

gradual decline of per cent dead trees was observed while moving from high to low disturbance zone i.e. 15.3% to 5.0% of dead trees.

Table 4.24 - Dead Trees in Seven TFCS (Values in %)

Sl. No.	TFCS	Sub-watershed	Disturbance Level			
			High	Moderate	Low	Overall TFCS
1	Dulanga	Tirthan	19.4	3.4	3.7	9.7
2	Shilt	Tirthan	22.7	4.3	6.0	10.2
3	Pardi	Tirthan	14.2	10.0	10.5	10.8
4	Rangthar	Tirthan	11.1	9.0	3.4	7.2
5	Kundari	Tirthan	15.3	3.5	0.0	4.9
6	Nara	Tirthan	9.0	6.9	0.0	4.8
7	Manjhouni	Tirthan	8.3	10.5	15.7	12.0
Overall			15.3	6.4	5.0	8.3

(d) Tree Regeneration: The values of tree regeneration among seven TFCS and across three disturbance levels ranged from 6.6 individual/ha to 453.3 individual/ha (Table 4.25). Tree regeneration was comparatively low in Dulanga, Pardi and Kundari TFCS while higher values were recorded in the case of Rangthar and Manjhouni TFCS. The values of overall tree regeneration in seven TFCS gradually increased from high disturbance zone to low disturbance zone. Thus, the high disturbance zone had only 1/3 of tree regeneration (48.5 individual/ha) than recorded in the low disturbance zone (159.0 individual/ha).

Table 4.25 - Tree Regeneration in Seven TFCS (Values in number of individual/ha).

Sl. No.	TFCS	Sub-watershed	Disturbance Level			
			High	Moderate	Low	Overall TFCS
1	Dulanga	Tirthan	93.3	93.3	20.0	68.8
2	Shilt	Tirthan	66.6	133.3	106.6	102.2
3	Pardi	Tirthan	6.6	100.0	100.0	68.8
4	Rangthar	Tirthan	46.6	213.3	453.3	237.7
5	Kundari	Tirthan	33.3	46.6	106.6	62.2
6	Nara	Tirthan	46.6	153.3	160.0	120.0
7	Manjhouni	Tirthan	46.6	300.0	166.6	171.1
Overall			48.5	148.5	159.0	118.6

4.5.2 Shrubs

4.5.2.1 Shrub Diversity

Altogether 32 shrub species were recorded in seven TFCS (Table 4.26). Among these, four species of *Cotoneaster* (*C. acuminatus*, *C. affinis*, *C. bacillaris*, and *C. microphyllus*); three species of *Viburnum* (*V. cotinifolium*, *V. grandiflorum* and *V. nervosum*); two species of *Rhododendron* (*R. anthopogon* and *R. campanulatum*); three species of *Rosa* (*R. sericea*, *R. webbiana* and *R. macrophylla*); two species of *Ribes* (*R. himalense* and *R. orientale*); and two species of *Juniperus* (*J. communis* and *J. pseudosabina*) were included. In the case of TFCS, only one bamboo species (*Thamnocalamus spathiflorus*) was present. The absence of shrub *Sarcococca hookerana* was conspicuous in the case of TFCS. This was due to its restricted distribution in lower altitudes. The characterizing shrub

species in TFCS were *Rhododendron* sp., *Thamnocalamus* sp., *Rosa* sp. and *Cotoneaster* sp.

Table 4.26 - Diversity and Shrub Density in Selected Seven TFCS

SI No.	Shrub Species	No. of Individuals	Density (shrub/ha)	Abundance
1	<i>Thamnocalamus spathiflorus</i>	381	604.8	37.8
2	<i>Rhododendron campanulatum</i>	114	181.0	11.3
3	<i>Rosa sericea</i>	96	152.4	9.5
4	<i>Indigofera heterantha</i>	55	87.3	5.5
5	<i>Salix denticulata</i>	46	73.0	4.6
6	<i>Berberis lycium</i>	36	57.1	3.6
7	<i>Viburnum cotinifolium</i>	28	44.4	2.8
8	<i>Viburnum nervosum</i>	28	44.4	2.8
9	<i>Rosa webbiana</i>	27	42.9	2.7
10	<i>Jasminum humile</i>	23	36.5	2.3
11	<i>Juniperus communis</i>	23	36.5	2.3
12	<i>Desmodium elagans</i>	16	25.4	1.6
13	<i>Juniperus pseudosabina</i>	15	23.8	1.5
14	<i>Viburnum grandiflorum</i>	14	22.2	1.4
15	<i>Cassiope fastigiata</i>	10	15.9	1.0
16	<i>Cotoneaster microphyllus</i>	10	15.9	1.0
17	<i>Sorbus lanata</i>	10	15.9	1.0
18	<i>Ribes orientale</i>	9	14.3	0.9
19	<i>Berberis aristata</i>	8	12.7	0.8
20	<i>Cotoneaster acuminatus</i>	8	12.7	0.8
21	<i>Rhamnus purpureus</i>	7	11.1	0.7
22	<i>Buddleja crispa</i>	6	9.5	0.6
23	<i>Lonicera purpurascens</i>	6	9.5	0.6
24	<i>Cotoneaster affinis</i>	5	7.9	0.5
25	<i>Rhododendron anthopogon</i>	5	7.9	0.5
26	<i>Sorbaria tementosa</i>	5	7.9	0.5
27	<i>Syringa emodi</i>	5	7.9	0.5
28	<i>Prinsepia utilis</i>	4	6.3	0.4
29	<i>Coraria napalensis</i>	2	3.2	0.2
30	<i>Cotoneaster bacillaris</i>	2	3.2	0.2
31	<i>Rosa macrophylla</i>	2	3.2	0.2
32	<i>Ribes himalense</i>	1	1.6	0.1

4.5.2.2 Shrub Density

The values of shrub density of individual species among seven TFCS ranged from 33.3 shrub/ha to 3,566.7 shrub/ha (Table 4.27). No discernible pattern

was evident across three disturbance zones. The lower values of shrub density were recorded at Dulanga (566.6 shrub/ha) and Rangthar (833.3 shrub/ha) TFCS (Table 4.28). While Pardi and Nara TFCS registered higher values of shrub density being 2,488.8 shrub/ha and 2,600.0 shrub/ha, respectively. On comparison of the overall shrub density in three different zones for all seven TFCS, the highest value, being 1,942.8 shrub/ha was recorded in the case of low disturbance zone.

Table 4.27 - Shrub Diversity and Density Among Seven Studied TFCS and Across Three Disturbance Regimes

1. TFCS - Dulanga

A. Biotic Pressure - High (0 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Berberis lycium</i>	1	33.3
2	<i>Buddleja crispa</i>	2	66.7
3	<i>Desmodium elegans</i>	4	133.3
4	<i>Rhamnus purpureus</i>	3	100.0
5	<i>Rosa macrophylla</i>	2	66.7
6	<i>Sorbaria tomentosa</i>	2	66.7

B. Biotic Pressure - Moderate (2 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Buddleja crispa</i>	2	66.7
2	<i>Coraria napalensis</i>	1	33.3
3	<i>Cotoneaster bacillaris</i>	2	66.7
4	<i>Desmodium elegans</i>	1	33.3
5	<i>Indigofera heterantha</i>	2	66.7
6	<i>Jasminum humile</i>	8	266.7
7	<i>Prinsepia utilis</i>	2	66.7
8	<i>Rosa sericea</i>	1	33.3
9	<i>Rosa webbiana</i>	1	33.3
10	<i>Sorbaria tomentosa</i>	1	33.3
11	<i>Viburnum grandiflorum</i>	2	66.7

Contd...

Table 4.27 Contd...

1. TFCS - Dulanga

C. Biotic Pressure - Low (4 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Desmodium elagans</i>	4	133.3
2	<i>Indigofera heterantha</i>	10	333.3

2. TFCS - Shilt

A. Biotic Pressure - High (0 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Berberis lycium</i>	11	366.7
2	<i>Cotoneaster affinis</i>	2	66.7
3	<i>Indigofera heterantha</i>	24	800.0
4	<i>Rosa sericea</i>	10	333.3
5	<i>Viburnum grandiflorum</i>	2	66.7

B. Biotic Pressure - Moderate (2 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Thamnocalamus spathiflorus</i>	12	400.0
2	<i>Coriaria nepalensis</i>	1	33.3
3	<i>Cotoneaster affinis</i>	3	100.0
4	<i>Desmodium elegans</i>	1	33.3
5	<i>Jasminum humile</i>	7	233.3
6	<i>Lonicera purpurascens</i>	1	33.3
7	<i>Rosa sericea</i>	1	33.3
8	<i>Rosa webbiana</i>	4	133.3
9	<i>Viburnum grandiflorum</i>	2	66.7

C. Biotic Pressure - Low (4 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Thamnocalamus spathiflorus</i>	10	333.3
2	<i>Buddleja cripa</i>	2	66.7
3	<i>Cotoneaster acuminatus</i>	3	100.0
4	<i>Jusminum humile</i>	1	33.3
5	<i>Lonicera purpurascens</i>	4	133.3
6	<i>Rosa webbiana</i>	4	133.3
7	<i>Viburnum nervosum</i>	1	33.3

Contd...

Table 4.27 Contd...

3. TFCS - Pardi

A. Biotic Pressure - High (0 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Thamnocalamus spathiflorus</i>	88	2933.3
2	<i>Cotoneaster microphyllus</i>	10	333.3
3	<i>Ribes himalense</i>	1	33.3
4	<i>Rosa sericea</i>	10	333.3
5	<i>Rosa webbiana</i>	16	533.3
6	<i>Viburnum nervosum</i>	2	66.7
7	<i>Viburnum cotinifolium</i>	3	100.0

B. Biotic Pressure - Moderate (2 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Thamnocalamus spathiflorus</i>	23	766.7
2	<i>Cassiope fastigiata</i>	10	333.3
3	<i>Lonicera purpurascens</i>	1	33.3
4	<i>Ribes orietales</i>	1	33.3
5	<i>Rosa sericea</i>	5	166.7
6	<i>Rosa webbiana</i>	2	66.7
7	<i>Sorbus lanata</i>	3	100.0
8	<i>Viburnum nervosum</i>	3	100.0

C. Biotic Pressure - Low (4 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Thamnocalamus spathiflorus</i>	5	166.7
2	<i>Juniperus communis</i>	15	500.0
3	<i>Rhododendron anthopogon</i>	5	166.7
4	<i>Rhododendron campanulatum</i>	15	500.0
5	<i>Rosa sericea</i>	3	100.0
6	<i>Syringa emodi</i>	3	100.0

4. TFCS - Pardi

A. Biotic Pressure - High (0 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Berberis lycium</i>	16	533.3
2	<i>Indigofera heterantha</i>	19	633.3
3	<i>Sorbaria tomentosa</i>	2	66.7

Contd...

Table 4.27 Contd...

4. TFCS Pardi
B. Biotic Pressure - Moderate (2 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Berberis lycium</i>	1	33.3
2	<i>Desmodium elegans</i>	3	100.0
3	<i>Jasminum humile</i>	1	33.3
4	<i>Rhamnus purpureus</i>	4	133.3

C. Biotic Pressure - Low (4 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Thamnocalamus spathiflorus</i>	17	566.7
2	<i>Berberis lycium</i>	7	233.3
3	<i>Desmodium elegans</i>	3	100.0
4	<i>Prinsepia utilis</i>	2	66.7

5. TFCS - Kundari
A. Biotic Pressure - High (0 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Rhododendron campanulatum</i>	7	233.3
2	<i>Ribes orientale</i>	3	100.0
3	<i>Rosa sericea</i>	13	433.3
4	<i>Sorbus lanata</i>	2	66.7

B. Biotic Pressure - Moderate (2 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Juniperus pseudosabina</i>	15	500.0
2	<i>Sorbus lanata</i>	3	100.0
3	<i>Viburnum nervosum</i>	2	66.7

C. Biotic Pressure - Low (4 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Thamnocalamus spathiflorus</i>	107	3566.7
2	<i>Berberis aristata</i>	8	266.7
3	<i>Rhododendron campanulatum</i>	7	233.3
4	<i>Rosa sericea</i>	2	66.7
5	<i>Sorbus lanata</i>	2	66.7
6	<i>Viburnum nervosum</i>	3	100.0

Contd...

Table 4.27 Contd...

6. TFCS – Nara

A. Biotic Pressure - High (0 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Rhododendron campanulatum</i>	11	366.7
2	<i>Ribes orientale</i>	5	166.7
3	<i>Rosa sericea</i>	20	666.7
4	<i>Viburnum grandiflorum</i>	8	266.7
5	<i>Viburnum nervosum</i>	7	233.3

B. Biotic Pressure - Moderate (2 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Thamnocalamus spathiflorus</i>	37	1233.3
2	<i>Rhododendron campanulatum</i>	23	766.7
3	<i>Rosa sericea</i>	15	500.0
4	<i>Viburnum nervosum</i>	3	100.0

C. Biotic Pressure - Low (4 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Thamnocalamus spathiflorus</i>	82	2733.3
2	<i>Rhododendron campanulatum</i>	16	533.3
3	<i>Viburnum nervosum</i>	7	233.3

7. TFCS – Manjhouni

A. Biotic Pressure - High (0 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Cotoneaster acuminatus</i>	2	66.7
2	<i>Rhododendron campanulatum</i>	7	233.3
3	<i>Rosa sericea</i>	16	533.3

B. Biotic Pressure - Moderate (2 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Cotoneaster acuminatus</i>	3	100.0
2	<i>Jasminum humile</i>	4	133.3
3	<i>Rhododendron campanulatum</i>	11	366.7
4	<i>Salix denticulata</i>	29	966.7
5	<i>Syringa emodi</i>	2	66.7
6	<i>Viburnum cotnifolium</i>	9	300.0

Contd...

Table 4.27 Contd...

C. Biotic Pressure - Low (4 km distance)

SI No.	Shrub Species	No of Individuals	Density (Shrub/ha)
1	<i>Jasminum humile</i>	2	66.7
2	<i>Juniperus communis</i>	8	266.7
3	<i>Rhododendron campanulatum</i>	17	566.7
4	<i>Salix denticulata</i>	17	566.7
5	<i>Viburnum cotnifolium</i>	16	533.3

Table 4.28 - Shrub Density in Seven TFCS (Values in shrub/ha)

SI. No.	TFCS	Sub-watershed	Disturbance Level			
			High	Moderate	Low	Overall TFCS
1	Dulanga	Tirthan	466.6	766.6	466.6	566.6
2	Shilt	Tirthan	1,633.3	1,066.6	833.3	1,177.7
3	Pardi	Tirthan	4,333.3	1,600.0	1,533.3	2,488.8
4	Rangthar	Tirthan	1,233.3	300.0	966.6	833.3
5	Kundari	Tirthan	833.3	666.6	4,300.0	1,933.3
6	Nara	Tirthan	1,700.0	2,600.0	3,500.0	2,600.0
7	Manjhouni	Tirthan	833.3	1,933.3	2,000.0	1,588.8
Overall			1,576.1	1,276.1	1,942.8	1,598.4

4.5.3 Ground Vegetation

Out of seven TFCS studied, the ground vegetation was assessed only in two of the sites viz., Nara and Manjhouni. Among ground vegetation all herbs, grasses, ferns and sedges were included. Seventy five (75) and 40 quadrats

of 1m x 1m size were laid for assessment in Nara and Manjhouni TFCS, respectively. Field data was used for assessing species diversity, % frequency occurrence, density and abundance. The results for two studied sites and overall TFCS are presented in the following sections.

4.5.3.1 Floristic Inventory: The Table 4.29 presents a plant diversity of 120 species in ground vegetation representing 107 herbs, 7 grasses, 1 fern and 5 sedges. Among the two studied sites, Nara TFCS registered a higher number of species i.e. 91 while Manjhouni TFCS obtained only 56 species. A check list of these species for two sites with corresponding names of their Family are given in Table 4.30.

Table 4.29 - Representation of Ground Vegetation in Two Studied TFCS

Sl.No.	Habit	TFCS		Total species in Two TFCS
		Nara	Manjhouni	
1	Herbs	80	51	107
2	Grasses	5	4	7
3	Ferns	1	0	1
4	Sedges	5	1	5
Total		91	56	120

Table 4.30 - Checklist (Presence of Species) for Ground Vegetation in Two Studied TFCS

Sr No	Species	Family	Habit Type	TFCS		Presence
				Nara	Manjhouni	
1	<i>Athyrium foliolosum</i>	Athyriaceae	F	*		1
2	<i>Agrostis pilosula</i>	Poaceae	G	*		1
3	<i>Calamogrostis pulchella</i>	Poaceae	G		*	1
4	<i>Danthonia cachymeriana</i>	Poaceae	G		*	1
5	<i>Eulalia mollis</i>	Poaceae	G	*		1
6	<i>Muhlenbergia duthieana</i>	Poaceae	G	*		1
7	<i>Aconitum violaceum</i>	Ranunculaceae	H		*	1
8	<i>Ajuga bractiosa</i>	Lamiaceae	H		*	1
9	<i>Allium humile</i>	Amaryllidaceae	H		*	1
10	<i>Anaphalis nepalensis</i>	Asteraceae	H		*	1
11	<i>Anaphalis triplinervis</i>	Asteraceae	H		*	1
12	<i>Aquilegia fragrans</i>	Ranunculaceae	H	*		1
13	<i>Arabidopsis himalaica</i>	Brassicaceae	H	*		1
14	<i>Arabis amplexicaulis</i>	Brassicaceae	H	*		1
15	<i>Arabis benthemii</i>	Brassicaceae	H		*	1
16	<i>Arenaria festucoides</i>	Caryophyllaceae	H	*		1
17	<i>Aster falconeri</i>	Asteraceae	H	*		1
18	<i>Brassica juncea</i>	Brassicaceae	H	*		1
19	<i>Campanula cashmeriana</i>	Campanulaceae	H		*	1
20	<i>Campanula latifolia</i>	Campanulaceae	H	*		1
21	<i>Cardamine hirsuta</i>	Brassicaceae	H	*		1
22	<i>Chaerophyllum reflexum</i>	Apiaceae	H	*		1
23	<i>Chaerophyllum villosum</i>	Apiaceae	H	*		1
24	<i>Cirsium wallichii</i>	Asteraceae	H		*	1
25	<i>Corydalis meifolia</i>	Fumariaceae	H	*		1
26	<i>Cynoglossum glochidiatum</i>	Boraginaceae	H	*		1
27	<i>Cynoglossum lanceolatum</i>	Boraginaceae	H		*	1
28	<i>Dactylorhiza hatagirea</i>	Orchidaceae	H	*		1
29	<i>Dipsacus inermis</i>	Dipsacaceae	H	*		1
30	<i>Dipsacus strictus</i>	Dipsacaceae	H	*		1
31	<i>Epilobium cylindricum</i>	Onagraceae	H	*		1
32	<i>Epilobium latifolium</i>	Onagraceae	H	*		1
33	<i>Eritichium canum</i>	Boraginaceae	H	*		1
34	<i>Fritillaria roylei</i>	Liliaceae	H		*	1
35	<i>Gagea elegans</i>	Liliaceae	H		*	1
36	<i>Galium vestitum</i>	Rubiaceae	H	*		1
37	<i>Geranium pratense</i>	Geraniaceae	H		*	1
38	<i>Geranium wallichianum</i>	Geraniaceae	H	*		1
39	<i>Geum elatum</i>	Rosacea	H	*		1
40	<i>Hackelia uncinata</i>	Boraginaceae	H	*		1

Contd...

Table 4.30 Contd...

Sr No	Species	Family	Habit Type	TFCS		Presence
				Nara	Manjhouni	
41	<i>Heracleum nepalense</i>	Apiaceae	H		*	1
42	<i>Heracleum wallichii</i>	Apiaceae	H		*	1
43	<i>Impatiens racemosa</i>	Balsaminaceae	H		*	1
44	<i>Lecanthus peduncularia</i>	Urticaceae	H	*		1
45	<i>Leontopodium himalayanum</i>	Asteraceae	H	*		1
46	<i>Leontopodium jacotianum</i>	Asteraceae	H	*		1
47	<i>Leucas lanata</i>	Lamiaceae	H	*		1
48	<i>Lindelofia longiflora</i>	Boraginaceae	H	*		1
49	<i>Lloydia longiscapa</i>	Liliaceae	H	*		1
50	<i>Lychnis fimbriata</i>	Caryophyllaceae	H	*		1
51	<i>Maconopsis aculata</i>	Papaveraceae	H	*		1
52	<i>Morina coulteriana</i>	Dipsacaceae	H		*	1
53	<i>Oxyria digyna</i>	Polygonaceae	H		*	1
54	<i>Pleurospermum densiflorum</i>	Apiaceae	H		*	1
55	<i>Podophyllum hexandrum</i>	Podophyllaceae	H		*	1
56	<i>Polygonatum cirrhifolium</i>	Liliaceae	H	*		1
57	<i>Polygonum affinis</i>	Polygonaceae	H		*	1
58	<i>Polygonum alpinum</i>	Polygonaceae	H	*		1
59	<i>Polygonum vacciniifolium</i>	Polygonaceae	H		*	1
60	<i>Potentilla eriocarpa</i>	Rosaceae	H		*	1
61	<i>Potentilla fulgens</i>	Rosaceae	H	*		1
62	<i>Potentilla microphylla</i>	Rosaceae	H	*		1
63	<i>Potentilla nepalensis</i>	Rosaceae	H	*		1
64	<i>Potentilla peduncularis</i>	Rosaceae	H	*		1
65	<i>Primula denticulata</i>	Primulaceae	H	*		1
66	<i>Primula reidii</i>	Primulaceae	H	*		1
67	<i>Ranunculus brotherusii</i>	Ranunculaceae	H	*		1
68	<i>Ranunculus hirtellus</i>	Ranunculaceae	H	*		1
69	<i>Ranunculus pulchellus</i>	Ranunculaceae	H	*		1
70	<i>Rheum webbianum</i>	Polygonaceae	H		*	1
71	<i>Rumex acetosa</i>	Polygonaceae	H	*		1
72	<i>Saussurea albescens</i>	Asteraceae	H		*	1
73	<i>Saussurea taraxacifolia</i>	Asteraceae	H		*	1
74	<i>Selinum condolii</i>	Apiaceae	H	*		1
75	<i>Selinum papyraceum</i>	Apiaceae	H	*		1
76	<i>Silene tenius</i>	Caryophyllaceae	H	*		1
77	<i>Staychus sp</i>	Lamiaceae	H	*		1
78	<i>Stellaria media</i>	Caryophyllaceae	H	*		1
79	<i>Stellaria monosperma</i>	Caryophyllaceae	H	*		1
80	<i>Swertia cuneata</i>	Gentianaceae	H		*	1

Contd...

Table 4.30 Contd...

Sr No	Species	Family	Habit Type	TFCS		Presence
				Nara	Manjhouni	
81	<i>Taraxacum officinale</i>	Asteraceae	H	*		1
82	<i>Thalictrum alpinum</i>	Ranunculaceae	H	*		1
83	<i>Thalictrum cultratum</i>	Ranunculaceae	H	*		1
84	<i>Thlaspi cochleariforme</i>	Brassicaceae	H	*		1
85	<i>Urtica dioica</i>	Urticaceae	H	*		1
86	<i>Urtica parviflora</i>	Urticaceae	H	*		1
87	<i>Verbascum thapsus</i>	Scrophulariaceae	H	*		1
88	<i>Viola biflora</i>	Violaceae	H	*		1
89	<i>Waldheimia tomentosa</i>	Asteraceae	H		*	1
90	<i>Carex cruciata</i>	Cyperaceae	Sg	*		1
91	<i>Carex foliosa</i>	Cyperaceae	Sg	*		1
92	<i>Carex haematostoma</i>	Cyperaceae	Sg	*		1
93	<i>Carex nubigena</i>	Cyperaceae	Sg	*		1
94	<i>Phleum alpinum</i>	Poaceae	G	*	*	2
95	<i>Poa alpina</i>	Poaceae	G	*	*	2
96	<i>Artemisia maritima</i>	Asteraceae	H	*	*	2
97	<i>Aster albescens</i>	Asteraceae	H	*	*	2
98	<i>Cerastium cerastoides</i>	Caryophyllaceae	H	*	*	2
99	<i>Erigeron bonariensis</i>	Asteraceae	H	*	*	2
100	<i>Fragaria vesca</i>	Rosaceae	H	*	*	2
101	<i>Galium aparine</i>	Rubiaceae	H	*	*	2
102	<i>Galium verum</i>	Rubiaceae	H	*	*	2
103	<i>Geranium nepalense</i>	Geraniaceae	H	*	*	2
104	<i>Impatiens glandulifera</i>	Balsaminaceae	H	*	*	2
105	<i>Impatiens sulcata</i>	Balsaminaceae	H	*	*	2
106	<i>Leonurus cardiaca</i>	Lamiaceae	H	*	*	2
107	<i>Nepeta connata</i>	Lamiaceae	H	*	*	2
108	<i>Origanum vulgare</i>	Lamiaceae	H	*	*	2
109	<i>Paraquilegia microphylla</i>	Ranunculaceae	H	*	*	2
110	<i>Phlomis bracteosa</i>	Lamiaceae	H	*	*	2
111	<i>Polygonum amplexicaulis</i>	Polygonaceae	H	*	*	2
112	<i>Polygonum polystachyum</i>	Polygonaceae	H	*	*	2
113	<i>Polygonum viviparum</i>	Polygonaceae	H	*	*	2
114	<i>Potentilla atrosanguinea</i>	Rosaceae	H	*	*	2
115	<i>Potentilla fruticosa</i>	Rosaceae	H	*	*	2
116	<i>Rumex nepalensis</i>	Polygonaceae	H	*	*	2
117	<i>Selinum vaginatum</i>	Apiaceae	H	*	*	2
118	<i>Selinum wallichianum</i>	Apiaceae	H	*	*	2
119	<i>Silene cucubalus</i>	Caryophyllaceae	H	*	*	2
120	<i>Carex alpina</i>	Cyperaceae	Sg	*	*	2
Total				91	56	

H - Herb; G - Grass; Sg - Sedge; F - Fern; * - Present

Data on presence and absence of herb species in two sites revealed that out of 107 herb species recorded for two TFCS, more than $\frac{3}{4}$ or 77.5% species were unique to each site while 24 herb species (22.4%) were common to two studied sites.

