Ecological Impact of Anthropogenic Pressures on High Altitude Forests along Bhagirathi Catchment

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By
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Wildlife Institute of India

Certificate

This is to certify that the thesis entitled **"Ecological Impacts of Anthropogenic Pressures on High Altitude Forests along Bhagirathi Catchment"** submitted for the award of degree of **Doctor of Philosophy** in **Botany** to Forest Research Institute (Deemed University), Dehra Dun (Uttaranchal), is a record of bonafide research work carried out by Ms. Anjali Awasthi under my guidance and supervision. No part of this thesis has been submitted for any other degree and it fulfills all the requirements laid down in the ordinance of FRI (Deemed University) for this purpose.

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Executive Summary

1. The forests of Bhagirathi catchment in Garhwal Himalaya (Uttaranchal) have faced anthropogenic pressures since pre-British period. However, human induced disturbances increased during British period when the commercial exploitation of these forests started. It was during this period that the cultivation of potato and apple orchards were introduced in the region. These initial phases of transformation paved way for more recent changes in land-use practices and degradation of high altitude forests. The modern phase of degradation started with the construction of road to Gangotri in the middle of 20th century and opening up of Garhwal for tourism which led to development of infrastructural facilities and influx of mass tourism in the inner valleys. These added pressures on the remaining forests of Bhagirathi valley.
2. Ecological impacts of anthropogenic pressures and patterns and processes of forest degradation have not been quantified in this valley so far. Therefore, the present study was carried out in a part of the Bhagirathi catchment (78^{0}15' to 79^0 E long. & 30^{0}30' to 31^{0}08' N lat.). The objectives of the study were: to assess the resource use patterns of villagers, transhumant communities and tourists, to assess the impacts of anthropogenic activities on forests and wildlife and to detect changes in land-cover classes over time and space. The study area covers an area of *ca.* 2050 km^2. The terrain is mountainous and rugged. The altitudinal range of the study area is 279 to 6600m. River Bhagirathi forms the main drainage system. For the intensive field work two representative watersheds *viz.,* Duggada watershed (DWS) and Bhatwari watershed (BWS) were selected.
3. The general methods adopted for the present study include collection of data from two sources. Field work (Primary data source) was carried out for the period ofduring July 1996 to July 1999. Secondary information was gathered from reports, published literature, district gazetteer and forest department. Besides satellite data of different time periods (1988, 1995 & 1998) were also acquired from National Remote Sensing Agency (NRSA), Hyderabad. Information regarding lifestyle, socio-economic structure and resource use pattern of local villagers, transhumant communities and tourists was collected through questionnaire surveys, informal interviews and personal observations. Quantification of resource use was done using displacement method. Anthropogenic pressures on the surrounding forests were assessed in the permanently marked belt transects of 30X5m in a 3 km long trail (n=9). Signs of lopping, cattle grazing and wild animals were also recorded every month in each belt for two years. Remote Sensing data of all the time periods were rectified and study area of interest was put to classification. Computer software ERDAS Imagine was used for digital image processing whereas ARC/INFO was used for rule based classification. The classified maps of different years were overlaid in ARC/VIEW to detect changes over time and space. These changes in land-cover classes were later correlated with altitude, aspect and slope.
4. Biomass, which is an important source of energy for most of the rural population, is also an essential component of the entire ecosystem. Patterns of biomass use define the sustainability of

this resource in near future. The resource utilization patterns of local villagers were assessed. It was found that fuelwood, fodder and bamboo are the three main biomass resources extracted from forests by the locals. There was a seasonal variation in the extraction as well as consumption of these resources. Fuelwood and leaf fodder extraction was more in summer and winter seasons whereas bamboo extraction was maximum during rains. A significant variation was also found in the fuelwood burnt per day per household in different seasons. The fuelwood consumption was highest during winters (*ca.* 20.2kg) and least in summers (11.5kg). Fuelwood consumption also differed across dependency categories *viz.,* highly, moderately and least dependent families. Similarly, fodder consumption across different dependency groups also differed significantly. Leaf-fodder consumption was highest in summer season while grass fodder was fed more during rains. Availability of agricultural by-products was low in BWS where more area is under potato cultivation. Besides fuelwood and fodder, bamboo culms were also extracted from the surrounding forests in the summer and early rainy season to support the climbers of kidney beans, which is preferred as a cash crop in the area. An average of *ca.* 380 culms per day per headload were removed from the forest. It was found that inclination of people towards market oriented crops such as potato, kidney bean and soyabean has increased pressure on the surrounding forests.

5. The study area is visited seasonally by various transhumant communities who also depend on the surrounding forests for a period of about six months. Four forms of transhumance viz., Nomadism, Semi-nomadism, Transmigration and Nuclear Transhumance were identified in the Bhagirathi valley. Nomadism is followed by *Gujjars,* semi-nomadism by *Gaddis*, transmigration by *Jadhs* and *Garhwalis* and Nuclear transhumance by resident *Garhwalis*. Nomadic people have temporary huts at both summer and winter settlements whereas transmigrants have permanent houses. Semi-nomadic and nuclear transhumants have one temporary and one permanent settlement. The four communities have different economic basis. *Gujjars* have livestock based economy, *Gaddis* have agro-pastoral economy, *Jadhs* have trade based economy whereas economy of *Garhwalis* is based on agriculture. The pattern of resource use among different communities was also different. People with livestock based economy covered a larger altitudinal gradient and wider spatial range than those who had agriculture based economy. Per day consumption of fuelwood and fodder also differed significantly among different communities. It was found that for *Gujjars*, transhumance practice is not viable even economically. Although there is no overlap in the movement patterns and ecological zones of different transhumant communities, their stay for six months in the sensitive sub-alpine and alpine areas would certainly widen the region of influence resulting in degradation of timberline forests.

6. Besides, local villagers and transhumant communities, a large number of tourists also visit the valley. Uttarkashi, Gangotri and Gaumukh are the famous pilgrimage sites whereas trails to Kedar Taal, Nandanvan, Dodital, Dayara Bugyal, Kush-Kalyan are some of the favoured sites for nature lovers. The attitude, behaviour and resource use pattern of different visitor's *viz.,* domestic &

international, pilgrims and nature lovers was compared. It was found that different visitors had different priorities and requirements. Pilgrims having less than a day stay were not so dependent on the surrounding forests whereas nature lovers or trekking parties required forest resources such as fuelwood from the surrounding forests. The nature lovers were more conscious about the problems of garbage and visitor crowds during peak season whereas pilgrims were more concerned about sanitary and transport facilities. The increase in the number of both pilgrims and nature tourists has led to increased construction of lodges and hotels. The restaurants burn more fuelwood during autumn season when there is no check by the authorities and also when there is no facility of cooking gas. Similarly more number of garbage dumps were quantified during autumn season and in the off road trails which are less visited by VIPs and authorities and hence are more neglected. It was not the number but the attitude and behaviour of visitors that would exert a greater influence on the surrounding forests.

7. The impact of resource extraction by locals, transhumant communities and tourists on the forests was assessed. It was found that forests located close to villages (zone-I) and temporary settlements (zone-III) were under high lopping/cutting pressure. There was a spatial and temporal variation in the lopping intensities in the forests. It was observed that more trees in the zone III were lopped in rainy season while more trees in the zone-I were lopped in winter season. Species of oaks were most preferred both as fuelwood and leaf-fodder. Most of the oak trees were lopped repeatedly and were converted into bush or pole form. The increasing pressure on sensitive sub-alpine forests during their restricted growth period has affected not only the physiognomy of trees but also their regeneration and population structure. The seasonal disturbance in the forests has also influenced the abundance of wild animals. It was found that the indirect evidences of wild mammals were recorded most frequently in the mid-elevation forests which are still relatively undisturbed. Increased human activities in the forests has led to increased human-wildlife conflicts. It was found that maximum number of killing by leopard occurred either during migration of livestock to alpine meadows or during winter months when livestock grazed freely in the forests around villages. More number of cases of crop damage were recorded from the fields in the vicinity of the forests or amidst forest. Thus, human induced disturbances played a major role in degradation of forests and regulated the presence of wild animals.

8. After assessing the trends of resource use and its impact on surrounding forests in the two ISS, the status of forest and other land-use categories for the entire Bhagirathi valley was assessed using Remote Sensing data (IRS LISS II & LISS III) for the months November 1988, 1995 and 1998. It was found that most of the area (>80%) is very rugged and unsuitable for cultivation and habitation hence it is under forests (>80%). The flat and accessible lands have already been occupied by people. The trends of change between different time periods revealed an increase in area under habitation/ agriculture since past few decades. There is an inter-conversion of vegetation types from broadleaf to broadleaf-conifer mixed and scrub land. This could be because excessive lopping

of broadleaf forests convert them to pole or bush form which gives a spectral reflectance of scrub. The degradation of broadleaf forests also leads to encroachment by conifer species such as chirpine. Besides, chirpine is also preferred by forest department for plantation in degraded area hence there was an increase in area under chirpine. As revealed from field work, RS also proved that transformations in the land-use practices have influenced the status of different land-cover categories.

9. This study has identified the causes and processes of changes in the Bhagirathi valley and also collected baseline information on the current status of forests, landuse practices and biomass needs of local people which can be used for future monitoring and conservation planning. The main causes identified for the degradation and changes in land-cover classes include changes in socio-economic patterns from subsistence to market based economy, transformations in the traditional form of transhumance and attitude of tourists visiting the valley. The processes taking place due to above-mentioned causes include increase in area under cash crop, change in the livestock composition, increased extraction of forest resources, resource scarcity from cropland and inter-conversion of different land-cover types. Increased human-induced disturbances in the forests close to villages and temporary huts has led to increased human-wildlife conflicts. The mid-elevation forests are the relatively free from disturbances but with increasing demands for agricultural land and forest resources, these may also become threatened.

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List of Abbreviations

AOI = Area of Interest

BWS= Bhatwari Watershed

DEM = Digital Elevation Model

DIP= Digital Image Processing

DM = District Magistrate

DSO = District Statistical Office

DWS= Dugadda Watershed

EH = Eastern Himalaya

FCC = False Colour Composite

FDR = Forest Department Records

GBH = Girth at Breast Height

GIS = Geographic Information System

GHNP= Great Himalayan National Park

GNP= Gangotri National Park

GPS =Global Positioning System

GCPs = Ground Control Points

H.P = Himachal Pradesh

HDT= Highly Disturbed Trail

ISS = Intensive Study Sites

IRS = Indian Remote Sensing

ISR = Intensive Study Records

KWLS= Kedarnath Wildlife Sanctuary

LVT = Less Visited Trail

LDT= Least Disturbed Trail

MDT= Moderately Disturbed Trail

MVT= More Visited Trail

NRSA = National Remote Sensing Agency

NE = North-East

NP= National Park

NTFP= Non Timber Forest Product

NT = Nuclear Transhumance

NW = North-West

OSD = Officer on Special Duty

PA = Protected Area

RS = Remote Sensing

RF= Reserved Forest

R.M.S =Root Mean Square

RTO = Regional Tourist Office

SE = South-East

SN =Semi-Nomadism

SOI =Survey of India

SW = South-West

TM = Transmigration

UNCED = United Nations Conference on Environment and Development

WH= Western Himalaya

WLS= Wildlife Sanctuary

CHAPTER-1

General Introduction

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General Introduction

1.1 Background

Man has been an integral part of the natural landscape and his every decision in social, economic and political spheres of life affects the natural systems in some way or the other (Smith 1972). This interrelationship of man with nature, has given rise to the realm of "Human ecology", which is expressed as the study of man's position within the natural environment (Quinn 1950). Human ecology is never constant. It is a dynamic state that changes in the dimensions of space and time. Different forms of interactions take place between man and his environment. Being exposed to nature, man receives the pressure of natural environment and simultaneously influences the natural resources with his activities (Ghosh *et al.* 1997).

Human ecology in the Himalayan context is particularly interesting. Both man and Himalaya being relatively young on earth have influenced each other tremendously. It is believed that early Hominoids experienced the last phase of Himalayan upliftment and they began to occupy parts of western Himalaya during Pleistocene (Pilbeam 1969, Prasad 1971). Initially, the man appears to have colonized the lower elevation ranges (300 to 1200m). This suggested that the area was favourable for habitation with abundant food supply and shelter. The cooperation between Hominoid and nature was in ecological equilibrium at that time because of least interference with nature and natural processes. However, with time, the culture and social behaviour of man underwent ramification and development. This disturbed the ecological stability and slowly the imbalance set in. There are records of dispersal of earliest type of *Homo sapiens sapiens* from southern China to as far as south-east Asia and Australia due to population pressure and resource scarcity (Shutler 1984). Later, the spread of first civilized race 'Aryans' from Trans-Indus areas to east of Sutlej further increased the pressure on the natural resources. The extensive destruction of natural habitats by the civilized man for expansion of agriculture has not only resulted changes in the flora and fauna but also the status of primitive man (Lal 1974). Thus, the gradual influence of earliest known civilizations initiated the degradation and deforestation processes in these mountains. Heske (1931) identified uncontrolled forest use by the locals for supplementing agricultural activities, fodder and fuelwood as the primary cause of deforestation. The situation worsened due to rise in population, development of infrastructure and transport networks. More forest land was cleared for fulfilling the growing demands of local as well as global population. Climax forests of oak, which not only bring ecological stability but also form an important resource base for the locals are most threatened (Singh and Singh 1987). Exploitation of forests especially the oak forests in the Himalaya has led to frequent landslides, increased floods in the rivers, drying up of springs and scarcity of resources for the locals. These factors have also influenced the human populations residing in the Indo-Gangetic plains (Hamilton 1987). Changes in the natural resource use pattern by the human societies and resultant influences on the forests of Himalaya have generated concern among many naturalists, ecologists, scientists and conservationists (Bajracharya 1983, Myers 1986, Ives and Messerli 1989). In order to evolve strategies for ecologically sustainable landuse practices it is imperative to study the patterns of biomass use by the local people and assess the ecological impacts of current anthropogenic pressures in the area (Dar 1996, Doshi and Kumar 1996). Present study initiated in the Bhagirathi valley to assess the human dependency on the high altitude forests and the impacts of their activities on forest is an attempt towards this direction.

1.2 History of deforestation and landuse changes in Garhwal Himalaya:
A closer look at the sequence of the processes of deforestation in Garhwal Himalaya reveals that the present status of forest is as a result of several political and social transformations in the society. By ignoring historical and political processes of deforestation in the past, the interpretation of more recent changes would be biased. The entire history of deforestation can be divided into four phases viz., Pre-British, British, Post independence and Modern period (Figure-1.1).

Figure-1.1: Chronological history of Garhwal Himalaya with respect to deforestation and land-use practices

Pre-British Period

- traditional management of forest as common property
- influence of *Gorkha* rule
- no legal records of forest and land management available

↓

British Period

- 1840: forest s leased to Wilson
- 1873: first record of land settlement
- 1903: land settlement leading to land classification
- revenue charged according to quality of land
- initiation of people's resentment
- free rights of forest resource use limited
- 1930: Rawain Kand (People's revolt)

↓

Post Independence

- 1944: land settlement could not be completed
- Merger of Tehri estate with U.P. in 1949
- 1949: encroachment by people
- 1955: all extensions in forest land declared illegal

↓

Modern period

- creation of district Uttarkashi (1960)
- 1963: measurement of all land except forest
- increment in cultivated and orchard land
- decrease in area under *katil* farming
- commercial exploitation of forests
- 1973: initiation of 'Chipko'
- 1974: formation of UP forest corporation
- opening of Garhwal for tourism
- 1980: ban on commercial felling

↓

Reorganization of UFD in 1994

- increase in number of ranges
- notification of Gangotri National Park

Pre-British Period: During this period, forests were the owned by the ruler (Raja) of Garhwal and people enjoyed traditional rights of forest resources. The sources of revenue were agriculture and milk products. The processes of struggle initiated with the attack of *Gorkha* rulers. During Gorkha war (early 19th century) many villages were abandoned. People took shelter in more pristine and inaccessible forests and agricultural fields were ruined that later turned into thick forests or scrub (Atkinson 1882). The outcome of *Gorkha* war led to the annexation of Kumaun and Garhwal to the Britishers.

British Period: The British ruled over Kumaun-Garhwal for more than thirteen decades and shaped the economy and ecology of the region. The erstwhile Garhwal territories to the east of Alaknanda were annexed to Kumaun and the territories to the west of it with the exception of Nagpur, Rawain and Dehradun were given to Raja Sudershan Shah. The forests under the territory of Raja were managed traditionally and no record was available till 1840. In 1840, the forests of erstwhile Tehri-Garhwal were leased to a British contractor, Friedrick Wilson (Raturi 1938). He was one of the several people who settled in the hills of Garhwal, adopted the local culture and transformed the hill economy by introducing commercialized exploitation of forests and cash crops such as potato and apple (Saili 1995). He exploited large patches of blue pine (*Pinus wallichiana*) and deodar (*Cedrus deodara*) in order to meet the demands of railway sleepers and timber and transported them through rivers. Gradually need for scientific management of these forests was realized. In response to this need, Forest Department was established under British rule. For the management of forests the Tehri-Garhwal estate constituted its own department with four ranges and twenty-three beats under a Conservator of Forest in 1885 and since 1897, the systematic forestry started in the region (Raturi 1938). Restrictions on felling of trees without permits, hammer marking, grazing and extension of agriculture in the wastelands were also imposed on the local people. This initiated resentment among the villagers. To overcome the resentment among locals, Pt. R.D. Raturi made several modifications in the Working Plan and divided forests into three classes viz., Reserved, Protected and Civil. The first two were under the Forest Department while the civil authorities controlled the third one (Singh

1963). Later, Indian Forest Services came into existence with a goal to organize the sustained timber yield, to preserve forest cover and to ensure subsistence needs of the local people. However, only the first stated objective could only be achieved. In 1910, the first forest settlement demarcated the forest boundaries and reduced concessions enjoyed by the villagers. Consequently, in 1930, a public movement known as "Rawain Kand" took place against the forest settlement, which resulted in large-scale destruction of forests, illegal encroachments and forest fires. Thus, the degradation of high altitude forests due to commercial exploitation by contractors was further enhanced by conflicts between villagers and the managers.

Post independence period: After India's independence in 1947, the Tehri-Garhwal estate was merged with the state of Uttar Pradesh (U.P.) in 1949. Thus, the control of forests also came under U.P. Forest Department. The primary aim of the forest managers still remained the conservation of commercially importance species and all encroachments made in the forest were declared illegal (Anonymous 1970). Depletion of broadleaf forests of oak and promotion of monoculture plantation of conifers reduced the resource availability to villagers for their subsistence needs resulting in the " Chipko" movement (Mathew 1978). It led to a 15 years moratorium on commercial felling of high altitude forests and the formation of U.P. Forest Corporation (Guha 1989).

Modern period: Modern phase of deforestation and degradation of forests in Garhwal Himalaya began in the middle of 20th century. In early sixties, Indo-China war accelerated the construction of roads through the virgin high-altitude forests. This provided easy access to market resulting in orientation of people towards commercial crops and changed land-use practices (Shah 1981, Gaur *et al.* 1985, Singh 1996.). Cultivation gradually extended to sensitive zones and steep slopes and developmental activities such as hydroelectric projects were initiated in the fragile environment. Along with this, the influx of tourists has also increased manifold after the opening up of Garhwal for tourism. The 'mass tourism' has led to unplanned construction of hotels and lodges and excessive exploitation of natural resources (Singh & Kaur 1989).

All the afore-mentioned faulty and unplanned land-use practices coupled with the growth of population has put immense pressure on already degraded forests. The signs of degradation have been recognized in the form of deforested slopes, increased landslides, invasion of weeds, loss of bio-diversity and habitat fragmentation (Haigh 1984, Paliwal 1984). It has been realized that for the proper management and conservation of the high altitude forests, an in-depth analysis of the local-level information on anthropogenic pressures is very essential.

1.3 Review of literature

The Himalaya has influenced the life, culture and history of the Indian subcontinent since time immemorial. Earliest known description of Himalaya and its resources is available in the Indian epics such as *Ramayana*, *Mahabharata* and *Srimad Bhagavat Geeta.* First detailed account of the history, forests, ethno-botany, geology and landuse of the Himalayan districts has been given by Atkinson (1882). Oakely (1905), Walton (1910). Tolia (1994), William (1995) and White (1995) emphasized on traditions, culture and land settlement practices of central Himalaya during British rule.

During the first half of 20th century, several botanical explorations started in the inner valleys of Himalaya. Duthie (1906), Osmaston (1927) and Smythe (1938) were some of the pioneer workers on the botany of the Garhwal region. Gupta (1956, 1957) and Dey *et al.* (1969) explored the Bhillangana and Bhagirathi valley respectively in erstwhile Tehri Garhwal. Several workers such as Rau (1955, 1961,1963, 1964), Uniyal (1968), Naithani (1978), Goel and Bhattacharya (1981), Naithani (1985), Biswas (1988,1989) and Uniyal *et al.* (1995), added more information on the flora of the Western Garhwal.

1.3.1 Ecological studies: The earliest known ecological work in Garhwal region was by Osmaston (1920). He observed some effects of fire and lightning in Chir (*Pinus roxburghii*) forests. In another work, Osmaston (1922) gave an account on forest communities of Garhwal Himalaya. Subsequently, Dudgeon & Kenoyer (1925) contributed to the ecology of erstwhile Tehri Garhwal. Puri and Gupta (1951) gave a detailed account of the ecology of Himalayan conifers and emphasized that distribution of pine is more dependent on edaphic factors. Later, in a series of papers, Gupta (1964, 1966) emphasized the ecological status of forests of Tehri Garhwal. Gupta and Singh (1962) studied different forest types and succession of oak-conifer forests in the Garhwal Himalaya. In nineteen hundred eighties, Gaur (1984), Joshi (1984), Pangtey *et al* (1987), Negi and Gupta (1987) provided some quantitative information on the forests of Garhwal Himalaya. Later Quan (1993), Bhandari *et al.* (1997) and Rawat *et al.* (1999) added more information on the dynamics and phytosociology of woody species in the Garhwal Himalaya. The ecological aspects of both lower valley pastures and alpine pastures of Garhwal Himalaya and the impact of livestock grazing on them were studied by many workers such as by Joshi (1982), Rawat *et al* (1994), Dobhal (1990, 1991), Joshi and Srivastava (1991), Nautiyal *et al.* (1997), Kala *et al.* (1998) and Rawat (1998). Few studies on the ecological aspects of soil, phenology of high altitude plants and processes of vegetational changes in Tipra glacier have been done by Dimri *et al.* (1997), Sundriyal *et al.* (1987) and Bhattachrya & Chauhan (1997) respectively. In Kumaun Himalaya, major contributions towards the dynamics and structural ecology of forests have been made by Saxena *et al.* (1984), Upreti (1985), Singh & Singh (1987), Rawat & Singh (1988) and Adhikari *et al.* (1991). Few works on the ecology of forests of Central or Nepal Himalaya are also available (Schmidt-vogt 1990, Metz 1997).

Anecdotal information on the Himalayan fauna is available through Searight (1926), Srivastava (1969), Atkinson (1974), Schaller (1977) and Gaston *et al.* (1980). Since then many studies on the distribution of mammals and avi-fauna of western Himalaya have been published. Ranjitsingh (1981), Lamba (1987), Tak (1987), Sharma (1994) and ZSI (1995) have prepared checklists of the mammals of Western Himalaya. One of the pioneering works on the ecology of Himalayan ungulates in Garhwal Himalaya was by Green (1986,1987) who studied the ecology of Himalayan musk deer (*Moschus chrysogaster*) in Garhwal Himalaya. Later, Sathyakumar (1994) added more information on the habitat ecology of other ungulates in

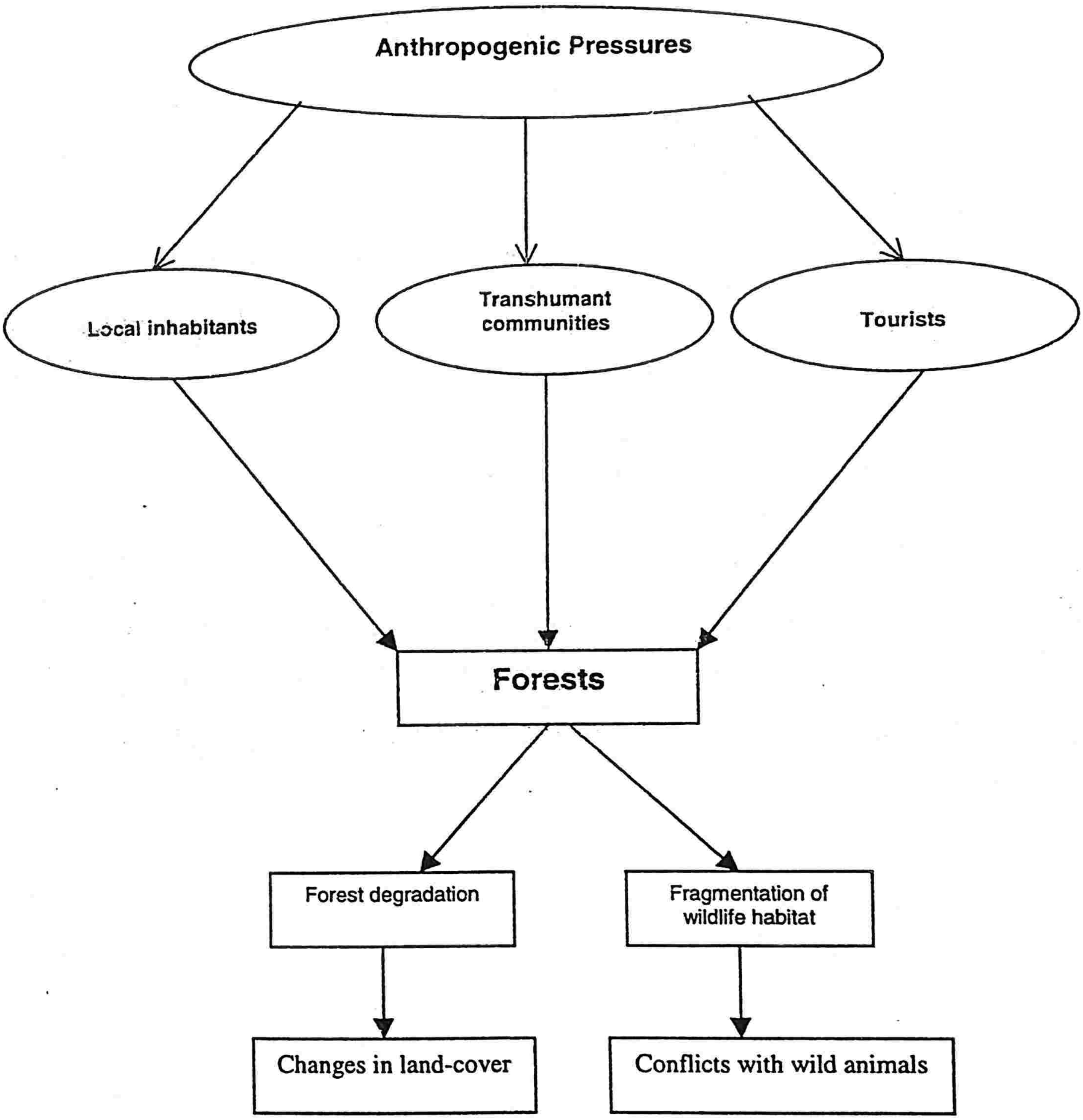
Kedarnath Wildlife Sanctuary. Most of the surveys and ecological works have been done in the Alaknanda and Yamuna valleys, however, there exists very little information on the ecology of forest and fauna in the Bhagirathi valley.

1.3.2 Resource inventory and mapping: Since the past few decades, Remote Sensing (RS) has emerged as a tool to supplement various ecological studies. This technique has helped in the inventorying and mapping of natural resources (Karale 1992). It also helps in the time series analysis of a particular region due to the repetitive coverage of the area by the satellites (Lillesand and Kiefer 1979). Remote sensing when combined with Geographic Information System (GIS) provides integration of spatial and non-spatial data and ability to see through different layers (Burrough 1990). In the earliest work of Tewari & Singh (1978) in western Himalaya, Aerial Photographs (AP) were used to classify forest and landuse categories and compare it with ground methods in Tehri Garhwal. For the assessment of forest cover in the Indian Central Himalaya, Tewari (1987) visually interpreted the Landsat-1 images. He also computed forest biomass for the entire area using aerial photographs (Tewari *et al.* 1987). Later, Kawosa (1988) prepared vegetation maps of the Himalayan ranges using satellite data. Another study by Pant & Roy (1994) dealt with the analysis of forest cover and land use dynamics in Central Himalaya using RS whereas Sahai & Kimothi (1992) made use of satellite data for surveying areas of conservation values in the Nanda Devi Biosphere Reserve. Remote Sensing and GIS have also been found useful in mapping the fire risk zones (Jain *et al.* 1996, Kimothi & Jadhav 1998). With the launch of a series of satellites, data analysis for different time-periods has become easy. In the Aglar watershed of Mussorrie, Pant and Roy (1990) detected changes in the land-use patterns using remote sensing data of different time periods. Ghosh *et al.* (1996) have integrated RS and GIS to study the landuse/land cover changes in a mountainous terrain. It was found from their study that the expansion of agriculture in 2200-2400m altitudinal gradient was the main cause of loss of vegetal cover between 1963-1993. In few areas of Shiwalik ranges i.e. Rajaji National Park (RNP) also, Das *et al* (1996) have monitored and detected changes in the forest cover using temporal data of 1960 (AP) and 1993 (IRS 1B LISS II FCC's). Similarly, Singh (1986) analyzed forest-cover type and land-use classes in Ranikhet tehsil of Kumaon. Recently, use of RS and GIS for sustainable development and integration of socio-economic aspects has been emphasized (Rao 1992). One such study has been done to assess the biotic interference in the RNP (Jain *et al.* 1994). Rathore *et al.* (1997) have analyzed changes in the forest cover due to human interference in the Baliya catchment of Central Himalaya using IRS 1A LISS I data. From the survey of literature available on the use of RS and GIS as a tool for ecological works, it becomes evident that though this technology has been initiated since early seventies in the western Himalaya, no work has been done to classify and map the land-cover in Bhagirathi valley, an important area in the western Himalaya.

1.3.3 Studies on man-forest relationships: Studies on the relationships of forest with human beings are not very old. However, the relationship between the two exists since the origin of *Homo sapiens*. Most of the works on the man-nature relationship dealt with the natural, social or cultural history. Need to study the ecological relationship of man with nature given rise to a science called "Human Ecology" (Quinn 1950). Though, many workers have emphasized the importance of forests for the sustenance of human beings, little quantitative information such as Kaushik (1962), Gupta (1983), Negi and Todaria (1993) and Saxena *et al.* (1995) exists from the Garhwal Himalaya. Most of the ecological studies dealing with man-nature relationships have been conducted in the Kumaun Himalaya (Pandey and Singh 1984, Singh *et al.* 1984, Singh 1989, Ralhan *et al.* 1991 and Singh & Singh 1991). These studied first identified that for the sustenance of agriculture in hills, the forests should be sustained. They also emphasized that forest resource scarcity has resulted in the degradation of hill agriculture. Later, Shah (1982) and Swarup (1993) also emphasized the transformation processes in hill agriculture and land use practices which also influenced the surrounding forests. Negi and Bhatt (1993) studied the biomass utilization pattern of villagers in Central Himalaya and highlighted that though currently the extraction is sustainable but in near future, the depletion of surrounding forests would become a cause of resource scarcity for the locals. Few workers have also studied the behaviour and lifestyle of migratory communities (Pant 1935, Lal, 1974, Shashi 1979, Chatterjee 1980, Burman 1981, Hoon, 1996, Farooque and Nautiyal 1996). However, most of them were related to the social or cultural life of migratory communities and no quantification of their resource use pattern was done. Few studies dealing with the ecology of migratory communities in the Northwest Himalaya and Shiwalik hills include Rao & Casimir (1982) and Edgaonkar (1995) respectively. Rao & Casimir revealed that resource use patterns of Bakerwals of Jammu influenced the surrounding vegetation. Edgaonkar on the other hand studied the lopping pressures by Gujjars in their winter settlements. No study has been done to quantify the resource use pattern of Gujjars in their summer settlements. Recently Maikhuri *et al.* (1998) and Silori (1999) worked on the ecology of village ecosystem around Nanda Devi biosphere reserves with a view to promote eco-development. However, Bhagirathi valley, where local as well as transhumant people depend on the surrounding forests for their subsistence needs, is little studied.

1.3.4 Assessment of anthropogenic pressures: The large scale effects of human induced disturbances on the Himalayan forests in the form of deforestation and destruction have been frequently highlighted by various authors e.g. Eckholm (1975), Reiger (1977), Bajracharya (1983), Ives (1985) yet very little work has been done to quantify the trends. Few works such as English (1985) and Rawat (1985) discussed impacts of historical processes such as British rule and forest management on the forests and the people of Himalaya. Impacts of various human and livestock induced pressures such as fuelwood, fodder, MFP collection and grazing on high altitude forests and alpine meadows of Western Himalaya were initiated by Gupta (1978). More detailed studies on the resource extraction and its impact on surrounding vegetation were conducted by Babu *et al.* (1984), Singh and Singh (1987), Moench (1989) and Singhal (1994). Moench found that forests in the vicinity of the villages were the most threatened and emphasized how the nibble effect is going to put more pressure. Babu et al. revealed a decline in forest structure and composition due to overgrazing and lopping by the livestock and people respectively. Studies relating to human induced pressures on forests of Nepal include works of Fox (1984), Mahat *et al.* (1986a, 1986b), Gilmour

Figure-1.2: Types of anthropogenic pressures on forests of Bhagirathi valley



(1988), Metz (1990) and Osei (1993). Most of them emphasized that patterns of fuelwood and fodder extraction influenced the surrounding vegetation. Another anthropogenic activity "mass tourism" and its impacts on the biologically rich areas of Garhwal such as Valley of Flowers and Hemkund were initiated by Singh (1977). It was highlighted from their studies that deforestation and construction is on rise in the fragile zones. Further works of Kaur (1985), Jayal (1986) and Khadka (1992) added more information on this aspect.

Several papers in Pangtey & Joshi (1987) have emphasized on the changed land-use practices in the western Himalaya and its influence on surrounding forests. Other studies by Murthy and Pandey (1978), Gaur *et al.* (1985), Schroeder (1985), Stone (1990), Farooque (1992) and Badooni and Negi (1995) have also dealt with the changes in socio-economic conditions and related changes in landuse practices of people inhabiting the Himalayan region.

Thus, the perusal of literature reveals that the ecological relationship of man and forest has been studied by a large number of workers but most of the studies pertain to the Himalayan region such as Nepal, Kumaun, Sikkim and Himachal Pradesh. Very few studies have been carried out in the Bhagirathi valley, which has been heavily exploited since pre-British period. Recent changes in the land-use practices of locals, transhumant communities and tourists have further influenced the status of these forests (Figure-1.2) resulting in degradation of forests and increased conflicts with wild animals. Hence, the present study was undertaken to assess the ecological impacts of anthropogenic activities on high altitude forests of Bhagirathi valley.

1.4 Objectives of the study

Following were the objectives of the study:

1) To quantify the resource use patterns of local villagers, transhumant communities and tourists in Bhagirathi valley.
2) To assess the impacts of anthropogenic pressures on the forests of Bhagirathi valley.
3) To map land-cover categories in Bhagirathi valley and detect changes in different categories over time and space.

CHAPTER-2

Study Area

CHAPTER-2

Study Area

2.1 Western Himalaya

2.1.1 Biophysical setting: The Himalayan region lying between river Sharda in the Eastern Kumaun and the river Sutlej in Himachal Pradesh (H.P.) is generally termed as the Western Himalaya (WH). It extends approximately from 76^0 36' to 81^0 E long. and 28^0 to 32^0 N lat.. River Sutlej forms an important landmark in delineating WH from the Northwest Himalaya. Towards east of river Sutlej, more of Indo-Chinese and Malayan elements are found whereas to the west of this river, Ethiopian and Mediterranean elements are prevalent (Mani 1974). This highlights the ecological importance of WH as a distinct bio-geographic zone. There is an abrupt fall in the mean elevation of all mountain ranges to the west of river Sutlej while in the other part, the high peaks rise to mean elevations of 6500m. Nanda Devi (7822m), Swargarohini (6562m), Satopanth (7075m), Gangotri group of peaks (6613m), Bhagirathi group of peaks (6607m), Bandarpunch (6720m) and Kamet (7758m) are some of the better known peaks of WH. The mountain ranges in the east of the defile are aligned mostly on east-westerly direction whereas in the other part there is a southeast-northwest trend. The *Tarai* and *Bhabhar* areas of Kumaon and *Duns* of Garhwal lie in the outer Himalaya while mountain ranges with an average altitude of 3600-4600m come under Lesser Himalaya. The high zones extending up to 6000m with perpetual snow cover fall in the Greater Himalayan range while the rainshadow zone to its north is categorized under the cold arid areas of Indo-Tibet border or the Trans Himalayan zone. Geologically, the Tibetan zone is composed of sediments of all ages from Cambrian to the late tertiary whereas the Greater Himalayan zone of the snow-covered peaks is composed of some sedimentary and metamorphic rocks of Pre-Cambrian and Palaeozoic. The Sub-Himalaya (Lesser Himalaya) is formed of sediments ranging from Pre-Cambrian upward to the Mesozoic and are mostly unfossiliferous and the Shiwalik hills are composed of tertiary sandstones and shales (Wadia 1975).

2.1.2 Bio-geographic zones and protected area network: Rodgers & Panwar (1988) have divided Himalaya into six biotic provinces *viz.*, Ladakh mountains, Tibetan Plateau, North-West Himalaya, Western Himalaya, Central Himalaya and the Eastern Himalaya. Western Himalaya covers an area of 72000 km^2 (*ca.* 17.04%) of the total Himalayan region. Of the total area in WH, about 74% comes under Uttaranchal and rest under eastern Himachal Pradesh. Bio-geographically the WH has more of European elements in its flora whereas Eastern Himalaya (EH) has the dominance of Malayan, Burmese and Chinese elements (Mani 1974). Western Himalaya has a wide representation of conifers and less diversity of rhododendrons and orchids. The region also lacks eastern faunal elements such as blood pheasants and red panda. In WH also, there are local variations due to soil, altitude and aspect (Puri *et al.*1989). Species of oaks form the climax vegetation in Garhwal while conifers are regarded as seral communities. In the southern warm aspects more of agriculture, habitation and chirpine forests are found whereas broadleaf forests generally occupy northern slopes. The presence of undercanopy dwarf bamboos (*Arundinaria falcata* and *Thamnocalamus spathiflorus*) highlight the ecological richness of these forests. Presently, *ca.* 20% area (existing and proposed) of the WH including biologically rich areas of Nanda Devi, Valley of Flowers, Kedarnath, Har ki Dun and Askot has been notified as Protected Area (PA). Some patches of Reserved Forest in WH, which are rich in floral and faunal diversity, also need immediate concern due to increasing human activities.

2.1.3 Eco-climatic zones: The ecology of Himalaya is temperature dominated and except for parts of extreme eastern end, the Himalaya is almost outside the influence of monsoon rainfall. The atmospheric temperature determines the altitudinal zonation of life, the east- west gradation and numerous other peculiarities of the Himalaya. Western Himalaya experiences lower monsoonal rainfall compared to the EH but receives heavy snowfall during winter. Local variations in the climate due to topography and relief features are common. There is a fall in the temperature with rise in elevation. Within the altitudinal range of 800-1200m the climate is warm subtropical, 1200-2400m belt exhibits cool temperate climate while in 2400-3600m elevational range climate becomes alpine and above 3600m climate is alpine and arctic type (Mani 1981). Other factors affecting microclimatic conditions include the direction of ridges, the degree and aspect of slope, nearness to permanent snowline or glaciers and nature of forest cover.

2.1.4 Forest and wildlife: Geographic and climatic conditions play an important role in the distribution of forests and representative fauna. The varying altitudes and aspects of WH support different vegetation types ranging from subtropical to alpine and the characteristic faunal species inhabiting them. The fauna of WH is represented by Oriental elements, which have spread westwards from EH, as well as Palaearctic forms and to some extent Mediterranean and Ethiopian elements (Mani 1974) and shows wide adaptability represented by varied forest types. Various broad forest types found here can be classed as; subtropical deciduous (below 1300 m), Himalayan warm temperate (1300-1800m), Himalayan moist temperate (1800-3300 m), sub-alpine (2500-3500 m) and above 3500m alpine (Champion & Seth 1968, Puri 1989).

At lower altitudes between 500-1500m, the dominant tree species are *Shorea robusta*, *Terminalia tomentosa*, *Adina cordifolia*, *Syzygium cumunii,and Mallotus philippinensis*. Pure patches of chir (*Pinus roxburghii*) also occur on the dry and degraded sites. Important shrubs include *Murraya koenigii*, *Carissa spinarum*, *Clerodendrum viscosum*, *Jasminum multiflorum* and *Colebrookia oppositifolia*. Common fauna of the region includes elephant (*Elephas maximus*), tiger (*Panthera tigris*), rhesus macaque (Macaca *mullata*), common langur (*Phresbytes entellus*), Chital (*Axis axis*) and Jackal (Canis *aureus*). Peafowl (*Pavo cristatus*) and red jungle fowl (*Gallus gallus*) are the important birds of the area.

The temperate zone lying between 1500-3000m is usually dominated by oaks (*Quercus* spp) as climax species. Other associated tree species found here are *Lyonia ovalifolia*, *Litsea chinensis*, *Machilus odoratissimma*, *Acer* spp and *Rhododendron* spp., *Ilex dipyrena*, *Myrica esculenta and Euonymus* spp. Species of *Daphne*, *Sarcococca*, *Rubus* and *Rhamnus* form the important shrubs of this zone whereas *Berberis lycium*, *Prinsepia utilis*, *Pyracantha crenulata and Caesalpinea* spp. are generally found in the degraded areas. Important fauna of these forests include common leopard (*Panthera pardus*), Asiatic black bear (*Selenarctos thibetanus*), sambar (*Cervus unicolor*), barking deer (*Muntiacus muntjac*) and wild pig (*Sus scrofa*). Cheer (*Catreus wallichii*) and Khaleej (*Lophura leucomelana*) pheasants, chukor (*Chukar chukar*) and black partridge (*Francolinus ---*) are the important birds of this zone.

The subalpine zone occupies the altitudinal range between 3000-3500m in the WH whereas in the EH it is comparatively higher lying between 3600-4000m. The dominant species forming timberline forests are *Quercus semecarpifolia, Betula utilis* and *Rhododendron campanulatum.* Other common species of the region are *Taxus wallichiana, Abies pindrow, Abies spectabilis, Picea smithiana. Skimmia laureola, Ribes glaciale* and *Cotoneaster* are some of the important subalpine shrubs. Himalayan tahr (*Hemitragus jemlahicus*), Serow (*Capricornis sumatraensis*), Goral (*Nemorhaedus goral*), Brown bear (*Ursos arctos*) and Himalayan musk deer (*Moschus chrysogaster*) are the important faunal species of this zone. Monal (*Lopophorus impejanus*), Tragopan (*Tragopan* spp), Koklas (*Pucrasia macrolopha*) are some of the important pheasants of the area.

Above timberline, lies the alpine zone comprising alpine scrub and alpine pastures. The complete absence of trees and the dominance of herbaceous flora characterize this zone. The dominant plant genera include Potentilla, Primula, Anemone, Saxifraga and Polygonum. Blue sheep (*Pseudois nayaur*) red fox (*Vulpes vulpes*) and snow leopard (*Panthera uncia*) are the important faunal species of this zone. Snow cock (*Tetraogallus tibetanus*), Yellow billed chough, Red billed chough (*Pyrrhocorax* spp) and Pipits are the important avi- fauna of this region.

2.1.5 People and environment: People and forests in the WH as elsewhere, have been intricately associated with each other since time immemorial. The varied landscape has contributed to the cultural and ethnic diversity of people. The history of human habitation in western Himalaya dates back to almost the dawn of human civilization whereas EH was populated much later (Burman 1981). Hence, the density of population per unit of land is more in WH as compared to the EH. Hill districts of WH such as Nainital, Dehradun and

Mussoorie, which were largely developed during the British period usually, have higher population densities. Human habitations generally extend up to 4000m. However, the optimum belts where majority of population lives, extends only up to 2500m (Bose 1972). Above 3000m, the temporary hutments of local and semi-nomadic communities are found which are used seasonally. Usually shepherds migrate to ranges above 3000m during summer season. The people inhabiting WH belong mainly to two ethnic groups *viz.,* Indo-Aryan and Indo- Mongoloid (*Bhotiya*). The former group is represented by most of the population whereas *Jadhs* of Uttarkashi, *Marchas* of Chamoli and *Shaukas* of Pithoragarh represent the latter one. The *Bhotiya* is the tribal community and generally practice trans-humance. Other transhumant communities of WH include *Gaddi and Gujjar. Gaddis* generally belong to H.P whereas *Gujjars* are the semi-nomadic people who move between Bhabhar belt of Uttaranchal to high altitude meadows. Most of the people except tribal communities, have agriculture as their main occupation.. Generally wool based trade and rearing of sheep and goat has been the traditional occupation of *Bhotiyas.* People depend on forests for their basic need of fuelwood, fodder and leaf-litter. In addition, several medicinal plants and other NTFPs are also extracted from the forest. Impact of excessive forest resource use and incompatible landuse practices by human beings is visible in the form of deforestation, soil erosion, drying up of springs, recession of glaciers and recurring floods in several parts of the Himalaya (Singh and Pande 1989, Singh and Singh 1987, Sati *et al.* 1998). Thus, concern has been raised to protect the land and forests of WH on a priority basis (Anonymous 1992).