Above 120 plant species in ground vegetation at two TFCS represented 30 Families and 77 Genera. Amongst two studied sites, Nara TFCS represented higher plant diversity in terms of representation of Families (26) and 60 Genera while in the case of Manjhouni, the ground vegetation was represented by 21 Families and 41 Genera (Table 4.31).

Table 4.31 - Ground Vegetation Diversity in Two Studied TFCS

Sl. No.	Category	TFCS		Total For Two TFCS
		Nara	Manjhouni	
1	Species	91	56	120
2	Genera	60	41	77
3	Families	26	21	39

4.5.3.2 Frequency, Density and Abundance: The % frequency, density and abundance values were worked out for all the species site-wise. The results on all grasses, ferns, sedges while values of only 20 most abundant herb species are presented in Table 4.32 and 4.33 for Nara and Manjhouni TFCS, respectively.

Table 4.32 - Percentage Frequency, Density and Abundance of Selected Herbs, Grasses, Ferns and Sedges in Nara TFCS

Sr No.	Species	Family	No. of Individuals	% Frequency	Density (no./m ²)	Abundance
A. Fern						
1	<i>Athyrium foliolosum</i>	Athyriaceae	15	1.33	0.20	15.00
B. Grasses						
1	<i>Agrostis pilosula</i>	Poaceae	591	9.33	7.88	84.43
2	<i>Poa alpina</i>	Poaceae	230	8.00	3.07	38.33
3	<i>Muehlenbergia duthieana</i>	Poaceae	15	1.33	0.20	15.00
4	<i>Phleum alpinum</i>	Poaceae	44	4.00	0.59	14.67
5	<i>Eulalia mollis</i>	Poaceae	13	1.33	0.17	13.00
C. Herbs						
1	<i>Galium aparine</i>	Rubiaceae	604	10.67	8.05	75.50
2	<i>Selinum condollii</i>	Apiaceae	85	2.67	1.13	42.50
3	<i>Campanula latifolia</i>	Campanulaceae	443	22.67	5.91	26.06
4	<i>Leontopodium himalayanum</i>	Asteraceae	24	1.33	0.32	24.00
5	<i>Leontopodium jacotianum</i>	Asteraceae	22	1.33	0.29	22.00
6	<i>Arabidopsis himalaica</i>	Brassicaceae	20	1.33	0.27	20.00
7	<i>Chaerophyllum reflexum</i>	Apiaceae	20	1.33	0.27	20.00
8	<i>Selinum vaginatum</i>	Apiaceae	873	58.67	11.64	19.84
9	<i>Thalictrum cultratum</i>	Ranunculaceae	78	5.33	1.04	19.50
10	<i>Potentilla microphylla</i>	Rosaceae	18	1.33	0.24	18.00
11	<i>Hackelia uncinata</i>	Boraginaceae	142	10.67	1.89	17.75
12	<i>Polygonum polystachyum</i>	Polygonaceae	601	50.67	8.01	15.82
13	<i>Rumex nepalensis</i>	Polygonaceae	956	82.67	12.75	15.42
14	<i>Thalictrum alpinum</i>	Ranunculaceae	30	2.67	0.40	15.00
15	<i>Staychus melissaefolia</i>	Lamiaceae	15	1.33	0.20	15.00
16	<i>Cardamine hirsuta</i>	Brassicaceae	75	6.67	1.00	15.00
17	<i>Aster albescens</i>	Asteraceae	15	1.33	0.20	15.00
18	<i>Selinum papyraceum</i>	Apiaceae	15	1.33	0.20	15.00
19	<i>Polygonum amplexicaulis</i>	Polygonaceae	193	17.33	2.57	14.85
20	<i>Leonurus cardiaca</i>	Lamiaceae	227	22.67	3.03	13.35
D Sedges						
1	<i>Carex alpina</i>	Cyperaceae	1056	18.67	14.08	75.43
2	<i>Carex haematostoma</i>	Cyperaceae	11	1.33	0.15	11.00
3	<i>Carex foliosa</i>	Cyperaceae	133	17.33	1.77	10.23
4	<i>Carex nubigena</i>	Cyperaceae	10	2.67	0.13	5.00
5	<i>Carex cruciata</i>	Cyperaceae	1	1.33	0.01	1.00

Table 4.33 - Percentage Frequency, Density and Abundance of Selected Herbs, Grasses, and Sedges in Manjhouni TFCS

Sr No.	Species	Family	No. of Individuoals	% Frequency	Density (no./m ²)	Abundance
A Grasses						
1	<i>Phleum alpinum</i>	Poaceae	260	25.00	6.50	26.00
2	<i>Danthonia cachymeriana</i>	Poaceae	25	12.50	0.63	5.00
3	<i>Poa alpina</i>	Poaceae	8	5.00	0.20	4.00
4	<i>Calamagrostis pulchella</i>	Poaceae	1	2.50	0.03	1.00
B Herbs						
1	<i>Impatiens glandulifera</i>	Balsaminaceae	227	7.50	5.68	75.67
2	<i>Galium verum</i>	Rubiaceae	278	10.00	6.95	69.50
3	<i>Rumex nepalensis</i>	Polygonaceae	109	5.00	2.73	54.50
4	<i>Potentilla atosanguinea</i>	Rosaceae	235	17.50	5.88	33.57
5	<i>Oxyria digyna</i>	Polygonaceae	25	2.50	0.63	25.00
6	<i>Anaphalis triplinervis</i>	Asteraceae	25	2.50	0.63	25.00
7	<i>Heracleum neplense</i>	Apiaceae	47	5.00	1.18	23.50
8	<i>Impatiens racemosa</i>	Balsaminaceae	23	2.50	0.58	23.00
9	<i>Campanula cashmeriana</i>	Campanulaceae	88	10.00	2.20	22.00
10	<i>Polygonum polystachyum</i>	Polygonaceae	175	20.00	4.38	21.88
11	<i>Potentilla eriocarpa</i>	Rosaceae	40	5.00	1.00	20.00
12	<i>Artemisia maritima</i>	Asteraceae	229	30.00	5.73	19.08
13	<i>Ajuga bracteosa</i>	Lamiaceae	18	2.50	0.45	18.00
14	<i>Galium vestitum</i>	Rubiaceae	17	2.50	0.43	17.00
15	<i>Potentilla fruticosa</i>	Rosaceae	68	10.00	1.70	17.00
16	<i>Impatiens sulcata</i>	Balsaminaceae	34	5.00	0.85	17.00
17	<i>Polygonum amplexicaulis</i>	Polygonaceae	134	20.00	3.35	16.75
18	<i>Galium aparine</i>	Rubiaceae	125	20.00	3.13	15.63
19	<i>Leonurus cardiaca</i>	Lamiaceae	31	5.00	0.78	15.50
20	<i>Pleurospermum densiflorum</i>	Apiaceae	31	5.00	0.78	15.50
C Sedges						
1	<i>Carex alpina</i>	Cyperaceae	263	7.50	6.58	87.67

4.5.3.2.1 Nara TFCS: In case of Nara TFCS, Values of % frequency for different plants in ground vegetation varied from 1.3% to 82.7% (Table 4.32). The *Rumex nepalensis* obtained the highest value, being 82.67%. This was a clear sign of intense grazing pressure as *Rumex* sp., was widely distributed in the site. Other prominent species in terms of their value of % frequency of occurrence were: *Selineum vaginatum* (58.6%), *Polygonum polystachyum* (50.6%), *Leucas lanata*

(30.67%) and *Leonurus cardiaca* (22.67%). Only five grass species viz., *Agrostis pilosula*, *Eulalia mollis*, *Muehlenbergia duthieana*, *Phleum alpinum* and *Poa alpina* were recorded. In general, values of % frequency were quite low in case of five grasses. *Agrostis pilosula* and *Phleum alpinum* obtained values of 9.3% and 4.0%, respectively. The only fern species, the *Athyrium foliolosum* was recorded that too in just one quadrat only out of 75 quadrats laid. Five sedges species viz., *Carex alpina*, *Carex cruciata*, *Carex foliosa*, *Carex haematostoma*, and *Carex nubigena* were recorded in Nara TFCS. *C. alpina* and *C. foliosa* obtained higher values of frequency, being 18.67% and 17.33%, respectively.

Among five grass species recorded, *Agrostis pilosula* obtained the highest density value, being 7.88 individual/m² while in the case of sedges, *Carex alpina* and *Carex cruciata* obtained higher values, being 18.67 individual/m², and 17.33 individual/m² respectively. Density values were again higher in the case of herb species viz., *Rumex nepalensis*, *Polygonum polystachyum*, *Selineum vaginatum* and *Leucas lanata*.

Agrostis pilosula was the most abundant among five grass species recorded. *Galium aparine* (Family Rubiaceae) was the most abundant herb. *Carex alpina* was the most abundant among five sedge species recorded.

4.5.3.2.2 Manjhouni TFCS: No fern species was recorded in the Manjhouni TFCS. Four grass species were recorded (Table 4.33). Two grass species viz., *Calamagrostis pulchella* and *Danthonia cachaeriana*

were present in this site. *Phleum alpinum* obtained the highest value of frequency, being 25.0%, followed by *D. cacymeriana* (12.50%). Only one sedge species, the *Carex alpina* was recorded in this site while 5 sedge species were recorded in Nara TFCS. Based on the values of % frequency of occurrence, herb species viz., *Artemisia maritima*, *Nepeta connata*, *Gallium verum*, *Polygonum amplexicaulis* and *P. polystachyum* characterized the site. Five species of *Polygonum* viz., *P. affinis*, *P. amplexicaulis*, *P. polystachyum*, *P. vacciniifolium* and *P. viviparum* were recorded. The higher % frequency values of *Polygonum* sp., *Artemisia* sp., *Nepeta* sp. Indicate higher grazing pressure. *Impatiens glandulifera* obtained higher density value (5.68 individual/m²), again indicating higher grazing disturbance. Among herbs, *Impatiens glandulifera* was the most abundant (75.67), followed by *Gallium verum* (69.50), *Rumex nepalensis* (54.50), and *Potentilla atrosanguinea* (33.57). *Phleum alpinum* was the most abundant (26.00) among four grass species recorded.

4.5.3.3 Diversity Indices: The values of species Richness (NO), Margalef Index – R for species richness, diversity indices – Simpson's Index (λ), Shannon's Index (H') and Evenness Index (Ep) were determined for the plant diversity in ground vegetation in two TFCS and presented in **Table 4.34**.

Table 4.34 - Diversity Indices for the Ground Vegetation in Two TFCS

Sl.No.	Indice/Value		TFCS	
			Nara	Manjhouni
1	Richness	No.of Species	91	56
		Margalef Index - R	10.01397	6.904437
2	Diversity	Simpson's Index (λ)	0.068871	0.057624
		Shannon's Index (H')	3.165045	3.191987
3	Evenness Index	EP	0.5958498	0.70077

The **Table 4.34** revealed that among the two assessed TFCS for ground vegetation, the species richness based on the number of species recorded as well as Margalef Index (R) was higher in the case of Nara TFCS. The value of Simpson's Index was low in the case of Manjhouni TFCS indicating higher diversity than Nara. Higher values of Shannon's Index (H') and Evenness Index (Ep) in the case of Manjhouni indicate that the site represents higher even distribution of abundances and species in the sample. Thus, the ground vegetation was more even in Manjhouni TFCS than the Nara TFCS.

4.5.3.4 Ground Cover: The proportion of grass, herb, shrub, rock, dung and weed as constituents of ground cover were assessed in seven studied TFCS across three disturbance regimes presumed from the center of each livestock camping site. As in the case of Village surrounds, values of livestock dung and weed abundance declined in all seven TFCS on moving

away from the center point of 'Thatch' or high disturbance zone to the low disturbance zone (Table 4.35). On the contrary, % values of herbs increased considerably on moving towards the low disturbance zone. On comparison of data on weed abundance among seven sites, it was revealed that Rangthar and Kundari were having comparatively higher preponderance of weed plants than others. The overall assessment of ground cover for seven sites revealed that herbs occupied nearly 1/3 of the ground cover. Dung, weeds and rock together constituted almost 50% of the ground. Grass cover was just 8.64% while shrubs occupied 9.75% of the ground cover.

Table 4.35 - Percentage Values of the Ground Cover Constituents Across Different Disturbance Level in Seven TFCS

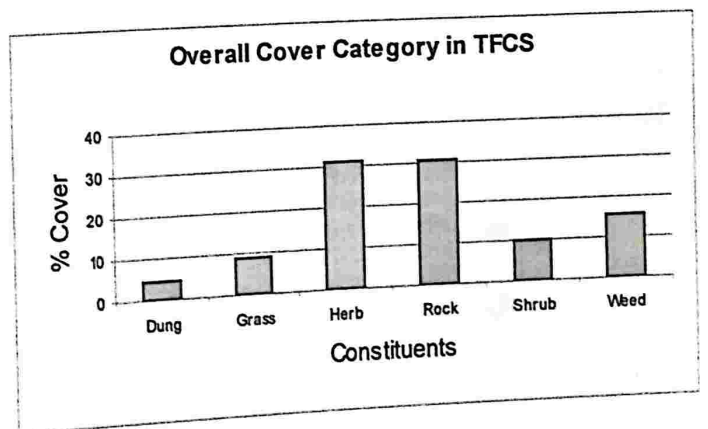
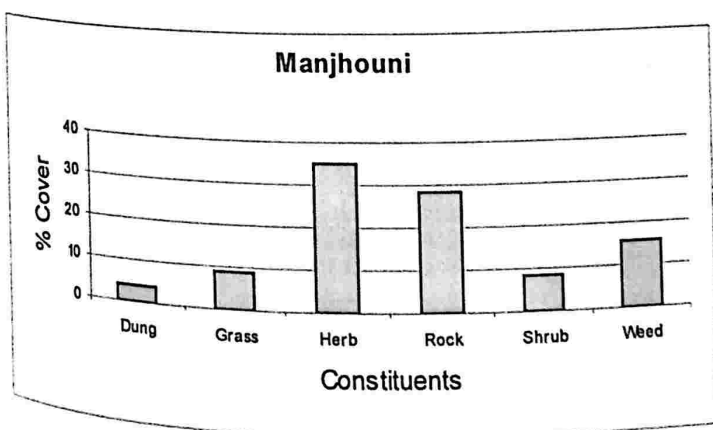
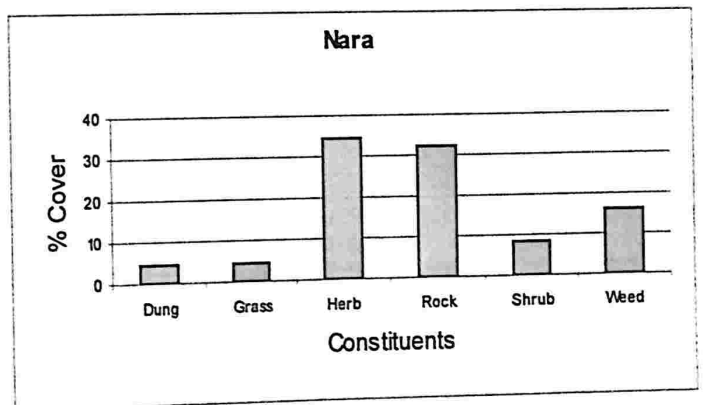
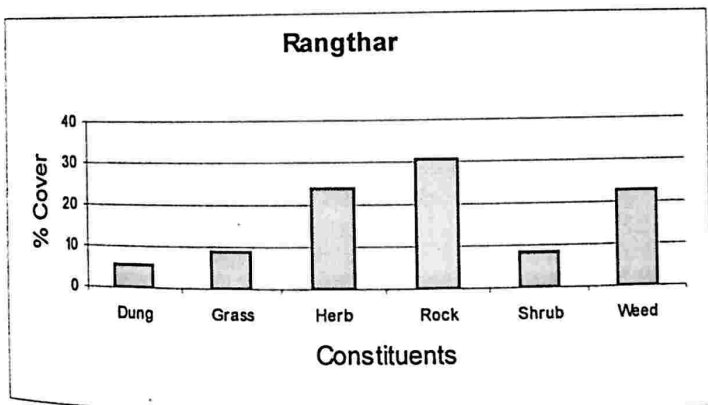
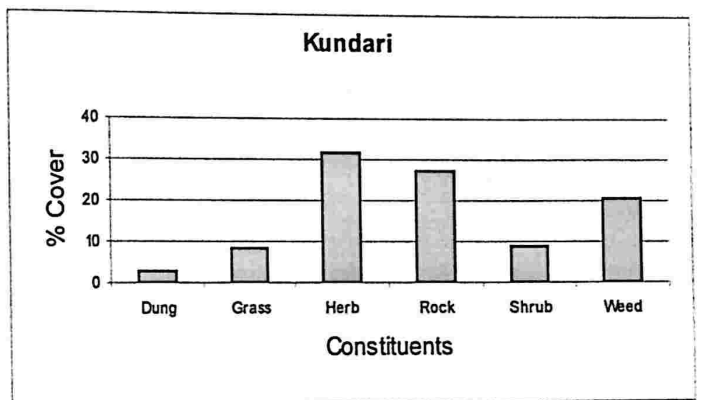
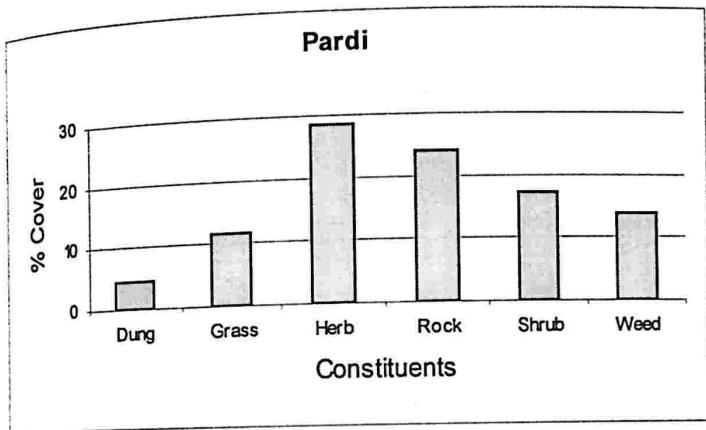
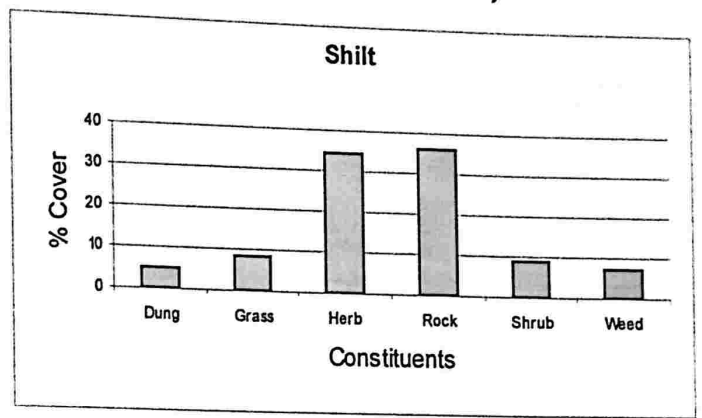
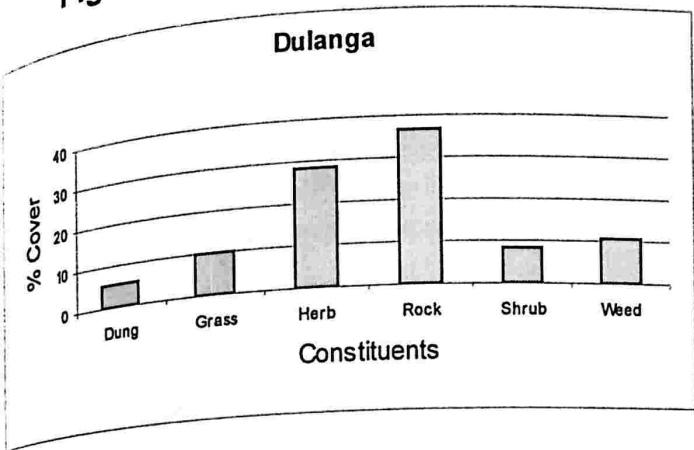
Sl. No.	Constituent	Disturbance Level			Overall TFCS
		High	Moderate	Low	
1. Dulanga TFCS					
1	Dung	13.67	2.67	0.00	5.44
2	Grass	9.00	8.00	13.67	10.22
3	Herb	16.83	31.50	37.33	28.56
4	Rock	32.33	40.67	37.50	36.83
5	Shrub	7.50	11.00	6.00	8.17
6	Weed	20.67	6.17	5.50	10.78
2. Shilt TFCS					
1	Dung	11.50	3.83	0.00	5.11
2	Grass	10.33	8.00	6.17	8.17
3	Herb	24.67	34.83	43.17	34.22
4	Rock	32.17	36.83	38.83	35.94
5	Shrub	8.50	10.17	8.83	9.17
6	Weed	12.83	6.33	3.00	7.39
3. Pardi TFCS					
1	Dung	7.17	6.33	0.00	4.50
2	Grass	12.50	11.50	11.00	11.67
3	Herb	20.17	29.50	35.50	28.39
4	Rock	23.50	26.33	22.50	24.11
5	Shrub	9.83	14.17	27.83	17.28
6	Weed	26.83	12.17	3.17	14.06

Contd...

Table 4.35 Contd...

Sl. No.	Constituent	Disturbance Level			Overall TFCS
		High	Moderate	Low	
4. Rangthar TFCS					
1	Dung	12.17	4.83	0.00	5.67
2	Grass	6.67	6.83	12.50	8.67
3	Herb	12.83	25.50	33.67	24.00
4	Rock	20.33	37.33	33.50	30.39
5	Shrub	11.67	5.33	7.83	8.28
6	Weed	36.33	20.17	12.50	23.00
5. Kundari TFCS					
1	Dung	5.17	2.83	0.00	2.67
2	Grass	8.33	6.00	10.17	8.17
3	Herb	19.83	34.67	41.33	31.94
4	Rock	18.00	33.83	30.67	27.50
5	Shrub	11.67	6.00	9.33	9.00
6	Weed	37.00	16.67	8.50	20.72
6. Nara TFCS					
1	Dung	10.00	3.33	0.00	4.44
2	Grass	2.67	5.83	5.67	4.72
3	Herb	19.50	38.50	45.67	34.56
4	Rock	29.17	30.83	36.00	32.00
5	Shrub	9.00	8.83	6.50	8.11
6	Weed	29.67	12.67	6.17	16.17
7. Manjhouni TFCS					
1	Dung	6.67	4.67	0.00	3.78
2	Grass	8.00	9.67	9.00	8.89
3	Herb	23.00	34.17	48.67	35.28
4	Rock	25.67	28.67	29.83	28.06
5	Shrub	8.00	9.67	7.17	8.28
6	Weed	28.67	13.17	5.33	15.72
6. Overall TFCS					
1	Dung	9.48	4.07	0.00	4.52
2	Grass	8.21	7.98	9.74	8.64
3	Herb	19.55	32.67	40.76	30.99
4	Rock	25.88	33.50	32.69	30.69
5	Shrub	9.45	9.31	10.50	9.75
6	Weed	27.43	12.48	6.31	15.40

Fig. 4.4 - Ground Cover Composition in various TFCS (Values in %)



4.6 Alpine Pastures (AP)

The 'Thaches' in higher altitudes or Alpine pastures (> 3,600m) dominated by herbaceous vegetation constituted one of the four set of grazing resources utilized by migratory livestock – sheep and goat for a considerable time during their summer migration. The diversity pattern and biotic pressure in other three grazing resources *viz.*, Village Surrounds (VS), Migratory Routes (MR) and Transitory Forest Camping Sites (TFCS) have already been described. In the present section, results based on field assessments in nine intensively studied sites are discussed. Details of these nine Alpine pastures and field sampling were provided in the para 2.3.2.2.4. As all selected nine Alpine pastures were devoid of trees and shrubs, only ground vegetation constituted by herbs, grasses, ferns and sedges as in the case of TFCS was quantified.

4.6.1 Floristic Inventory

Altogether, 192 plant species representing 173 herbs, 10 grasses, 2 ferns and 7 sedges were recorded in nine Alpine pastures (Table 4.36).