2.2 The intensive study area (Bhagirathi catchment)

2.2.1 Location: Bhagirathi valley lies in the district Uttarkashi, which is located between 30^0 28' to 31^0 28' N lat. and 77^0 49' to 79^0 25' E long. It covers an area of 8016 km^2. The district is bounded by Kinnaur district of Himachal Pradesh and Tibet in the north, Tibet and district Chamoli in the east and by Tehri and Dehradun districts in the southern and western boundaries respectively. The terrain is rugged consisting of high ridges and narrow

Figure-2.1: Catchment area of river Bhagirathi

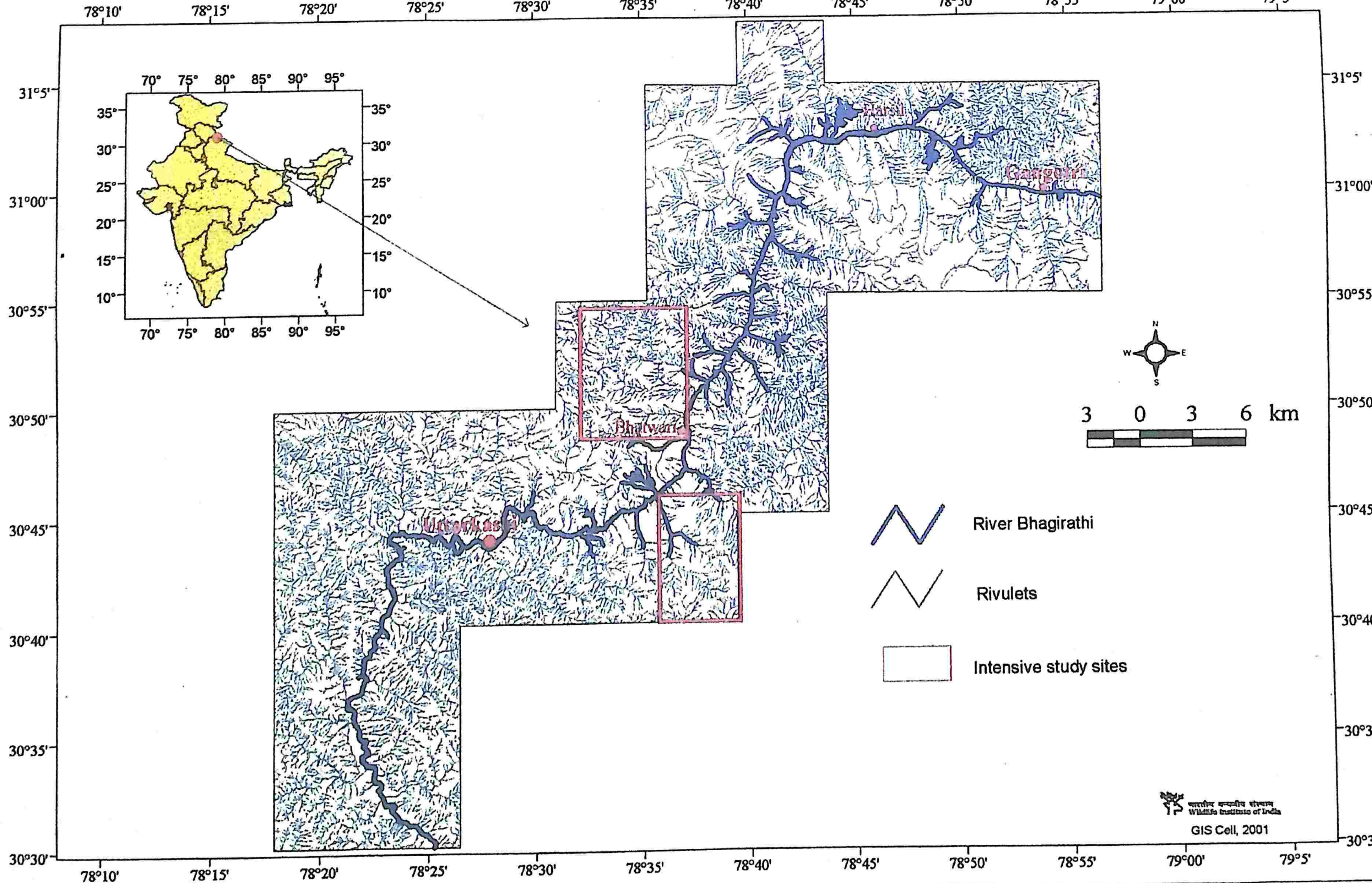


Figure-2.2: North facing- Duggada watershed

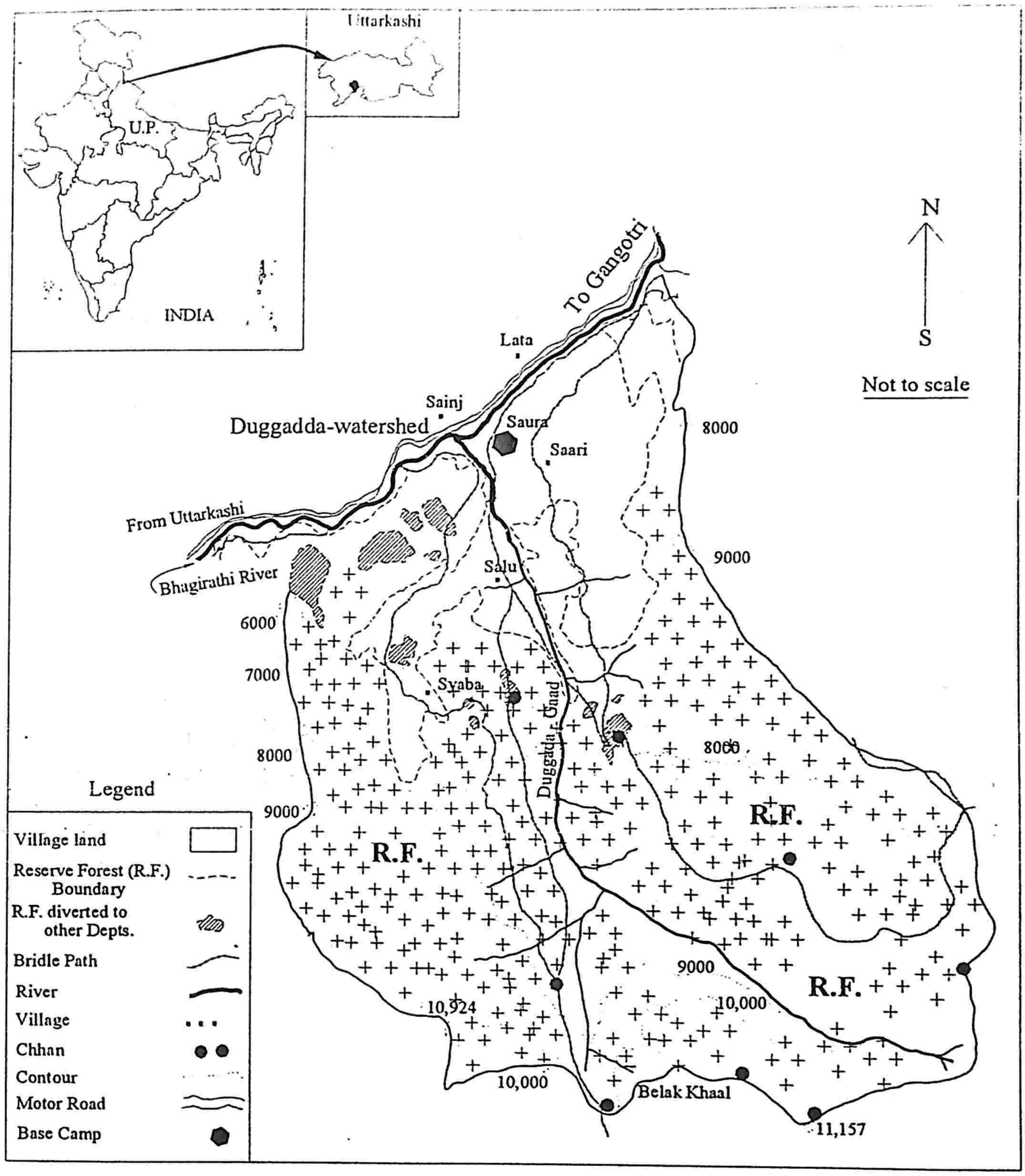
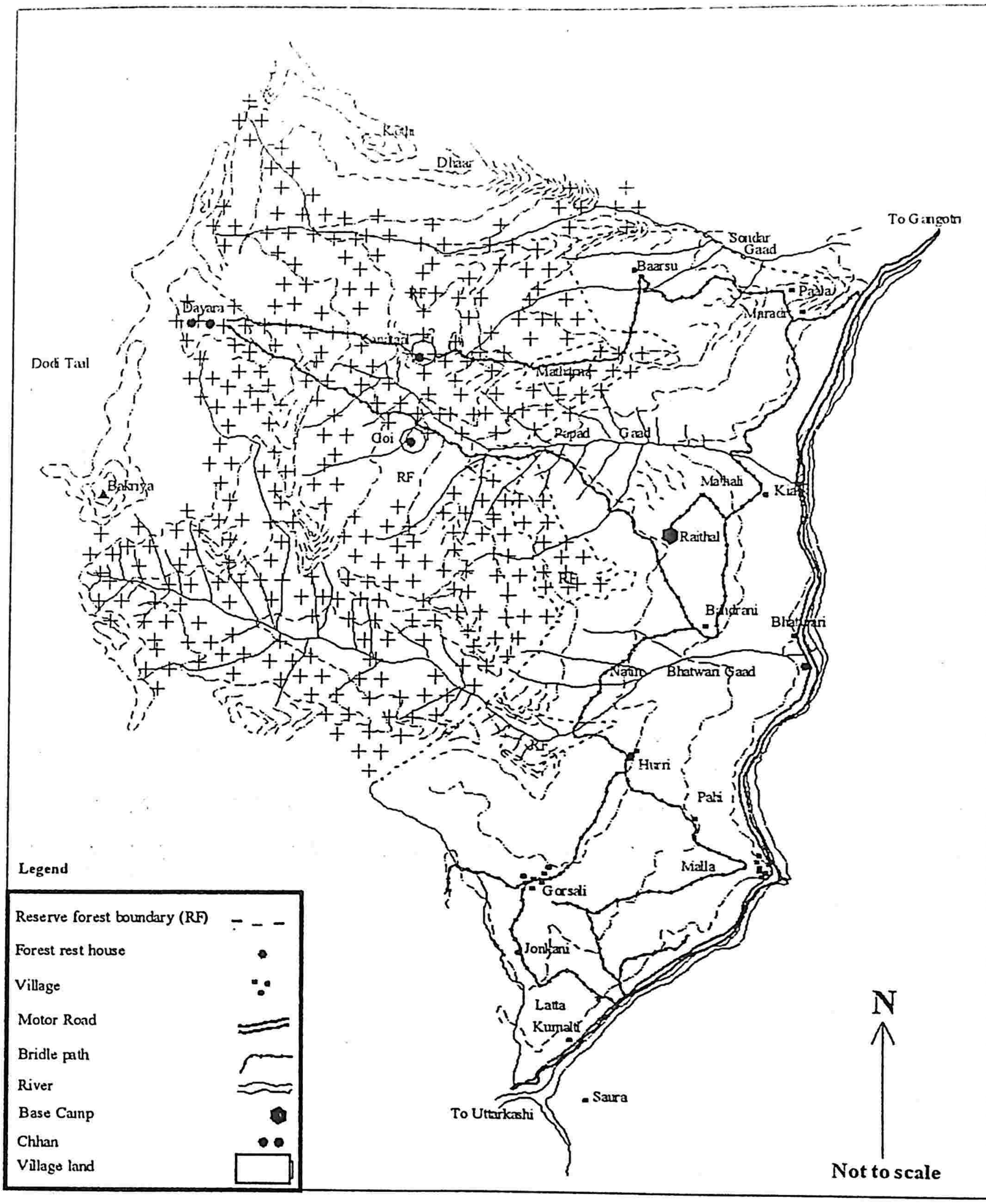


Figure-2.3: South facing-Bhatwari watershed



valleys. For the present study, part of Bhagirathi valley lying between 30^0 30' to 31^0 08' N lat. and 78^0 18' to 78^0 58' E long. was selected (Figure-2.1).

2.2.2 Drainage*:* The intensive study area is well drained. One of the great rivers of India viz., Bhagirathi (called the Ganga beyond Deoprayag) forms the main drainage system of the region. River Bhagirathi has its origin from Gangotri Glacier. Its main tributaries are Janhavi and Bhilangana. It flows westerly for about 40km and then turns south across the axis through a deep gorge where the streambed is *ca.* 2100m asl. Many rivulets locally called as *Gads* form different watersheds in the catchment of river Bhagirathi (Figure-2.1). Some of the rivulets include Jadhganga, Kankora, Jalandhari, Pilangana, Dugadda, Bhatwari, Sainj and Assiganga. Of these, two watersheds *viz.,* Dugadda and Bhatwari being representative of the entire valley were selected for the intensive field work. The altitudinal gradient of the two watersheds varies from 1700-3600m (Figures-2.2 and 2.3).

2.2.3 Geology and Soil*:* Geologically the valley may be divided into two major belts the northern and the southern, demarcated by the river Sainj. The former is occupied mainly by the higher ranges and snow covered peaks and consists entirely of high grade metamorphic rocks such as quartzites, marble and various type of micaceous schists and gneisses whereas the southern belt comprises essentially of sedimentary and low grade metamorphic rocks such as limestones and sericite biotite schists (Wadia 1975). The quality of the soil is determined by the kind of rocks in the subsoil. In Himalaya very shallow skeletal to very deep soils are found. The surface soil or the upper layer of a soil profile is richer in organic matter and darker in colour. The profile characteristics of soil vary from place to place. Soils on steep slopes ($>30^0$) are shallow due to erosion and mass wasting processes and have very thin surface horizons. Texturally, they are medium to coarse depending on the type of material from which they have been derived. Soils in general are acidic except those developed from limestone which are neutral to slightly alkaline.. Valley soils are developed from the colluvium and alluvium brought down from the slopes and deposited in valleys. The soils, therefore, are coarse textured unless the surrounding hills are of shale rocks (Ghildiyal 1981). Entisols or young soils are generally present in the terraces and along channels on the colluvial and alluvial materials. Less developed soils or Incepticols are common on the surface of the slopes whereas brown forest soils are medium to heavy textured, deep, moderately well drained, rich in organic matter and acidic in nature. In the alpine areas either meadow soil or soil rich in morainic contents are found.

2.2.4.Climate: Climate in the Bhagirathi valley is temperate monsoonal type and it varies according to aspect and elevation. Three seasons *viz.*, rainy (mid June-September), winter (October-March) and summer (April-June) are well defined. Winters are severe with frosts and snowfall common during December to February in the upper and middle slopes. Monsoon bearing winds penetrate through the valleys usually in June and the rainfall is at the maximum during July-September. Rainfall data was gathered from Tehsil Bhatwari, where the concerned authorities have set a Rain Gauge. For recording temperature, a Minimum-Maximum thermometer was used at the base camps for the present study. The monthly rainfall at Bhatwari for the period of 1996 to 1998 is shown in Figure-2.4. Maximum annual rainfall for the upper catchment of river Bhagirathi was recorded in the year 1986 and minimum during the year 1995 (Figure-2.5). Average monthly temperature from 1996 to 1999 is shown in Figure-2.6. The highest temperature of 30.86^{0}C was recorded in the month of June whereas lowest temperature 3.6^{0}C was recorded during the month of December and January. It was not the true representation of the temperature because the thermometer was kept at base camp. Humidity is highest nearly 90% in the monsoon and the lowest during pre-monsoon months when it may drop to even less than 40%.

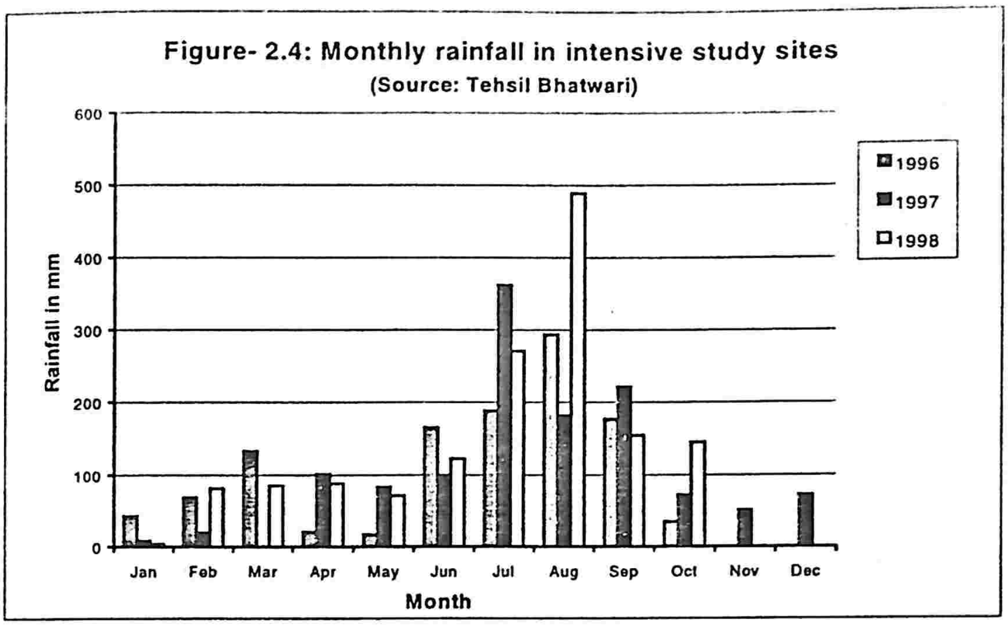


Figure- 2.4: Monthly rainfall in intensive study sites
(Source: Tehsil Bhatwari)
Rainfall in mm
600
500
400
300
200
100
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
1996
1997
1998

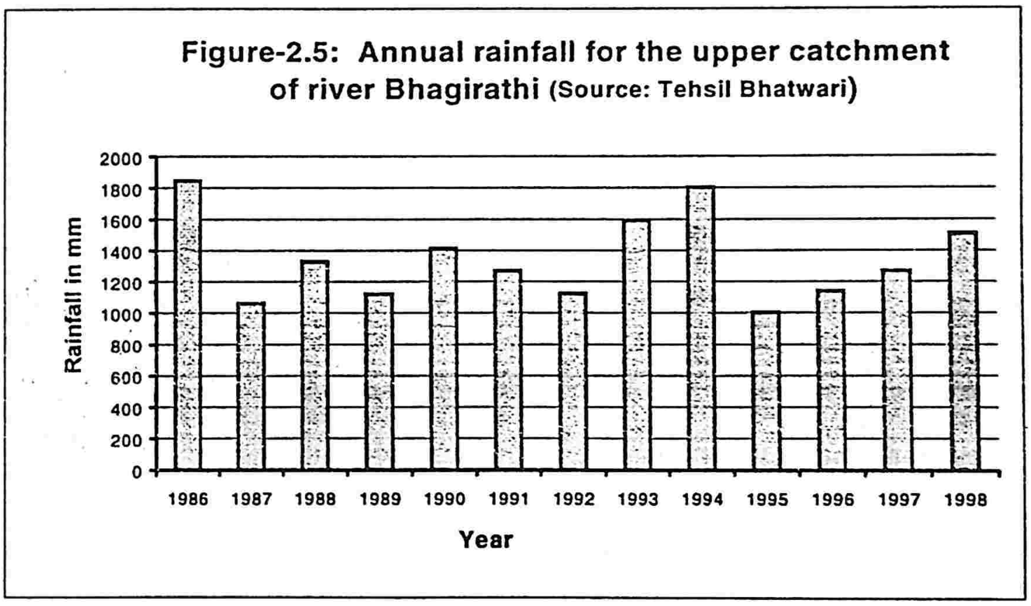


Figure-2.5: Annual rainfall for the upper catchment of river Bhagirathi (Source: Tehsil Bhatwari)
Rainfall in mm
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
Year

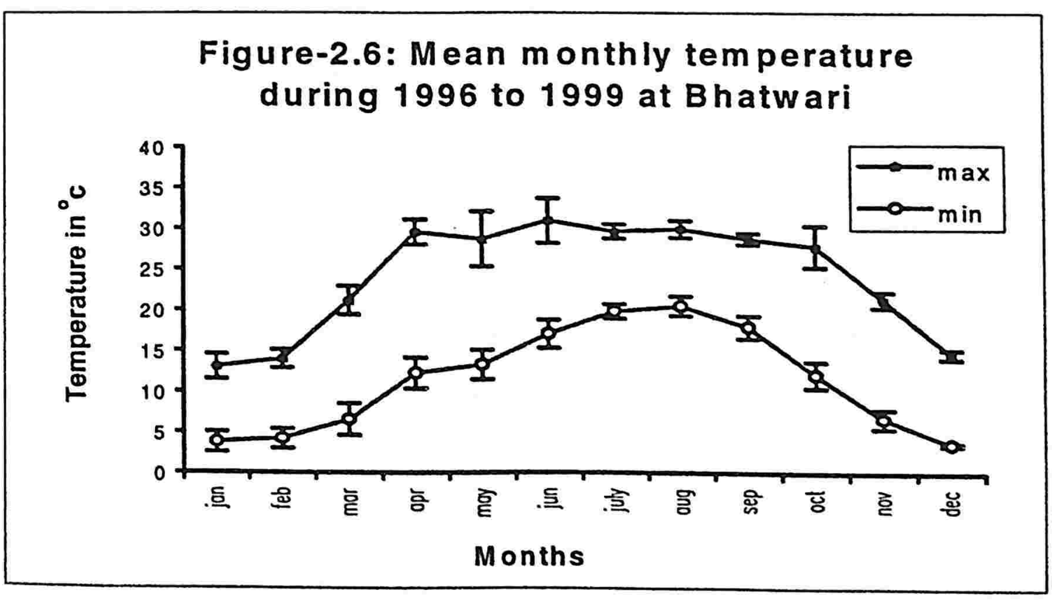


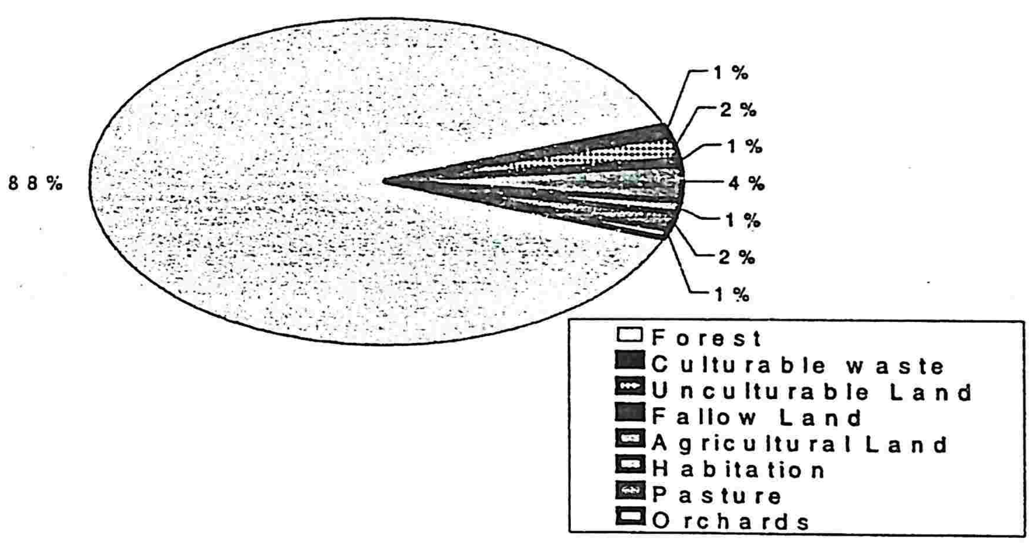
Figure-2.6: Mean monthly temperature during 1996 to 1999 at Bhatwari
Temperature in °c
40
35
30
25
20
15
10
5
0
jan
feb
mar
apr
may
jun
july
aug
sep
oct
nov
dec
Months
max
min

2.2.5 Forest and fauna: The varied topography and diverse habitats support a large number of forest formations ranging from *Euphorbia* scrub to dry alpine scrub in the study area. The following categories of forests according to Champion and Seth's classification (1968) are found in the study area; Subtropical pine forest, Himalayan Moist Temperate Forest, Himalayan Dry Temperate Forest, Sub-alpine Forest, Moist Alpine Scrub and Dry Alpine Scrub. The diverse forest types serve as good habitat for various faunal species. Important ungulate species found here include sambar, goral, barking deer, wild pig, musk deer, serow, tahr and bharal. Tahr and bharal are found in the higher reaches of Gangotri, Gaumukh and Govind Pashu Vihar whereas sambar, barking deer, wild pig and goral are seen in the mixed- broadleaf forests with an under growth of hill bamboo (vern. *Ringal*) and adjacent grassy slopes. Musk deer and serow are confined to relatively undisturbed and inaccessible forest patches of the valley. Some of the carnivorous species inhabiting these forests include Himalayan black bear, brown bear, common leopard and red fox. Some of the small mammals frequently seen are pale weasel (*Mustela sibirica*), Himalayan yellow throated marten (*Martes flavugula*) and flying squirrels (*Petaurista petaurista albiventer*). Pheasants such as monal, kaleej, red jungle fowl and koklas form the important component of avi-fauna in the area.