A varying number of 1m x 1m quadrats (40 –100) were laid in different pastures. The maximum number of herbs, being 96 was recorded in Patal while Saketi had the minimum number i.e. 47 herb species among 9 studied sites. The number of grass species ranged from 04 to 09 among nine AP. Only two species of ferns were recorded. Bhlundwari had the highest number of sedge species, being 07, followed by 05 species in the case of Patal. While comparing the overall plant diversity in nine sites with respect to their

corresponding ground vegetation, it was revealed that Patal registered the maximum number of 111 species, followed by 106 species in Bhlundwari.

Table 4.36 - Vegetation Diversity in Selected Nine Alpine Pastures

Sr. No.	Alpine Pastures	No. of quadrats studied	Plant species				
			Herbs	Grasses	Ferns	Sedges	Total of Each AP
1.	Ghumtarao	90	78	05	02	01	86
2.	Patal	50	96	09	01	05	111
3.	Manoni	40	52	05	01	02	60
4.	Batlijani	80	92	06	01	01	100
5.	Bhlundwari	100	93	05	01	07	106
6.	Tharthadhar	40	66	04	01	02	73
7.	Saketi	40	47	05	00	01	53
8.	Kobari	40	65	06	01	04	76
9.	Dhela	100	83	05	01	01	90
Overall Nine Alpine Pastures		580	173	10	02	07	192

The lowest number of species, being 53 was recorded in the case of Saketi. Higher species richness in the case of Patal and Bhlundwari can be accounted possibly for two reasons, firstly these two pastures showed marked patterns of varying topography (gentle to steep slopes), altitude and moisture regime, and secondly, both pastures experienced low to moderate grazing pressure only. On the contrary, lowest species richness in Saketi can be

explained on the basis of its highest location (> 4,200m) among nine pastures, comparatively smaller size and had high grazing pressure.

The **Table 4.37** provides distribution of Families, Genera and Species in nine pastures. The analysis revealed that the diversity of 192 species was represented by 39 Families and 104 Genera. Bhlundwari had the maximum representation of 31 families, followed by 30 families in Ghumtarao and Patal each. Saketi had the lowest representation of families (18). The number of Genera among nine studied AP varied from 42 to 74. Bhlundwari had the highest representation of 71.1% recorded Genera while Saketi had the lowest representation of Genera, being 40.3% (**Fig. 4.5**).

Table 4.37 - Representation of Plant Families, Genera and Species in the Ground Vegetation Among Nine Alpine Pastures

Sr. No.	Alpine Pastures	No. of Quadrats Studied	Ground Vegetation		
			Families	Genera	Species
1.	Ghumtarao	90	30	65	86
2.	Patal	50	30	73	111
3.	Manoni	40	22	52	60
4.	Batlijani	80	29	70	100
5.	Bhlundwari	100	31	74	106
6.	Tharthadhar	40	27	56	73
7.	Saketi	40	18	42	53
8.	Kobari	40	25	56	76
9.	Dhela	100	28	56	90
Overall For Nine Alpine Pastures		580	39	104	192

Fig. 4.5 - Representation of Plant Families, Genera and Species Among Nine Alpine Pastures

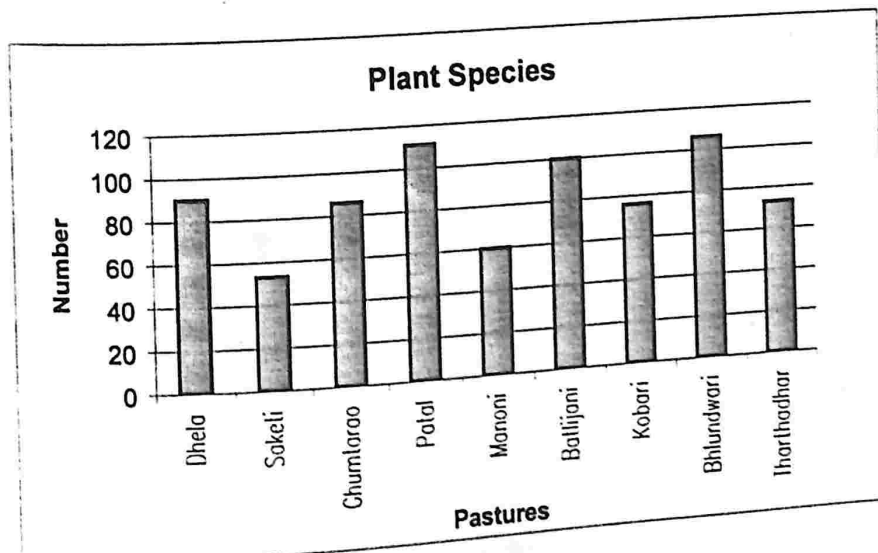
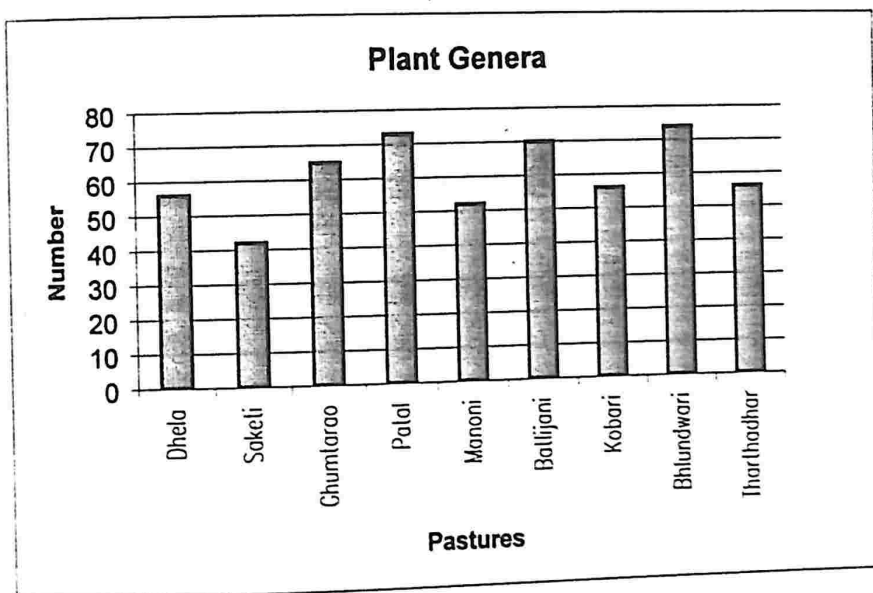
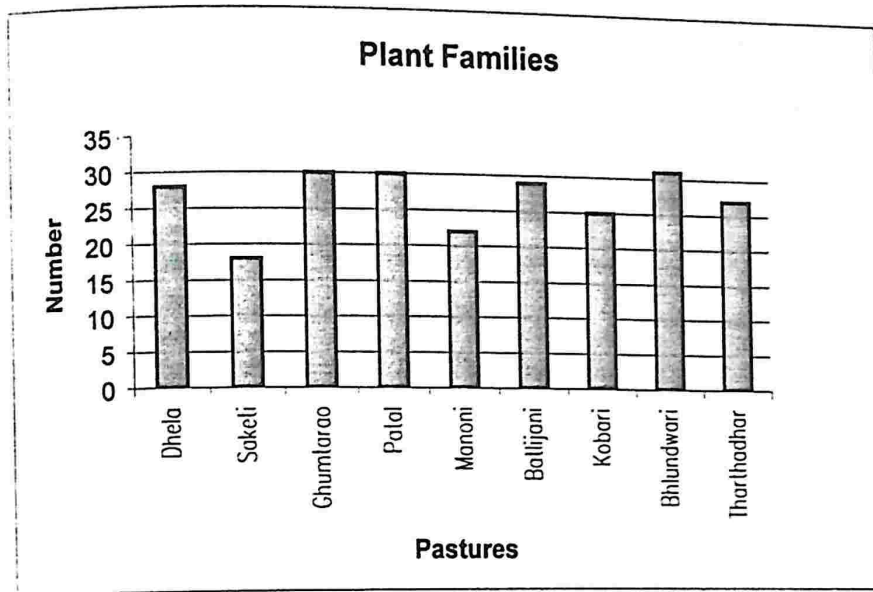


Table 4.38 provides the complete checklist of 192 species recorded. Further, an analysis of 192 species based on their distribution among nine Alpine pastures is presented in a summary **Table 4.39**. Interestingly, just 7 herb species or 4.04% species out of total 173 herb species recorded occurred in all nine pastures. These common herb species to all pastures were : *Rumex nepalensis*, *Potentilla atrosanguinea*, *Jurinea macrocephala*, *Geum alatum*, *Anaphalis nepalensis*, *Aster albescens* and *Epilobium cylindricum*.

In contrast, 36 herb species or nearly $\frac{1}{4}$ of the total herb species recorded were represented in one pasture only. Likewise, 28 herb species or 16.18% of the total recorded herb species were represented in any of the two studied Alpine pastures. Thus, it can be said that >50% herb species were represented in just 1 to 3 studied sites indicating that each alpine pasture was highly unique in its composition of herbs. Likewise, among recorded grass species *Phleum alpinum* and *Poa alpina* were common to all the nine Alpine pastures while *Festuca gigantea* occurred only in one of the nine sites. The fern – *Athyrium foliolosum* was common to atleast eight sites, while *Adiantum* sp. was present only in one case. The *Carex alpina* was the most common sedge in all nine sites while *Carex foliosa* was recorded in just one pasture only.

Table 4.38 - A Checklist of Ground Vegetation Recorded Among Nine Alpine Pastures

Sr No	Species	Family	Type	Dehla	Saketi	Ghumta-rao	Patal	Manoni	Batljani	Kobari	Bhlundwari	Tharthadhar	Presence
1	<i>Adiantum</i> sp	Adiantaceae	F			*							1
2	<i>Festuca gigantea</i>	Poaceae	G				*						1
3	<i>Allium humile</i>	Amaryllidaceae	H				*						1
4	<i>Arabidopsis himalaica</i>	Brassicaceae	H								*		1
5	<i>Asperula brachyantha</i>	Rubiaceae	H						*				1
6	<i>Campanula argyrotricha</i>	Campanulaceae	H				*						1
7	<i>Circium wallichii</i>	Asteraceae	H		*								1
8	<i>Codonopsis ovata</i>	Campanulaceae	H			*							1
9	<i>Cremanthodium nanum</i>	Asteraceae	H						*				1
10	<i>Cynoglossum lanceolatum</i>	Boraginaceae	H						*				1
11	<i>Delphinium denudatum</i>	Ranunculaceae	H						*				1
12	<i>Dianthus angulatus</i>	Caryophyllaceae	H						*				1
13	<i>Galium vestitum</i>	Rubiaceae	H				*						1
14	<i>Gentiana algida</i>	Gentianaceae	H						*				1
15	<i>Gentiana tubiflora</i>	Gentianaceae	H								*		1
16	<i>Goodyera repens</i>	Orchidaceae	H			*							1
17	<i>Gypsophylla cerastioides</i>	Caryophyllaceae	H	*									1
18	<i>Iris kumaonensis</i>	Iridaceae	H								*		1
19	<i>Juncus prismatocarpus</i>	Juncaceae	H						*				1
20	<i>Lilium oxypetalum</i>	Liliaceae	H	*									1
21	<i>Nardostachys grandiflora</i>	Valerianaceae	H			*							1
22	<i>Oxygraphis polypetalla</i>	Ranunculaceae	H		*								1
23	<i>Pedicularis brevifolia</i>	Scrophulariaceae	H									*	1
24	<i>Plantago depressa</i>	Plantaginaceae	H	*									1
25	<i>Pleurospermum candolleii</i>	Apiaceae	H							*			1
26	<i>Potentilla argyrophylla</i>	Rosaceae	H						*				1

Contd...

Table 4.38 Contd...

Sr No	Species	Family	Type	Dehla	Saketi	Ghumta-rao	Patal	Manoni	Batlijani	Kobari	Bhlundwari	Tharthadhar	Presence
27	<i>Primula stuartii</i>	Primulaceae	H			*							1
28	<i>Ranunculus diffusus</i>	Ranunculaceae	H				*						1
29	<i>Ranunculus trichophyllus</i>	Ranunculaceae	H	*					*				1
30	<i>Salvia hians</i>	Lamiaceae	H				*						1
31	<i>Selinum condollii</i>	Apiaceae	H				*						1
32	<i>Senecio rufinervis</i>	Asteraceae	H						*				1
33	<i>Silene cucubalus</i>	Caryophyllaceae	H								*		1
34	<i>Swertia cuneata</i>	Gentianaceae	H										1
35	<i>Tanacetum tibeticum</i>	Asteraceae	H	*									1
36	<i>Thalictrum foliolosum</i>	Ranunculaceae	H					*					1
37	<i>Urtica dioica</i>	Urticaceae	H			*							1
38	<i>Urtica hyperborea</i>	Urticaceae	H	*									1
39	<i>Carex foliosa</i>	Cyperaceae	Sg				*		*				2
40	<i>Agrostis munroana</i>	Poaceae	G					*		*			2
41	<i>Poa pratensis</i>	Poaceae	G					*		*			2
42	<i>Androsace rutindifolia</i>	Primulaceae	H	*									2
43	<i>Anemone rivularis</i>	Ranunculaceae	H	*			*		*				2
44	<i>Bupleurum candollii</i>	Apiaceae	H				*		*				2
45	<i>Bupleurum falcatum</i>	Apiaceae	H				*		*				2
46	<i>Bupleurum longicoule</i>	Apiaceae	H					*	*				2
47	<i>Campula cashmeriana</i>	Campanulaceae	H			*			*				2
48	<i>Cardamine hirsuta</i>	Brassicaceae	H							*			2
49	<i>Cepseilla bursa pastoris</i>	Brassicaceae	H				*						2
50	<i>Cicerbita macrorhiza</i>	Asteraceae	H			*	*			*			2
51	<i>Corydalis govaniana</i>	Fumariaceae	H							*			2
52	<i>Erigeron canadensis</i>	Asteraceae	H	*			*						2

Contd...

Table 4.38 Contd...

Sr No	Species	Family	Type	Dehla	Saketi	Ghumta-rao	Patal	Manoni	Batlijani	Kobari	Bhlundwari	Tharthadhar	Presence
53	<i>Erigeron multiradiatus</i>	Asteraceae	H	*			*						2
54	<i>Heracleum nepense</i>	Apiaceae	H				*		*				2
55	<i>Leontopodium jacotianium</i>	Asteraceae	H									*	2
56	<i>Lloydia longiscapa</i>	Liliaceae	H		*				*				2
57	<i>Origanum vulgare</i>	Lamiaceae	H									*	2
58	<i>Polygonum emodi</i>	Polygonaceae	H										2
59	<i>Polygonum vacciniifolium</i>	Polygonaceae	H	*		*			*				2
60	<i>Potentilla nepalensis</i>	Rosaceae	H				*						2
61	<i>Primula petiolaris</i>	Primulaceae	H	*			*						2
62	<i>Ranunculus brotherusii</i>	Ranunculaceae	H	*			*		*				2
63	<i>Saussurea obvallata</i>	Asteraceae	H					*		*			2
64	<i>Saxifraga brunonis</i>	Saxifragaceae	H						*				2
65	<i>Saxifraga diversifolia</i>	Saxifragaceae	H				*						2
66	<i>Selinum wallichianum</i>	Apiaceae	H	*			*						2
67	<i>Silene tenuis</i>	Caryophyllaceae	H	*					*				2
68	<i>Tanacetum gracile</i>	Asteraceae	H	*									2
69	<i>Viola serpens</i>	Violaceae	H				*				*		2
70	<i>Carex nubigena</i>	Cyperaceae	Sg				*				*		2
71	<i>Kobresia royleana</i>	Cyperaceae	Sg				*				*		3
72	<i>Stipa roylei</i>	Poaceae	G	*			*		*		*		3
73	<i>Stipa sibirica</i>	Poaceae	G	*			*				*		3
74	<i>Ajuga bractiosa</i>	Lamiaceae	H							*	*		3
75	<i>Anaphalis rotundifolia</i>	Asteraceae	H				*				*		3

Contd...

Table 4.38 Contd...

Sr No	Species	Family	Type	Dehla	Saketi	Ghumta-rao	Patal	Manoni	Batlijani	Kobari	Bhlundwari	Tharthadhar	Presence
76	<i>Anaphalis royleana</i>	Asteraceae	H			*			*	*			3
77	<i>Bergenia ciliata</i>	Saxifragaceae	H			*			*	*			3
78	<i>Corydalis cashmeriana</i>	Fumariaceae	H			*			*	*			3
79	<i>Cynoglossum glochidiatum</i>	Boraginaceae	H		*	*	*	*					3
80	<i>Delphinium vestitum</i>	Ranunculaceae	H			*	*		*				3
81	<i>Dipsacus inermis</i>	Dipsacaceae	H	*		*	*	*					3
82	<i>Erigeron alpinus</i>	Asteraceae	H	*				*		*		*	3
83	<i>Fragaria vesca</i>	Rosacea	H	*			*			*		*	3
84	<i>Geranium wallichianum</i>	Geraniaceae	H			*							3
85	<i>Herminium angustifolium</i>	Orchidaceae	H			*			*				3
86	<i>Jurinea ceratocarpa</i>	Asteraceae	H		*		*		*				3
87	<i>Potentilla eriocarpa</i>	Rosaceae	H	*		*	*						3
88	<i>Primula denticulata</i>	Primulaceae	H	*	*	*			*				3
89	<i>Ranunculus pulchellus</i>	Ranunculaceae	H				*		*				3
90	<i>Salvia lanata</i>	Lamiaceae	H	*	*	*							3
91	<i>Saussurea albescens</i>	Asteraceae	H	*	*	*	*		*				3
92	<i>Saussurea gossypiphora</i>	Asteraceae	H			*			*				3
93	<i>Saussurea taraxacifolia</i>	Asteraceae	H		*	*		*	*				3
94	<i>Senecio graciliflorus</i>	Asteraceae	H			*	*	*	*				3
95	<i>Stellaria decumbens</i>	Caryophyllaceae	H	*				*		*			3
96	<i>Swertia petiolata</i>	Gentianaceae	H	*	*			*	*		*	*	3
97	<i>Thymus linearis</i>	Lamiaceae	H						*		*		3
98	<i>Waldheimia tomentosa</i>	Asteraceae	H		*				*		*		3

Contd...

Sr No	Species	Family	Type	Dehla	Saketi	Ghumta-rao	Patal	Manoni	Batijani	Kobari	Bhlundwari	Tharthadhar	Presence
99	<i>Kobresia nepalensis</i>	Cyperaceae	Sg				*			*	*		3
100	<i>Androsace lanuginosa</i>	Primulaceae	H	*			*			*	*		4
101	<i>Anemone obtusiloba</i>	Ranunculaceae	H					*		*	*		4
102	<i>Aquilegia nevalis</i>	Ranunculaceae	H			*		*		*	*		4
103	<i>Campanula latifolia</i>	Campanulaceae	H			*	*	*	*				4
104	<i>Circium falconeri</i>	Asteraceae	H	*	*				*		*		4
105	<i>Cortia depressa</i>	Apiaceae	H		*			*	*				4
106	<i>Cyananthus lobatus</i>	Campanulaceae	H		*	*		*	*	*			4
107	<i>Epilobium latifolium</i>	Onagraceae	H	*		*	*	*		*	*		4
108	<i>Galium verum</i>	Rubiaceae	H	*	*		*	*	*	*	*		4
109	<i>Gentiana cachemirica</i>	Gentianaceae	H		*		*	*	*	*	*		4
110	<i>Gnaphalium thomsonii</i>	Asteraceae	H	*			*	*	*	*	*		4
111	<i>Leontopodium himalayanum</i>	Asteraceae	H	*		*	*	*	*	*	*		4
112	<i>Leucas lanata</i>	Lamiaceae	H		*	*			*	*	*		4
113	<i>Ligularia amplexicaulis</i>	Asteraceae	H				*		*	*	*		4
114	<i>Morina longifolia</i>	Dipsacaceae	H				*		*	*	*		4
115	<i>Paraquilegia microphylla</i>	Ranunculaceae	H		*		*		*	*	*		4
116	<i>Pedicularis bicornuta</i>	Scrophulariaceae	H	*			*		*	*	*		4
117	<i>Polygonum amplexicaulis</i>	Polygonaceae	H	*			*		*	*	*		4
118	<i>Potentilla fruticosa</i>	Rosaceae	H	*			*		*	*	*		4
119	<i>Primula involucrata</i>	Primulaceae	H	*	*				*	*	*		4
120	<i>Senecio amplexicaulis</i>	Asteraceae	H	*	*	*			*	*	*		4
121	<i>Silene griffithii</i>	Caryophyllaceae	H	*	*				*	*	*		4
122	<i>Viola biflora</i>	Violaceae	H			*				*	*		4
123	<i>Carex setigera</i>	Cyperaceae	Sg					*		*	*		4
124	<i>Kobresia pugmaea</i>	Cyperaceae	Sg				*	*		*	*		4
125	<i>Anemone rupicola</i>	Ranunculaceae	H		*		*	*		*	*		5

Contd....

Table 4.38 Contd...

Sr No	Species	Family	Type	Dehla	Saketi	Ghumta-rao	Patal	Manoni	Batlijani	Kobari	Bhlundwari	Tharthadhar	Presence
126	<i>Chaerophyllum reflexum</i>	Apiaceae	H	*			*	*			*	*	5
127	<i>Chaerophyllum villosum</i>	Apiaceae	H	*			*			*	*	*	5
128	<i>Impatiens sulcata</i>	Balsaminaceae	H	*		*		*			*	*	5
129	<i>Parnassia nubicola</i>	Paranassiaceae	H		*	*	*	*					5
130	<i>Picrohiza kurrooa</i>	Scrophulariaceae	H	*		*	*		*		*	*	5
131	<i>Pleurospermum brunonis</i>	Apiaceae	H	*		*	*		*		*	*	5
132	<i>Roscoeia alpina</i>	Zingiberaceae	H		*	*	*			*	*	*	5
133	<i>Salvia nubicola</i>	Lamiaceae	H	*	*	*			*		*	*	5
134	<i>Saussurea fastuosa</i>	Asteraceae	H		*	*		*			*	*	5
135	<i>Saxifraga jacquemontiana</i>	Saxifragaceae	H				*			*	*	*	5
136	<i>Thalictrum alpinum</i>	Ranunculaceae	H	*		*	*		*		*	*	6
137	<i>Aconitum heterophyllum</i>	Ranunculaceae	H				*		*		*	*	6
138	<i>Anaphalis triplinervis</i>	Asteraceae	H	*		*	*		*		*	*	6
139	<i>Astragalus himalayanus</i>	Fabaceae	H			*	*	*			*	*	6
140	<i>Bergenia stracheyi</i>	Saxifragaceae	H		*	*	*	*			*	*	6
141	<i>Delphinium cachemirianum</i>	Ranunculaceae	H			*	*	*		*	*	*	6
142	<i>Delphinium denudatum</i>	Ranunculaceae	H			*	*		*		*	*	6
143	<i>Galium aparine</i>	Rubiaceae	H	*		*	*	*		*	*	*	6
144	<i>Heracleum wallichii</i>	Apiaceae	H			*	*	*		*	*	*	6
145	<i>Maconopsis aculata</i>	Papaveraceae	H	*		*	*	*		*	*	*	6
146	<i>Pedicularis oederi</i>	Scrophulariaceae	H	*		*	*	*		*	*	*	6
147	<i>Podophyllum hexandrum</i>	Podophyllaceae	H	*		*	*	*		*	*	*	6
148	<i>Polygonum affinis</i>	Polygonaceae	H	*	*	*	*	*		*	*	*	6
149	<i>Potentilla peduncularis</i>	Rosaceae	H			*	*	*		*	*	*	6
150	<i>Ranunculus hirtellus</i>	Ranunculaceae	H	*	*	*	*	*		*	*	*	6

Contd...

Table 4.38 Contd..

Sr No	Species	Family	Type	Dehla	Saketi	Ghumta-rao	Patal	Manoni	Baflijani	Kobari	Bhlundwari	Tharthadhar	Presence
151	<i>Rheum australe</i>	Polygonaceae	H		*		*	*	*		*	*	6
152	<i>Rumex acetosa</i>	Polygonaceae	H	*			*		*	*	*	*	6
153	<i>Saussurea graminifolia</i>	Asteraceae	H		*		*	*	*	*	*	*	6
154	<i>Agrostis pilosula</i>	Poaceae	G		*	*	*	*	*	*	*	*	7
155	<i>Calamagrostis pulchella</i>	Poaceae	G		*	*	*	*	*	*	*	*	7
156	<i>Danthonia cachymeriana</i>	Poaceae	G	*	*	*	*	*	*	*	*	*	7
157	<i>Achillea millefolia</i>	Asteraceae	H		*	*	*	*	*	*	*	*	7
158	<i>Anemone tetrasepala</i>	Ranunculaceae	H	*	*	*	*	*	*	*	*	*	7
159	<i>Arenaria festucoides</i>	Caryophyllaceae	H		*	*	*	*	*	*	*	*	7
160	<i>Dactylorhiza hatagirea</i>	Orchidaceae	H	*		*	*	*	*	*	*	*	7
161	<i>Geranium pratense</i>	Geraniaceae	H	*		*	*	*	*	*	*	*	7
162	<i>Impatiens glandulifera</i>	Balsaminaceae	H			*	*	*	*	*	*	*	7
163	<i>Lindelia longiflora</i>	Boraginaceae	H	*		*	*	*	*	*	*	*	7
164	<i>Morina coultieriana</i>	Dipsacaceae	H			*	*	*	*	*	*	*	7
165	<i>Pleurospermum densiflorum</i>	Apiaceae	H		*	*	*	*	*	*	*	*	7
166	<i>Potentilla microphylla</i>	Rosaceae	H	*	*	*	*	*	*	*	*	*	7
167	<i>Primula macrophylla</i>	Primulaceae	H	*	*	*	*	*	*	*	*	*	7
168	<i>Taraxacum officinale</i>	Asteraceae	H	*	*	*	*	*	*	*	*	*	7
169	<i>Trachydium roylei</i>	Apiaceae	H	*	*	*	*	*	*	*	*	*	8
170	<i>Athyrium foliolosum</i>	Athyriaceae	F	*	*	*	*	*	*	*	*	*	8
171	<i>Aconitum violaceum</i>	Ranunculaceae	H		*	*	*	*	*	*	*	*	8
172	<i>Artemisia maritima</i>	Asteraceae	H	*	*	*	*	*	*	*	*	*	8
173	<i>Erigeron bonariensis</i>	Asteraceae	H	*	*	*	*	*	*	*	*	*	8

(Contd...)

Table 4.38 Contd...

Sr No	Species	Family	Type	Dehla	Saketi	Ghumta-rao	Patal	Manoni	Batlijani	Kobari	Bhlundwari	Tharthadhar	Presence
174	<i>Geranium nepalense</i>	Geraniaceae	H	*		*	*	*	*	*	*	*	8
175	<i>Hackelia uncinata</i>	Boraginaceae	H	*		*	*	*	*	*	*	*	8
176	<i>Nepeta connata</i>	Lamiaceae	H		*	*	*	*	*	*	*	*	8
177	<i>Oxyria digyna</i>	Polygonaceae	H		*	*	*	*	*	*	*	*	8
178	<i>Phlomis bracteosa</i>	Lamiaceae	H	*		*	*	*	*	*	*	*	8
179	<i>Polygonum polystachyum</i>	Polygonaceae	H	*		*	*	*	*	*	*	*	8
180	<i>Polygonum viviparum</i>	Polygonaceae	H		*	*	*	*	*	*	*	*	8
181	<i>Selinum vaginatum</i>	Apiaceae	H	*		*	*	*	*	*	*	*	8
182	<i>Tanacetum longifolium</i>	Asteraceae	H	*	*	*	*	*	*	*	*	*	9
183	<i>Phleum alpinum</i>	Poaceae	G	*	*	*	*	*	*	*	*	*	9
184	<i>Poa alpina</i>	Poaceae	G	*	*	*	*	*	*	*	*	*	9
185	<i>Anaphalis nepalensis</i>	Asteraceae	H	*	*	*	*	*	*	*	*	*	9
186	<i>Aster albescens</i>	Asteraceae	H	*	*	*	*	*	*	*	*	*	9
187	<i>Epilobium cylindricum</i>	Onagraceae	H	*	*	*	*	*	*	*	*	*	9
188	<i>Geum elatum</i>	Rosaceae	H	*	*	*	*	*	*	*	*	*	9
189	<i>Jurinea macrocephala</i>	Asteraceae	H	*	*	*	*	*	*	*	*	*	9
190	<i>Potentilla atrosanguinea</i>	Rosaceae	H	*	*	*	*	*	*	*	*	*	9
191	<i>Rumex nepalensis</i>	Polygonaceae	H	*	*	*	*	*	*	*	*	*	9
192	<i>Carex alpina</i>	Cyperaceae	Sg	*	*	*	*	*	*	*	*	*	9
Total Species in Each Alpine Pasture													73
													106
													76
													100
													60
													111
													86
													53
													90

Table 4.39 - Relative Occurrence of Grass, Herb, Fern and Sedge Species Among Nine Alpine Pastures

Sr. No.	Species Representation in Alpine Pastures	Herbs (n=173)	Grasses (n=10)	Ferns (n=2)	Sedges (n=7)	Total Species (n=192)
1.	One pasture	36	01	01	01	39
2.	Two pastures	28	02	00	02	32
3.	Three pastures	25	02	00	01	28
4.	Four pastures	23	00	00	02	25
5.	Five pastures	12	00	00	00	12
6.	Six pastures	17	00	00	00	17
7.	Seven pastures	13	03	00	00	16
8.	Eight pastures	12	00	01	00	13
9.	All nine pastures	07	02	00	01	10

4.6.2 Frequency, Density and Abundance

Tables 4.40 to 4.48 provide values of % frequency of occurrence, density and abundance of prominent herbs, grasses, ferns and sedges in each studied Alpine Pastures.

4.6.2.1 Ghumtarao Alpine Pasture

Two fern species – *Adiantum* sp. and *Athyrium foliolosum* were recorded. *Poa alpina* was the most abundant grass among five grass species recorded. The values of grass density were quite low and ranged from 0.82 individuals/m² to 2.91 individuals/m². Among herbs, *Polygonum polystachyum* and *Rumex nepalensis* obtained higher values of % frequency of occurrence. Based on the density values, *P. polystachyum*, *Rumex nepalensis* and *Galium*

aparine were dominant. The most abundant herb species was *Gallium aparine*, followed by *Primula stuartii*. Among the first 20 most abundant herbs, four species of genus *Polygonum* were recorded. The *Carex alpina* was the most abundant sedge at this site.

4.6.2.2 Patal Alpine Pasture

Among nine grass species recorded, the *Poa alpina* was the most abundant. This site had the maximum number of grass as well as herb species among nine studied pastures. Other prominent grasses were: *Phelum alpinum* and *Danthonia cachymeriana*. Herb species viz., *Polygonum polystachyum*, *R. nepalensis*, *Impatiens glandulifera* and *Hackelia uncinata* obtained higher values of % frequency. The most abundant herb was *Leontopodium himalayanum*, followed by *Taraxacum officinale*. *Carex alpina* was the most abundant sedge among the five sedge species recorded. The genus *Kobresia* was represented by three species viz., *K. pugmaea*, *K. royleana* and *K. nepalensis*. Thus, this site was characterised by *Kobresia* genus.

Table 4.40 - Percentage Frequency, Density and Abundance of Selected Herbs, Grasses, Ferns and Sedges in Ghumtarao AP

Sr No.	Species	Family	No. of Individuals	% Frequency	Density (no./m ²)	Abundance
A. Fern						
1	<i>Adiantum sp</i>	Adiantaceae	54	2.22	0.60	27.00
2	<i>Athyrium foliolosum</i>	Athyriaceae	225	12.22	2.50	20.45
B. Grasses						
1	<i>Poa alpina</i>	Poaceae	262	4.44	2.91	65.50
2	<i>Calamagrostis pulchella</i>	Poaceae	95	2.22	1.06	47.50
3	<i>Agrostis pilosula</i>	Poaceae	126	4.44	1.40	31.50
4	<i>Phleum alpinum</i>	Poaceae	20	1.11	0.22	20.00
5	<i>Danthonia cachymeriana</i>	Poaceae	74	22.22	0.82	3.70
C. Herbs						
1	<i>Galium aparine</i>	Rubiaceae	272	2.22	3.02	136.00
2	<i>Primula stuartii</i>	Primulaceae	60	1.11	0.67	60.00
3	<i>Goodyera repens</i>	Orchidaceae	158	3.33	1.76	52.67
4	<i>Urtica dioica</i>	Urticaceae	100	2.22	1.11	50.00
5	<i>Aster albescens</i>	Asteraceae	90	2.22	1.00	45.00
6	<i>Anaphalis nepalensis</i>	Asteraceae	245	6.67	2.72	40.83
7	<i>Potentilla peduncularis</i>	Rosaceae	37	1.11	0.41	37.00
8	<i>Rumex nepalensis</i>	Polygonaceae	328	10.00	3.64	36.44
9	<i>Picrorhiza kurrooa</i>	Scrophulariaceae	35	1.11	0.39	35.00
10	<i>Oxyria digyna</i>	Polygonaceae	35	1.11	0.39	35.00
11	<i>Roscoea alpina</i>	Zingiberaceae	134	4.44	1.49	33.50
12	<i>Cynoglossum glochidiatum</i>	Boraginaceae	31	1.11	0.34	31.00
13	<i>Saussurea taraxacifolia</i>	Asteraceae	31	1.11	0.34	31.00
14	<i>Potentilla microphylla</i>	Rosaceae	25	1.11	0.28	25.00
15	<i>Corydalis cashmeriana</i>	Fumariaceae	50	2.22	0.56	25.00
16	<i>Selinum vaginatum</i>	Apiaceae	200	8.89	2.22	25.00
17	<i>Polygonum viviparum</i>	Polygonaceae	49	2.22	0.54	24.50
18	<i>Polygonum polystachyum</i>	Polygonaceae	385	17.78	4.28	24.06
19	<i>Polygonum vacciniifolium</i>	Polygonaceae	47	2.22	0.52	23.50
20	<i>Polygonum amplexicaulis</i>	Polygonaceae	97	5.56	1.08	19.40
D Sedges						
1	<i>Carex alpina</i>	Cyperaceae	611	6.67	6.79	101.83
2	<i>Carex setigera</i>	Cyperaceae	9	1.11	0.10	9.00

Table 4.41 - Percentage Frequency, Density and Abundance of Selected Herbs, Grasses, Ferns and Sedges in Patal AP

Sr No.	Species	Family	No. of Individuals	% Frequency	Density (no./m ²)	Abundance
A. Fern						
1	<i>Athyrium foliolosum</i>	Athyriaceae	89	4.00	1.78	44.50
B. Grasses						
1	<i>Poa alpina</i>	Poaceae	338	14.00	6.76	48.29
2	<i>Phleum alpinum</i>	Poaceae	234	22.00	4.68	21.27
3	<i>Stipa sibirica</i>	Poaceae	19	2.00	0.38	19.00
4	<i>Agrostis munroana</i>	Poaceae	35	4.00	0.70	17.50
5	<i>Festuca gigantea</i>	Poaceae	42	6.00	0.84	14.00
6	<i>Calamagrostis pulchella</i>	Poaceae	36	6.00	0.72	12.00
7	<i>Agrostis pilosula</i>	Poaceae	8	2.00	0.16	8.00
8	<i>Danthonia cachymeriana</i>	Poaceae	44	12.00	0.88	7.33
9	<i>Stipa roylei</i>	Poaceae	6	2.00	0.12	6.00
C. Herbs						
1	<i>Leontopodium himalayanum</i>	Asteraceae	395	4.00	7.90	197.50
2	<i>Taraxacum officinale</i>	Asteraceae	381	4.00	7.62	190.50
3	<i>Galium verum</i>	Rubiaceae	277	6.00	5.54	92.33
4	<i>Androsace lanuginosa</i>	Primulaceae	50	2.00	1.00	50.00
5	<i>Erigeron multiradiatus</i>	Asteraceae	43	2.00	0.86	43.00
6	<i>Rumex acetosa</i>	Polygonaceae	80	4.00	1.60	40.00
7	<i>Chaerophyllum villosum</i>	Apiaceae	102	6.00	2.04	34.00
8	<i>Roscoea alpina</i>	Zingiberaceae	51	4.00	1.02	25.50
9	<i>Rumex nepalensis</i>	Polygonaceae	132	12.00	2.64	22.00
10	<i>Achillea millefolium</i>	Asteraceae	44	4.00	0.88	22.00
11	<i>Erigeron canadensis</i>	Asteraceae	22	2.00	0.44	22.00
12	<i>Polygonum affinis</i>	Polygonaceae	42	4.00	0.84	21.00
13	<i>Polygonum polystachyum</i>	Polygonaceae	160	16.00	3.20	20.00
14	<i>Impatiens glandulifera</i>	Balsaminaceae	120	12.00	2.40	20.00
15	<i>Hackelia uncinata</i>	Boraginaceae	94	10.00	1.88	18.80
16	<i>Primula denticulata</i>	Primulaceae	18	2.00	0.36	18.00
17	<i>Epilobium cylindricum</i>	Onagraceae	53	6.00	1.06	17.67
18	<i>Polygonum viviparum</i>	Polygonaceae	50	6.00	1.00	16.67
19	<i>Potentilla eriocarpa</i>	Rosaceae	33	4.00	0.66	16.50
20	<i>Geranium nepalense</i>	Geraniaceae	48	6.00	0.96	16.00
D Sedges						
1	<i>Carex alpina</i>	Cyperaceae	655	10.00	13.10	131.00
2	<i>Kobresia pugmaea</i>	Cyperaceae	63	10.00	1.26	12.60
3	<i>Kobresia royleana</i>	Cyperaceae	53	12.00	1.06	8.83
4	<i>Carex nubigena</i>	Cyperaceae	16	4.00	0.32	8.00
5	<i>Kobresia nepalensis</i>	Cyperaceae	8	2.00	0.16	8.00

4.6.2.3 Manoni Alpine Pasture

Grass *Danthonia cachymeriana* obtained highest value of % frequency of occurrence among five grass species recorded. However, the most abundant species was *Poa pratensis*, followed by *Calamagrostis pulchella*. Among the first five abundant herbs, species viz., *Galium verum*, *Saussurea graminifolia*, *Rumex nepalensis*, *Polygonum polystachyum* and *Aster albescens* were included. *Carex alpina* was the most abundant sedge species (Table 4.42).

4.6.2.4 Batlijani Alpine Pasture

This site was second in number of species recorded. Altogether, 92 species of herbs, 6 species of grasses, 1 fern and 4 species of sedges were recorded. The most abundant grass species at this site was *Stipa roylei*, followed by *Poa alpina* (Table 4.43). Other important constituents were *Danthonia cachymeriana* and *Phleum alpinum*. Among herbs, *Arenaria festucoides* was the most abundant, followed by *Thymus linearis* and *Salvia hians*. *Rumex nepalensis*, *Polygonum polystachyum*, *Anaphalis royleana* and *Selinum vaginatum* were also represented in more than 10% of the quadrats laid. *Carex alpina* was the only sedge species recorded.

Table 4.42 - Percentage Frequency, Density and Abundance of Selected Herbs, Grasses, Ferns and Sedges in Manoni AP

Sr No.	Species	Family	No. of Individuals	% Frequency	Density (no./m ²)	Abundance
A. Fern						
1	<i>Athyrium foliolosum</i>	Athyriaceae	92	12.50	2.30	18.40
B. Grasses						
1	<i>Poa pratensis</i>	Poaceae	88	2.50	2.20	88.00
2	<i>Calamagrostis pulchella</i>	Poaceae	47	5.00	1.18	23.50
3	<i>Phleum alpinum</i>	Poaceae	10	5.00	0.25	5.00
4	<i>Danthonia cachymeriana</i>	Poaceae	36	20.00	0.90	4.50
5	<i>Poa alpina</i>	Poaceae	10	7.50	0.25	3.33
C. Herbs						
1	<i>Galium verum</i>	Rubiaceae	128	2.50	3.20	128.00
2	<i>Saussurea graminifolia</i>	Asteraceae	55	2.50	1.38	55.00
3	<i>Rumex nepalensis</i>	Polygonaceae	71	5.00	1.78	35.50
4	<i>Polygonum polystachyum</i>	Polygonaceae	166	12.50	4.15	33.20
5	<i>Aster albescens</i>	Asteraceae	110	10.00	2.75	27.50
6	<i>Saxifraga brunonis</i>	Saxifragaceae	25	2.50	0.63	25.00
7	<i>Arenaria festucoides</i>	Caryophyllaceae	25	2.50	0.63	25.00
8	<i>Achillea millefolium</i>	Asteraceae	25	2.50	0.63	25.00
9	<i>Polygonum viviparum</i>	Polygonaceae	54	7.50	1.35	18.00
10	<i>Potentilla atosanguinea</i>	Rosaceae	168	25.00	4.20	16.80
11	<i>Anaphalis nepalensis</i>	Asteraceae	143	22.50	3.58	15.89
12	<i>Campanula latifolia</i>	Campanulaceae	15	2.50	0.38	15.00
13	<i>Phlomis bracteosa</i>	Lamiaceae	58	10.00	1.45	14.50
14	<i>Potentilla microphylla</i>	Rosaceae	26	5.00	0.65	13.00
15	<i>Stellaria decumbens</i>	Caryophyllaceae	13	2.50	0.33	13.00
16	<i>Aconitum violaceum</i>	Ranunculaceae	36	7.50	0.90	12.00
17	<i>Chaerophyllum reflexum</i>	Apiaceae	23	5.00	0.58	11.50
18	<i>Selinum vaginatum</i>	Apiaceae	68	15.00	1.70	11.33
19	<i>Epilobium cylindricum</i>	Onagraceae	20	5.00	0.50	10.00
20	<i>Cyananthus lobatus</i>	Campanulaceae	10	2.50	0.25	10.00
D Sedges						
1	<i>Carex alpina</i>	Cyperaceae	213	10.00	5.33	53.25
2	<i>Kobresia pugmaea</i>	Cyperaceae	68	10.00	1.70	17.00

Table 4.43 - Percentage Frequency, Density and Abundance of Selected Herbs, Grasses, Ferns and Sedges in Batlijani AP

Sr. No.	Species	Family	No. of Individuals	% Frequency	Density (no./m ²)	Abundance
A. Fern						
1	<i>Athyrium foliolosum</i>	Athyriaceae	103	3.75	1.29	34.33
B. Grasses						
1	<i>Stipa roylei</i>	Poaceae	45	1.25	0.56	45.00
2	<i>Poa alpina</i>	Poaceae	430	12.50	5.38	43.00
3	<i>Phleum alpinum</i>	Poaceae	70	3.75	0.88	23.33
4	<i>Agrostis pilosula</i>	Poaceae	87	6.25	1.09	17.40
5	<i>Agrostis munroana</i>	Poaceae	10	1.25	0.13	10.00
6	<i>Danthonia cachymeriana</i>	Poaceae	124	21.25	1.55	7.29
C. Herbs						
1	<i>Arenaria festucoides</i>	Caryophyllaceae	260	2.50	3.25	130.00
2	<i>Thymus linearis</i>	Lamiaceae	77	1.25	0.96	77.00
3	<i>Salvia hians</i>	Lamiaceae	55	1.25	0.69	55.00
4	<i>Gentiana cachemirica</i>	Gentianaceae	131	3.75	1.64	43.67
5	<i>Rumex acetosa</i>	Polygonaceae	84	3.75	1.05	28.00
6	<i>Salvia lanata</i>	Lamiaceae	55	2.50	0.69	27.50
7	<i>Pleurospermum densiflorum</i>	Apiaceae	52	2.50	0.65	26.00
8	<i>Galium aparine</i>	Rubiaceae	101	5.00	1.26	25.25
9	<i>Roscoea alpina</i>	Zingiberaceae	50	2.50	0.63	25.00
10	<i>Potentilla nepalensis</i>	Rosaceae	22	1.25	0.28	22.00
11	<i>Anaphalis royleana</i>	Asteraceae	195	11.25	2.44	21.67
12	<i>Senecio amplexicaulis</i>	Asteraceae	21	1.25	0.26	21.00
13	<i>Polygonum polystachyum</i>	Polygonaceae	123	7.50	1.54	20.50
14	<i>Rumex nepalensis</i>	Polygonaceae	180	11.25	2.25	20.00
15	<i>Anaphalis nepalensis</i>	Asteraceae	277	17.50	3.46	19.79
16	<i>Potentilla peduncularis</i>	Rosaceae	18	1.25	0.23	18.00
17	<i>Bergenia stracheyi</i>	Saxifragaceae	16	1.25	0.20	16.00
18	<i>Potentilla eriocarpa</i>	Rosaceae	48	3.75	0.60	16.00
19	<i>Epilobium cylindricum</i>	Onagraceae	47	3.75	0.59	15.67
20	<i>Selinum vaginatum</i>	Apiaceae	199	16.25	2.49	15.31
D. Sedges						
1	<i>Carex alpina</i>	Cyperaceae	1575	13.75	19.69	143.18

4.6.2.5 Bhlundwari Alpine Pasture

The site was characterised by *Poa alpina* and *Phleum alpinum* grass species. This site was more rich in species number as well as it was overall diverse. The absence of *Rumex nepalensis* among first 20 herb species on the basis of abundance values was conspicuous. Interestingly, the first five abundant species were: *Androsace lanuginosa*, *Campanula latifolia*, *Polygonum viviparum*, *Thymus linearis* and *Saliva nubicola*. This site also had a maximum number (07) of sedge species recorded among nine pastures. The *Carex alpina* characterised the site in terms of its highest density value among seven sedge species recorded (Table 4.44).

4.6.2.6 Tharthadhar Alpine Pasture

Poa alpina was the most abundant grass species, followed by *Phleum alpinum*, *Thymus linearis*, *Campanula latifolia*, *Rumex nepalensis*, *Roscoea alpina* herbs obtained comparatively higher values of density. However, the most abundant herb species was: *Campanula latifolia*, followed by *Thymus linearis* and *Anemone obtusiloba*. The *Carex alpina* was the most abundant sedge species at this site (Table 4.45).

Table 4.44 - Percentage Frequency, Density and Abundance of Selected Herbs, Grasses, Ferns and Sedges in Bhlundwari AP

Sr No.	Species	Family	No. of Individuals	% Frequency	Density (no./m ²)	Abundance
A. Fern						
1	<i>Athyrium foliolosum</i>	Athyriaceae	210	5.00	2.10	42.00
B. Grasses						
1	<i>Poa alpina</i>	Poaceae	1557	9.00	15.57	173.00
2	<i>Phleum alpinum</i>	Poaceae	1340	21.00	13.40	63.81
3	<i>Agrostis pilosula</i>	Poaceae	130	3.00	1.30	43.33
4	<i>Calamagrostis pulchella</i>	Poaceae	75	2.00	0.75	37.50
5	<i>Stipa sibirica</i>	Poaceae	1	1.00	0.01	1.00
C. Herbs						
1	<i>Androsace lanuginosa</i>	Primulaceae	180	1.00	1.80	180.00
2	<i>Campanula latifolia</i>	Campanulaceae	500	3.00	5.00	166.67
3	<i>Polygonum viviparum</i>	Polygonaceae	295	2.00	2.95	147.50
4	<i>Thymus linearis</i>	Lamiaceae	410	3.00	4.10	136.67
5	<i>Salvia nubicola</i>	Lamiaceae	363	3.00	3.63	121.00
6	<i>Galium aparine</i>	Rubiaceae	115	1.00	1.15	115.00
7	<i>Potentilla peduncularis</i>	Rosaceae	95	1.00	0.95	95.00
8	<i>Anemone obtusiloba</i>	Ranunculaceae	360	4.00	3.60	90.00
9	<i>Impatiens glandulifera</i>	Balsaminaceae	312	4.00	3.12	78.00
10	<i>Roscoea alpina</i>	Zingiberaceae	270	4.00	2.70	67.50
11	<i>Corydalis govaniiana</i>	Fumariaceae	65	1.00	0.65	65.00
12	<i>Anaphalis rotundifolia</i>	Asteraceae	65	1.00	0.65	65.00
13	<i>Bergenia ciliata</i>	Saxifragaceae	64	1.00	0.64	64.00
14	<i>Polygonum affinis</i>	Polygonaceae	60	1.00	0.60	60.00
15	<i>Aster albescens</i>	Asteraceae	243	5.00	2.43	48.60
16	<i>Corydalis cashmeriana</i>	Fumariaceae	80	2.00	0.80	40.00
17	<i>Arabidopsis himalaica</i>	Brassicaceae	79	2.00	0.79	39.50
18	<i>Leontopodium jacotianum</i>	Asteraceae	116	3.00	1.16	38.67
19	<i>Polygonum polystachyum</i>	Polygonaceae	319	9.00	3.19	35.44
20	<i>Primula involucrata</i>	Primulaceae	35	1.00	0.35	35.00
D Sedges						
1	<i>Carex nubigena</i>	Cyperaceae	250	1.00	2.50	250.00
2	<i>Carex alpina</i>	Cyperaceae	1739	22.00	17.39	79.05
3	<i>Kobresia pugmaea</i>	Cyperaceae	55	1.00	0.55	55.00
4	<i>Carex foliosa</i>	Cyperaceae	95	3.00	0.95	31.67
5	<i>Carex foliosa</i>	Cyperaceae	49	2.00	0.49	24.50
6	<i>Kobresia royleana</i>	Cyperaceae	16	1.00	0.16	16.00
7	<i>Carex setigera</i>	Cyperaceae	3	1.00	0.03	3.00
7	<i>Kobresia nepalensis</i>	Cyperaceae				

Table 4.45 - Percentage Frequency, Density and Abundance of Selected Herbs, Grasses, Ferns and Sedges in Tharthadhar AP

Sr No.	Species	Family	No. of Individuals	% Frequency	Density (no./m ²)	Abundance
A.	Fern					
1	<i>Athyrium foliolosum</i>	Athyriaceae	201	12.50	5.03	40.20
B.	Grasses					
1	<i>Poa alpina</i>	Poaceae	832	12.50	20.80	166.40
2	<i>Phleum alpinum</i>	Poaceae	582	20.00	14.55	72.75
3	<i>Calamagrostis pulchella</i>	Poaceae	60	2.50	1.50	60.00
4	<i>Agrostis pilosula</i>	Poaceae	49	2.50	1.23	49.00
C.	Herbs					
1	<i>Campanula latifolia</i>	Campanulaceae	398	2.50	9.95	398.00
2	<i>Thymus linearis</i>	Lamiaceae	406	7.50	10.15	135.33
3	<i>Anemone obtusiloba</i>	Ranunculaceae	115	2.50	2.88	115.00
4	<i>Galium aparine</i>	Rubiaceae	111	2.50	2.78	111.00
5	<i>Potentilla peduncularis</i>	Rosaceae	95	2.50	2.38	95.00
6	<i>Roscoea alpina</i>	Zingiberaceae	244	7.50	6.10	81.33
7	<i>Aster albescens</i>	Asteraceae	225	7.50	5.63	75.00
8	<i>Anaphalis rotundifolia</i>	Asteraceae	67	2.50	1.68	67.00
9	<i>Leontopodium jacotianum</i>	Asteraceae	66	2.50	1.65	66.00
10	<i>Geranium pratense</i>	Geraniaceae	166	10.00	4.15	41.50
11	<i>Epilobium cylindricum</i>	Onagraceae	41	2.50	1.03	41.00
12	<i>Polygonum polystachyum</i>	Polygonaceae	116	7.50	2.90	38.67
13	<i>Aquilegia nivalis</i>	Ranunculaceae	213	15.00	5.33	35.50
14	<i>Polygonum emodi</i>	Polygonaceae	67	5.00	1.68	33.50
15	<i>Herminium angustifolium</i>	Polygonaceae	31	2.50	0.78	31.00
16	<i>Nepeta connata</i>	Orchidaceae	62	5.00	1.55	31.00
17	<i>Nepeta connata</i>	Lamiaceae	61	5.00	1.53	30.50
18	<i>Chaerophyllum reflexum</i>	Apiaceae	145	12.50	3.63	29.00
19	<i>Hackelia uncinata</i>	Boraginaceae	279	25.00	6.98	27.90
20	<i>Rumex nepalensis</i>	Polygonaceae	107	10.00	2.68	26.75
20	<i>Polygonum affinis</i>	Polygonaceae				
D	Sedges					
1	<i>Carex alpina</i>	Cyperaceae	697	27.50	17.43	63.36
2	<i>Carex setigera</i>	Cyperaceae	73	7.50	1.83	24.33

4.6.2.7

Saketi Alpine Pasture

The values of % frequency occurrence in case of grasses, herbs and sedges recorded at this site were generally low i.e. <17.50% (Table 4.46). The highest value of % frequency was in the case of *Carex alpina* (17.5%), followed by *Ranunculus pulchellus* (12.5%), *Tanacetum longifolium* (12.5%) and *Anaphalis nepalensis* (12.5%). *Saliva nubicola* obtained highest density (14.33 individuals/m²) value among recorded herbs. Other abundant species were: *Potentilla eriocarpa*, *Ranunculus pulchellus* and *Anemone rupicola*. No fern species was recorded for this site.