2.2.6 The administrative divisions and villages: The villages in district Uttarkashi are situated along the catchment areas of river Bhagirathi and its tributaries. The district at present comprises 4 tehsils and 6 community development blocks. It has 3 towns and 686 villages, which are distributed under different blocks *viz.*, Mori, Purola, Naugaon, Dunda, Chinyalisaur and Bhatwari. Bhatwari block was selected for the intensive study as it has maximum variation of altitude, aspect and moderate pressure. This block has 94 villages (including 2 abandoned ones). For the present study (two ISS) eight inhabited villages were selected. The total area of block Bhatwari is about 249 km^2 with a population of 42,078. Few villages e.g., Baghori, *Harsil, Mukhba* and *Dharali* of this block follow winter migration to villages such as *Dunda, Nakori, Gangori, Netala, Lata* and *Saura*. Besides local villagers, seasonal transhumants such as *Gujjars* and *Gaddis* from neighbouring districts of Dehradun, Haridwar and some parts of Himachal Pradesh, also visit the alpine zones of the study area during summer season. People inhabiting the area seasonally or permanently, differ in their lifestyle and land-use practices.

2.2.7 Landuse: Of the total 8016 km^2 of land in district Uttarkashi, about 2050km^2 lies in Bhagirathi valley (AOI). As much as 88% of total area, is administered by the Uttaranchal (erstwhile Uttar Pradesh) forest department and area under habitation and agriculture is comparatively low. The distribution of area under major land-use classes in district Uttarkashi are shown in Figure-2.7. Major land-use practices in the district are related to forests, agriculture, horticulture, animal husbandry and tourism.

Figure-2.7: Area under different land-use in Uttarkashi



Forests: The forests of Bhagirathi Catchment lie in the Uttarkashi Forest Division. The division has two subdivisions, five ranges and 39 beats. The total area under the division is 4,633.73 km^2. Out of the total area managed by forest department, *ca.* 49.9% is covered with snow, 16.67% is under alpine vegetation while 7.65% is rocky, 0.86% is open, and rest (24.92%) is covered by forests. The forests of ISS selected for the present study lie in Taknaur and Mukhem range having *ca* 3,731.87 km^2 and 232 km^2 areas respectively. The lower valleys are dominated by chirpine (*Pinus* *roxburghii*) covering an area of 405.68 km^2. The timberline is formed by Kharsu oak (*Quercus semecarpifolia)* covering 144.71 km^2. The largest area falls under alpine pastures 798.34 km^2. These forests support fuel, fodder, leaf-litter and NTFP needs of the local as well as transhumant communities. Over exploitation of forest resources especially in the vicinity of habitations, have converted rich broadleaf forests into degraded lands with abundance of scrubs. Presence of *Chaks* (agricultural land amidst the forest) has also increased the pressures on surrounding forests. A total of 325 *chaks* covering an area of 98.71 km^2 are found in these forests. During the summer season, livestock herds are housed in temporary huts called *Chhans* in the subalpine and alpine meadows locally known as *Kharaks (*meadows where local people construct their *Chhans*). However, forests, which are relatively inaccessible and away from the habitation, are relatively intact.

Agriculture: The upper catchment of river Bhagirathi has rugged terrain and the land is poor in fertility due to large content of outcrops of rocks and boulders, yet the majority of the population (>80%) has agriculture as their main occupation. Net sown area in Uttarkashi is 316.34 km^2 whereas net irrigated area is just 43.28 km^2 (Anonymous 1994). This shows that most of the agriculture is rain-fed. Most of the agricultural fields are terraced but for crops such as potato and amaranth generally fields on the steep slopes are preferred. Land Settlement of 1963-64, classified the cultivated land into five groups depending upon the irrigation, altitude and slope (Anonymous 1970). These classes are: Irrigated land (*Talaon*), Unirrigated and fertile land (*Upraon I*), Unirrigated terraced land (*Upraon II*), Marginal land with low productivity (*Ijran*) and forested land on steeper slopes where tilling and terracing is not possible (*Katil*). Though *Katil* farming is banned after the development of forest policy, it is still practiced in some parts of the study area. Villagers harvest both *rabi* (wheat and barley) and *kharif* (paddy, potato, kidney bean and small millets) crops. Potato is exported from the district while wheat and rice are imported.

Animal Husbandry: In most of the villages, except those inhabited by *Jadhs*, animal husbandry is the supplementary source of income. Usually the animals are kept for supplementing agricultural needs. The hill cattle are usually small in size, active and surefooted. The production of milk per milch animal is very low. Efforts are under way for introducing high yielding strain. Total livestock population in district Uttarkashi is 344,213 of which, 15.23% is in block Bhatwari. Sheep rearing and production of wool forms the primary source of income for tribal villages. Most of the wool products such as shawls, blankets, carpets and jackets are manufactured by them and sold in the local market. Average wool production in the district is estimated to be 200 tons (Bhat 1997, Johri & Prasad 1985).

Orchards: The district has an ideal climate for the plantation and growth of orchards but the farmers prefer to grow food and cash crops. Of the total geographic area just 0.94% is under orchards. At few villages such as *Harsil, Dharali, Mukhba* and *Baghori* the apple orchards are well maintained and form a good source of income. Few orchards, which were set up at village *Raithal, Barsu* and *Syaba* have now been abandoned due to the inclination of villagers towards less time and labour requiring cash crops such as potato and soyabean.

Tourism: The area is an important center for both pilgrimage and nature tourism. Ancient Hindu shrines of Gangotri, Gaumukh and Uttarkashi, attract large number of pilgrims from different parts of India since very early times. Earlier, the route to these shrines was perilous. The number of tourists increased manifold as the access became easy with the construction of roads in 1962. Annually over 70,000-80,000 people visit Uttarkashi. Since last few years nature tourism, which includes mountaineering, trekking, skiing and expeditions, has come up as an important activity in the wilderness areas of the valley. Nature trails to Har ki Dun, Dodital, Tapovan, Gaumukh, Kheratal, Dayara Bugyal, Kush Kalyan, Belak khal and Nachiketa Taal are visited by a large number of trekkers from all over the world. Local people have indirectly benefited from the growing tourist industry. They work as guide and porters to trekking parties. Though halting or resting-places called *Chattis* or *Chhans* all along the pilgrim routes to Gangotri, Gaumukh and Buda Kedar are present since ancient time, construction of concrete hotels and lodges has increased recently. Many *Chhans* at Belak Khal *en-route* to Gangotri - Kedarnath are some of the oldest and better known ones. With increased influx of tourists and unmanaged development of tourism in the area, pressure on the surrounding forests is on the rise, which would certainly affect the ecology of these fragile mountain ranges.

CHAPTER-3

General Methods

CHAPTER 3

General Methods

3.1 Background

Recognizing the ecological importance of forest formations in the study area in terms of their intrinsic values as life support system for the local people and as repository of regional biodiversity, this study aimed at assessing the anthropogenic pressures on these forests and sustainability of current landuse practices. The questions of sustainability and carrying capacity of ecosystem are complex and can be addressed only with multi-disciplinary approach. The present study was complimented by another parallel study on the structure and composition of forest ecosystem in the upper catchment of Bhagirathi river (Uniyal 2001). Both the study components aimed at assessing the overall conservation status of the forests in the area. The general methodology adopted for the present study is shown in Figure 3.1. In order to address various questions pertaining to this study both the primary and secondary data were required. Primary information was gathered through field work and secondary using satellite data of different time periods and records of various departments for relevant information. The data collected from two sources were then analyzed to determine various trends and patterns. The extensive field survey of Bhagirathi valley was carried out in July 1996 and the work in two Intensive Study Sites (ISS) was initiated in October 1996. Fieldwork in the first intensive study site *i.e.* Duggada watershed was carried out during October 1996-February 1998 and in the other ISS, Bhatwari watershed during the period March 1998-July 1999.

3.2 Selection of Intensive Study Sites (ISS)

For extensive survey of the Bhagirathi valley, 20% of the villages were selected randomly. Structured questionnaires (Clarke 1986, Patton 1987) were used to gather information on parameters such as socio-economics, landholding, land-use pattern and forest resource use of the locals (appendix 3.1). Based on the analysis of the information gathered from the extensive surveys, two watersheds *viz.*, Dugadda and Bhatwari, being representative of

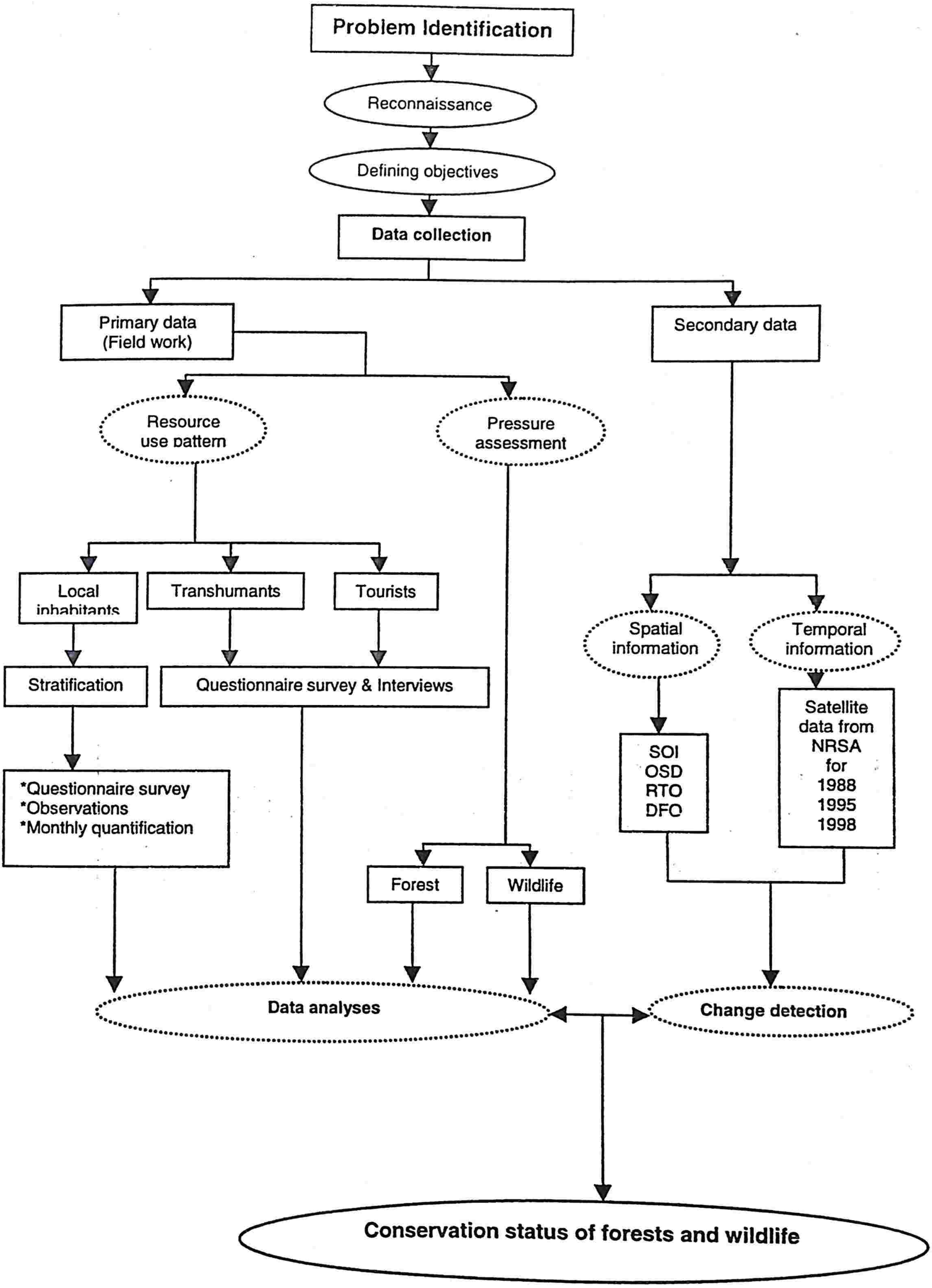


Figure-3.1: Layout of general methods followed for the present study

the upper catchment in terms of altitude, aspect, landuse, lifestyle, forest types and socio-economics were selected as ISS.

3.3 Study Of Resource Use Pattern

3.3.1 Questionnaire surveys: A door to door questionnaire survey (Appendix-3.2) of all the villages (n=6) in both the ISS was carried out to know heterogeneity in population, land use, landholding and forest resource use within and among the villages. Based on the information collected, households in each village were stratified into highly dependent, moderately dependent and least dependent strata (Ravindranath and Premnath 1997). Criteria of stratification were as follows: number of family members ≥ 6, number of livestock units ≥ 6, number of settlements ≥ 2, Primary occupation i.e. agriculture. Based on the number of criteria being fulfilled, the households were stratified as highly dependent (if ≥ 3 criterion are fulfilled), moderately dependent (if two of the criterion are fulfilled) and least dependant (if < 2 criteria are fulfilled). In each strata 15% of the households were selected randomly from each village for monthly monitoring and quantification of the resource use (chapter-4). A different questionnaire (Appendix–3.3) was designed to collect information on the lifestyle and resource use pattern of different transhumant communities visiting Bhagirathi valley during summer season (chapter –5).

Besides, tourists, trekkers and pilgrims were also interviewed using structured questionnaires in two seasons of peak tourist influx for three years (appendix-3.4). For them questionnaires were framed to elicit information regarding their behaviour, lifestyle and resource use during their stay in the area. A total of six hundred questionnaires were distributed to the tourists. In-depth interviews of local trekking agencies and hotel owners were also undertaken (chapter-7).

3.3.2 Observation techniques: Observation points on the village to forest routes were selected. Long day observation at each route was undertaken twice per month in each village following Patton (1987). At these points, resources extracted by villagers from the surrounding forests were observed.

Number of individuals collecting biomass, type and quantity of the biomass collected, species composition, distance covered and time taken to collect were recorded (chapter-4).

3.3.3 Pressure assessment: For the assessment of anthropogenic pressures on surrounding forests, permanent plots were marked. Based on altitude, the area was stratified into three zones *viz.,* 1700-2200m (Zone I), 2200-2700m (Zone II) and >2700m (Zone III). In each zone three trails (3 kms each) *viz;* highly disturbed, moderately disturbed and least disturbed were identified based on disturbance indices such as distance from village, cut/lopped signs, cattle signs and presence of weedy species. In each trail, alternate belt transects of 30×5m were marked perpendicular to the trail after every 150m. A total of twenty belt transects were marked in each trail. All the trees in each belt and their number, species were mapped in a graph. Girth of trees at breast height (GBH ≥1.5m) and lopping/cut signs were recorded following Sale & Berkmuller (1988). These permanent belt transects were then monitored monthly for new signs of cutting/lopping, use by livestock, indirect evidences such as pellets and scat of wild animals etc (chapter-6 and 8).

For quantifying availability of grass, herb and agricultural by-products as fodder, ten plots of 1×1m (Ravindranath & Premnath 1997) were laid randomly in each landuse type *viz.,* cropland, unculturable wasteland, chirpine forest and mixed-oak forest in three seasons *i.e.* summer (mid March-mid June), rainy (mid-June- September) and winter (October-mid March).

For assessing impacts of tourists in Gangotri, circular plots of 10m radius (n=4) were laid at an interval of 250m distance in the two trails (1 km each) selected on either side of the river. In these plots, tree species, their number and girth at breast height (GBH ≥1.5m) and lopping/cutting signs were recorded. Non-biodegradable garbage lying inside these plots were also sorted and weighed using spring balance (chapter-7).

3.4 Secondary Source

3.4.1 Records and Publications: Information on location and area was obtained from SOI toposheets. Data on past human and livestock population, land-use, rainfall and village maps were collected from secondary sources such as, Block Development Office, Tehsil and village revenue offices in block Bhatwari. District Statistical Office (DSO) and District Magistrate (DM) offices were visited to elicit information on the settlement of district Uttarkashi and its development. Information on the number of transhumant communities visiting district Uttarkashi, cases of wildlife-human conflicts, forest working plans and block maps were gathered from Divisional Forest Office at Kotbangla, Uttarkashi. Data on tourist influx were elicited from the records of Regional Tourist Office at Uttarkashi.

3.4.2 Remote Sensing technique: Remote Sensing (RS) coupled with Geographic Information System (GIS) was used as a tool to map different land-cover categories in the Bhagirathi Valley and detect changes in different land-cover over space and time (chapter-9). Spatial database on land-use, drainage, altitude, aspect and slope was generated in the GIS after digitizing land-use, streams and contours from Survey of India toposheets (SOI). From the digitized contours (at 100m interval) Digital Elevation Model (DEM) was generated which was further used to extract slope and aspect map. Digital data (IRS LISS-II and LISS- III) of different time periods viz., 1988, 1995 and 1998 were acquired from National Remote Sensing Agency (NRSA). The data were processed using digital image processing software ERDAS IMAGINE ver. 8.3. and final classified maps were generated. These maps of different time periods were overlaid in GIS software ARC/VIEW ver. 3.1 to analyze changes in different land-cover classes.

3.5 Analyses

Information collected from field and secondary sources was put to simple statistical analyses such as mean and standard errors. Spatial and temporal differences in resource use were examined. Differences in resource use between different socio-economic classes were also analyzed. Density and basal area of the woody species was calculated following Misra (1968).

Indirect evidences were used as an index of wild animals and the relative abundance of wild animals was calculated using formula D=N/A;

where 'N' is the number of pellet groups or scat counted and 'A' is the area of belt transects (Rodgers 1991).

Classified land-cover maps were correlated with the topographical features such as altitude, aspect and slope in ARC/VIEW ver. 3.1 to determine area of different land-cover classes in different altitudes, aspects and slopes. Changes in different land-cover classes were also correlated with the above mentioned topographical features (ESRI 1996 and 1998). For testing the significance of results statistical tests such as Kruskal Wallis one way and two way ANOVA (Analysis of Variance), t-test, Pearsons Correlation Coefficient and Regression (Zar 1984) were applied using computer software Analysis Tool Pack in Microsoft Excel. Details of the analyses are given in each chapters 4 to 8.

CHAPTER-4

Patterns of Biomass Utilization by Local People

CHAPTER-4

Patterns of Biomass Utilization by the Local People

4.1 Introduction

Biomass, in its various forms, represents one of the truly renewable resources upon which the planet can and must build in order to ensure a sustainable future. There is an urgent need for the development of more efficient management systems, in order to increase the productivity and ensure the sustainability of resource harvesting (Ravindranath and Premnath 1997). Plant biomass accounts for about 15% of the world energy use and 38% of this energy is consumed in developing countries (Singh and Singh 1999). It is an important source of food and firewood for human beings, fodder for livestock, timber for housing and furniture and many other products needed for existence of man and animals. Forests, the chief reservoirs of biomass, constitute nearly 44% of the geographical area in Uttaranchal (FSI 1997). Although, the share of biomass in national total primary energy use is low (36% of the total), yet it is the most important source in rural areas (Monga & Ramana 1992). A variation in the type and extent of biomass use is found in accordance with agro-climatic zones because its use is likely to be determined by the local climate and vegetation type (Ravindranath and Hall 1995). Ecological conditions of an area affect the socio-economics of the people and their lifestyle, which consequently determine the demand for forest biomass (Veena 1988) and this ultimately defines the level of pressure on surrounding forests. Excessive pressures then lead to degradation of forests and scarcity of basic resources for fuelwood and fodder (Eckholm *et al.* 1984). For the conservation of the natural resources, an understanding of the region specific needs, socio-economics of the local people and patterns of biomass utilization has been emphasized (Moss and Morgan 1981). Collection of baseline information on the forest resource utilization is also important for long-term monitoring and efficient land use management. This chapter deals with the patterns of biomass (fuelwood, fodder and bamboo) utilization by the local people vis-a-vis their socio-economic conditions in the upper catchment of river Bhagirathi. The specific objectives were:

- To study the socio-economic structure and patterns of resource use among different dependency groups
- To study the seasonal variation in resource extraction and consumption by the local people
- To assess the variation in resource use due to various land use practices

4.2 Methods

4.2.1. Field Methods: Information available from the published literature and unpublished records of district headquarters at Uttarkashi revealed that Block Bhatwari covers major portion of the upper catchment of river Bhagirathi. Villages of this block lie in two *pattis* (village circles) *viz.,* Taknore and Naald Kathur with a total of 30 and 16 villages respectively in the upper valley. The forests surrounding these villages fall under Taknore and Mukhem ranges of Uttarkashi Forest Division. For an extensive survey, 30% villages from each *Patti* were selected randomly representing a total of 20% villages (n=18) in block Bhatwari. In the extensive survey information at village level was elicited using village profiles (Appendix-3.1). Based on this information, two Intensive Study Sites (ISS) were selected for the detailed sampling. Stratified random sampling was used to select the households within each ISS. In the randomly selected households in each category monthly monitoring was done using structured questionnaires (Appendix- 3.2) and conducting direct measurements. Although use of structured questionnaire is a systematic and standardized approach (Clarke 1986) that makes quantitative measurements possible, its limitation is that it restricts the range of possible answers. This limitation was overcome by leaving the questionnaire open ended to include any other information not incorporated in the standardized format. The selected households were monitored for the forest resource use especially fuel wood, leaf-fodder, grass fodder and bamboo thrice in a month. Three days were chosen randomly. Displacement method (Ravindranath & Premnath 1997) was used to measure the quantity of fuel wood and fodder consumed in the households. In this method the individual who cooks for the household or looks after the livestock was requested to set aside an indicative quantities of fuel or fodder to be consumed in a day. The weight (in kg), species, circumference at base (CAB), length of the wood (size class) etc. were recorded in the data sheet. Fuel/ fodder from the weighed bundle was used for the whole day. Early next morning, the remaining fuel wood/ fodder from the bundle was weighed and the values were recorded. In case of livestock, the time period (in hours) of grazing in a day was recorded if the animal was not stall fed during day.

The *Kharaks or* cattle camps (sub-alpine and alpine meadows where temporary huts of locals are present) that are used mainly by the villagers from mid -May to mid -September were surveyed during summer of 1997 and 1998. It was found that the pattern of resource use was homogeneous in all the cattle camps. Of twelve (12) cattle camps, six (6) were selected for the intensive quantification. The selection of cattle camps was based on accessibility from the base camp and logistic facilities. In each cattle camp, 20% of *Chhans* (temporary huts) were selected randomly for monitoring use of forest resources such as fuel wood and leaf-fodder. These temporary huts were visited monthly. Like permanent settlements, here too, the displacement method was used for quantification of fuel-wood and leaf-fodder.

In addition Observation Points (OPs) on the village to forest routes were selected in each village for recording the extraction of forest products and forest related activities of the villagers. The OPs were selected on two routes in each village. Long day observation from early morning to late evenings was undertaken twice per month per route. Information on number of individuals going to and coming from forest, type of head load, species composition, distance covered and time taken to collect a typical load was noted and resource collected was quantified using a Dial balance. Observation technique helps to crosscheck the information collected through interviews. Integration of observation data with questionnaire surveys gives more reliable information (Clarke 1986, Fox 1984).

Besides primary data collection, information from Village Revenue Officer, *Tehsil* Office, Block Development Office, Veterinary hospital, District Statistical Office, Office of the District Magistrate and Divisional Forest Office was also recorded. Information on village land use, population trends, area under different crops (*Jinswar*) and major developmental programs in the block was collected.

It took about three months to take people into confidence for household's survey and monitoring. Initially, people were non-cooperative but later provided all the necessary help. Due to accessibility problems, more interior villages could not be surveyed. The information collected from various secondary sources was inconsistent and made analyses difficult and time consuming. Some gaps also existed on account of destruction of old records at the time of earthquake in October 1991.

4.2.2 Analyses: Data collected from the field were sorted and grouped in tabular forms. Information in primary tables was later fed to computer program Microsoft Excel at the Wildlife Institute of India (WII). Bray and Curtis (1957) Polar-Ordination method was used to assess similarity between extensively surveyed villages. To assess variation in resource use between villages, socio-economic groups and seasons, statistical tests such as t-Test and Analysis of Variance (ANOVA) (Zar 1984), were applied using computer program Analysis Tool Pack. Livestock number was converted to units following Singh and Singh (1988) as, 1 sheep= 1 livestock unit (L.U), 1 goat= 1.5 L.U, 1 cow/ox/mule= 4 L.U and 1 buffalo=6 L.U. Grazing pressure was calculated as a ratio of livestock units to total land (L.U/Total.land). Cropping Intensity Index (CII), which is a measure of use of agricultural land, was calculated as a ratio of agriculture land harvested to total agricultural land.

4.3 Results

4.3.1 General profile of villages of upper catchment of river Bhagirathi: A general profile of extensively surveyed villages is given in Table-4.1, which shows that most of the villages were spread between an altitudinal gradient of 1700-2800m. The villages were surrounded by different types of forests such as Chir Pine (*Pinus roxburghii*) at the lower elevations to Deodar-Murand (*Cedrus deodara- Abies pindrow*) at higher altitudes. Distance to nearest forest varies from <0.5 Km to 5km whereas distance to nearest motor road varies from <0.5 Km to 8 Km. Almost all villages perform one or the other form of migration and primary occupation in all villages except Baghori was agriculture related. Population of the villages varied from 200-1800 and average population was 579.11± 107.65. Trends of the population since past

Table-4.1: A profile of villages surveyed extensively

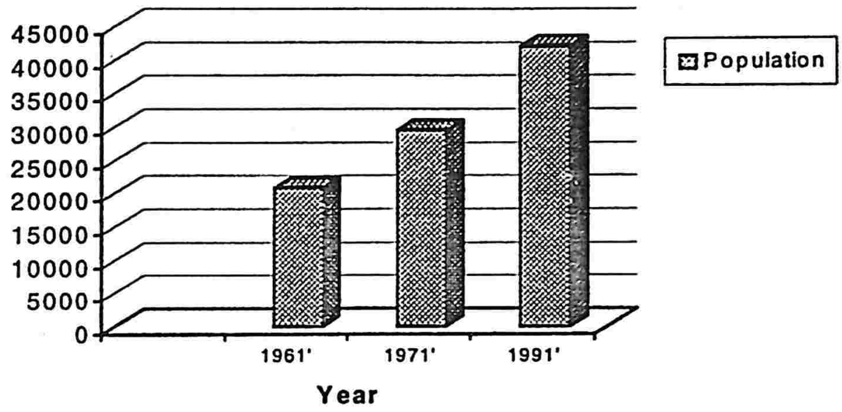
Village	Village circle	Altitude (m)	Distance to forest (Km)	Forest type	Distance to road (Km)	Population (number)	Occupation	Migration	Tourists
Dharali	Taknore	2800	1.5	D-K	<0.5	700	Agriculture	TM	V
Mukhba	Taknore	2954	1.0	D-K	2.0	1500	Agriculture	TM	DV
Harsil	Taknore	2487	0.5	D-K	<0.5	200	Agriculture	TM	V
Baghori	Taknore	2487	1.0	D-K	2.5	1700	Wool trade	TM	DV
Purali	Taknore	2727	1.0	D-K	3.0	200	Agriculture	NT	DV
Juspur	Taknore	2900	3.5	D-K	0.5	175	Agriculture	TM & NT	DV
Jhala	Taknore	2575	5.0	D-K	2.5	275	Agriculture	NT	DV
Sukhi	Taknore	2945	1.5	D-K-T	<0.5	475	Agriculture	NT	DV
Saalang	NaaldKathur	2100	1.5	MO	4.0	350	Agriculture	NT	DV
Malla	Taknore	1700	3.0	P-MO.	0.5	600	Agriculture	NO	DV
Bhatwari	Taknore	1550	3.0	P-MO	<0.5	1280	Agriculture	NO	DV
Dwari	Taknore	2400	2.5	MO	3.0	450	Agriculture	NT	DV
Raithal*	Taknore	2400	1.5	MO	<0.5	684	Agriculture	NT	V
Barsu*	Taknore	2400	0.5	MO	<0.5	340	Agriculture	NT	V
Saura*	NaaldKathur	1700	<0.5	P-MO	2.0	580	Agriculture	NT	V
Saari*	NaaldKathur	2000	0.5	MO	3.5	390	Agriculture	NT	DV
Saalu*	NaaldKathur	1900	0.5	MO	4.0	200	Agriculture	NT	DV
Syaba*	NaaldKathur	2300	<0.5	MO	8.0	325	Agriculture	NT	DV

D-K: Deodar-Kail, D-K-T: Deodar-Kail-Thunaer, MO: Mixed Oak, P-MO: Pine-Mixed Oak, TM: Transmigration, NT: Nuclear Transhumance, V: visit, DV: Don't Visit,

* villages selected for intensive study

few decades shows that population in block Bhatwari has almost doubled since 1961 (Figure-4.1). Polar ordination results showed that most of the villagers were similar (similarity >40%) in respect of altitude, population, occupation and forest types. Six villages i.e. four from North facing slopes with an altitudinal gradient of 1700-3600m in Duggada watershed (DWS) and two from South facing slopes with an altitudinal gradient of 2400-3600m situated in Bhatwari watershed (BWS) were selected as representatives of the area after the analysis of extensive survey.

Figure-4.1:Trends of human population in block Bhatwari



4.3.2 General Profile of Villages

4.3.2.1 Demography and caste composition: There were four villages *viz.,* Saura, Saari, Saalu and Syaba in the DWS and two villages *viz.,* Raithal and Barsu in BWS. Of the total 229 families in DWS, about 160 were migratory. In BWS, village Raithal with 123 families was a large village whereas village Barsu had 60 families. All families follow summer migration to alpine meadows. A general profile of the villages prepared after door to door survey (Table-4.2) revealed that the villages in DWS had a total population of 1495. Average family size was 6.11± 0.04 (n=229) with a male to female ratio of 1:1.16. Of the total population 27.42% was literate (excluding children less than 4 years). On the other hand villages in BWS had a total population of 1030. Average family size was 7.55± 0.2 (n=183) with a male to female ratio of 1:1.12. Here 35.33% of total population was literate. Due to the presence of one primary and one junior school and availability of motor road in villages of

BWS, number of literate persons was higher compared to DWS. In DWS majority of literate persons were in village Saura (nearest to school and road head). Average level of education was upto primary (class V).

In DWS, more than 60% of the population belonged to Rajputs, just two families of Nepali labourers were found in village Syaba. No tribal population was found in these villages. In BWS, more than 90% of the population belonged to Rajputs in village Barsu and rest were Nepali labourers migrated from outside whereas in village Raithal more than 50% families were of Rajputs followed by Schedule castes (36.59%).

Table-4.2: A general profile of the six villages

	DWS				BWS*	
Parameter	**Saura**	**Saari**	**Saalu**	**Syaba**	**Raithal***	**Barsu***
Altitude (in m)	1700	2100	2000	2300	2400	2400
Dist. from road (km)	2	3.5	4	8	<0.5	<0.5
School	p	p	p	p	P	P
Hospital	p	A	A	A	P	A
Vet. Hospital	p	A	A	A	A	A
Post Office	p	A	A	A	P	A
Electricity	P	P	P	A	P	P
Dist. from forest (km)	<0.5	0.5	0.5	<0.5	1.5	0.5
Middle settlement	4	13	14	21	41	15
Upper settlement	0	27	17	28	10	6
Migratory distance (km)	0.5	12	15	9	8	6
# of households	69	65	30	65	123	60
Population (total)	**580**	**390**	**200**	**325**	**684**	**346**
Adult male	219(37.76)	144(36.92)	76(38)	150(46.2)	305 (44.6)	156 (45.1)
Adult female	221(38.10)	126(32.3)	59(29.5)	100(30.8)	275 (40.2)	137 (39.6)
Young male	84(14.48)	80(20.5)	28(14.0)	53(16.31)	52 (7.6)	29 (8.4)
Young female	56(9.66)	40(10.3)	37(18.5)	22(6.77)	52 (7.6)	24 (6.9)

Literate	162(27.9)	79(20.3)	79(39.5)	90(27.7)	226 (33.04)	138 (39.88)
Education level (mean)	7th	7th	8th	5th	6th	7th
Occupation						
Ag.+DW	51	57	28	60	99	47
Ag.+S	8	6	2	2	19	7
Ag.+ Ots.	10	2	0	3	5	6
Livestock holding	484	610	431	463	1453	980
Caste						
Rajputs	54(78.3)	42(64.6)	30(100)	53(81.5)	68 (55.28)	56 (93.3)
Brahmins	6(8.70)	2(3.18)	0(0.00)	0(0.00)	10 (8.13)	0
S. Castes	9(13.04)	21(32.3)	0(0.00)	10(15.4)	45 (36.59)	0
S. tribes	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0	0
Nepali	0(0.00)	0(0.00)	0(0.00)	2(3.2)	0	4 (6.67)
Fuel Use						
LPG	8(11.6)	1(1.54)	1(3.33)	0(0.00)	51 (41.46)	13 (21.67)
Kerosene	0(0.00)	0(0.00)	0(0.00)	0(0.00)	3 (2.44)	0
Firewood	69(100)	65(100)	30(100)	65(100)	123 (100)	60 (100)
Electricity	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0	0
Income (Rs)						
H.hold/annum	7497.1	6693.85	5240	6475.4	13915.69	19592.9
Capita/annum	1249.	1115.64	873.33	1079.23	1739.46	2798.9
Landholding (ha)	133.76	483.663	180.274	190.115	372.663	145.844

Values in parenthesis represent percentage, P=present, A= absent, A+ Dw= agriculture and daily wages, Ag.+S= agriculture+ service, agriculture + ots.= agriculture and business or others.

4.3.2.2 Landuse and landholding distribution: Distribution of land under different landuses in the study villages is shown in Figures-4.2 and 4.3.

Figure-4.2: Distribution of area under different land use in DWS

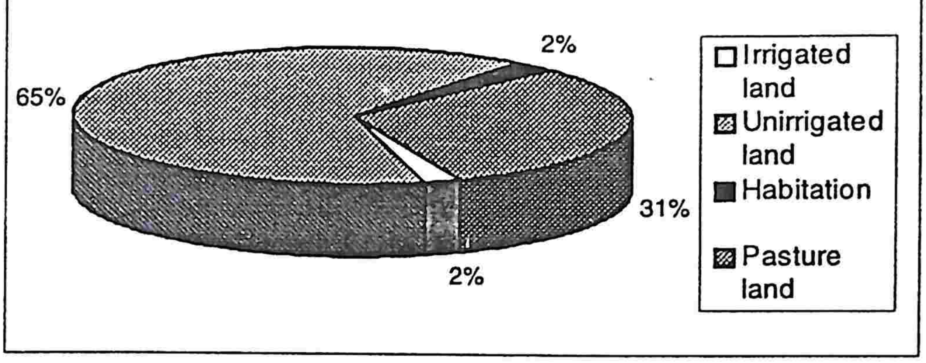
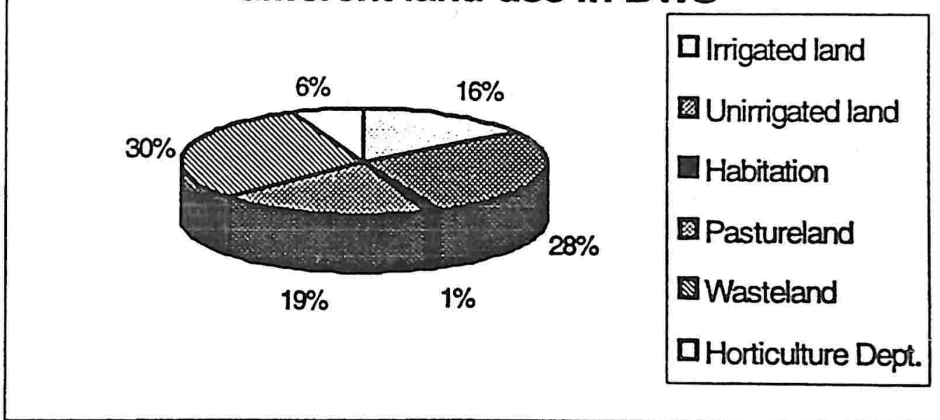


Figure-4.3: Distribution of area under different land-use in BWS



Of the total 987.812 ha of land holding in all four villages of DWS, (Table-4.3), village Saari had a maximum land holding size of 483.663 ha and village Saura had a minimum land holding size of 133.76 ha. Of the total land, 29.32% was cultivated for different crops and about 47% land remained as wasteland. Of the total cultivable land, only 3.5% was irrigated (in village Saura). In BWS, of the total 518.507ha of land, (Table-4.3) village Raithal had 71.9% of the landholding. Irrigated land occupied 15.15% of the total land and about 30.67% of the land remained as wasteland.

Table-4.3: Area (ha) under different land-use in villages of ISS

Land-use	Saura	Saari	Saalu	Syaba	Raithal	Barsu
Irrigated land	10.138	0	0	0	80.375	0
Unirrigated land	10.028	138.466	48.362	82.598	109.651	33.787
Habitation	2.601	2.489	2.444	3.056	5.854	0.72
Common land	1.22	76.358	3.206	3.112	NA	NA
Wasteland	69.672	179.486	121.378	97.13	107.902	51.137
Pastureland	40.101	86.864	4.884	4.219	51.023	45.2
Horticultural land	0	0	0	0	17.858	15
Total	**133.76**	**483.663**	**180.274**	**190.115**	**372.663**	**145.844**

* Source:village revenue office

Most of the families (n=229) fall under landholding strata of marginal farmers (0.88± 0.3 ha) in villages of DWS (Table-4.4). Only one family in village Saari had landholding of more than 4 ha. In BWS, most of the families (n=123) in village Raithal fall under the category of small farmers (1.46 ± 0.69 ha) whereas in village Barsu most of the families (n=60) were marginal (0.67± 0.58ha).

Table-4.4: Land holding distribution in villages of ISS

Landholding Strata	Area (ha)	Saura	Saari	Saalu	Syaba	Raithal	Barsu
Landless	None	0 (0)	0 (0)	4 (13.3)	10 (15.4)	0(0)	0 (0)
Marginal	0-1	33 (47.83)	32 (49.2)	20 (66.7)	49 (75.4)	41 (33.3)	48 (80)
Small	1-2	27 (39.13)	4 (6.2)	5 (16.7)	3 (4.6)	65 (47.2)	8 (13.3)
Medium	2-4	9 (13.04)	28 (43.1)	1 (3.3)	3 (4.6)	23 (18.7)	4 (6.67)
Large	>4	0 (0)	1 (1.5)	0 (0)	0 (0)	1 (0.8)	0

Values in parenthesis represent percentage, Land holding strata are used following State Planning Institute, U.P. criteria

Primary occupation of the people was based on agriculture activity (85.59%) The average per capita annual income ranges between Rs. 873.33 to Rs. 1249.52. About 6% families in villages Raithal and Barsu had hotels or shops at villages or block headquarter Bhatwari. No discrimination of occupation based on castes was found.

4.3.2.3 Cropping pattern: Cropping pattern differed with season. However, altitude didn't have much influence on cropping pattern. In *kharif* season (April-November) irrigated land at Saura in DWS and Raithal in BWS was occupied for paddy cultivation whereas in rain-fed agricultural land mixed crops of potato, millets, cucumber, paddy, pulses and oilseeds were sown. In 32.86 ha of land apple orchards were present in villages of BWS. In *Rabi* season (November-April) maximum area under both irrigated and unirrigated land was under cultivation of wheat (Table-4.5 and 4.6).