4.6.2.8

Kobari Alpine Pasture

Only one species of fern – *Athyrium foliolosum* was recorded. *Poa alpina* was the most dominant grass on the basis of its highest density value, being 20.58 tillers/m². Otherwise, the most abundant grass was *Poa pratensis*. Among the first five abundant herbs, species viz., *Androsace lanuginosa*, *Impatiens glandulifera*, *Anemone obtusiloba*, *Chaerophyllum villosum* and *Corydalis govaniana* were included. Noticeably, *Rumex nepalensis* and *Polygonum polystachyum* were not listed among first 20 abundant species. Four species of sedges were recorded represented by genera *Carex* and *Kobresia*. *Carex alpina* was the most abundant sedge at this site (Table 4.47).

Table 4. 46 - Percentage Frequency, Density and Abundance of Selected Herbs, Grasses, Ferns and Sedges in Saketi AP

Sr No.	Species	Family	No. of Individuals	% Frequency	Density (no./m ²)	Abundance
A Grasses						
1	<i>Phleum alpinum</i>	Poaceae	177	2.5	4.4	177.0
2	<i>Poa alpina</i>	Poaceae	499	10.0	12.5	124.8
3	<i>Calamagrostis pulchella</i>	Poaceae	55	2.5	1.4	55.0
4	<i>Agrostis pilosula</i>	Poaceae	55	5.0	1.4	27.5
5	<i>Danthonia cachymeriana</i>	Poaceae	2	2.5	0.1	2.0
B Herbs						
1	<i>Salvia nubicola</i>	Lamiaceae	573	7.5	14.3	191.0
2	<i>Potentilla eriocarpa</i>	Rosaceae	298	5.0	7.5	149.0
3	<i>Ranunculus pulchellus</i>	Ranunculaceae	275	5.0	6.9	137.5
4	<i>Anemone rupicola</i>	Ranunculaceae	75	2.5	1.9	75.0
5	<i>Ranunculus hirtellus</i>	Ranunculaceae	334	12.5	8.4	66.8
6	<i>Aconitum violaceum</i>	Ranunculaceae	266	10.0	6.7	66.5
7	<i>Lloydia longiscapa</i>	Liliaceae	65	2.5	1.6	65.0
8	<i>Aster albescens</i>	Asteraceae	120	5.0	3.0	60.0
9	<i>Polygonum affinis</i>	Polygonaceae	171	10.0	4.3	42.8
10	<i>Waldheimia tomentosa</i>	Asteraceae	74	5.0	1.9	37.0
11	<i>Tanacetum longifolium</i>	Asteraceae	170	12.5	4.3	34.0
12	<i>Anaphalis nepalensis</i>	Asteraceae	140	12.5	3.5	28.0
13	<i>Arenaria festucoides</i>	Caryophyllaceae	55	5.0	1.4	27.5
14	<i>Cyananthus lobatus</i>	Campanulaceae	25	2.5	0.6	25.0
15	<i>Pleurospermum densiflorum</i>	Apiaceae	25	2.5	0.6	25.0
16	<i>Achillea millefolium</i>	Asteraceae	49	5.0	1.2	24.5
17	<i>Nepeta connata</i>	Lamiaceae	88	10.0	2.2	22.0
18	<i>Gentiana cachemirica</i>	Gentianaceae	70	10.0	1.8	17.5
19	<i>Saxifraga jacquemontiana</i>	Saxifragaceae	15	2.5	0.4	15.0
20	<i>Potentilla atosanguinea</i>	Rosaceae	15	2.5	0.4	15.0
C Sedges						
1	<i>Carex alpina</i>	Cyperaceae	455	17.5	11.4	65.0

Table 4.47 - Percentage Frequency, Density and Abundance of Selected Herbs, Grasses, Ferns and Sedges in Kobari TFCS

Sr No.	Species	Family	No. of Individuals	% Frequency	Density (no./m ²)	Abundance
A. Fern						
1	<i>Athyrium foliolosum</i>	Athyriaceae	19	2.5	0.5	19.0
B. Grasses						
1	<i>Poa pratensis</i>	Poaceae	95	2.5	2.4	95.0
2	<i>Poa alpina</i>	Poaceae	823	22.5	20.6	91.4
3	<i>Phleum alpinum</i>	Poaceae	73	2.5	1.8	73.0
4	<i>Calamagrostis pulchella</i>	Poaceae	36	5.0	0.9	18.0
5	<i>Agrostis pilosula</i>	Poaceae	21	7.5	0.5	7.0
6	<i>Danthonia cachymeriana</i>	Poaceae	12	7.5	0.3	4.0
C. Herbs						
1	<i>Androsace lanuginosa</i>	Primulaceae	166	2.5	4.2	166.0
2	<i>Impatiens glandulifera</i>	Balsaminaceae	142	2.5	3.6	142.0
3	<i>Anemone obtusiloba</i>	Ranunculaceae	112	2.5	2.8	112.0
4	<i>Chaerophyllum villosum</i>	Apiaceae	88	2.5	2.2	88.0
5	<i>Corydalis govaniiana</i>	Fumariaceae	67	2.5	1.7	67.0
6	<i>Aquilegia nivalis</i>	Ranunculaceae	61	2.5	1.5	61.0
7	<i>Saussurea graminifolia</i>	Asteraceae	53	2.5	1.3	53.0
8	<i>Leontopodium himalayanum</i>	Asteraceae	173	10.0	4.3	43.3
9	<i>Polygonum viviparum</i>	Polygonaceae	34	2.5	0.9	34.0
10	<i>Cephsella bursa pastoris</i>	Brassicaceae	62	5.0	1.6	31.0
11	<i>Geranium nepalense</i>	Geraniaceae	59	5.0	1.5	29.5
12	<i>Corydalis cashmeriana</i>	Fumariaceae	88	7.5	2.2	29.3
13	<i>Potentilla peduncularis</i>	Rosaceae	29	2.5	0.7	29.0
14	<i>Paraquilegia microphylla</i>	Ranunculaceae	58	5.0	1.5	29.0
15	<i>Anaphalis nepalensis</i>	Asteraceae	143	12.5	3.6	28.6
16	<i>Oxyria digyna</i>	Polygonaceae	81	7.5	2.0	27.0
17	<i>Epilobium latifolium</i>	Polygonaceae	48	5.0	1.2	24.0
18	<i>Epilobium latifolium</i>	Onagraceae	48	5.0	1.2	24.0
19	<i>Thalictrum alpinum</i>	Ranunculaceae	70	7.5	1.8	23.3
20	<i>Pedicularis oederi</i>	Ranunculaceae	70	7.5	1.8	23.3
19	<i>Pedicularis oederi</i>	Scrophulariaceae	162	17.5	4.1	23.1
20	<i>Saxifraga brunonis</i>	Saxifragaceae	23	2.5	0.6	23.0
D Sedges						
73	<i>Carex alpina</i>	Cyperaceae	610	17.5	15.3	87.1
76	<i>Kobresia pugmaea</i>	Cyperaceae	15	2.5	0.4	15.0
74	<i>Carex setigera</i>	Cyperaceae	6	2.5	0.2	6.0
75	<i>Kobresia nepalensis</i>	Cyperaceae	17	10.0	0.4	4.3

4.6.2.9 Dhela Alpine Pasture

Poa alpina and *Danthonia cachaeriana* were the most abundant and abundant grass species at Dhela Alpine pasture. Herbs viz., *Erigeron bonariensis*, *Galium verum*, *Polygonum polystachyum* and *Hackelia uncinata* obtained lower values of % frequency i.e. >10%. *Leontopodium himalayanum* was denset herb. The *Taraxacum officinale* was the most abundant herb, followed by *Leontopodium himalayanum* and *Senecio amplexicaulis*. The *Polygonum polystachyum* was included among first 20 abundant herb species while *Rumex nepalensis* was conspicuously absent. *Carex alpina* was the only sedge species recorded at this site (Table 4.48).

Table 4.48 - Percentage Frequency, Density and Abundance of Selected Herbs, Grasses, Ferns and Sedges in Dhela AP

Sr No.	Species	Family	No. of Individuals	% Frequency	Density (no./m ²)	Abundance
A. Fern						
1	<i>Athyrium foliolosum</i>	Athyriaceae	184	2	1.8	92.0
B. Grasses						
1	<i>Poa alpina</i>	Poaceae	1139	4	11.4	284.8
2	<i>Danthonia cachaeriana</i>	Poaceae	326	2	3.3	163.0
3	<i>Phleum alpinum</i>	Poaceae	86	6	0.9	14.3
4	<i>Stipa roylei</i>	Poaceae	12	2	0.1	6.0
5	<i>Stipa sibirica</i>	Poaceae	9	2	0.1	4.5
C. Herbs						
1	<i>Taraxacum officinale</i>	Asteraceae	690	2	6.9	345.0
2	<i>Leontopodium himalayanum</i>	Asteraceae	1575	6	15.8	262.5
3	<i>Senecio amplexicaulis</i>	Asteraceae	244	2	2.4	122.0
4	<i>Androsace lanuginosa</i>	Primulaceae	96	2	1.0	48.0
5	<i>Tanacetum gracile</i>	Asteraceae	92	2	0.9	46.0

Contd...

Table 4.48 Contd...

Sr No.	Species	Family	No. of Individuals	% Frequency	Density (no./m ²)	Abundance
6	<i>Tanacetum tibeticum</i>	Asteraceae	88	2	0.9	44.0
7	<i>Galium verum</i>	Rubiaceae	565	13	5.7	43.5
8	<i>Erigeron bonariensis</i>	Asteraceae	585	14	5.9	41.8
9	<i>Gypsophylla cerastioides</i>	Caryophyllaceae	249	6	2.5	41.5
10	<i>Primula macrophylla</i>	Primulaceae	82	2	0.8	41.0
11	<i>Erigeron multiradiatus</i>	Asteraceae	82	2	0.8	41.0
12	<i>Aster albescens</i>	Asteraceae	152	4	1.5	38.0
13	<i>Polygonum affinis</i>	Polygonaceae	210	6	2.1	35.0
14	<i>Impatiens sulcata</i>	Balsaminaceae	123	4	1.2	30.8
15	<i>Polygonum vacciniifolium</i>	Polygonaceae	119	4	1.2	29.8
16	<i>Erigeron canadensis</i>	Asteraceae	52	2	0.5	26.0
17	<i>Hackelia uncinata</i>	Boraginaceae	283	11	2.8	25.7
18	<i>Selinum wallichianum</i>	Apiaceae	152	6	1.5	25.3
19	<i>Galium aparine</i>	Rubiaceae	140	6	1.4	23.3
20	<i>Polygonum polystachyum</i>	Polygonaceae	291	13	2.9	22.4
D	Sedges					
1	<i>Carex alpina</i>	Cyperaceae	621	4	6.2	155.3

4.6.3 Diversity Indices

Various Diversity Indices worked out for nine Alpine pastures on the basis of their ground vegetation are presented in Table 4.49. The following inferences were made:

- (a) The values of Species Richness (NO) ranged from 53 to 111. The highest species richness was recorded in the case of Patal pasture, followed by Batiijani. The least was in the case of Saketi.
- (b) The value of Margalef's Index (R) for species richness was highest in the case of Patal.

- (c) The value of Simpson's Index (λ) was highest in the case of Batiijani Alpine pasture while the lowest value was in the case of Dhela pasture indicating the lowest diversity in Batlijani while the highest diversity in Dhela pasture.
- (d) The values of Shannon's Index (H') among nine pastures were more or less. Thus, no inference was made. However, the Patal Alpine pasture obtained the highest value of H' indicating even distribution of abundances.
- (e) The values of EP – Evenness Index among nine pastures ranged from 0.36 (Batlijani) to 0.72 (Manoni) indicating that various species in the sample were more even in the case of Manoni alpine pasture.

Table 4.49 - Diversity Indices For Nine Studied Alpine Pastures

Sl. No.	Alpine Pasture	Diversity Indices				
		Species Richness (NO)	Margalef's Index (R)	Simpson's Index (λ)	Shannon's Index (H')	Evenness Index (Ep)
1	Ghumtarao	86	1.210	0.044	3.579	0.617
2	Patal	111	1.531	0.042	3.763	0.536
3	Manoni	60	1.287	0.044	3.423	0.725
4	Batlijani	100	1.315	0.093	3.319	0.364
5	Bhlundwari	106	0.881	0.045	3.727	0.522
6	Tharthadhar	73	0.872	0.048	3.470	0.624
7	Saketi	53	0.796	0.060	3.079	0.682
8	Kobari	76	1.085	0.056	3.548	0.492
9	Dhela	90	0.779	0.041	3.656	0.608

4.6.4 Plant Phenology

The alpine and sub-alpine pastures exhibited an interesting cycle of their growth, particularly flowering. A detailed and careful survey of the study sites

was conducted from March to late October, rest of the time these areas were covered by snow. Altogether, 123 observations on 85 different herbaceous plants were made in the sub-alpine and alpine pastures.

The observations revealed that the initiation of flowering was synchronized with the commencement of summer season or rise in temperature and snow melt. Thus, in general, the flowering commenced in late March in the case of sub-alpine pastures while it was in late April in the case of alpine pastures. The peaks of various phenophases succeeded one after the other during the snow-free period. It was also observed that plants complete their growth within a short period of favourable conditions. The flowering phase of various plant species varied from shorter period as of 10–15 days to comparatively longer period of 1–3 months. The given phase was considered to have commenced when more than 10% of individuals of a particular species were flowering. This was based on scanning large areas. When >10% of the individual remained in flowering phenophase it was considered that the particular species has completed its flowering phase.

The pastures showed prolific growth of *Primulla* and *Gagea* species during late March till late April which made it almost impossible for other plants to grow at this time. After the decay of *Primulla* and *Gagea* species i.e. in the month of May and June these sites were found fully covered with the species of *Anemone*, *Gentiana*, *Ranunculus* and *Fritillaria*. In the month of June and July, these species after completion of their flowering were replaced by other plants such as *Potentilla*, *Geum*, *Rumex*, *Chaerophyllum*, and *Geranium*. In

July and August the pastures were packed with *Phlomis* and *Impatiens* and it was wet and difficult to walk through it. In due course of time these species also completed their short life cycle allowing growth of the next group of subsequent species like *Jurinea*, *Polygonum* and *Anaphalis* during the month of September–October. Thus, there was a marked sequential replacement of one species after the other.

In all 123 observations were made on 85 different herbaceous plants in the sub-alpine and alpine pastures. Out of these 85 plants, 38 were common both to sub-alpine and alpine pastures and 21 were specific to sub-alpine areas only. Thus, in all 64 species were observed in the case of Alpine pastures while 59 species were observed in the case of sub-alpine pastures (Table 4.50). Analysis of flowering data revealed that 8.94% plant species in sub-alpine pastures flowered in March–April whereas flowering in the case of alpine pastures was yet to commence (Table 4.51). In case of sub-alpine pastures, the peak value i.e. 45.76% flowering was in May–June while in the case of alpine pastures, the peak flowering to the extent of 56.25% plant species was observed in July–August. The % flowering in September–October had reduced drastically. Thus, only 5.08% species flowered in the case of sub-alpine pastures while remaining 14.06% studied plant species flowered in alpine pastures during these two months. Therefore, considering the peak flowering phase, it can be inferred that at least May–June were critical in the case of sub-alpine pastures while July–August months were of greatest significance in the case of alpine pastures.

Table 4.50 - Details of Flowering Plants in Sub-alpine and Alpine Pastures During Different Months

Month	Sl. No	Flowering Species	Distribution Alpine/Sub-alpine
March-April	1	<i>Corydalis rutaefolia</i>	SA
	2	<i>Fragaria nubicola</i>	SA
	3	<i>Gagea elegans</i>	SA
	4	<i>Oxalis acetosella</i>	SA
	5	<i>Oxygraphis polypetala</i>	SA
	6	<i>Paris polyphylla</i>	SA
	7	<i>Primulla denticulata</i>	SA
	8	<i>Primulla glomerata</i>	SA
	9	<i>Ranunculus diffusus</i>	SA
	10	<i>Trillidium govianum</i>	SA
	11	<i>Viola pilosa</i>	SA
May-June	1	<i>Allium humile</i>	A
	2	<i>Anemone rivularis</i>	SA
	3	<i>Anemone rupicola</i>	SA, A
	4	<i>Aquilegia pubiflora</i>	SA
	5	<i>Caltha palustris</i>	SA, A
	6	<i>Bergenia stracheyi</i>	SA
	7	<i>Capsella bursa-pastoris</i>	SA
	8	<i>Corydalis govianiana</i>	SA, A
	9	<i>Chaerophyllum villosum</i>	SA
	10	<i>Epipactus royleana</i>	SA, A
	11	<i>Euphorbia stracheyi</i>	SA, A
	12	<i>Euphorbia wallichii</i>	SA, A
	13	<i>Gentiana tubiflora</i>	SA, A
	14	<i>Geranium tuberaria</i>	SA
	15	<i>Gypsophila cerastioides</i>	SA,
	16	<i>Iris kemaonensis</i>	A
	17	<i>Lilium oxypetalum</i>	SA
	18	<i>Picrorhiza kurrooa</i>	SA, A
	19	<i>Podophyllum hexandrum</i>	SA,
	20	<i>Polygonum polystachya</i>	SA, A
	21	<i>Polygonum vivipara</i>	SA, A
	22	<i>Potentilla fruticosa</i>	SA, A

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Table 4.50 Contd...

Month	Sl. No	Flowering Species	Distribution Alpine/Sub-alpine
	23	<i>Potentilla penduncularis</i>	SA, A
	24	<i>Primula raptans</i>	SA, A
	25	<i>Ranunculus hirtellus</i>	SA, A
	26	<i>Rumex nepalensis</i>	SA, A
	27	<i>Taraxacum officinale</i>	SA, A
	28	<i>Tirfolium repens</i>	SA, A
	29	<i>Viola wallichiana</i>	SA
July-August	1	<i>Anaphalis triplinervis</i>	SA, A
	2	<i>Anemone polyanthes</i>	SA, A
	3	<i>Anemone tetrasepala</i>	A
	4	<i>Barbarea vulgaris</i>	SA, A
	5	<i>Cardamine macrophylla</i>	SA, A
	6	<i>Dactylorhiza hatagirea</i>	A
	7	<i>Epilobium laxum</i>	SA, A
	8	<i>Fragaria nubicola</i>	SA, A
	9	<i>Galearis stracheyi</i>	A
	10	<i>Geranium pratense</i>	A
	11	<i>Geranium wallichianum</i>	A
	12	<i>Geum elatum</i>	SA, A
	13	<i>Impatiens sulcata</i>	SA, A
	14	<i>Hackelia uncinata</i>	SA, A
	15	<i>Juncus thomsonii</i>	A
	16	<i>Lindelofia anchusoides</i>	A
	17	<i>Meconopsis aculeata</i>	A
	18	<i>Morina longifolia</i>	SA, A
	19	<i>Pedicularis bicornuta</i>	A
	20	<i>Pedicularis oederi</i>	A
	21	<i>Pedicularis pyramidata</i>	A
	22	<i>Phlomis bracteosa</i>	A
	23	<i>Polygonatum verticillatum</i>	SA, A
	24	<i>Polygonum amplexicaulis</i>	A
	25	<i>Potentilla atrosanguinea</i>	A
	26	<i>Potentilla microphylla</i>	A
	27	<i>Ranunculus pulchellus</i>	SA, A
	28	<i>Rheum emodi</i>	SA, A
	29	<i>Rhodiola imbricata</i>	A

Contd...

Table 4.50 Contd...

Month	Sl. No	Flowering Species	Distribution Alpine/Sub-alpine
	30	<i>Saussurea roylei</i>	SA, A
	31	<i>Sedum linearifolium</i>	SA, A
	32	<i>Silene tenius</i>	SA, A
	33	<i>Strobilanthes wallichii</i>	SA, A
	34	<i>Tanacetum longifolium</i>	A
	35	<i>Thalictrum alpinum</i>	SA, A
	36	<i>Viola biflora</i>	A
Sep-Oct	1	<i>Achillea millefolium</i>	A
	2	<i>Aconitum heterophyllum</i>	A
	3	<i>Aconitum violaceum</i>	A
	4	<i>Anaphalis triplinervis</i>	SA, A
	5	<i>Delphinium vestitum</i>	A
	6	<i>Jurinea macrocephala</i>	A
	7	<i>Saussurea graminifolia</i>	A
	8	<i>Urtica parviflora</i>	SA, A
	9	<i>Verbascum thapsus</i>	SA, A

SA=Sub-alpine A=Alpine

Table 4.51 - Phenology: Flowering in Sub-alpine and Alpine Pastures

Sl. No.	Months	Pastures		Overall Pastures (No. of species and %)
		Sub-Alpine (No. of Species and %)	Alpine (No. of Species and %)	
1	March – April	11 (18.64%)	0 (0%)	11 (12.94%)
2	May-June	27 (45.76%)	19 (29.68%)	29 (34.11%)
3	July-August	18 (30.50%)	36 (56.25%)	36 (42.35%)
4	September-October	03 (5.08%)	09 (14.06%)	09 (10.58%)
Total Species		59	64	85

4.6.5 Ground Cover

The ground cover composition in terms of proportion of grass, herb, weed, dung and rock across three disturbance zones from the centre point of each 'Thatch' or Alpine pasture was assessed and corresponding % values are presented (Table 4.52). More or less, the general trend of ground cover composition in nine pastures was resembling to each other as well as to that of TFCS. However, specific observations made in the case of nine Alpine pastures are discussed below:

- (a) In all cases, the proportion of dung in high disturbance zone or the center point of each 'Thatch' was nearly 40-45%. However, the % values of livestock dung greatly reduced in the low disturbance zone (0.50 – 2.52%), except in the case of Manoni pasture wherein the value as high as 10.83% was recorded. This general pattern of drastic reduction in dung intensity while moving away from the centre point clearly indicates that the intense pressure of grazing was highly localised due to night camping, otherwise grazing pressure was uniformly distributed.
- (b) The % values of grass considerably increased in all cases on moving away from the centre point. This again supports the above view that grazing pressure was highly localised that too in a very small area around the centre point of the 'Thatch'.
- (c) Like % values of grass, the % values of herb also significantly increased in all the cases while moving away from the centre point of 'Thatch'.

- (d) The intensity of weed was lowest in the low disturbance zone. Percentage values of weed in several cases were low in the high disturbance zone indicating that the intense livestock pressure has resulted into soil compaction, trampling, high nutrient level, grazing, etc. and this type of situation was not even allowing growth of weed plants.
- (e) The shrub layer was absent in all the cases.
- (f) Comparing to TFCS and as expected the Alpine pastures obtained higher values of overall dung (20.88%). Herbs still occupied >30% of the ground. Rocks covered nearly 1/5 of the ground. The overall value of grass was 10.88% while opportunistic plants covered >15% of ground (Fig. 4.6).