Table-4.5: Area under different crops in the villages of DWS (1996)

Village	Kharif		Rabi	
Saura	**Crop**	**Area (ha)**	**Crop**	**Area (ha)**
	Paddy (IR)	10.514	Wheat (IR)	7.965
	Paddy (UIR)	13.51	Wheat (UIR)	14.425
	Soyabean	3.14	Oat (IR)	0.479
	Barnyard millet	2.525	Oat (UIR)	0.008
	Black gram	1.985	Pea	0.086
	Horse gram	2.805	Lentil (UIR)	1.126
	Other Pulses	2.005	Potato (IR)	0.264
	Sesame	1.125	Potato (UIR)	0.133
	Capsicum	0.31	Other Veg.	0.183
	Finger millet	0.435	Mustard (IR)	2.07
	Amaranth	0.33	Mustard (UIR)	0.847
Total		**38.684**		**27.586**
Saari	Amaranth	39.66	Wheat	42.623
	Paddy	30.279	Mustard	1.079
	Potato	2.135	Garlic	0.146
	Kidney bean	1.224	Spinach	0.017
	Sesame	0.147	Lentil	0.117
	Cucumber	0.759	Coriander	0.027
	Soyabean	0.397	Oat	0.577
	Maize	0.25		
	Capsicum	0.33		

	Finger millet	0.293		
Total		**75.474**		**44.586**
Saalu	Amaranth	11.454	Wheat	20.099
	Potato	1.327	Oat	0.446
	Paddy	17.639	Mustard	1.288
	Soyabean	3.617	Spinach	0.249
	Kidney bean	7.611	Coriander	0.129
	Sesame	1.776	Pea	0.019
	Horse gram	3.2		
	Black soyabean	1.567		
	Black gram	0.471		
Total		**48.662**		**22.23**
Syaba	Paddy	21.169	Wheat	31.8
	Finger millet	1.912	Oat	0.461
	Amaranth	25.757	Mustard	2.795
	Kidney bean	4.034	Other vegetable.	0.153
	Horse gram	0.267		
	Potato	10.999		
	Capsicum	0.082		
	Soyabean	1.2		
	Sesame	0.73		
Total		**66.15**		**35.209**

IR: Irrigated, UIR: Unirrigated *Source: Village Revenue Office

Table-4.6: Area under different crops in the villages of BWS (1997)

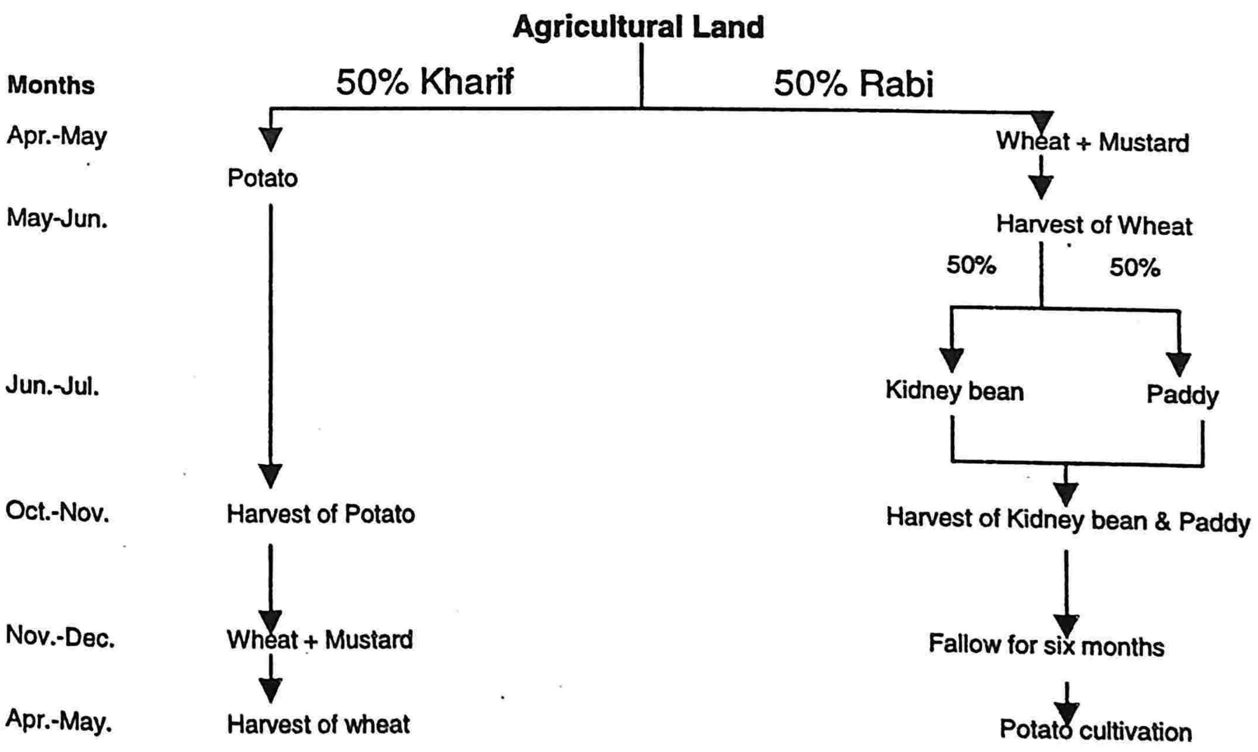
Village	Kharif		Rabi	
	Crop	Area (in ha)	Crop	Area (in ha)
Raithal	Paddy (IR)	27.425	Wheat (IR)	11.671
	Paddy(UIR)	1.78	Wheat(UIR)	50.328
	Maize	0.18	Oat (UIR)	0.368
	Finger millet	5	Mustard	1.419
	Horse gram	0.2	Other vegetable	0.126
	Other cereals	11.2		

	Other pulses	0.902		
	Soyabean	28.908		
	Potato	88.55		
	Other vegetable	18.2		
	Apple	8		
	Kidney bean	2.09		
Total		**192.435**		**83.913**
Barsu	Maize	0.078	Wheat(UIR)	21.997
	Amaranth	2.421	Oat (UIR)	0.026
	Pulses	0.954	Onion	0.045
	Potato	29.883	Other vegetable	2.117
	Soybean	7.583	Oilseeds	2.122
	Kidney bean	2.87		
	Other vegetable	0.532		
Total		**44.321**		**26.307**

IR: Irrigated, UIR: Unirrigated *Source: village revenue office

Crop rotation is followed in all villages (Figure-4.4). In this practice, potato fields remain fallow for six months.

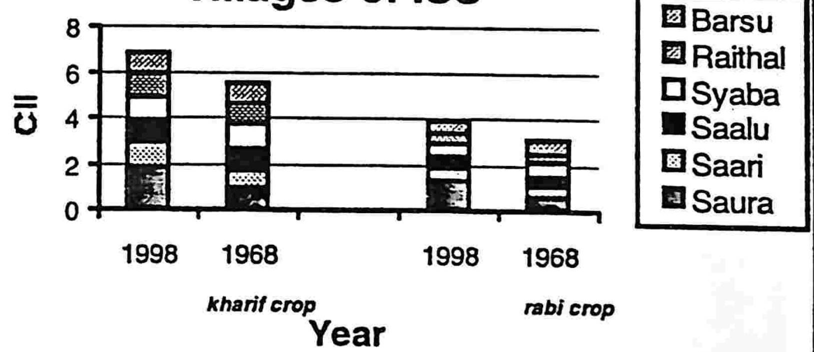
Figure-4.4: Crop rotation in the study villages



In the recent years there has been an increase in area under cash crops such as potato, soyabean, cucumber, kidney bean and amaranth. Of the two watersheds, BWS had more area under potato and soyabean cultivation probably due to southern warm slopes having good productivity. Also, the easy availability because of motor road turned people more towards these market-oriented crops. Interviews with the villagers revealed that cultivation of crops *viz.,* kidney bean, soyabean and cucumber as cash crops has been initiated in the study area very recently. Earlier, area under potato was also low. Area under cultivation of amaranth, once a major food crop of the locals, has also reduced. Some villagers still grow it to earn liquid cash.

Cropping Intensity Index (CII) calculated at both the watersheds revealed that in most of the villages cropping intensity was around 1. Comparative account of CII of recent and past shows an increase in the cropping intensity of *kharif* season, which is the season to grow cash crops (Figure-4.5).

Figure-4.5:Cropping intensity at villages of ISS



It was also found that an average of eight new fields (these fields are locally called as *dogaddas*) of *ca.* 670±145.49 m^2 (Table-4.7.a) were prepared in DWS between October 1996 and February 1998. In BWS an average of 9.5 fields of *ca.*2200 m^2 (Table-4.7.b) were prepared between March1998 and July 1999.

Table-4.7.a : New fields (*doggadas*) in DWS between Oct.1996 - Feb. 1998

Village	# of Fields	Area of field (m^2)	Original landuse
Saura	5	260 ± 87.18	SL, WL, RS
Saari	10	940 ± 179.01	SL, OF
Saalu	7	700 ± 242.02	SL, OF
Syaba	10	780 ±21 1.77	SL,OF
Mean± S.D	**8 ± 1.22**	**670 ± 145.48**	

SL: Scrub land, WL: Waste land, RS: River Side, OF: Oak Forest

Table-4.7.b: New fields (*doggadas*) in BWS between Mar.1998-Jul.1999

Village	# of fields	Area of field (m^2)	Original landuse
Raithal	10	40*60	SL, BF, BTF, BOF
Barsu	9	40* 50	MF, SL

SL: Scrubland, BF: Boxwood forest, BTF: Boxwood-Taxus forest, BOF: Buxus-Oak forest, MF: Mixed forest

The original land use of these fields was either scrubland or mixed-oak forest. In most of the fields either potato or amaranth was sown. No information about these fields was available in land use records. Also, area under apple orchards is now under cultivation and hence, most of the orchards are in ruined state. Analysis of questionnaire also revealed that maximum production was of potato in each village whereas least was of mustard (Table-4.8).

Table-4.8: Average production of crops (Q/hh) in villages of ISS

	DWS				BWS*	
Crop	**Saura**	**Saari**	**Saalu**	**Syaba**	**Raithal***	**Barsu***
Wheat	4.481	2.241	1.498	1.935	5.13	3.32
Mustard	0.246	0.286	0.324	0.243	0.09	0.094
Paddy	5.12	0.476	0.467	0.589	0.3	0.77
Amaranth	0.013	0.806	1.553	1.477	0.05	0.097
Potato	2.76	**11.377**	**6.05**	**10.474**	**25.12**	**35.18**
Kidney bean	1.22	1.184	0.845	1.88	0.45	0.31
Soyabean	NA	NA	NA	NA	1.94	6.92
Other	0.463	0.556	0.608	0.64	NA	NA

Prior to 1980, approximately 97.33% families (n=401) used to grow indigenous crops such as amaranth (*Amranthus* sp.), kodu (*Eleusine coracona*), cheena (*Panicum miliaceum*), phaphra (*Fagopyrum tataricum*) and bhat (*Glycine soja*) but now just 48.47% (n=111) families cultivate these crops that too in minor proportion. Besides these crops fruit trees such as walnut (*Juglans regia*), apricot (*Prunus armeniaca*), Mol (*Pyrus pashia*), apple (Pyrus malus) were also grown.

4.3.2.4. Livestock holdings: Livestock (n=1988) and (n=2433) in villages of DWS and BWS respectively, was kept basically for draught power and manure. Livestock comprised mainly of buffaloes, cows and oxen. Very few families own mules, horses, sheep and goats (Table-4.9).

Table-4.9: Livestock composition in villages of ISS (1996-1997)

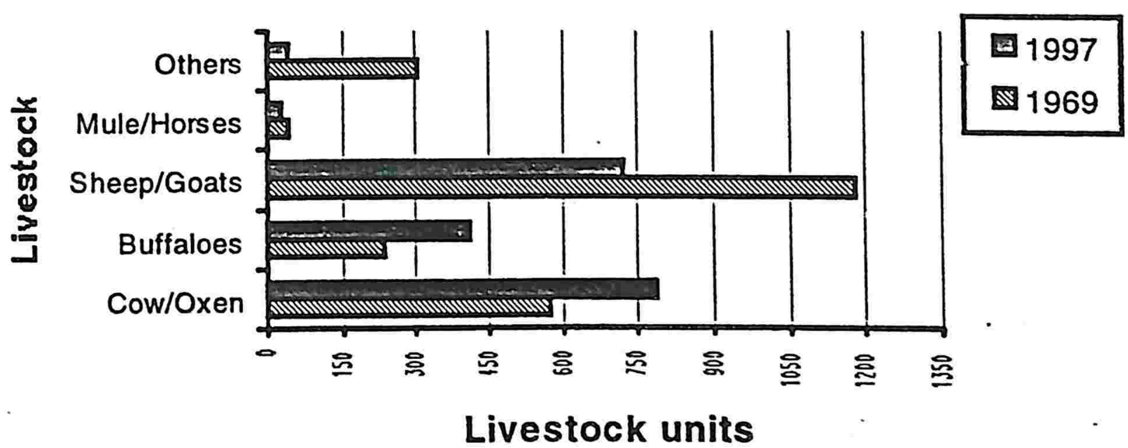
	DWS				BWS*	
Livestock	Saura	Saari	Saalu	Syaba	Raithal*	Barsu*
Cow/Oxen	161	235	153	238	520	257
Buffaloes	58	94	145	110	234	99
Sheep	105	68	71	0	332	403
Goats	143	203	47	86	305	204
Mule/Horses	10	6	2	9	24	0
Others	7	4	13	18	38	17
Total	484	610	431	463	1453	980
Livestock Units	1359	1905	1645	1795	4408	2348

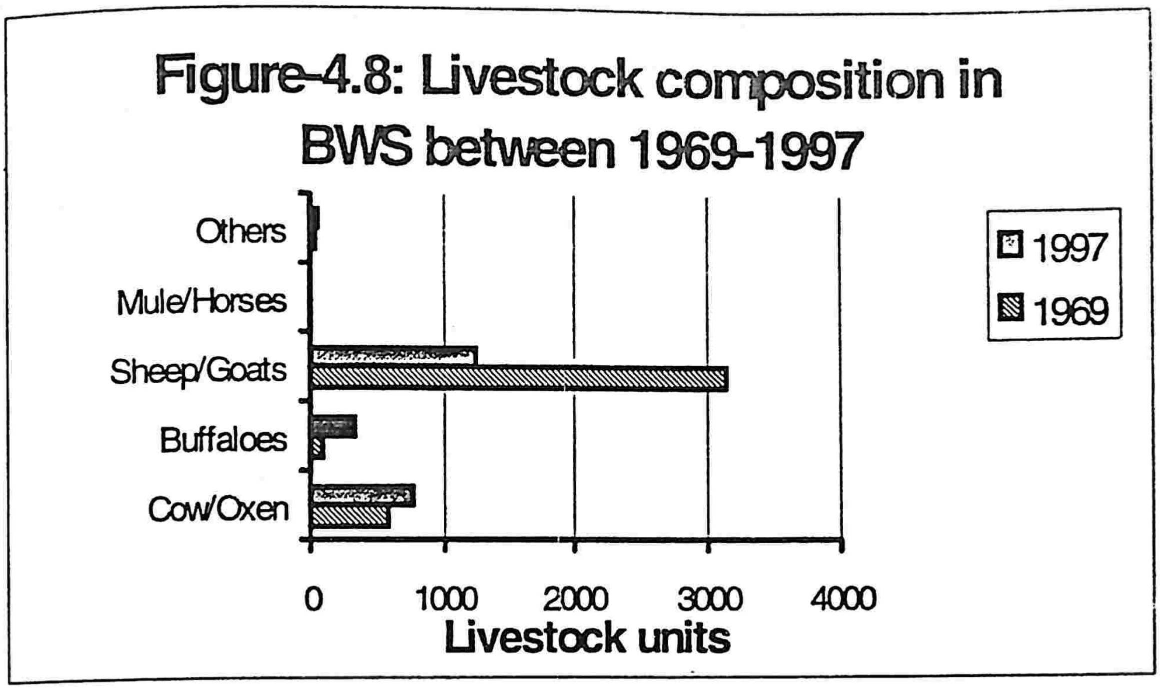
Livestock number was converted into livestock units' (L.U) that is equal to 6703 L.U in DWS and 6756 L.U in BWS. An average of 1676± 7.7 L.U and 3377.8± L.U were found in villages of DWS and BWS respectively. In DWS, village Saari had maximum livestock units whereas village Saura had minimum units. In BWS, village Raithal had 65.24% of the total livestock units. Per capita L.U. varied from 2 in village Saura to 8 in village Saalu whereas in villages of BWS per capita L.U was 7, which was higher than that of DWS. Information regarding the trends in the livestock population (Figure-4.6) shows that number of L.U has increased since 1969 in both the watersheds.

Figure-4.6: Trend of livestock population in villages of ISS

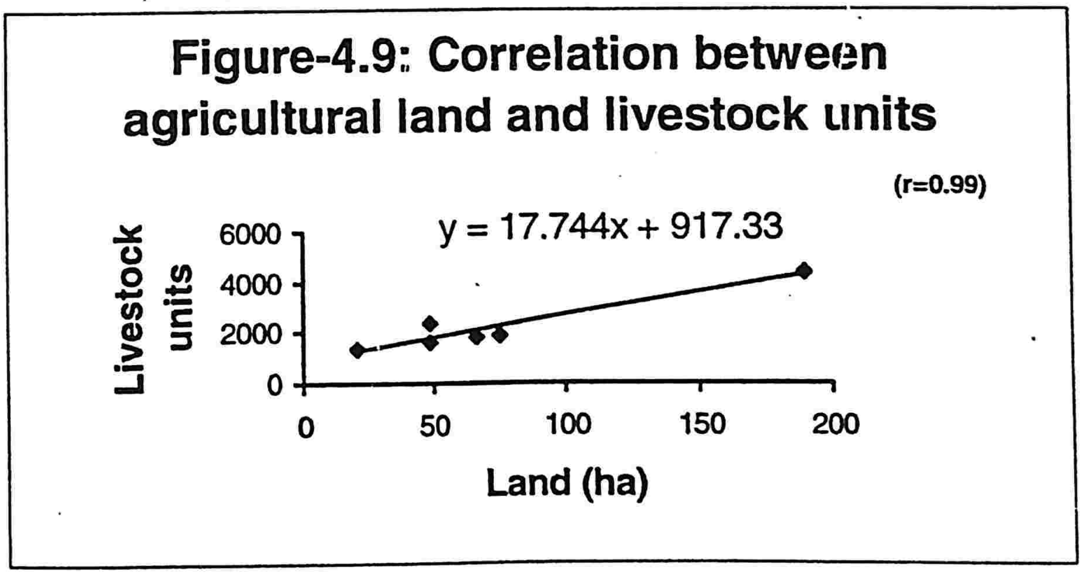
The composition of livestock has also changed since past three decades. Earlier sheep and goats (n=1182 L.U in DWS) and (n=3699 L.U in BWS) comprised majority of livestock and buffaloes (n=235 in DWS and n=462 in BWS) were less, but now a reverse trend was evident. Earlier mules and horses were found in village Saari only but now all villages have 2-10 number of mule or horses (Figure-4.7 and 4.8). The reason for this could be the need of transporting cash crops to road head for sale.

Figure-4.7: Livestock composition in DWS between 1969-1997





It was found that percent increase in L.U. since 1969 was maximum in village Syaba and minimum in village Saari in DWS whereas increase in L.U since 1969 was 3.57% in village Raithal and 2.6% in village Barsu of BWS. Cattle to land ratio was highest (10:1) in village Saura and least (3:1) in village Saari in DWS while in BWS it was higher in village Barsu (7:1) compared to Raithal (4:1). A positive correlation was found between area under agricultural land and livestock holding (Figure-4.9).



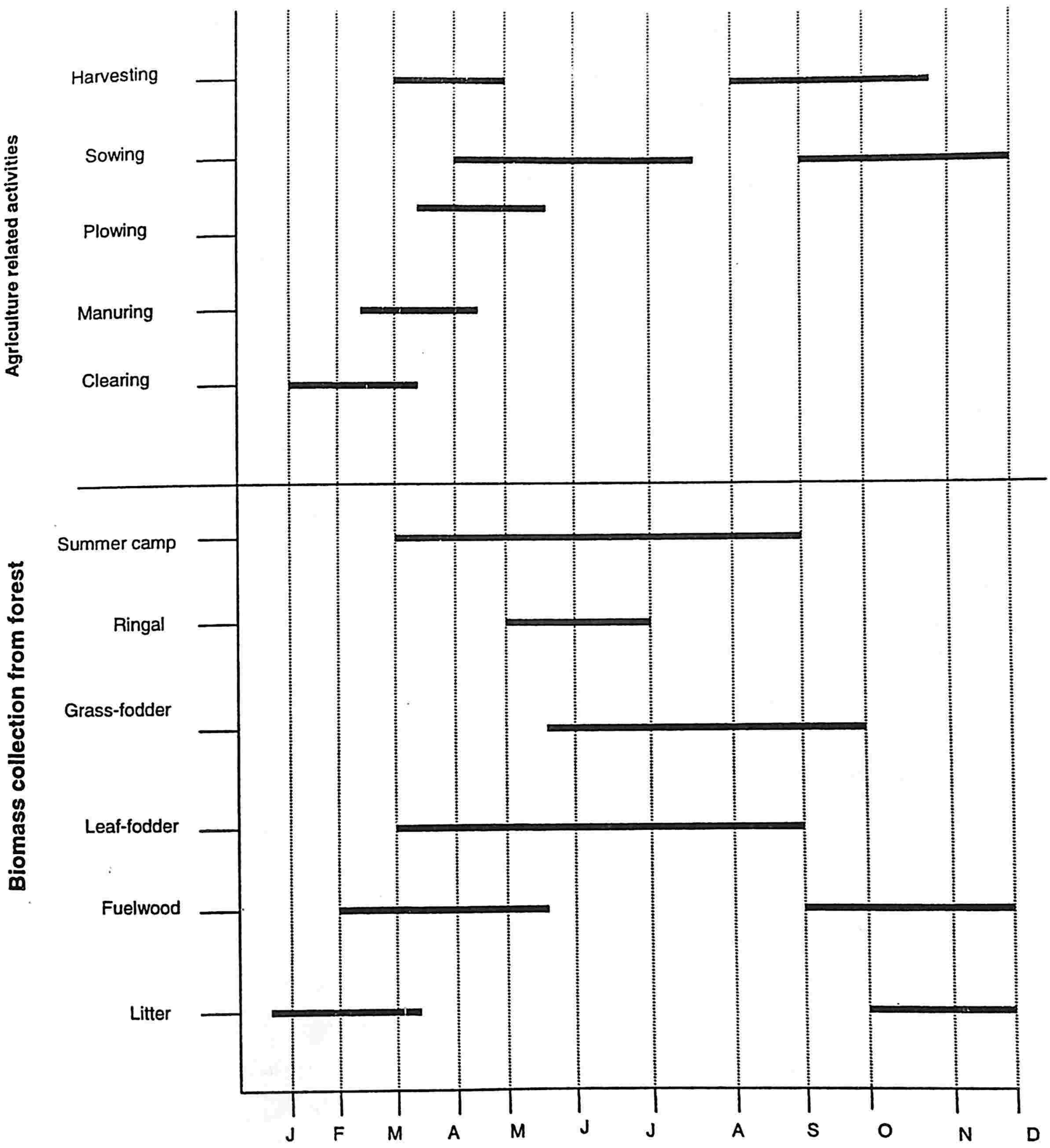
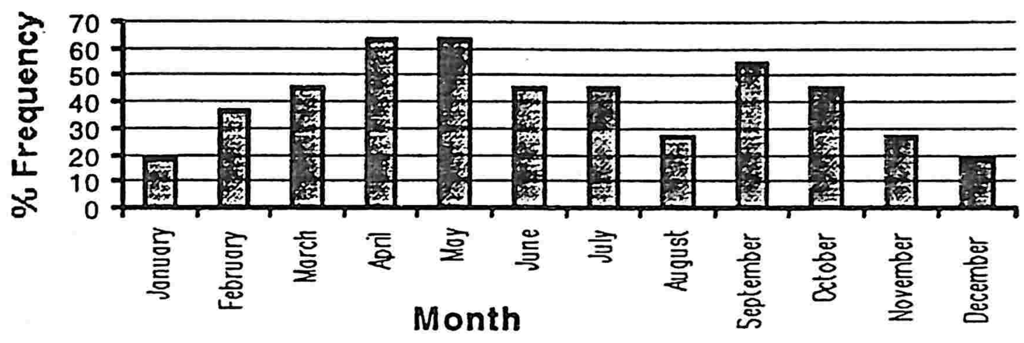


Figure-4.10: Seasonal calendar of various activities

4.3.2.5. Seasonal calendar: The seasonal calendar of various activities ascertained after analysis of questionnaire (Figure-4.10) showed that villagers were involved in two types of interrelated activities *viz.*, extraction of biomass from forests and agriculture related activities (**Plate-4.1**). It was found that April and May were the busiest months whereas December and January were comparatively relaxed months (Figure-4.11).