4.7 Conclusion

Grazing has a detrimental effect on communities with little history of grazing, but is necessary to maintain communities with a long history of grazing (Naveh and Whittaker, 1980; Andren *et al.*, 1997). This may be interpreted in two ways: (i) grazing is a disturbance for the former system, but not for the latter; (ii) grazing is, by definition, a disturbance and the former system is 'disturbance – prone' while the latter is 'disturbance – dependent'. Further, certain plant communities are more 'resilient' than others. Likewise, some communities may exhibit 'resistance' to grazing but may be sensitive to other natural or biotic factors (Rawat, 1998).

Table 4.52 – Ground Cover Composition Across Disturbance Gradient in Nine Alpine Pastures (Values in %)

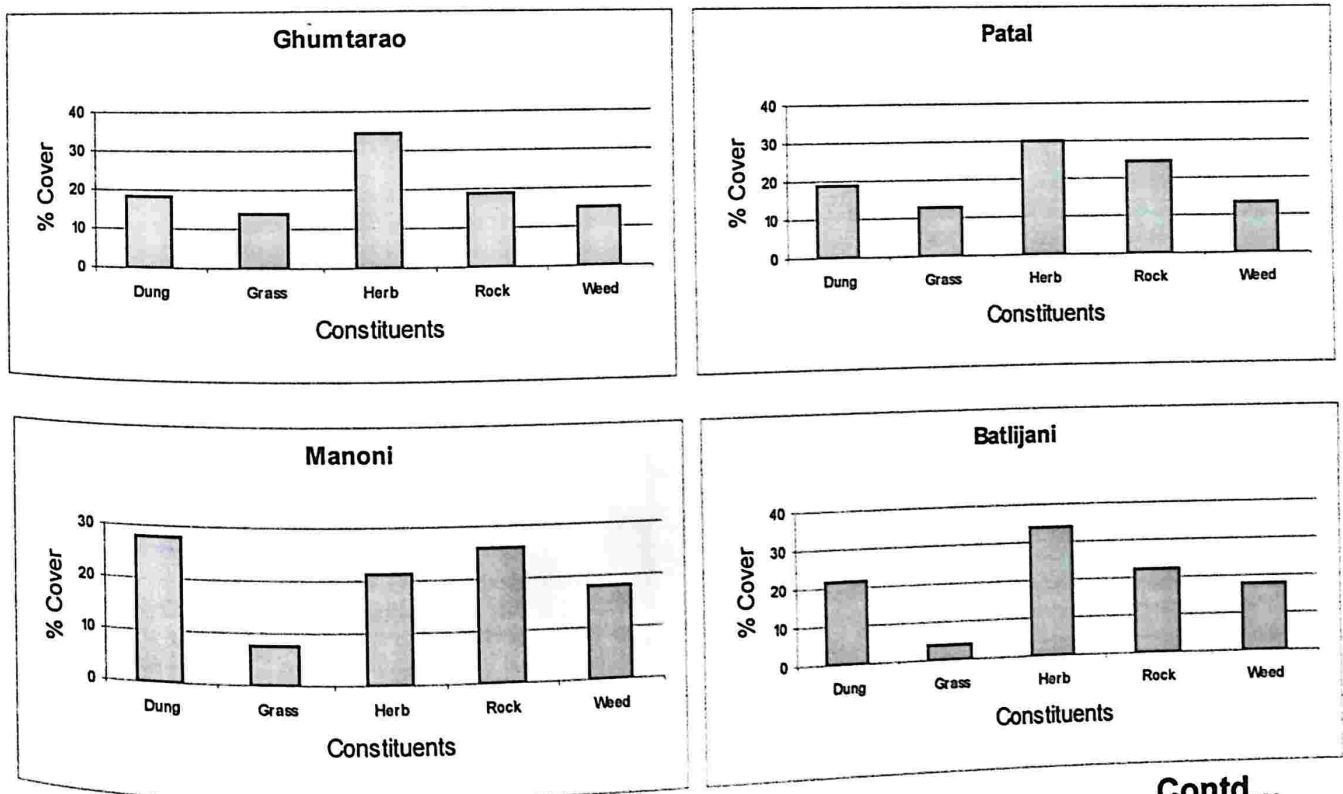
Sl. No.	Constituent	Disturbance Level			Overall AP
		High	Moderate	Low	
A. Ghumtarao					
1.	Dung	39.17	13.83	1.50	18.17
2.	Grass	6.33	12.00	24.00	14.11
3.	Herb	10.83	40.83	51.33	34.33
4.	Rock	23.67	19.17	13.17	18.67
5.	Weed	20.00	14.17	10.00	14.72
B. Patal					
1.	Dung	44.33	10.50	1.67	18.83
2.	Grass	6.33	11.83	20.33	12.83
3.	Herb	7.83	35.50	47.17	30.17
4.	Rock	26.50	27.50	19.83	24.61
5.	Weed	15.00	14.67	11.00	13.56
C. Manoni					
1.	Dung	43.33	29.67	10.83	27.94
2.	Grass	2.50	8.83	10.67	7.33
3.	Herb	8.83	11.17	43.17	21.06
4.	Rock	32.00	26.00	19.17	25.72
5.	Weed	13.33	24.33	16.17	17.94
D. Batlijani					
1.	Dung	46.33	18.50	1.00	21.94
2.	Grass	3.67	1.50	7.17	4.11
3.	Herb	6.50	33.67	60.67	33.61
4.	Rock	24.67	21.17	21.00	22.28
5.	Weed	18.83	25.17	10.17	18.06
E. Bhlundwari					
1.	Dung	44.33	20.83	1.83	22.33
2.	Grass	3.67	6.17	24.33	11.39
3.	Herb	4.50	32.33	49.50	28.78
4.	Rock	25.67	22.67	17.17	21.83
5.	Weed	21.83	18.00	7.17	15.67
F. Tharthadhar					
1.	Dung	46.00	14.00	1.50	20.50
2.	Grass	8.00	20.17	14.50	14.22
3.	Herb	10.33	31.83	60.83	34.33
4.	Rock	22.17	17.83	14.33	18.11
5.	Weed	13.50	16.17	8.83	12.83
G. Saketi					
1.	Dung	42.17	18.67	2.00	20.94
2.	Grass	2.00	8.33	9.33	6.56
3.	Herb	18.00	43.67	61.67	41.11
4.	Rock	21.17	17.00	21.00	19.72
5.	Weed	16.67	12.33	6.00	11.67

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Table 4.52 Contd...

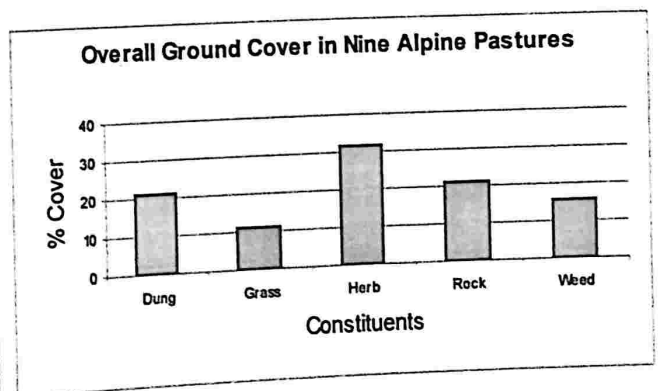
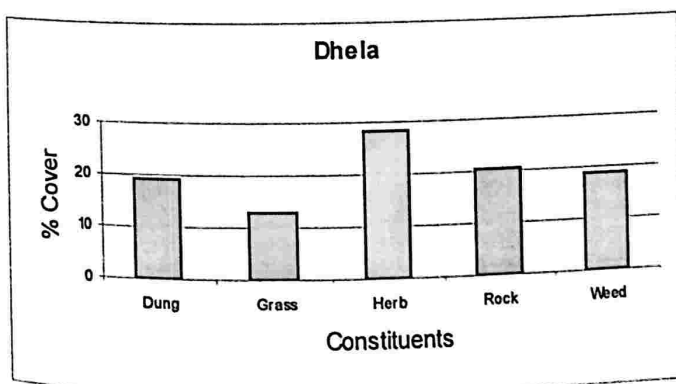
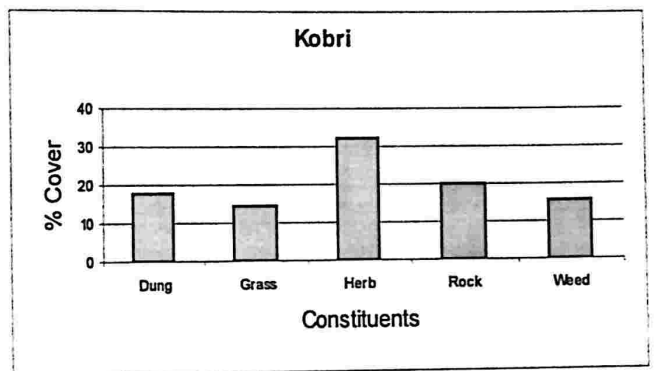
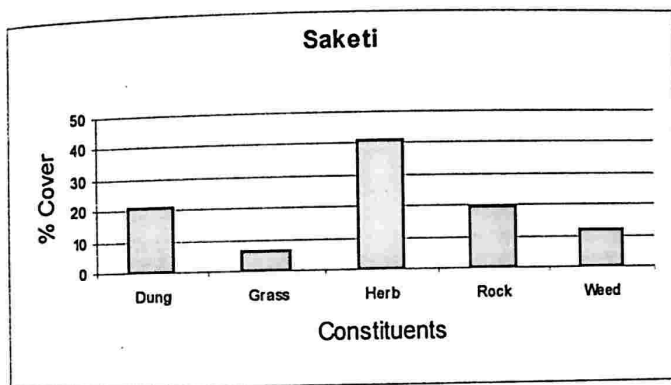
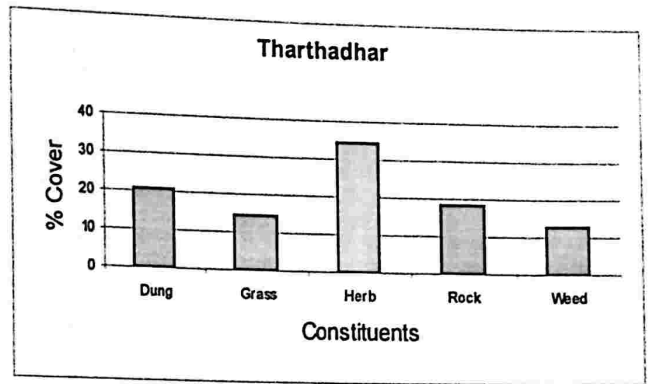
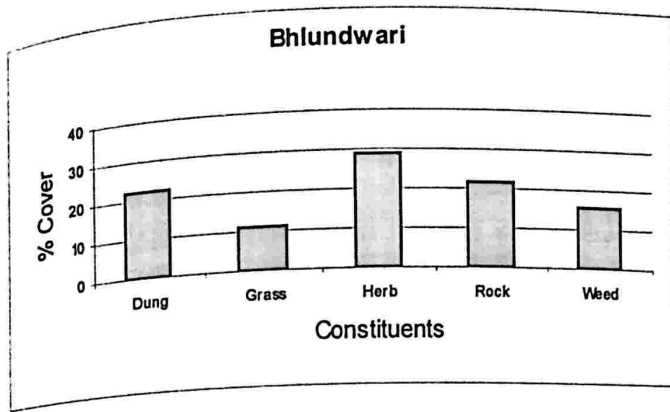
Sl. No.	Constituent	Disturbance Level			Overall AP
		High	Moderate	Low	
H. Kobri					
1.	Dung	41.00	11.33	1.83	18.06
2.	Grass	8.17	14.67	19.83	14.22
3.	Herb	10.00	32.33	54.17	32.17
4.	Rock	23.00	22.17	14.17	19.78
5.	Weed	17.83	19.50	10.00	15.78
I. Dhela					
1.	Dung	45.33	11.67	0.50	19.17
2.	Grass	6.00	14.67	18.67	13.11
3.	Herb	5.67	29.50	50.17	28.44
4.	Rock	27.83	17.33	16.50	20.56
5.	Weed	15.17	26.83	14.17	18.72
Overall – Nine Alpine Pastures					
1.	Dung	43.56	16.56	2.52	20.88
2.	Grass	5.19	10.91	16.54	10.88
3.	Herb	9.17	32.31	53.19	31.56
4.	Rock	25.19	21.20	17.37	21.25
5.	Weed	16.91	19.02	10.39	15.44

Fig. 4.6 – Ground Cover Composition in Various Alpine Pastures



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Fig. 4.6 Contd...



The migratory pastoralism is common throughout the Himalaya (Saberwal, 1999). Many herding communities (Bakrawals, Gujjars, Gaddi, Bhotias, Sherpas, etc.) in different regions of the Himalaya continue a long standing tradition of moving up to the alpine pastures for the summer and descending to the lower reaches in the winter. The transhumant pastoralism in the case of GHNPCA was no exception and it dates back to 2,000 years (Tucker, 1997). This fact illustrates that plant communities in various grazing resources of the GHNPCA must be disturbance dependent. It is therefore, obvious that such 'disturbance dependent' communities have evolved over a long period and also have an in-built mechanism of 'resiliency' and 'resistance'. Thus, these plant communities are able to sustain some level of grazing and maintain their diversity.

The foregoing description based on empirical results justifies that the pastoralists in the GHNPCA have followed strict means of seasonal utilisation of various grazing resources. Not only this, the resource use pattern at any one time was also widely distributed. Comparative to many other similar areas elsewhere, the overall grazing pressure in the GHNPCA has remained low. Even this low pressure was well distributed across various sub-watersheds, scattered Village surrounds, several migratory routes and numerous temperate, sub-alpine and alpine pastures. This type of spatial and temporal use of various grazing resources has thus, allowed to maintain a high level of species diversity. This can be substantiated by the fact that the

majority of the Village surrounds, Transitory Forest Camping Sites and Alpine pastures have maintained high and unique diversity in spite low to moderate level of grazing pressure. In many instances, the grazing and other biotic pressures recorded and its reflections were highly localised in nature.

As such the present intensive field study and subsequent analysis of large data sets across four types of grazing resources has not provided a clue or even single evidence which reflected severe impairment of natural system and its diversity.

Grazing Practices and its Socio-Economics

5.1 Grazing Practices

Livestock grazing practices based on a seasonal exploitation of vegetational resources along altitudinal gradients have been a common feature for most of the mountain systems across the world (Netting, 1981; Goldstein *et al.*, 1990; Brower, 1991; Phillimore, 1982; Saberwal, 1999). The high altitude transhumant migration in the case of GHNPCA is one among them. Shepherds in the GHNPCA had grazed their flocks of sheep and goat throughout different temperate forests and alpine pastures much prior to the beginning of written records (Tucker, 1997). This Chapter therefore, intends to examine the age old grazing practices and establish its linkages with the present socio-economics of the dependent community.

5.2 The Pastoral System

This section describes the nature and extent of grazing rights, livestock holdings, pastoral cycle – migratory routes and different grazing resources used, allied activities, and livestock–wild animal interactions.

5.2.1 Grazing Rights

The earliest official reference for the settlement of Kullu forests dates back to 1866. During this year, the District authorities were directed to handover the possession of forests to the Forest Department. Till then, these forests were managed by the District authorities. The recommendations made by the then Settlement Officer (Mr. Lyall) were lost sight of as early as 1870s. In 1876, Mr. Dietrich Brandis, the then Inspector General of Forests visited the region and expressed concern about the ill effects of increasing grazing pressure on these forests. It was in 1878, that the forests were classified and demarcated as the Reserved Forests (RFs) and Protected Forests (PFs) of different classes in accordance with the Forest Act, 1878.

Subsequently, Mr. Alex Anderson worked for full five years and submitted a monumental 'Forest Settlement Report' in the year 1886, providing minuscule details of rights granted to the local people (Anderson, 1886). However, a debate among forest officials and local people continued for a considerable time with regard to the fixing of ceilings of overall numbers of villagers, their livestock and rights of grazing to 'outsider' pastoralists from the adjacent areas. It was finally decided not to fix any numerical limits. The chief livestock usages described in the Settlement Report of 1886 were: (i) grazing was open to cattle, sheep and goat, except in a few fenced portions, (ii) trees could be lopped for fodder inside as outside the forest, and (iii) grass could be cut wherever it was found. It took exactly ten years (1886-1896) for the Government to finally adopt the Anderson's Report. Later, these forests were

managed scientifically on the principles of silviculture and prescriptions as laid in the periodically revised Forest Working Plan(s). These consequent Forest Working Plans recognised and continued with rights those were described in the Settlement Report of 1886. Further details on the chronology of events and extended rights under each category of usage have been described by Nangia *et al.*, (1999), Tucker (1997) and Baviskar (1998). Noticeably, the Settlement Report in its unequivocal remark stated that, in Kullu, it would be 'impossible' to commute rights by cash payments since 'the people are dependent on these rights for their very existence and the extinction of these rights would be most unjustifiable expropriation' (Baviskar, 1998). This very fact deterred any action regarding revision/settlement of rights for a long span of 113 years (1886-1999). During this long period, the landscape and the human population that the Anderson's Report had described have radically transformed. While the desired actions to revise the Settlement Report or extinguish rights described therein have not kept pace with the changing demography growing market forces and several conservation related laws enacted time to time.

At last, recently i.e. in the beginning of year 1999, the Government of Himachal Pradesh instead of revising these long established rights, ultimately decided to extinguish rights forever in order to bring the long awaited final notification of the GHNP. Through a rapid course of proceedings, multiple traditional rights – either full rights or exclusive for the collection of medicinal plants, timber, non-timber forest produces and livestock grazing in the area of the Great Himalayan National Park (pre-revised 765 sq km and finally notified

754.4 sq km) were ceased on 21 May, 1999 by the Notification issued by the District Collector, Kullu by making provisions for the cash compensation and proposed alternative development of pastures, fodder and medicinal plants. The notification on the final settlement of rights and declaration of the National Park has resulted into: (i) the abrupt non-availability of the GHNP area or 64.42% of the GHNP-CA landscape to the resident as well outside migratory people for any type of resource use; (ii) an over-burdening of resource use in the remaining area; (iii) constrained resource use and ensuing conflicts; and (iv) a great challenge for the PA staff to protect park resources and enforce law.

5.2.2 Land and Livestock Holdings

Like elsewhere in India, most of the cultivated land in the GHNP-CA was in small and scattered holdings of less than 1.5 ha. During the present investigations, a questionnaire survey conducted in 874 households representing 74 hamlets and across different sub-watersheds revealed an average land holding of 15.6 'Bighas' or 1.25 ha. The cultivators largely depend on bullock labour for tillage. The farming system including cultivation of cereals, pulses, vegetables and fruits was mainly carried out on the terrace land. As such the farming is the backbone of the local economy and thus, also the primary occupation of the inhabitants. The livestock rearing is the second main profession supporting: (a) agricultural activities through tillage labour, manure; (b) subsistence through meeting different needs of food and fibre; (c) economy through an additional income from sale of livestock and

livestock products; and (d) an overall insurance for livelihood against any natural vagary.

Bulk of the livestock in the GHNPCA was constituted by sheep and goat in addition to the essentially required number of cow and ox for milk and tillage purposes, respectively. Buffalo were usually not kept. A small number of mules and horses also made a part of the overall livestock, mainly used for transportation of goods.

Prior to the study, little information or trends on the livestock population and livestock holdings for the landscape under consideration was available. Moreover, it was difficult to discern any pattern, mainly on the account of different estimates documented from time to time for: (i) varying areas (Seraj, Outer Seraj, Inner Seraj, GHNP while there was no mention of Tirthan WLS, Sainj WLS and Ecodevelopment zone); (ii) resident vs. migratory livestock; and (iii) total livestock vs. sheep and goat only. The **Table 5.1** depicts a comparative account of livestock estimates based on the available different sources.

The salient highlights of earlier references were as follows:

- (i) The sheep and goat had constituted the bulk of livestock at any given time.
- (ii) No major change in the livestock pattern was evident.

Table 5.1 – A Comparative Account of Livestock Estimates

Sl. No.	Specified Area	Type of Livestock	Resident/Migratory/ Total Livestock	Estimate Number	Reference
1	Inner Seraj (GHNPCA and beyond)	Sheep and Goat	Total	14,583	Anderson (1886)
2	GHNP (Presuming present GHNPCA)	Sheep and Goat	Local origin	25,000	Gaston and Garson (1992)
			Migratory adjacent area	10,000	
			Total	35,000	
3	GHNP (Presuming present GHNPCA)	Sheep and Goat	Ecodevelopment Zone	20,645	Negi (1996)
			Adjacent Area	15-20,000	
			Total	35,645 - 40,645	
4	GHNP (Presuming present GHNPCA)	Total Livestock inclusive of cow, sheep and goat	Total Resident as well as from adjacent areas	19,146	IIPA (1995)

- (iii) The density of livestock in the area under consideration has always remained low in comparison to several other adjacent areas.
- (iv) The seasonal migration has been a traditional feature throughout specifically in the case of sheep and goat.
- (v) No evidence for significant increase in livestock number exists in spite a long time has passed.
- (vi) Despite an evident increase in human population through the past period, there was hardly any reliable evidence indicating proportionate increase in the livestock population.

Two types of assessments were made during the present study for the quantification of livestock in the GHNP. Firstly, 24 visiting groups of migratory sheep and goat to alpine pastures were identified based on interviews and by intercepting them at entry/exit points. Out of these 24 groups, 8 were from outside the GHNP while rest 16 were resident of the GHNP (Table 5.2).

Table 5.2 - Details on the Livestock Groups Those Visited Alpine Pastures (Values in Number)

SI No	Place of Origin	Visiting Livestock			Destined Alpine Pastures	Sub-Watershed
		Sheep	Goat	Total		
A Within the GHNP						
1	Nahi, Silinga, Katlinga	265	205	470	Kobri	Tirthan
2	Ghat, Lagcha, Shrikot	400	350	750	Kobri	Tirthan
3	Daran, Sungcha	600	200	800	Bhundwari	Tirthan
4	Dingcha, Jhalari, Tinder	1000	810	1810	Asurbagh	Tirthan
5	Dhara-shilinga, Chipini	290	280	570	Bhogara Dunga, Phupu	Tirthan
6	Janiyar, Banogi	290	240	530	Phupu, Dharach	Tirthan
7	Thanagad, Kamada	1000	940	1940	Ashurbagh	Tirthan
8	Pakhari, Manahara, Palach, Kulthi	350	360	710	Dhela	Sainj
9	Lapah, Shangarh	700	800	1500	Charkera	Sainj
10	Nohanda	300	200	500	Dhela	Sainj
11	Pashi	250	300	550	Ratithati	Jiwa
12	Sharan	240	280	520	Lahlibati	Jiwa

Contd...

Table 5.2 Contd...

Sl No	Place of Origin	Visiting Livestock			Destined Alpine Pastures	Sub-Watershed
		Sheep	Goat	Total		
13	Raila	300	400	700	Kandi	Jiwa
14	Shainsher (Khain)	500	700	1200	Kandi	Jiwa
15	Shainsher (Tung, Talara)	450	600	1050	Kandi, Barohi	Jiwa
16	Ropa	540	800	1340	Ranka	Jiwa
Sub - Total Within the GHNPCA		7,475	7,465	14,940		
B.	Outside GHNPCA					
1	Outer Seraj	500	300	800	Tharthadhar	Tirthan
2	Outer Seraj	900	600	1500	Saketi	Tirthan
3	Outer Seraj	400	300	700	Bandyog	Tirthan
4	Outer Seraj	700	800	1500	Rala, Munda-Tapra	Sainj
5	Outer Seraj	380	360	740	Rakti	Sainj
6	Outer Seraj	800	500	1300	Kamba	Sainj
7	Outer Seraj	600	500	1100	Jaraun	Sainj
8	Outer Seraj	500	200	700	Dhela	Sainj
Sub - Total Outside GHNPCA		4780	3560	8340		
Grand Total		12,255	11,025	23,280		

A total of 23,280 sheep and goat belonging to 24 groups visited different alpine pastures during the summer season of 1996. This figure was based on an actual enumeration. Nearly 2/3 or 64.2% of sheep and goat those reached to alpine pastures belonged to the Ecodevelopment zone while rest about 1/3 or precisely 35.8% came from outside the GHNPCA. Of the total migratory livestock, sheep constituted 52.6% while rest 47.4% were goat. The overall sheep to goat ratio was 1:0.09.

Based on their destined alpine pastures, 42.4% migratory sheep and goat utilized alpine pastures in the Tirthan SWS, 34.5% in Sainj SWS and rest 23.0% in Jiwa SWS (Table 5.3).

Table 5.3 - Distribution of Migratory Sheep and Goat in Different Sub-watersheds

Sl. No.	Sub-watershed	No. of visited Groups	Livestock		
			Sheep	Goat	Total
1	Tirthan	10	5,645	4,225	9,870
2	Sainj	08	4,330	3,720	8,050
3	Jiwa	06	2,280	3,080	5,360
	Total	24	12,255	11,025	23,280

The maximum number of livestock groups, being 10 had their destined alpine pastures located in the Tirthan SWS, followed by 8 groups to alpine pastures in Sainj SWS. Only six groups visited alpine pastures in the Jiwa SWS.