Figure-4.11: Activity calendar of local people



All families of three villages in DWS except those of village Saura follow a seasonal migration to temporary huts in Belak-Jaurai *bugyals* (sub-alpine & alpine meadows) with their livestock. In BWS too, villagers migrate to Dayara *bugyal.* The availability of fresh grass in meadows and infrequent use of animals at permanent villages after all the cropping work is over, force local people (one or two members per family) to migrate to temporary. There were seven cattle camps and about 20± 1.04 temporary huts per cattle camp (Table-4.10) in DWS and five cattle camps and about 14.4 ± 2.51 temporary huts per cattle camp in BWS. Temporary huts were constructed of stones and roof was made up of wooden logs such as yew (*Taxus baccata*), fir (*Abies pindrow*) and brown oak (*Quercus semecarpifolia*) thatched by *Chrysopogon gryllus* and bamboo (*Thamnocalamus spathiflorus).*

Table-4.10: Details of temporary huts in villages of ISS

Location	Altitude(m)	Village	# of temporary huts
Ranthali	3200	Saari	24
Dulgaa	2200	Saari	20
Nilara	2500	Saalu	14
Huriyata	2500	Syaba	21
Jamnia	3200	Syaba	22
Jaurai	3400	Syaba	28
Naali	3400	Saalu	17
Goi	2700	Raithal	16
Naheta	2700	Raithal	15
Chillapariya	3000	Raithal	10
Kanataal	2700	Barsu	15
Dayara	3200	Raithal & Barsu	16

Villagers had to depend on forest for their basic needs of fuelwood, fodder, leaf-litter and non-timber forest products (NTFP). There was a seasonal variation in the composition of various resources extracted from the forest and it was observed that all the families were dependent on fuelwood, it was extracted through out the year.

4.3.3. Resource Use: Fuelwood and fodder were the primary non-agricultural product necessary for the livelihood of locals. Besides these, forest resources such as leaf-litter and bamboo were also collected for supporting agriculture.

4.3.3.1 Fuelwood: Result of questionnaire survey revealed that all families (100%) in villages of both the watersheds were dependent on fuelwood. About 10% families in DWS and 35% families in BWS had LPG connection. The reason for higher number in BWS could be the easy access to road to transport the LPG. Fuelwood was either cut directly from the forest or dead wood of any kind was collected. Approximately 45% households also used dried twigs for fuel gathered as by product of leaf fodder.

Fuelwood extraction in villages: Observations at the entry/exit points on village routes showed that there was a significant difference (K-W 1 Way

ANOVA, $p<0.05$) in fuelwood extracted from forest in different seasons in villages of both the watersheds (Figure-4.12).

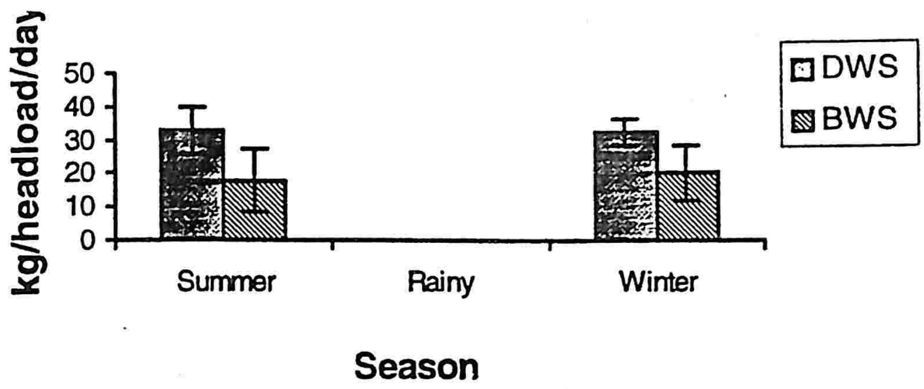


Figure-4.12: Extraction of fuelwood

(1 Way ANOVA, $P_{DWS}<0.05$, $P_{BWS}<0.001$)

There was no extraction of fuelwood during rain season in villages. Number of people collecting fuelwood varied with season. About 13.25±0.95, (n=96) persons per day were seen collecting fuelwood in winters whereas in summers 5± 0.71, (n=48) people were seen collecting fuelwood per day in DWS. People travelled for a distance of 3-4 km in both seasons to collect fuelwood. Depending on the distance to nearest forest, distance traversed by the people also varied (Table-4.11). In villages of BWS about 6.09±3.27 (n=12) persons per day were seen collecting fuelwood in summers and about 4.6± 4.7 (n=24) in winters. Distance covered to gather fuelwood also varied with seasons (Table-4.11). Mostly, females (80%) were seen collecting headloads of fuelwood. Approximately 3-5hours per day were spent in the forest to collect fuelwood. The time spent also varied with distance to nearest forest. It was 1-2 hours in villages Syaba, Saalu and Barsu and about 4-6 hours in village Saura and Raithal.

Table-4.11: Extraction of fuelwood in villages of ISS

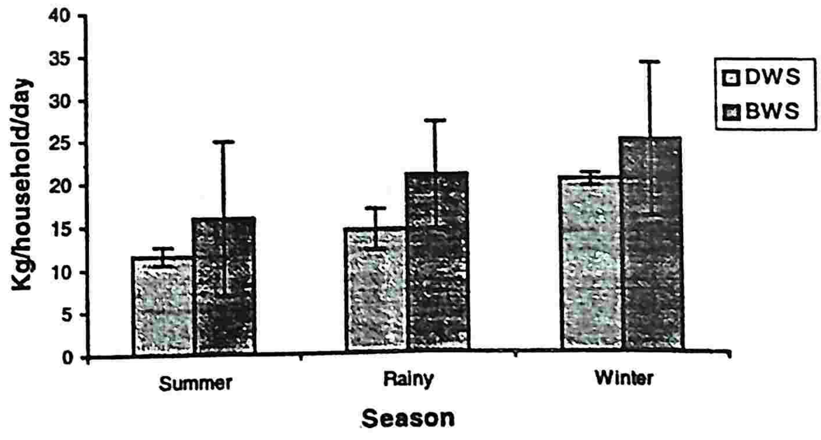
	Village	Summer			Winter		
		kg/head/day	# of people	Distance covered (km)	kg/head/day	# of people	Distance covered (in km)
DWS n_s=24, n_w=48	Saura	40±2.37	6±3.94	4.33±0.4	38.58±12.2	12.37±7.3	3.42±1.19
	Saari	23.56± 11.4	5.8±1.9	4.11±1.31	31.34±8.4	16.25±3.9	3.98±1.05
	Saalu	32.78±12.9	3±7.5	2.6±1.15	29.86±8.6	12.2±6.99	3.02±0.97
	Syaba	34.74±12.3	4.67±1.9	3.23±1.33	31.42±9.6	12.55±7.3	2.85±1.04
BWS n_s=12, n_w=24	Raithal	17.87± 9.5	6.09± 3.3	2.2± 0.5	12.57±7.2	4.6±4.7	2.6±0.8

±=Standard deviation

Fuelwood collected was mostly green wood during winter season and dried wood during summers was collected (**Plate-4.2**).

Fuelwood Consumption: There was a significant difference in fuelwood consumed per day per household in different seasons (Figure-4.13) in both the watersheds. It was maximum in winter season (20.24 kg/day/hh, in DWS and 24.9 kg/day/hh in BWS) and minimum in summer (11.55kg/day/hh in DWS and 15.85 kg/day/hh in BWS).

Figure-4.13: Consumption of fuelwood
(1 Way ANOVA, $p_{DWS}<0.05$ $p_{BWS}<0.001$)



Also, fuelwood consumption per day per household between different categories of households varied significantly with seasons (Table-4.12) in both the watersheds.

Table-4.12: Seasonal consumption of fuelwood (kg/hh/day) in different categories of dependency (Two Way ANOVA)

	Dependency	Summer	Rain	Winter	
	H.D (n=12)	12.91±1.16	16.28±1.53	21.32±0.53	
DWS	M.D (n=12)	11.67±0.49	14.51±2.62	20.33±0.87	P<0.05
	L.D (n=12)	10.08±1.74	12.34±3.46	19.05±0.97	
	H.D (n=4)	21.12±6.2	23.48±3.52	29.03±8.02	
BWS	M.D (n=4)	16.23±9.13	22.42±5.21	25.08±7.42	P<0.01
	L.D (n=2)	7.31±5.32	12.24±5.04	18.25±10.4	

H.D=highly dependant, M.D=moderately dependant, L.D=least dependant

Fuelwood consumption in three categories of households *viz;* highly dependant, moderately dependant and least dependant varied significantly (1 way ANOVA, p<0.05) in villages Saura, Syaba and Raithal but in villages Saari and Saalu variation was not much significant (Table-4.13).

Table-4.13: Fuelwood consumption (kg/hh/day) in different categories of dependency (K-W, 1 Way ANOVA)

ISS	Village	Categories of dependence			
		Highly dependent	Moderately dependent	Least dependent	p-value
	Saura	17.03 (n=24)	15.21 (n=36)	12.59 (n=48)	<0.05*
DWS	Saari	17.83 (n=48)	16.71 (n=36)	15.81 (n=36)	>0.05
	Saalu	18.96 (n=22)	17.88 (n=24)	17.02 (n=30)	>0.05
	Syaba	18.91 (n=42)	17.28 (n=45)	15.99 (n=24)	<0.05*
BWS	Raithal	25.69 (n=48)	22.2 (n=48)	14.01 (n=24)	<0.001*

H.D=highly dependant, M.D=moderately dependant, L.D=least dependant *=significant

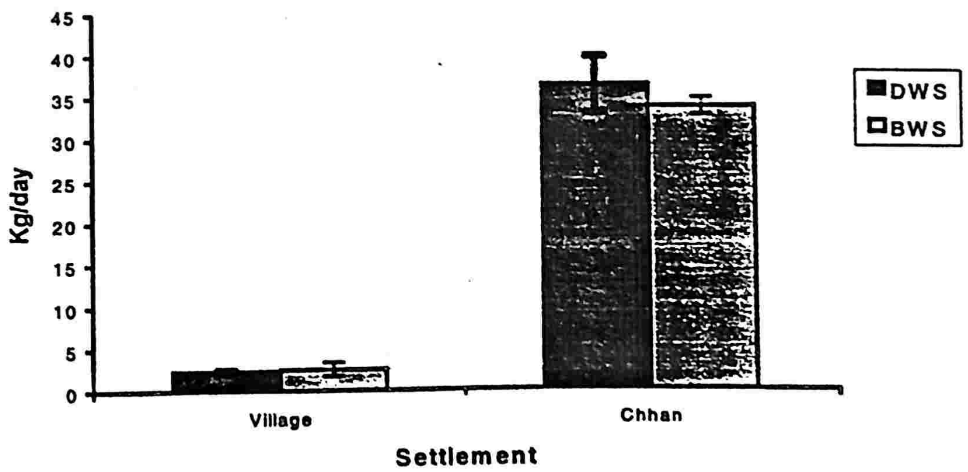
In summers, fuelwood consumption per household was least in village Saura (9.99 kg/day, n=9) and highest in village Saalu (12.16 Kg/day, n=7) whereas in winters all the three villages of higher altitude had higher per day fuelwood consumption as compared to village Saura (Table-4.14) in DWS.

Table-4.14: Seasonal consumption of fuelwood (kg/hh/day) in villages of DWS (K-W 1 Way ANOVA)

Village	Summer	Rain	Winter	p-value
Saura	9.99 ± 2.07 (n=81)	11.24 ± 3.8 (n=81)	19.27 ± 1.6 (n=162)	<0.05
Saari	11.98 ± 0.72 (n=90)	13.83 ± 1.26 (n=90)	20.66 ± 1.05 (n=180)	<0.05
Saalu	12.16 ± 1.33 (n=63)	15.94 ± 1.83 (n=63)	20.97 ± 1.11 (n=126)	<0.05
Syaba	12.06 ± 1.87 (n=90)	16.51 ± 1.49 (n=90)	20.04 ± 0.86 (n=180)	<0.05

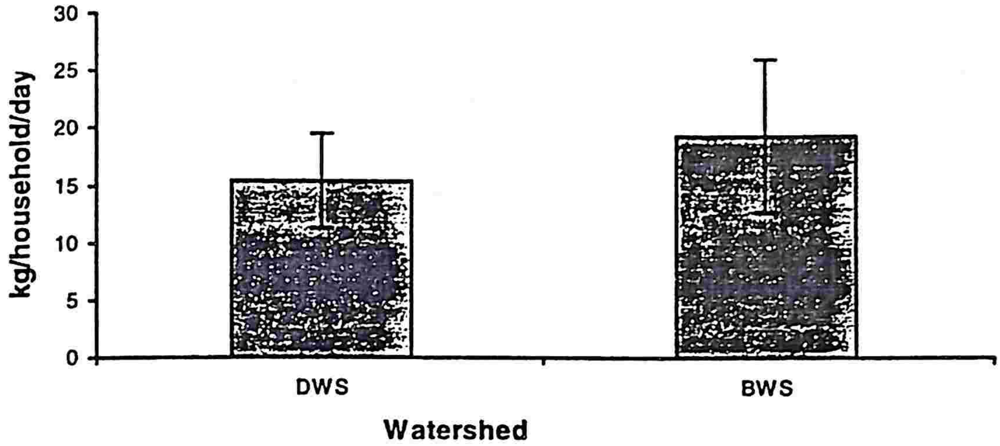
Fuelwood consumption at temporary huts: Although, fuelwood consumption at temporary huts was restricted between April to September but due to low temperature at sub-alpine and alpine meadows (>2700m), quantity of fuelwood burnt was quite high when compared to permanent settlement (villages). In DWS per capita fuelwood consumption at temporary hut was 36.42±3.35 Kg/day (n=34). It was significantly different (t-test, $p<0.05$, $n_v=36$ and $n_c=34$) from the per capita fuelwood consumption at villages in rain season (Figure-4.14). In BWS, per capita fuelwood consumption at temporary hut was 33.8 ± 1.05 kg/day (n=66). It also differed significantly (t-test, $p<0.001$, $n_v=91$ and $n_c=66$) from the per capita fuelwood consumption at villages in rain season.

Figure-4.14: Per capita fuelwood consumption in rainy season
(t-Test, p<0.001)



Fuelwood consumption per day per household varied significantly between two watersheds (Figure-4.15).

Figure-4.15: Fuelwood consumption in two watersheds (t-test, $t=2.88$, $p<0.05$)



It was higher in BWS (19.46±4.6kg) than DWS (15.39±4.43kg). Also fuelwood consumption between two watersheds varied significantly (Two Way ANOVA, $p<0.05$) with seasons (Table-4.15). The reason could be the altitudinal difference. Village Raithal is situated at much higher altitude (2400m) compared to villages of DWS (1700-2300m).

Table-4.15: Seasonal variation in consumption of fuelwood in two watersheds
(Two way ANOVA, $p<0.05$, $n_{BWS}=120$, $n_{DWS}=240$)

Watershed	Summer	Rain	Winter
DWS	11.55	14.38	20.23
BWS*	14.88	19.38	24.12

<u>*Species Preferred as fuelwood:*</u> It was found from the species composition analysis of headloads that there was a variation in species preferred as fuelwood at four villages. In village Saura, *Alnus nepalensis* was most frequently used fuelwood species whereas in village Saalu and Saari, *Quercus leucotrichophora* was the first choice followed by *Rhododendron arboreum.* In highest elevation village Syaba, *Desmodium tiliaefolium* was the most preferred fuelwood species followed by *Q. leucotrichophora.* Use of species such as *Berberis* spp., *Rosa brunonii, Deutizia* sp. and *Caesalpinia*

sp. was restricted to village Saura (table-4.16). No difference in species preference during various seasons was found. Choice of species at temporary huts was limited (table-4.17). Major constituent of the headloads of fuelwood was *Q.semecarpifolia* followed by *Taxus baccata* and *Viburnum cotinifolium*.

Table-4.16: Species preferred (% frequency) as fuelwood in villages of ISS

Species	Saura	Saari	Saalu	Syaba	Raithal
L.ovalifolia	3.7	10	5.33	5.88	3.33
Q.leucotrichophora	56.48	75	76	42.86	2.67
R. arboreum	49.07	59.17	64	33.61	19.33
Spirea sp.	22.22	15.83	5.33	22.69	2
Caesalpinia sp.	6.48	1.67	1.33	3.36	4
Cotoneaster spp.	4.63	25	9.33	21.85	3.33
A.nepalensis	63.89	39.17	50.67	13.45	0.67
P. roxburghii	16.67	12.5	16	0	0
R.punjabensis	9.26	0.83	5.33	0	0.67
Berberis spp.	11.11	3.33	0	0	9.33
P.pashia	3.7	0.83	0	0	0
C. viminea	2.78	3.33	0	0	0
Deutizia sp.	4.63	0	0	0	0
R. brunonii	10.19	0	1.33	0	0.67
T. sinensis	4.63	0	25.33	0	0
S. chinensis	0.93	0	0	0	0
Desmodium sp.	0	14.17	9.33	63.87	0
Q.glauca	0	0	1.33	0.84	0
Q.floribunda	0	0	4	28.57	24
Fraxinus sp.	0	3.33	0	0	0
Salix spp.	0	0	0	0.84	0
Q. semecarpifolia	0	0	0	0.84	3.33
I.dipyrena	0	0	0	1.68	0.67
Swida macrophylla	0	0	0	0.84	0
Indigofera sp.	0	0	0	2.52	0
T. baccata	0	0	0	0	5.33
Acer spp.	0	0	0	0	6
Corylus sp.	0	0	0	0	11.33
P. malus	0	0	0	0	4.67
B. wallichiana	0	0	0	0	18.67
A. indica	0	0	0	0	2.67

Table-4.17: Species preferred (% frequency) as fuelwood in temporary huts of both the ISS

Species	DWS	BWS
Q. semecarpifolia	49.03	100
T. baccata	23.2	0
V. cotinifolium	11	32.5
Q. floribunda	7.1	0
P.cornuta	0	31.03
A.pindrow	0	7.36
Others	2.6	3.2

4.3.3.2. Fodder: At villages, fodder demands of the livestock were basically fulfilled through leaf fodder, grass fodder (green and dried) and agricultural by-products. There was a seasonal variation in the type of fodder fed. Agricultural by-products and dried grasses (hay) constituted the major feed in winters whereas leaf fodder was fed during summer. Availability of grass fodder varied with the land use type (Table-4.18).

Table-4.18: Availability of grass and agricultural by-product

Watershed	Landuse	Fodder ($gm/m^2/year$)± S.D
	Cropland (grass)	191.8 ± 195.4
DWS	Uncultivated land (grass)	332.67 ± 353.3
	Pine forest (grass)	522.67 ± 723.9
	Mixed oak forest (grass)	391.67 ± 433.7
	Mean of grass	**359.7 ± 68.6**
	Cropland (agricultural by-products)	161.43 ± 26.09
BWS	Cropland (agricultural by-products)	136 ± 19.25
	Cropland (grass)	158.38 ± 40.38

Leaf fodder was extracted from the surrounding forests in both the watersheds (**Plate-4.3**) whereas grass fodder in DWS was collected from pine forest and from cropland in BWS. Fodder extraction varied significantly with season. Extraction of leaf fodder was maximum in summers and minimum during Rain season whereas extraction of grasses was highest during winters and lowest during summer in both the watersheds (Figure-4.16 & 4.17).

Figure-4.16: Extraction of fodder in villages of DWS
(K-W 1 Way ANOVA, P<0.05)

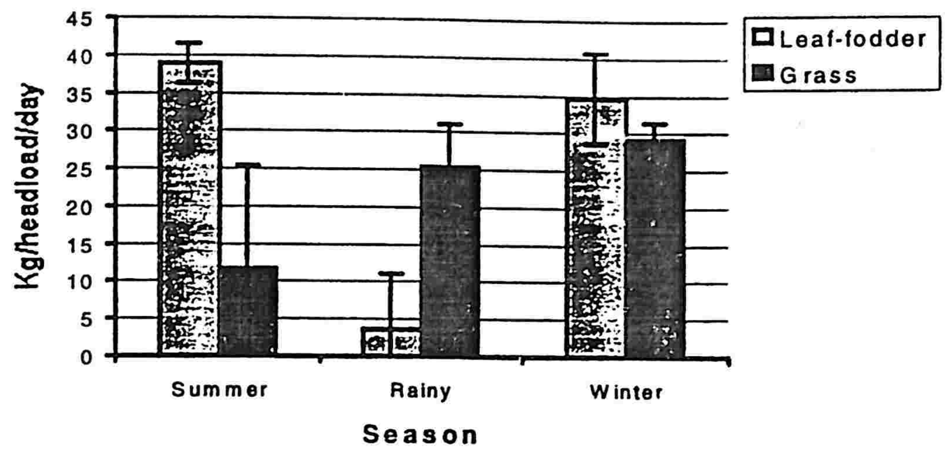
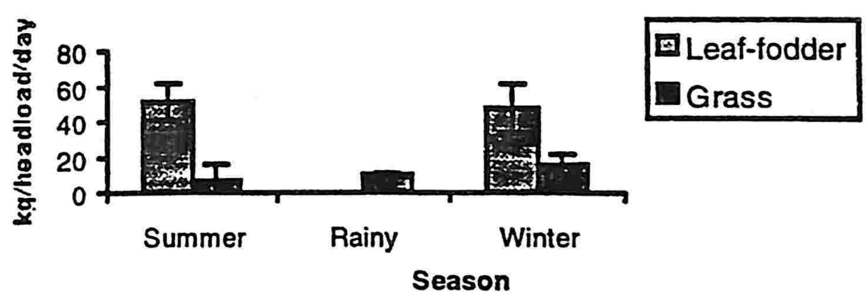


Figure-4.17: Extraction of fodder in villages of BWS
(K-W 1 Way ANOVA, p<0.05)



Number of people carrying head loads of fodder also varied with season. About nine people per day in DWS and one person per day in BWS were seen carrying headloads of leaf fodder in summer whereas in Rain season the number reduced to approximately two per day. In case of grass fodder extraction, maximum number of people (10.3±0.61 in DWS and 6.1±3.8 in BWS) were seen collecting headloads of grass during winter and minimum (1.63±0.9 in DWS and 1.3±2.9 in BWS) during summer season (Table-4.19).