Secondly, a questionnaire survey was administered on the 874 households of 5 'Kothis' (village clusters) viz., Raila, Shansher, Sangarh, Nohanda and Tung out of a total 8 'Kothis' in the GHNPCHA to estimate the livestock population. The **Table 5.4** provides details on the actual counts for different categories of livestock, mean, median and range values based on 874 respondents. The mean values were obviously on the higher side due to a large range of minimum and maximum values within samples. Thus, using mean values alone, a livestock population of 36,000⁺ was estimated for the entire landscape. This was probably an over-estimate of the livestock population.

On the contrary, the median values alone gave a livestock population of 20,800⁺ which was probably an under estimate. In order to arrive at a realistic estimate, average of mean and median values was used in each case and values were extrapolated for the total 2,313 households in the GHNPCA. Based on this type of analysis, it can be concluded that the total livestock population estimated to be about 28,500⁺. The average holdings/household of cow, ox, sheep and goat were 2.6 \pm 1.8; 2.0 \pm 1.8; 6.3 \pm 8.9; and 4.5 \pm 7.9, respectively.

Table 5.4 - Values of Actual Count, Mean, Median and Range For Different Categories of Livestock in Five 'Kothis' of the GHNPCA (Values in number).

(n = 874 households)

SI.No.	Values	Livestock						
		Cow	Ox	Sheep	Goat	Mule	Horse	Total
1	Actual Count	2,335	1,778	5,574	3,998	53	16	13,754
2	Mean	2.6	2.0	6.3	4.5	0.0	0.0	15.7
3	Median	2.00	2.00	3.00	1.00	0.00	0.00	9.00
4	Standard Deviation	1.8	1.9	8.9	7.9	0.4	0.1	18.1
5	Range	15	32	80	70	6	2	135
6	Derived Value (Mean + Median)	2.3	2.0	4.6	2.7	0.03	0.01	

The break up of the estimated livestock population category wise is presented in **Table 5.5**. Accordingly, 9,000–11,000 cattle and 16,000–18,000 sheep and goat in an overall resident livestock of 25,000–29,000 for the entire landscape were estimated. In addition, an outside pressure of migratory sheep and goat from the outer Seraj area was also dependent upon the forests and alpine

pastures in the GHNPCA. Thus, the GHNPCA had a cumulative grazing pressure of 33,000–38,000 resident as well as migratory livestock during the period of present study. Pre-dominantly native breeds constituted the resident as well as migratory livestock. However, a few farmers and pastrolists kept small numbers of exotic breeds or their hybrids viz., 'Jersey' in the case of cow while 'Marino' in the case of sheep.

Table 5.5 - Estimated Dependent Livestock Population on the GHNPCA

SI.No.	Category	Holdings per households (No.)	Estimated Range
A – Resident Within GHNPCA			
1	Cow	2.3	5,000 – 6,000
2	Ox	2.0	4,000 – 5,000
3	Sheep	4.6	10,000 – 11,000
4	Goat	2.7	6,000 – 7,000
5	Mule	0.06	125 – 150
6	Horse	0.01	20 - 30
Estimated Resident Livestock			25,000 – 29,000
B – Migratory Sheep and Goat From Outside GHNPCA			8,000-9,000
Estimated Total – Dependent Livestock on the GHNPCA			33,000 – 38,000

5.2.3 Grazing Cycle

The grazing cycle followed by resident and migratory pastrolists in the GHNPCA has evolved over a long period. It was primarily based on the principles of optimum use of grazing resources; adjustment to varying weather

conditions; mutual work sharing and community approach. These four principles and migration pattern are discussed in the following paragraphs.

5.2.3.1 Grazing Principles

The traditional activity of livestock rearing was managed through long standing local structures which minimize the occurrence of conflicts between villagers and pastrolists. Year after year, the livestock grazing in the GHNP CA has been managed by involved pastrolists in a smooth, coordinated and efficient manner. Each pastrolist followed a well defined grazing route, camping sites, grazing resources and duration of their stay or resource use in each of the site. The grazing routes were so meticulously worked out that it automatically minimized the possibility of over use, mixing up of flocks and resultant conflicts. The indigenous knowledge of grazing routes, grazing resources, tit bits of the survival strategy in adverse climatic conditions and also managing own needs of food and cover in the interiors of the landscape are systematically passed on from one generation to another. The unkind field conditions have made people to learn principles of sharing and participation. Thus, pastrolists have learnt a great deal to live in groups; and share space, work, food, responsibilities and feelings. A greater involvement of the community approach was evident in the entire organization of the transhumant pastrolism. For this inbuilt feature of the community approach, pastrolists and villagers do not recall any occasion where a conflict was resolved by a third party. Further, an old practice has continued wherein often

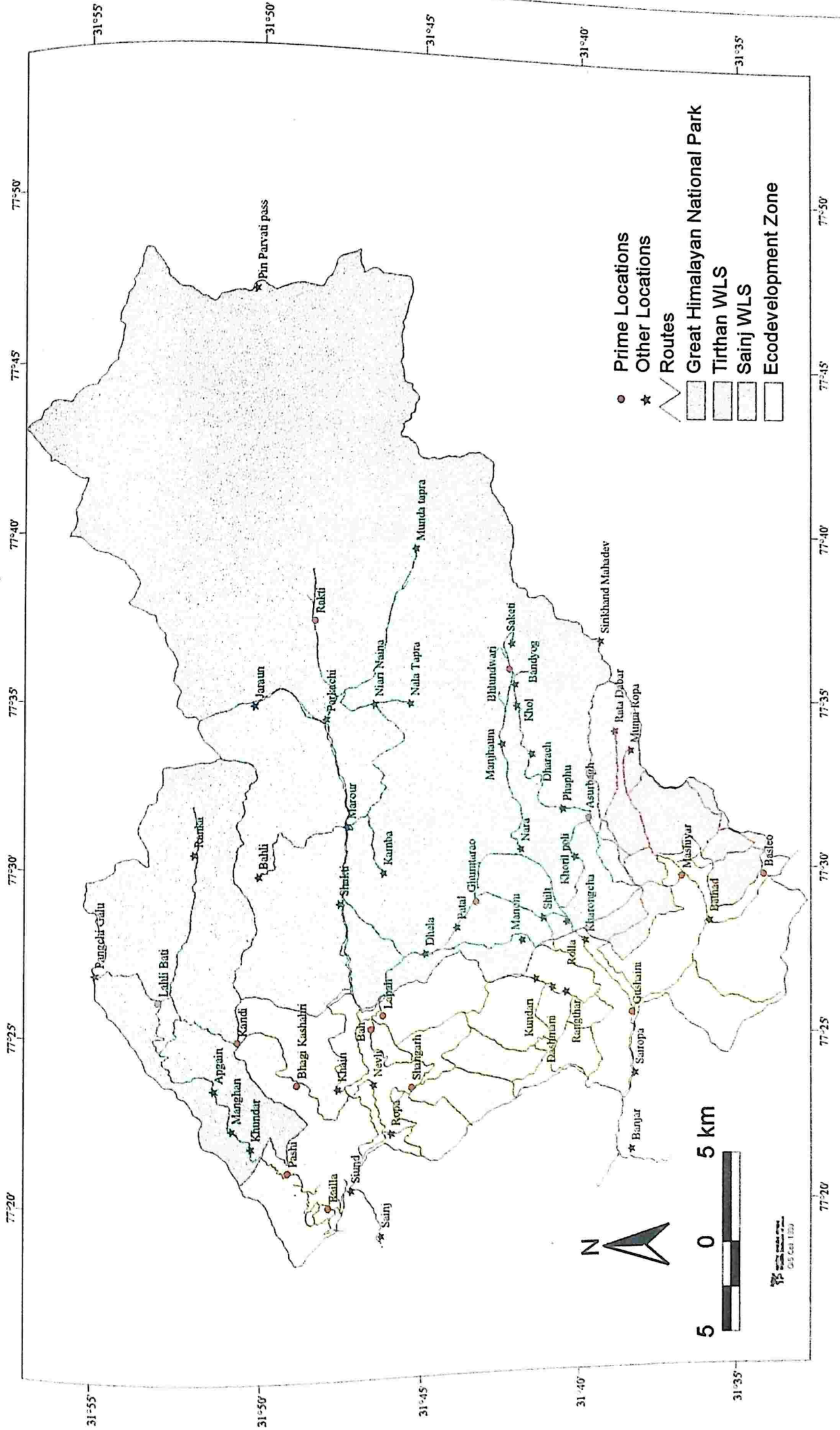
a pastrolist either takes animals belonging to the other member of the same village or other village during summer migration or acts as a hired labourer.

5.2.3.2 Grazing Pattern

As described earlier, well defined grazing routes are adopted by each visiting livestock group year after year. Fig 5.1 depicts a network of grazing routes across three sub-watersheds. The Parvati SWS was not used by pastrolists. Locally a pastrolist is called as 'Phual' while a pasture in TFCS or alpine areas as 'Thach'. The migratory livestock from outside areas entered in the GHNPCHA mainly from Gushaini and Basleo Pass in the Tirthan SWS. Three to four important places in each of the SWS made common meeting points during summer migration for pastrolists originating from different hamlets. These predominant initial hubs were: (i) Basleo Pass, Mashiyar and Gushaini in Tirthan SWS, (ii) Shangarh, Bah and Lapah in Sainj SWS; (iii) Pashi, Bhagi Kashahri and Railla in Jiwa SWS. Likewise, prime hubs in the alpine pastures were: (i) Asurbagh, Bhlundwari, Manoni and Ghumtarao in Tirthan SWS; (ii) Dhela and Rakti in Sainj SWS; and (iii) Lahli Bati, Ranka and Kandi in Jiwa SWS. Each migratory group camped at several Transit Forestry Camping Sites (TFCS) before reaching either the destined alpine pastures or back home.

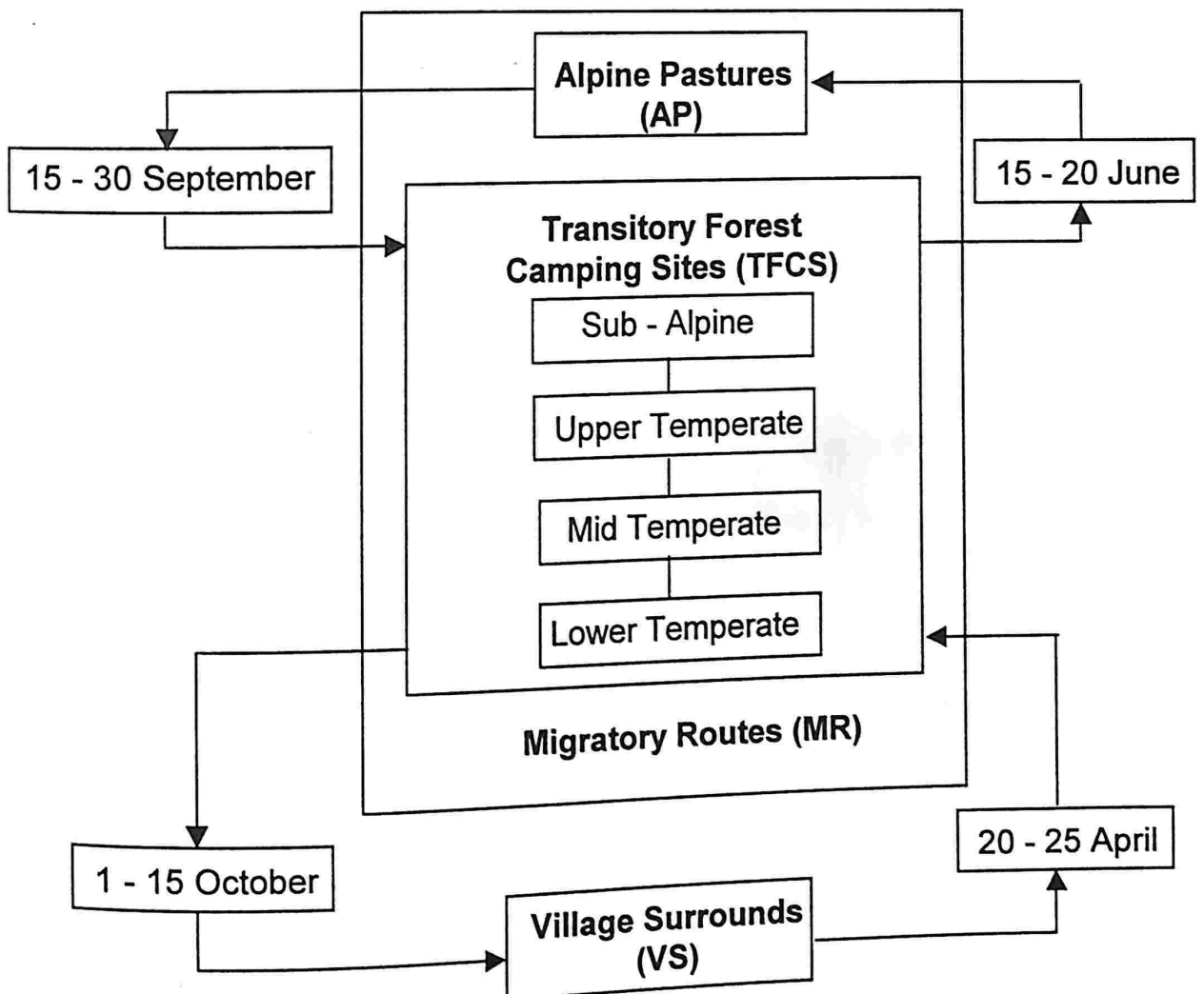
The flock size of sheep and goat varied from a smallest of 470 heads to the largest comprising 1,940 individuals. The flock size of pastoralist groups those visited different alpine pastures in Tirthan SWS were usually larger.

Fig. 5.1 - Major Migratory Routes in the Great Himalayan National Park Conservation Area



The seasonal upward migration generally started in the second fortnight of April. Nearly 2-month time was spent in traversing different temperate forests and intensive grazing in and around several TFCS during their short duration stay at each location prior reaching to the alpine pasture. Later, in each case almost a 3-month time was spent for intensive grazing across a set of alpine pastures. The return journey commenced in the second fortnight of September. While on the return journey, almost a month's time was spent through different forests before the final arrival in home village some time in the first fortnight of October. This general pattern of seasonal migration is presented diagrammatically in Fig 5.2.

Fig 5.2 - Seasonal Migration Cycle



Slight variations in migration schedule were noticed, mainly influenced by the onset of snowfall or snow melt or unprecedented rains. Monsoon rains were usually in the form of light showers. Interestingly, pastrolists played a significant role as 'path finders' or 'path makers' every year since they visited upper reaches first of all after a long winter season. Likewise, they returned first immediately after the rainy season. Several trail linkages made up of the wooden bridges were washed away during the year 1995 due to floods. Pastrolists re-established these linkages, thus facilitating movement of herb collectors and PA staff to the forest interiors and upper reaches.

The upward movement of livestock also coincided with the cropping season. Prior to the commencement of upward journey, flocks manured crop fields being prepared for the sowing of 'Kharif crop'. The Kharif crops were harvested before the return of pastrolists in October. Again on livestock return, farmers were active in the preparations of sowing of 'Rabi' crop. Thus, flocks again manured crops fields prior to the sowing.

The sheep lambing usually completed during January–February and lambs were weaned much before the pastrolists left for the upward migration and weaned lambs were able to accompany the migrating flock. In order to adjust with the migratory pattern, entire lambing was confined to 2-3 months when they were in village surrounds. Thus, there was only one peak of lambing during January. Sheep were shorn prior to the commencement of upward migration. They were ready for the second time shearing on their arrival in the village surrounds in the first fortnight of October. Goat were shorn only

once in a year and that was prior to the upward migration. This one time shearing in the case of goat was mainly to obtain optimal staple length.

5.3 Livestock – Wildlife Interactions

Livestock grazing in the GHNPCA was the central activity. Migratory livestock covered length and breadth of the landscape, obviously it comes into contact with different floral and faunal communities. Prominent inter-relationships among plant communities, wildlife, livestock, etc. have been dwelt upon in the Chapter 3. The floral and faunal communities as such have evolved with the seasonal pressure of livestock. Thus, it can be said that several plants and animals must be 'grazing dependent'. Regulated grazing might be thus, facilitating seed dispersal; stimulating plant regeneration and growth, providing foraging material to a large number of organisms – mainly beetles, earthworms and birds and also to some extent stimulating grass growth.

5.4 Impact of Livestock

A great volume of literature world wide exists which deals with different types of impact of livestock grazing on wild flora and fauna in different forests and grasslands. Majority of such studies have provided a broad spectrum of adverse impacts highlighting deleterious effects of excessive grazing or overgrazing. In view of this, it was neither desired here to present an extensive review describing adverse effects of livestock grazing nor this study at any time considered to look into the aspects of livestock grazing in the

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GHNPCA from such presumption. Instead the present study made an attempt to view the livestock grazing in the GHNPCA in a holistic manner. However, an attempt was made to analyse different types of impact viz., direct vs. indirect; short term vs. long term; and -ve impact vs. +ve impact or undetermined impact on the physical, biological and social environments of the GHNPCA. Existing or potential impacts are highlighted in Table 5.6 which are more or less self-explanatory.

Table 5.6 - Impact of Livestock Grazing on Different Sub-Environments

Sl. No.	Sub-Environment or Activity/ Process	Type of Impact	Observations and Remarks
A. Physical Environment			
A1	Soil Compaction	Direct, -ve, Short/ Long Term	Localised soil compaction in intensive grazing/movement zones in VS, MR, TFCS and AP witnessed. Small 'Piospheres' have been created. In many cases these Piospheres rejuvenate due to protection or favourable climatic conditions. Area of such impact was small and insignificant at the landscape as well site level.
A2	Soil Erosion	Direct, -ve, Long Term	Soil erosion due to selection of same trails and vegetation removal can lead to soil erosion. The traditional strategy of well distributed spatial resource use minimizes this problem. No major signs of soil erosion just along trails or camping sites due to livestock grazing were witnessed.
A3	Soil Fertility	Direct, +ve and -ve, Short and Long Term	Fertility in Piosphere was definitely enriched resulting into preponderance of opportunistic nitrophilic plants. In case of VS, fertility of land was enhanced. The extent of opportunistic plants in three SWS or different TFCS and AP was not alarming despite livestock grazing has continued in those sites year after year. This was again due to spatial and seasonal distribution of pressure.
B. Biological Environment			
B1	Species Diversity	Direct, +ve and -ve, Long Duration	As such no observation/information available about decline or permanent adverse effect on a floral/faunal species diversity due to livestock grazing alone in the GHNPCA. Temporary fluctuations did occurred. Instead the spatio-temporal use of grazing resources has maintained the heterogeneity.

Contd...

Table 5.6 Contd...

Sl. No.	Sub-Environment or Activity/ Process	Type of Impact	Observations and Remarks
B2	Habitat Availability and Use	Direct, -ve, Short and Long Term	The constant availability and movement of livestock, pastrolists and accompanying dogs in alpine pastures during 3-month period normally prohibit habitat use (alpine pasture) by wild animals viz., Himalayan Tahr, Blue Sheep, Musk Deer and Himalayan Brown Bear to forage. However, it appears that these animals have developed a different niche – using steep slopes. No evidence of population decline just due to the restriction on habitat use by livestock exists.
B3	Harvest of grass in Village Pastures (Ghasnis)	Dirct, +ve, Long Term	Harvest of grass from Ghasnis can lead to degradation and disturbance to grass dependent animal species. The protection of Ghasnis during 'active growth period' and prohibiting livestock grazing was not only helping in the maintenance of grass diversity and productivity but also helped grass dependent organisms.
B4	Lopping and Girdlings of trees – collection of Fodder, Livestock Bedding Material and Fuelwood	Direct, -ve, Long Term	Lopping and girdlings of trees in Village surrounds for fodder, livestock bedding material and fuelwood purposes was common. However, data revealed that the pressure was confined to small high disturbance zone in proximity to VS. Again, no severe impact due to this activity was evident as 127 hamlets and individual households were widely distributed. The overall pressure was therefore, not acute. Tree regeneration of prominent timber and fodder trees was fair. Collection of fuelwood from sub-alpine areas was definitely alarming. Unchecked lopping of Oak trees for collection of lichens may affect livestock and several wild ungulates, primates and pheasants.
B5	Fire	Direct, Mainly –ve, Short and Long Term	No significant/major fire – natural or man made in different temperate forests and alpine pastures was witnessed during the present study. Some old signs of fire at TFCS were recorded. People make use of fire in 'Ghasnis' in order to facilitate new shoots. This may have –ve impact on the ground dwelling organisms and birds.
B6	Disturbance to Nests and Predation by Accompanied Dogs	Direct, -ve, Long Term	Direct impact in terms of damage of nests of ground nesting birds including of endangered Western tragopan, monal and pipets. Occasional chasing, injury and predation of young ones of wild ungulates viz., goral, musk deer. Predation on cub of Red fox was witnessed during the present study. However, this type of impact can be reduced and checked.

Contd...

Table 5.6 Contd...

Sl. No.	Sub-Environment or Activity/ Process	Type of Impact	Observations and Remarks
B7	Disease Communication	Direct, -ve, Long Term	No available records or information through village elders regarding well known disease outbreak among wild animals due to livestock or any other reason.
B8	Collection of Medicinal Herbs	Direct, -ve, Long Term	Some evidences of pastrolists gradually turning into herb collect due to a lucrative market were recorded. Some of the medicinal herbs those are in the high demand were sparsely distributed and thus, less abundant.
C. Social Environment			
C1		Direct, -ve, Immediate	Livestock predation to the extent of >0.5% in any given year by leopard, Asiatic Black bear and Himalayan Brown bear was a concern of local people. The PA authorities have compensated the owners. As such declining evidence of this problem. It may be due to decline in population of predators or pastrolists/villagers taking due care.
C2	Human Injuries/Kills	Direct, -ve, Immediate	Villagers and Pastrolists spend considerable time in forests and alpine pastures for collection of forest produces and livestock grazing and they are prone to encounters with wild predators. Only >5 incidences reported during the last 4-5 years.

5.5 Livestock Dependent Socio-economics

The pivotal role of livestock in the socio-economics of the local people inhabiting the GHNPCA and beyond can not be over-emphasized. Broad aspects of the socio-economics have already been dwelt upon in the foregoing Chapters/Sections. The present section therefore, specifically focusses on the livestock based subsistence or socio-economics of the dependent communities. The result presented here are based on a questionnaire survey carried out on 874 households or constituting 37.7% of the total households in the GHNPCA.

Surveyed households (874) had a total population of 5,525 people (1,729 men, 1,655 women and 2,141 children). This gave an average family size of 6.3 members.

An indepth analysis of livestock holdings revealed noticeable features mismatching with several common beliefs. A small segment (5.6%) of the total households did not possess any kind of livestock (Table 5.7). Another ¼ of the total households (27.0%) just possessed upto 5 animals of different types of livestock. 5.84% of the households were without any cow. More than half of the households (53.6%) just had none or two cows only. Likewise, 15.9% households did not possess any ox. Majority of the households (62.0%) kept only upto a pair of ox, mainly used for tillage labour. Interestingly, 29.6% of the surveyed households did not possess even a single sheep. Another 52.7% of the households possessed small sheep holdings ranging from 1-10 animals. A small proportion of surveyed households or 6.1% had > 20 sheep. Similarly, 45.0% of the households did not had any goat. Another 15.1% household just had 1-2 animals. Only 4.2% households possessed >20 goats. Only a very small segment of households (<1.5%) kept mule and horse that too in small numbers. This detailed analysis indubitably illustrates that the majority of the households had very small to small holdings of livestock. Such small holdings predominantly catered to the requirements of subsistence.

Table 5.7 - Household-wise Distribution of Livestock Holdings (Values in %)

Sl. No.	Livestock	Total Count	Range of Animal holdings						
			0	1-2	3-5	6-10	11-20	21-30	>30
1	Cow	2,335	5.8	53.8	32.6	7.0	0.5	0.0	0.0
2	Ox	1,778	15.9	62.0	17.9	3.5	0.4	0.0	0.1
3	Sheep	5,574	29.6	16.9	19.7	16.0	11.4	4.0	2.1
4	Goat	3,998	45.0	15.1	17.1	9.8	8.5	2.6	1.6
5	Mule	53	98.4	0.2	1.2	0.1	0.0	0.0	0.0
6	Horse	16	98.2	1.7	0.0	0.0	0.0	0.0	0.0
Overall Livestock		13,754	5.6	7.7	19.2	22.4	20.5	9.7	14.6

The social system was based on the stationary family units. Crops were raised as the main occupation. The animals were maintained primarily to support the crop by way of power and manure, and to meet the animal-protein needs of the household. Crops were rain dependent in most of the areas as the irrigation facilities are minimal. Male members in the family were primarily responsible for herding, rearing and grazing of sheep and goat and moved along with their flocks to the summer grazing areas. Men were also involved in other outdoor activities *viz.*, agriculture, collection of fodder and marketing. Shearing of wool/hair in the case of sheep and goat was mainly done by men. Stall feeding, milking, cleaning of house and livestock sheds, dung collection and other household activities were mainly performed by women. Processing of fiber (wool/goat hair), spinning and preparation of woolen garments and other artifacts were jointly done by men and women. Likewise, women also actively participated in the various activities of agriculture. A small number of people were in the Government jobs.

In general, men, women and their grown up children were all the time busy in multifarious activities of mixed farming – agriculture, horticulture, livestock rearing, collection of non-timber forest produces, processing of woollen products, and other household works. As stated earlier, wool shearing was done twice in the case of sheep. Wool yield per animal per clip was as such low. However, nearly 1 kg wool yield per animal per annum was obtained in the case of healthy adult sheep. The market rate for wool ranged from Rs. 70/- to Rs. 90/- per kg. The annual hair yield in the case of goat was about 800 g per animal. Sheep and goat manure is considered better than those of cow as nitrogen content in the former is quite rich. Despite sheep and goat skins are valuable and important source of raw material to the leather industry, local people used skins to make bags ('Khalta'). Local people consume meat of sheep as well as of goat. Cow milk was used for making butter and 'ghee' (purified butter). People mainly used milk, butter, ghee for self-consumption. Number of dress items using sheep wool and goat hair are made by the local people. Among these prominent ones were: Drape ('Pattu'), shawl, jacket, trouser, muffler, mat (Shela), socks, etc. Majority households possessed wooden looms and people were usually busy in making these items during the winter season when other outdoor activities were at minimal. Often such items were sold within village or nearby markets. Otherwise, small livestock holdings largely cater to the needs of family members only. On occasions, farmers/pastoralists sold their livestock in local markets and also obtain cash incomes. Thus, livestock has been the part and parcel of the the social life style in the GHNPFA, and thus, provided various

goods, products and derivatives for sustenance and to some extent also supported the economy.

5.6 Livestock Grazing – People Perception

Different groups of people had different perceptions about the pastrolism in the GHNPCHA. These perceptions are described one by one.

5.6.1 Pastrolists

Pastrolists believed that there has not been any change in flock numbers. Moreover, over the years, the numerical strength of each flock has probably declined. Reasons attributed for this decline were as under:

- (a) Increasingly, less and less land for grazing is available in village surrounds due to the expansion of agriculture, horticulture and habitation areas. Obviously, the extent of grazing grounds once available in plenty have shrunk.
- (b) The average livestock holdings per household have reduced in recent decades. However, the overall number of livestock in the GHNPCHA has remained unaltered. This was probably a result of an increase in human population and number of households.
- (c) The concept of 'joint families' like elsewhere in the country was fast fading away. Thus, smaller nucleus families were unable to cope up with the multifarious activities, particularly rearing of livestock or practice of migratory pastrolism.

- (d) The educated youth has become averse to the traditional way of pastoralism realizing greater problems and hardships. Thus, they are now more interested in secured and comfortable life style.
- (e) The recent advancements in the fields of agriculture and horticulture have opened up new avenues and these professions are thus more lucrative than the primitive pastoralism.
- (f) The greater benefits obtained based on the short duration adventure in the interiors of the forests and alpine pastures for collection of medicinal herbs has given better dividends and thus, discouraged people to practice pastoralism.
- (g) Pastoralists have visualized the landscape as their belonging. Stricter enforcement of the Wildlife law by PA authorities and any type of restrictions imposed were perceived as hindrance in their traditional life style.
- (h) Pastoralists feel that the Government is more concern for wild animals while they and their livestock have been ignored. Indeed any effort by PA authorities in protection of the PAs and consequent likely increase in the population of wild predators will be a major threat to their livestock and themselves.

5.6.2 PA Management

- (a) Usually due to over-cautious and alarming attitude pastoralists and their livestock have been perceived as one of the major threats to wild animals and degradation of forests.

- (b) The livestock number, grazing pressure and resultant allied activities of pastoralists were on a sharp increase.
- (c) Livestock was more or less seen as destroyer of natural resources.
- (d) Overall pastoralists were considered as a burden on the forest resources and also a challenge for the forest/park protection staff.

5.6.3 Local People and Others

- (a) Local people see pastoralism as the central activity practiced over a long time. People perceived them as a source of multiple benefits.
- (b) Livestock was considered as an integral part of their lifestyle.
- (c) Local people perceived pastoralists as a treasure of indigenous knowledge based on their intimacy with the nature and also source of information as they are on constant move and come into contact with a large number of people.
- (d) People feel that pastoralists facilitate their access to difficult areas as they first make the way towards higher reaches.
- (e) Politicians always looked at pastoralists as their 'Vote banks' and in the changing scenario they have thus acquired greater importance.

5.7 Conclusion

The pastoralism in the GHNPCA has been a central and traditional occupation. It is based on the sound principles of optimum natural resource use while

ensuring its long term sustainability and stability. The pastrolism illustrates a greater harmony, sharing, participation and community approach. Despite rapid advancements in different frontiers, pastrolists have continued to follow their old traditions and way of life. This traditional profession and their rights of grazing have been recognized long ago, and accepted and documented. Sheep and goat form bulk of livestock. No significant change in number of livestock over a long period was noticed. As such the livestock holdings were small and mainly for the sustenance. The floral and faunal communities have adapted to livestock grazing and they are thus, tolerant to livestock grazing or grazing dependent. No alarming adverse impact of livestock grazing on the landscape and its values were observed during the present study. The pivotal role of livestock in the subsistence and socio-economics of the local people inhabiting the GHNPCA cannot be over emphasized. Varied perceptions regarding pastrolism existed among the different stakeholders. After a lapse of considerable time, the Government has succeeded in bringing out the final notification of the Great Himalayan National Park in order to fulfill the legal requirements of the wildlife law and to ensure long term conservation of its natural resources. However, the recent changed scenario due to curtailment of age old rights of local people is expected to overburden the already shrunken and depleted resources and is also likely to cause conflicts. The issue of livestock grazing thus calls for an holistic, scientific, participatory and socially acceptable management approach in the changed circumstances.

General Discussion And Conclusions

6.1 The Conservation Dilemma

The 'Conservation' and 'Development' are two much discussed subjects in different national and international forums. The sole factor responsible for these discussions are the burgeoning human population and resultant degradation of the natural environment. The prophecy made earlier that the World in 2000 will be more crowded, polluted and vulnerable came true. Most changes in different natural ecosystems are induced by human activities. These changes are driven by faulty landuse and intense resource use. Technological activities and market forces throughout the world have also contributed to rapid and potentially permanent changes or stressed environments. The situation in the tropical regions is more alarming due to the dependence of local communities on the resources of forests, grasslands and wetlands. Paradoxically the tropical regions have been endowed with a remarkably high level of biological diversity and greater spatial heterogeneity of ecosystems, habitats and species. Forests and grasslands have been extensively exploited by man so as to get low-cost animal products from its domesticated livestock.

The word 'Conservation' as such implies wise sustainable resource use. Managing for biological diversity is of critical importance because it is

essential to the ecological well being of the planet, and human welfare is ultimately dependent on this. Biological diversity refers to the diversity of life in all its forms and levels of organization: animals, plants and microorganisms are the three major forms; species, communities, ecosystems and landscape are among the many levels of organization (Hunter, 1990) Every element of biological diversity has some economic or ecological value, although in many instances the economic value remain unrealized. It is also essential to think in terms of maintaining a diversity of diversity across the landscape.

Landscape are kilometers – wide areas where a cluster of interacting stands or ecosystems are repeated in similar forms (Forman and Godron, 1981). In other words, landscape is an area composed of interacting ecosystems that are repeated because of geology, land form, soil, climate, biota and human influences throughout the area (Kaufman *et al.*, 1994). Landscapes like other ecological units are not only unique but dynamic in structure, function and spatial pattern. A major attribute of a landscape is its spatial pattern, i.e. the arrangement of its different elements in space. Conditions on smaller scale levels depend upon the status of the system at higher scales. Thus, any change at the landscape level, influences the distribution, abundance and dynamics of different species (Morris, 1987; Wiens, 1994; Andren *et al.*, 1997; Tomar, 1998).

6.2 Livestock Grazing and General Perception

Like several places in India, the local inhabitants in the Great Himalayan National Park Conservation Area (GHNP-CA), Himachal Pradesh have reared livestock since time immemorial. The transhumant pastrolism has been using different forests and alpine pastures in the three Protected Areas (PAs) of the Great Himalayan National Park (GHNP), Tirthan WLS and Sainj WLS in addition to the resources in their Village surrounds.

Prior to the present study, a general perception about the livestock grazing in the GHNP-CA existed among the local people, conservationists and wildlife managers. According to this common belief, the livestock population and herd or flock size have increased substantially over time; grazing practices are harmful to wildlife and also leading to a large scale degradation; and unregulated grazing in forests and alpine pastures is not compatible with the long term conservation objectives. This type of view has been supported by several studies (Samant, 1992; Pabla, 1992; Rikhari *et al.*, 1992; Rawat and Uniyal, 1993; Sundriyal, 1995; Pandey and Wells, 1997; and Tandon, 1997). Further, the Government intention of declaring the Great Himalayan National Park (GHNP) was reflected in the Notification issued in 1984. The legal provisions of the Wildlife (Protection) Act, 1972 required extinguish of all rights of local people and thus elimination of any type of resource use in the National Park so as to bring the final Notification of the National Park. The process of settlement was pending for quite some time for the want of information on the resource dependence including livestock grazing and right

holders. Recognising these specific management needs, the present study was undertaken as one of the several studies sponsored under the Forestry Research, Education and Extension Project (FREEP) - GHNP Research Programme.

6.3 The Holistic Approach

It was also realised that several earlier isolated research studies on different aspects of livestock grazing within and outside the country have hardly provided an insight on the implications of livestock grazing from the management perspective. Therefore, it was decided to use a holistic approach for the various types of field assessments during the present study so as to understand multiple dimensions of livestock grazing. The study thus, used a landscape approach to address this major concern of the PA management. The study was based on a hierarchical level assessments at the stand, species, ecosystem and landscape levels and a systematic understanding of the historical background, physical, biological and social environments of the landscape vis-a-vis dependent livestock and the grazing practices of migratory pastoralists. Ultimately information generated on the different environments has been used to evaluate the livestock grazing and its ecological, social and conservation implications.

The GHNPCA was recognised as one landscape in the present study. The landscape was assessed for its physical, biological and socio-economic environment while addressing issues relevant to the livestock grazing. The

physical environment influences the spatio-temporal variations in species diversity or the biological environment, while the resource use pattern by human and his dependent livestock depends upon the distribution of this biological diversity. Therefore, three components of the environment are inter-related.

6.4 The Landscape and Pastoralism

The landscape under consideration consists of four sub-watersheds (SWS) viz., Tirthan, Sainj, Jiwa and Parvati which together forms the upper catchment of one of the major perennial rivers i.e. river 'Beas'.

The compact block of the GHNP/CA comprising four administrative constituents - three PAs (the Great Himalayan National Park, Tirthan WLS and Sainj WLS) and an Ecodevelopment Area encompassing a total area of 1,171 sq km has a greater regional conservation significance due to its contiguity with other adjoining PAs and managed forests.

The spatial heterogeneity in terms of vertical and horizontal complexities arising due to varied land forms, altitudes, slopes, aspects and past management characterized the landscape. A perpetually snow bound area in the eastern part occupies 17.08% of the total landscape. Landscape is featured by a marked altitudinal gradient from 1,300 m to 6,110 m a.m.s.l. Interestingly, >87% area of the Ecodevelopment Zone lies below 3,200 m elevation, while on the contrary three PAs had 83.9% of their total area at

>3,200 m altitude. Thus, the Ecodevelopment Zone (EZ) harboured bulk of the forests and was highly deficient of alpine pastures. In contrast, the three PAs possessed disproportionately greater chunk of alpine pastures in comparison to the EZ. Only 5.89% of the total landscape or a small quantum of land (69 sq km) available in the EZ was under the 'Gentle' and 'Moderately Steep' slope categories. This means that the entire human population residing in the 125 hamlets of EZ was directly dependent upon this meager land for agriculture and horticulture purposes. The landscape experiences harsh climatic conditions. The temperature varies from -20°C to 30°C . Long period of winter constrained major outdoor activities and natural resource use. Such constraints have also led to an increased dependence on the livestock rearing for sustenance and economy. Harsh climate also restricts normal activities of the PA management. The complexities arising due to the topographical intricacies and severe climate have forced local human population since time immemorial to depend on the natural resources of forests and pastures.

The landuse pattern revealed that different type of forests, grass patches and alpine pastures covered 62.1% of the total landscape while nearly 1/3 of the landscape was not available for any meaningful purpose as such areas were constituted by rivers, water bodies, permanent snow, rocky slopes, cliffs and moraines. Only a very small proportion i.e. 2.3% of the landscape was under habitations, agriculture and orchards. The Ecodevelopment zone which possessed the majority of the resident livestock had only 8.01 sq km or 3.62% of the alpine pasture areas. The bulk (170.98 sq km or 73.37%) of the total

alpine pastures was located in the GHNP area alone while the EZ harbored a significant proportion i.e. 62.98% of total grass patches occurring on lower altitudes. The EZ was totally devoid of permanent snow while the GHNP alone possessed 97.5% of the total permanent snow bound areas. The Sainj SWS was the largest among four constituent sub-watersheds and occupied nearly 40% area of the landscape. More or less, each SWS had a resembling landuse pattern as that of the entire landscape. Over 50% of the Parvati SWS was under permanent snow. Though 16.12% of the Parvati SWS was under alpine pastures, these pastures were not available to migratory livestock due to their inaccessibility.

The GHNP CA has been characterized by a rich diversity of ecosystems, habitats, and floral and faunal species owing to the heterogeneity of landscape. More than 1,500 species representing different plant and animal taxonomic groups have been described for the landscape. In all, 1,174 floral and 377 faunal species have been listed so far. Further, still there is an ample scope to explore the treasure of species diversity specifically in the case of lower plants, invertebrates and microorganisms.

Like any other mountainous landscape or elsewhere in the Himalayan region, the landscape in consideration was colonized well over 2,000 years ago and man has utilized the natural resources for himself and his livestock. Thus, the dynamic landscape comprising diverse ecosystems, man and his livestock have co-evolved and they are tied up as a complex fabric.

The age old practice of seasonal transhumant pastoralism and their life style largely remained unaffected in spite of several changes brought in during different ruling regimes, new technologies and overall development since the Pre-colonial kingdoms to till date. The caste system has influenced the social structure, work distribution and resource use. A high level of illiteracy among man and women folks was observed. Comparing to several adjoining areas, the GHNPCA has remained underdeveloped. The villages still lack access through proper road network. People are highly religious and each village has got its own 'Devta' or local deity. Thus, the entire village community is tied up with this type of village level social institution. People have enjoyed extensive rights granted during the Colonial period. Minuscule details of these rights were then documented and local inhabitants have since followed them. However, all traditional rights in the largest constituent of the GHNPCA i.e. the Great Himalayan National Park covering 754.6 sq km area or 64.4% of the landscape have been extinguished recently in order to bring out the much awaited final notification of the GHNP. This final settlement was based on one time cash compensation and with the visualization that the Himachal Forest Department will develop pastures, raise fodder plantations and promote cultivation of medicinal herbs in coming years. Hence, no alternate forests or alpine pastures were assigned in lieu of age old rights. Thus, local inhabitants are completely shaken and dazed once they have been deprived of their traditional rights. In majority cases, both the sustenance and marginal economy have been affected. People are yet to overcome this shock and devise alternative means to sustain themselves and their livestock within meager available resources.

The Ecodevelopment zone has 125 hamlets under 13 revenue villages and 2,313 households, having a total human population of 13,145 individuals. In general, people had average holdings of about 1 to 1.5 ha. The pastrolism has remained the central point of traditions, life style, activities, economy, self-sufficiency, sectoral linkages (pastures–forests–agriculture–household–market), and the overall influence despite the rapid agricultural and horticultural advancement. The pastrolism is based on the sound principles of optimum natural resource use while ensuring its long term sustainability and stability of grazing resources. Each pastrolist follows a well defined grazing route, camping sites, grazing resources and duration of their stay or resource use in each of them. The grazing routes are meticulously worked out so that they automatically minimize the possibility of over use, mixing up of flocks and resultant conflicts. Not only this, the indigenous knowledge of grazing routes, grazing resources, tit bits of the survival strategy in extreme adverse climatic conditions and also managing self needs of food and cover in the interiors of the landscape is passed from generation to generation. Sheep and goat form bulk of the livestock. Comparing to the human population no significant change in number of livestock over a long period was noticed. As such livestock holdings were small and mainly for sustenance. The pivotal role of livestock in the subsistence economy of the local people inhabiting the GHNPCA can not be over emphasized.

The landscape had a total pressure of an estimated 33,000–38,000 livestock including resident of the GHNPCA as well as migratory beyond the

Conservation Area. Mainly four types of grazing resources utilized by livestock were identified. These were: (a) Village pastures and Village surrounds (VS); (b) Migratory Routes through different temperate and sub-alpine forests (MR); (c) Transitory Forest Camping Sites (TFCS); and (d) Alpine Pastures (AP). A total of 161 pastures (TFCS and AP) were identified, listed and mapped for the entire landscape. These pastures were located at varying altitudes ranging from 2,180 m to 4,600 m. Out of 161 pastures, 111 or 68.9% were located in the GHNP alone. Another 30 or 18.6% pastures were located in two other PAs i.e. Tirthan WLS and Sainj WLS. Thus, only remaining 20 pastures or 12.4% of the total pastures visited by pastoralists in the GHNP-CA were located in the Ecodevelopment zone.

The empirical results based on field assessments on the floral species diversity, biotic pressure and overall status of selected grazing resources under above four categories indicated high and unique diversity. The biotic pressure, livestock grazing pressure was highly localised and confined only to small areas ('Piospheres'). The resource use pattern in different types of grazing resources at any one time was widely distributed. Comparative to many other adjoining similar areas, the overall grazing pressure in the GHNP-CA remained low. Even this low pressure was well distributed across various sub-watersheds, scattered village surrounds, several migratory routes and numerous temperate, sub-alpine and alpine pastures. Obviously, this type of spatial and temporal use of various grazing resources despite over a long period of time has allowed to maintain a high level of species diversity. The intensive study and analysis of large data sets across the four types of

grazing resources have not yielded any clue or evidence which reflected severe impairment of natural system and its diversity. Further, as such floral and faunal communities in the GHNPCA have well adapted to livestock grazing and to some extent they are thus grazing dependent. Though some adverse impact on habitats and floral and faunal diversity was noticed due to allied activities of pastrolists and others *viz.*, herb collectors, visitors, pilgrims, etc, no alarming or severe negative impact of livestock grazing on the landscape, its varied wildlife and other ecological values was found.

The traditional way of seasonal resource use, mixed economy and simple life style had so far provided self sufficiency to the local people. However, these mechanisms of self sufficiency have been increasingly hindered due to growing demands, market forces; faulty land use practices; curtailment of seasonal spatial resource use; and over-burdening of already limited and depleted available grazing resources. Such disruptions in the traditional sustainable ways have left several permanent scars and this is the main cause of worry. Realising this very tenet concerning doubtful sustainability of natural resources and self sufficiency of local people, the Himachal Pradesh Forest Department with an external funding had initiated an ambitious programme of ecodevelopment 5-years ago. The process of trust and confidence building by forming village level ecodevelopment committees, undertaking minor developmental works, providing alternatives, and greater participation at all levels was started so as to ultimately reduce the negative impact of people on PAs and vice-versa. Probably the final notification of the GHNP at this juncture has been a set back to some extent to the well

meaning process of ecocodevelopment. The big challenge always is to ensure the confidence and greater participation of local people along side the continuity of monetary flow for a major programme like this for alternatives to the local people and the conservation of biodiversity.

In a nutshell, it can be concluded that the adverse impact of livestock grazing on number of different forests and grasslands including alpine pastures within and outside the country and several adjoining areas of the GHNP have been well documented. However, contrary to the common belief that the grazing pressure in the GHNP is on an increase and having detrimental effects on wildlife and other ecological values of the landscape, interestingly the present study amply indicated that the GHNP is probably one of the typical examples wherein the livestock grazing practiced over a long period of time has probably not demonstrated any severe adverse effect on the landscape and its values. Indeed livestock grazing was efficiently regulated by the pastrolists and effectively managed by PA authorities despite difficult terrain and harsh climatic conditions.

6.5 Changed Scenario and Likely Implications

Following ecological and socio-economic implications are visualized under the changed scenario due to the recent final notification of the GHNP and curtailment of traditional rights of resource use including migratory pastrolism to the alpine pastures:

- ❖ The exclusion of traditional multiple resource use and subsequent active protection of natural resources would definitely lead to an overall recovery of forests and pastures in the GHNP after a long history of gradual degradation. This way, the conservation goal expected of a National Park would be fulfilled. However, at this stage it is difficult to predict that how this overall ecological recovery would affect individual plant or animal species or the total diversity at species level. Two postulations with regard to the plant diversity in a more or less similar type of environment exists (Naithani *et al.*, 1992 and Rawat and Uniyal, 1993). Since both the postulations were largely based on the field observations at any given one time, professional judgement and not supported by any experimental study over a long period, therefore, it is difficult to forecast the likely situation of species diversity in the case of GHNP.

- ❖ It would be probably difficult to manage 25,000 – 30,000 estimated livestock in a shrunken area. The non-availability of 754.6 sq km or 64.4% area of the total landscape possessing 68.9% pastures visited by migratory livestock is likely to overburden the remaining area and several fold increased livestock pressure may thus accelerate the degradation process of those remaining grazing resources. This may ultimately lead to by default elimination of sheep and goat husbandry, creating unnecessary hardship for dependent communities and loss of overburdened grazing resources.

- ❖ It is difficult to calculate the subsistence value of livestock. In addition, livestock in the region is having several indirect values and linkages. Thus, it may be difficult to adequately compensate through cash amounts for the cumulative loss.
- ❖ Increased conflicts, and some setback to the newly initiated ecodevelopment and participatory approach cannot be over ruled.
- ❖ The transhumant pastoralists possess traditional knowledge and skills acquired through their forefathers and their long association with the nature. This traditional knowledge and their survival strategy are likely to diminish and may be lost for ever.
- ❖ The proposed development and provisioning of alternative pastures, fodder and cultivated medicinal herbs based on experiences elsewhere seem to be a tall order.

6.6 Research and Monitoring

The present study has provided a valuable baseline information on the resident as well as migratory pastoralists – their number, distribution and livestock holdings; grazing routes and resources used by them; and diversity pattern in each type of grazing pressure. No experimental study was carried out during the present investigations as it was beyond the current scope. A well designed systematic experimental and participatory research in order to evaluate the effect of recent closure of livestock grazing is desirable. Likewise, a long term ecological monitoring based on the monitoring of

population dynamics of selected taxa out of the total array of plant and animal diversity as described by Davis (1989) is proposed. Details of Long Term Ecological Monitoring (LTEM) Programme in the GHNPCA has been described by Mathur and Uniyal (1999). This LTEM Programme was developed through a participatory approach including co-workers of the concurrent research studies, PA staff and local people.

6.7 Epilogue

(a) Despite the common perception that the livestock grazing is deleterious for the high altitude forests and alpine pastures, the findings of present study based on a holistic and hierarchical level assessments, have not only astonished but well demonstrated that on one hand the traditional transhumant pastrolism has survived while on the other hand diversity of ecosystems, habitats and species has been maintained. Moreover, it is unfortunate that the livestock and pastrolists have been solely blamed for any type of destruction or decline of biodiversity. Natural factors, market forces, other resource use activities, past management practices, faulty landuse and illegal activities together are probably having greater and permanent influences. Thus, these factors, forces and activities are the main culprits. This view has also been supported by the comprehensive analysis of the origin and various dimensions (ecological, social, management and political) of pastrolism by Saberwal (1999). Thus, biodiversity concerns can be better dealt holistically, rather than in the traditional and fragmentary approach. To amplify this, conservation of biodiversity is not possible

using just a single approach. On the contrary, it requires an integrated approach.

- (b) The intricacies and large scale natural variations in the physical environment of the high altitude landscape greatly influences the biological and socio-economic environments. Thus, it is imperative to delineate boundaries of the protected areas in such landscapes carefully on the basis of physical characteristics and availability of representative natural resources. Further, management of biodiversity is relevant to landscape regardless of administrative boundaries. Management of complex and dynamic ecosystems calls for adopting a flexible and adaptive approach. It is recommended to maintain a diversity of diversity or mosaic through spatial distribution of variety of habitats, patch sizes, seral stages and forest/pasture stand attributes and structures; and maintaining connectivity among them.
- (c) The success of biodiversity conservation would largely depend on a coordinated strategy, effective communication and greater participation by all concerned.
- (d) The livestock grazing in the region can be and should be practiced on the sound principles of spatio-temporal use of grazing resources instead of overburdening any area at any given time. Thus, the pressure of livestock as far as possible should be uniformly distributed across different villages, migratory routes, camping sites, grazing resources, sub-watersheds and the landscape.

- (e) In order to minimize, site specific pressures viz., lopping, girdling for the collection of fodder, fuelwood, lichens, etc, a conservation awareness campaign for the local communities is recommended. The Village Ecodevelopment Committees thus, can play an important role.
- (f) More vigilance and regulation of livestock all along migratory routes, entry/exit points, and camping sites – TFCS and AP are required. It is difficult for the limited PA staff to check and regulate this, hence a greater participation of villagers and pastrolists themselves is visualized so as to avoid increase in the migratory livestock from outside areas and 'optimum' use of grazing resources instead 'maximum' use.
- (g) A comprehensive strategy for experimental research and inbuilt long term ecological monitoring as an indispensable arms of the sound PA management is critical for ensuring long term sustainability of the unique and diverse high altitude ecosystem of the GHNP.

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