Table-4.19: Extraction of fodder in ISS

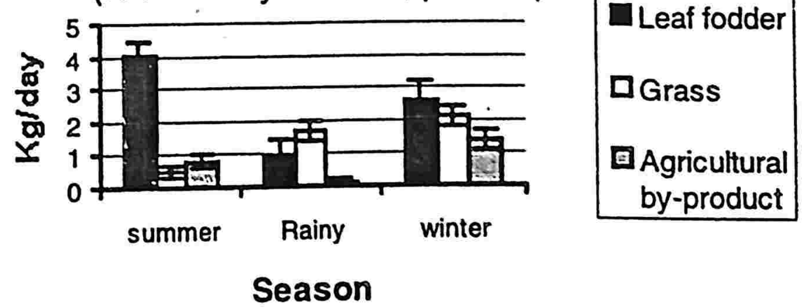
	Fodder Type	Summer		Rain		Winter	
		# of people	Distance covered (km)	# of people	Distance covered (km)	# of people	Distance covered (km)
DWS	Leaf fodder	8.9±0.96	3.85±0.3	1.87±1.8	1.07±1	5.6± 1.4	3.79±0.32
	Grass fodder	1.63±0.9	1.5±0.9	4.8±1.11	2.7±0.4	10.3±0.6	2.4±0.2
BWS	Leaf fodder	1.3±0.6	4.5±0.6	0	0	3±4.4	4±0.7
	Grass fodder	1.3±2.9	1.2±0.15	5.25±2.2	1.59±1.3	6.1±3.8	1.6±0.7

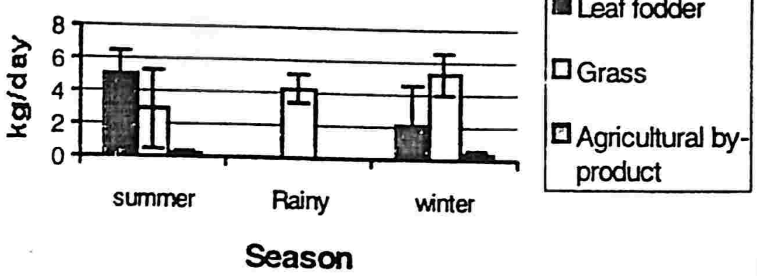
±: S.D

Distance covered varied both with the composition of fodder collected and season. Distance covered to collect leaf fodder varied from 1km in rain season to 4 km in summer and winters. On the other hand distance covered for collecting grasses varied from 1km in summer to 3 km in rain season. Fodder consumption also varied with season. Leaf fodder was fed during summers and grass and agricultural by-products during winters. In rain season, most of the livestock was left free for grazing in the alpine meadows. Fodder consumption per livestock unit varied significantly ($p<0.05$) with season (Figure-4.18 and 4.19).

Figure-4.18: Per L.U. fodder consumption in villages of DWS

(K-W 1 Way ANOVA, p<0.05)





However, the variation in fodder consumption per livestock unit between three categories of households was highly significant in BWS but insignificant in DWS (K-W 1 Way ANOVA, p>0.05)(Table-4.20).

Table-4.20: Fodder consumption (kg) per household in different dependency categories (K-W 1 Way ANOVA)

	Category	Leaf-fodder	Grass-fodder	Agricultural by-product	p-value
	H.D (n=12)	14.38 ± 10.78	5.84 ± 7.69	4.6 ± 4.8	
DWS	M.D (n=12)	16.51 ± 12.63	8.5 ± 7.6	5.6 ± 5.4	>0.05
	L.D (n=12)	14.72 ± 8.55	11.5 ± 7.64	3.5 ± 2.7	
	H.D (n=4)	42.5±8.7	39.48±10.23	3.15±0.9	
BWS	M.D (n=4)	34.18±6.34	31.54±12.8	1.62±0.8	<0.001
	L.D (n=2)	26.64±7.6	26.99±11.3	2.07±3.04	

H.D: Highly dependant, M.D: Moderately dependant, L.D: Least dependant, Per household:an: 6 livestock units

Seasonal variation in consumption of leaf-fodder was significantly different in all villages except village Saalu (Table-4.21) whereas consumption of grass fodder and agricultural by-products was significantly different in villages Saura, Saari and Syaba respectively (Tables-4.22 and 4.23).

Table-4.21: Leaf-fodder consumption (kg) per household in villages of DWS (K-W 1 Way ANOVA)

Village	Leaf-fodder			
	Summer	Rain	Winter	P-value
Saura	17.27±4.24	13.27±4.91	25.36±2.59	<0.05
Saari	25.88± 5.04	0	9.86±1.8	<0.05
Saalu	24.19± 5.12	9.36± 9.2	16.13±2.98	>0.05
Syaba	30.08±11.09	0	11.09± 2.9	<0.05

Per household: an average of 6 livestock units

Table-4.22: Grass-fodder consumption (kg) per household in villages of DWS (K-W 1 Way ANOVA)

Village	Grass- fodder			
	Summer	Rain	Winter	P- value
Saura	0	13.01± 7.8	16.81±3.32	<0.05
Saari	6.39±5.6	5.93± 10.2	10.72± 1.5	>0.05
Saalu	3.67±3.2	13.28± 11.71	9.83± 0.7	>0.05
Syaba	1.55± 2.7	8.87± 15.4	13.18± 3.8	>0.05

Per household: an average of 6 livestock units

Table-4.23: Agricultural by-product consumption (kg) per household in villages of DWS (K-W 1 Way ANOVA)

Village	Agricultural by-product			
	Summer	Rain	Winter	P-value
Saura	7.67±2.6	1.97±3.4	9.23± 4.7	>0.05
Saari	2.2± 3.7	0	5.99±0.9	<0.05
Saalu	3.8±3.7	0.8±1.4	5.32±0.27	>0.05
Syaba	5.42±2.01	0	12.37± 4.7	<0.05

Per household: an average of 6 livestock units

Leaf-fodder consumption between two watersheds was insignificantly different, however, consumption of grass and agricultural by-products differed significantly (Table-4.24).

Table-4.24: Fodder consumption (kg/household/day) in two watersheds
(Paired t-test)

Fodder	BWS	DWS	
Leaf-fodder	19.93	15.21	p>0.05
Grass fodder	25.94	8.60	P<0.05*
Agricultural by-products	2.12	4.57	P<0.05*

Fodder consumption in temporary huts: In temporary huts for most of the day, livestock were left free for grazing (**Plate-4.4**). At nights only, livestock were stall-fed with leaf-fodder in DWS. On the other hand in BWS, animals were left out at night too. Leaf fodder consumption per livestock unit was significantly different from that consumed at villages in rain season in both the watersheds (Figure-4.20). Leaf-fodder consumption in temporary huts of two watersheds also varied significantly (Figure-4.21). It was more in north facing slopes (DWS) compared to south facing slopes (BWS). The reason could be that most of the animals were stall-fed at night in DWS but not in BWS.

Figure-4.20: Leaf-fodder consumption in two settlements (t-test, P<0.05)

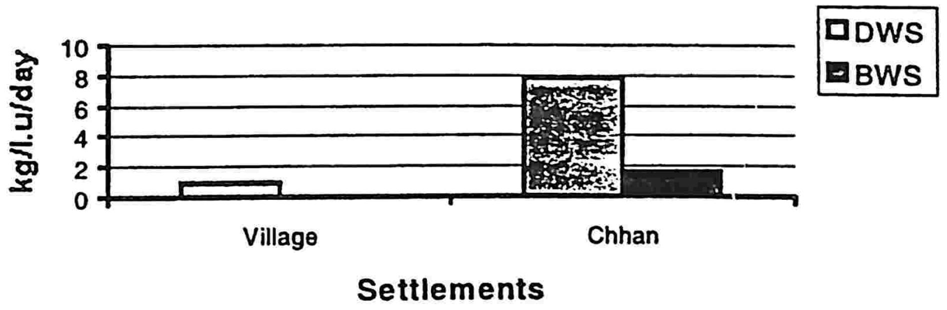
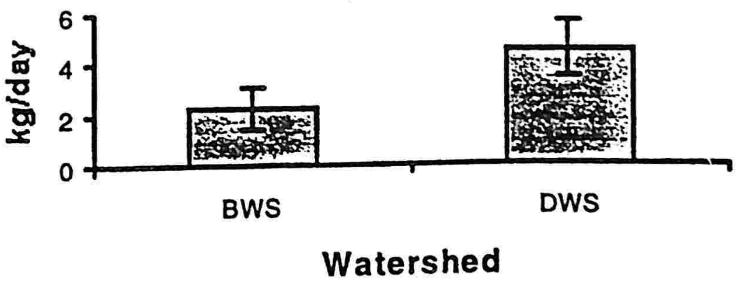


Figure-4.21: Leaf-fodder consumption in two watersheds (t-test, p<0.05)



In the villages livestock were left for free grazing in summer season for about eight hours a day. In winters, livestock at higher elevation villages in both the watersheds such as Saari, Saalu, Syaba, Raithal and Barsu were mostly stall-fed whereas those at lower elevation village Saura were grazed for about six hours a day except during the days of heavy rainfall.

Species preferred as leaf fodder: Choice of species fed as leaf fodder also varied at different aspects. In villages of north facing slopes *Quercus leucotrichophora* was the most frequently fed leaf fodder followed by other species such as *Carpinus viminea* and *Debregeasia longifolia*. In village Syaba, *Q. floribunda* was the highly preferred leaf fodder species followed by *Q. leucotrichophora* and *Carpinus viminea* whereas in village of south facing slopes *Q. floribunda* was the highly preferred species. The preference also depended on the availability of resources (table- 4.25).

Table-4.25: Species preferred (% frequency) as leaf-fodder in villages of ISS

Species	Saura	Saari	Saalu	Syaba	BWS
Q.leucotrichophora	35.21	61.04	41.07	19.12	1.39
Q.floribunda	0	5.19	10.71	69.12	90.28
Q.semecarpifolia	0	0	3.57	8.82	8.33
C.viminea	7.04	6.49	5.36	11.76	10.45
D.longifolia	29.51	0	0	1.47	0
U.wallichiana	0	1.3	1.79	4.41	0
Desmodium sp.	0	2.59	0	2.94	0
A.falcata	1.41	1.5	1.9	0	0
S.macrophylla	0	2.2	0	3.42	0
Indigofera sp.	0	0	0	0	0

Species preferred as grass fodder: Most frequently fed species of grasses were *Dactylis glomerata* (Hoatra), *Setaria* sp. (Kukra), *Pennisetum* sp. (Chibyara), *Apluda mutica* (Harra), *Arundinella* sp. (Chauva), *Digitaria* sp. (kaagiloo) and a sedge *Carex* sp. vernacular *mamoo*. These species of grasses were collected from the '*Rakeeta*' land (*Rakeeta* is a practice followed by local people to let forest land near villages remain ungrazed for rain season). The grass from *rakeeta* land was cut by entire village on single day in October or November and left for drying (**Plate-4.5**). Livestock were fed mostly on herbaceous species such as *Fagopyrum* sp. (Kaonlli), *Galium* sp. (Kuri), *Polygonum* sp. (Galda) and *Drymaria* sp. (Kumayi) growing in potato and soyabean fields. For entire Rain season, herbs and grasses from croplands were not collected. After the harvest of potato and soyabean in October-November, these grasses were extracted and fed during winter season. In temporary huts the species preferred as leaf-fodder were *Q. semecarpifolia, Q. floribunda, Acer* spp. and *Thamnocalamus strictus* (table-4.26).

Table-4.26: Species preferred (% frequency) as leaf-fodder in temporary huts

Species	DWS	BWS
Q.semecarpifolia	61.8	85.6
Q.floribunda	13.6	0
T.strictus	20.9	30.1
Acer spp.	3.6	34.2

4.3.3.3 Other NTFPs: Other non-timber forest products (NTFPs) collected from the forests include leaf litter and bamboo (*Arundinaria falcata* and *Thamnocalamus falconerri*). Leaf litter was collected for use in cattle sheds and further used in agricultural fields as manure. Bamboo (*Ringal*) culms were extracted mainly to support kidney bean (climber). A significant correlation was found between area under kidney bean and number of bamboo culms extracted (r=0.7). The bamboo culms were extracted in the months of June and July (**Plate-4.6**). An average of 380.75±190.9 culms per headload per day was extracted in the villages of DWS. Distance travelled to collect the culms also varied with village (Table-4.27). People of village Saura had to travel more distance to collect bamboo. An average of six people per day was seen collecting this resource in village Syaba whereas in village Saari the number was about one person per day. In BWS, just two people were seen collecting bamboo culms. The reason could be less area under kidney bean cultivation. Also unavailability of bamboo in the vicinity of forest left people to opt for other means to support seedlings.

Table-4.27: Seasonal variation in extraction of bamboo (*Arundinaria falcata*) culms (K-W 1 Way ANOVA, n= 24, p<0.05)

Season	# of culms/head/day	# of people	Distance travelled (km)
Summer	594.75± 51.9	5.09±4.3	4.9±0.9
Rain	547.5± 198.4	3.5±4.2	7.0±1.1
Winter	0	0	0

Leaf litter was collected mostly during winter season. An average of 23.10±1.02 kg, (n=48) of leaf litter was extracted per head load per day in the villages of DWS. An average distance travelled to collect leaf litter was about 1.95±0.07 km per person per day. An average number of 3.5± 0.2 persons collected litter from near by forest. In BWS, litter collected per headload varied with season. It was 6.93 ±10.5 kg/day in summers and 21.6 ± 1.69 kg/day in winters. Number of persons also varied with about 1.6 ± 2.5 people per day in summer to 3.04 ± 6.9 persons per day in winters.

4.4. Discussion and Conclusions

Patterns of biomass extraction and land-use by human beings bring about alteration of the vegetation structure and cover (Sousa 1984). The resource use pattern is in turn influenced by the socio-economic structure of the society and eco-climatic conditions of the region. Transition in the patterns of economy bring about rapid changes in the resource extraction (Goudie 1989). In the present study area, one of the major causes of forest degradation (Chapter-7) is the expansion of agricultural land and intensification of agricultural activities under the influence of market economy coupled with the increase in livestock population.

4.4.1 Recent changes in cropping pattern: As in many parts of the Himalaya, the economy of the local people in the present study area is based on agriculture. After the construction of motor road to Gangotri in 1962, subsistence based cropping has slowly changed into market driven agriculture and there has been an increase in area under cash crops such as potato, amaranth and kidney bean. Such changes have also been reported in other parts of the Himalaya (Shah 1981, Singh 1996, Nusser and Clemens 1996). It is known that cropping intensity, input of human labour and use of chemical fertilizers increases in a market oriented economy (Schroeder 1985). This pattern was also observed in the present study area where number of new agricultural fields (*doggadas*), at the cost of abandoned land and secondary forest have increased (**Plates 4.7 & 4.8**). An increase in cropping intensity also highlighted this fact. It was observed that for the cultivation of amaranth, people preferred *doggada* fields but for cultivation of potato, usually steeper slopes with well drained soil is preferred. These practices not only reduce the area under fallow land with secondary succession and but also degrade the quality of soil (Gaur *et al.* 1992, Mashalla 1988, Kappelle and Juarez 1995). Thus, the overall output to input ratio of such cash crops is very low as compared to traditional crops such as wheat and pea (Pandey and Singh 1984). A change in cropping pattern from straw producing crops to potato and beans might also affect the availability of agricultural by-products as fodder, as was observed in the villages of BWS where agricultural-by products were comparatively less fed. Another effect of market oriented crop production in the study area is the loss of crop diversity as also reported by Negi (1994) and Maikhuri *et al.*(1997). This would not only reduce the fertility of soil but will also affect the overall production. Along with this, an increasing human population (Figure-4.2) might increase pressure on the already dwindled per capita landholdings. According to Boserup (1965) agricultural intensification takes place in response to growth of population that is dependent on agriculture. Such trend has also been reported from Mamlay watershed of Sikkim Himalaya (Rai and Sundriyal 1994) where size of the landholding has decreased in past few years due to population growth. Garcia and Martinez (1990) observed that there was a decline in cultivated area and change in livestock composition from sheep to cattle, due to emigration of people in the Spanish Pyrenees. On the other hand, road construction in Los Limones encouraged a shift towards commercial crops, which led to forest clearance and monoculture plantations (Brothers 1997). In a study done by Lyrintzis (1996), it was found that intensified agricultural activities along with increased livestock grazing resulted in decreased forest cover (72.1% decrease between 1961-1981) with a 9.2% increase in the rangelands in Psilorites mountains. Loss of forest cover due to an increased agricultural activities and cropping intensity has also been seen in Nepal (Hrabovszky and Miyan 1987). Ecological threats of increasing agricultural activities in other parts of Himalaya have already caught attention of many workers (Ashish 1979, Reiger 1981, Thompson and Warburton 1985, Ives and Messerli 1989). With similar trends evident in the present study area, proper conservation measures are needed for sustained use of forests.

4.4.2 Changes in the livestock holding pattern: In most of the Himalayan villages, livestock are kept mainly as draught animals in order to supply manure for agricultural fields. Increase in human population and related expansion of agriculture results in increased animal population (Papola and Joshi 1985). In the Bhagirathi valley, need for cash income and market oriented attitude of local people seem to have changed their livestock composition from wool producing animals (sheep) to dung and draught power yielding animals (Buffaloes and Oxen). Supply of synthetic wool and alternative clothing have lowered the demand of wool. Need for horses and mules has increased for the transport of agricultural produce to the road head. This has resulted in the decreased land to livestock ratio. According to an estimate, two hectares of land is needed to support one livestock unit in Uttarkashi (Johri and Prasad 1985). The number had been within the carrying capacity in the area until past few years (Ram *et al.* 1993). However, within the intensive study area the number of livestock has gone as high as eight units per hectare. Such a trend in the entire district would mean tremendous pressure on land, reduction and rapid degradation of forest vegetation.

4.4.3. Fuelwood and fodder extraction: Pattern of fuelwood and fodder utilization also changes with increase in human and livestock population. In the mountainous regions climatic conditions and altitudinal gradient define the extraction and consumption of these resources. In a study done in the lower valley of river Bhagirathi, per day fuelwood consumption was quite low (12kg/day) as compared to the present study (Adhikari *et al.* 1997). In the present study, village Saura situated at relatively lower altitude had less per capita fuelwood consumption in comparison to other three villages. TERI

(1992) also found a positive relationship between altitude and fuelwood consumption. A seasonal variation in the per capita fuelwood consumption confirmed the effect of climate. Increased fuelwood consumption during winters was to keep the rooms warm besides cooking meals. Of the two watersheds, cooler north-facing DWS had high per capita fuelwood consumption in temporary huts than those in BWS. Other workers in the Himalayan region also found similar trends (Ramana and Kukreti 1992, Fox 1984). According to Rai and Chakrabarti (1996) per capita consumption of fuelwood per annum in U.P hills comes out to be 652Kg. Annual per capita estimates of the present study (941.7kg) fall between estimates of studies done at Nepal (829kg/capita/year) and Mussorie (1003.75kg/capita/year) by Schmidt-vogt (1990) and Moench & Bandhyopadhyay (1986) respectively.

Besides climatic conditions, economic structure also influenced the resource use pattern. It was found that fuelwood consumption among three categories of households was significantly different. The least dependant households had business or service based occupation and family size was small. They had cooking gas as a supplementary source of fuel. On the other side, highly dependant families had mostly agriculture-based occupation with larger family size. The variation in resource use based on socio-economic status of households has also been observed in other parts of the Himalaya (Singh *et al.* 1992, Monga and Lakhanpal 1992). Most of the farmers in present study area were marginal and per capita land holding was very small. This compelled people to use these resources, which were freely available in the surrounding forests. Till recently, twigs collected as by-product of leaf-fodder (after drying) also constituted a major part of fuelwood but now its use is declining. Major reason for this could be either people don't have time to collect twigs left after browsing by animals or they burn them in the fields to increase fertility. Reduction in the use of twigs and crop residues as fuel (between 1978 and 1993) has also been observed in the Sikkim Himalaya (Mukherjee 1997). Availability and accessibility to a resource also affect its extraction and use. It was seen that in the present study area, receding forest boundaries from lowest elevation village, compelled people to collect secondary species such as *Berberis, Deutzia, Caesalpinia* and *Rosa* as fuelwood which otherwise are not considered species of good fuel quality.

Plate-4.1: Wheat threshing in village Barsu

Plate-4.2: Storage of fuelwood

Plate-4.3: Collection of leaf fodder

Plate-4.4: Grazing in sub-alpine meadow

Plate-4.5: Storage of thatch grass

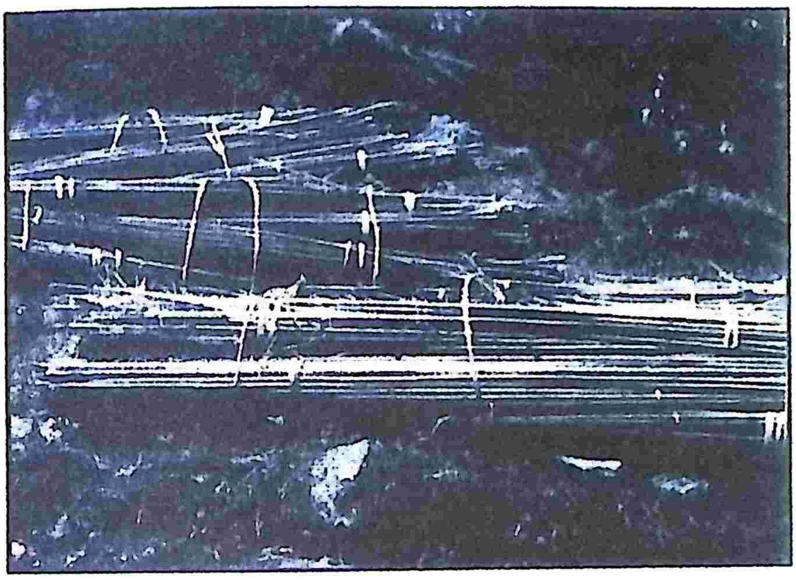


Plate-4.6: Extraction of bamboo culms

Plate-4.7: Preparation of new fields

Plate-4.8: New field amidst forest

(nomadism) rarely were two settlements occupied at the same season. This helped in sustainable use of resources whereas in the present form, resources are used simultaneously at two settlements. This has led to increased biomass consumption. Overall per capita consumption of fuelwood, which should otherwise decrease during summer and rain season, remains same or even increases due to firewood burnt at the *chhans*. Studies by Metz (1990) and Schmidt-Vogt (1990) in Nepal are comparable to present study. They also revealed that fuelwood consumption at temporary settlements (*goths*) was highest due to round the clock burning of fuelwood to keep the place warm. Another resource extracted from forests was bamboo culms (*ringal*). It was found that maximum number of culms was extracted during rain season. People had to walk >5km to collect this resource. However, during questionnaire survey people revealed that earlier the resource was available within 2 km radius. In BWS, people have started using other means to support the climbers, as bamboo culms were no longer available in the surrounding forests. Now people have to traverse >6Km to collect bamboo. This decline in bamboo might be due to its excessive extraction, which is related to area under kidney beans. Increased extraction of forest resources at lower settlements along with seasonal disturbance at higher zones might lead to shrinkage of relatively undisturbed middle elevation forests (Awasthi *et al.* 1998).

CHAPTER-5

Seasonal Transhumance and it's Impact

CHAPTER-5

Seasonal Transhumance and Its Impacts

5.1 Introduction

Transhumance has been a customary practice in several parts of the world (Balikci 1990, Perez & Saez 1990) including mountainous regions of Europe and Asia (Turnbull 1986, Rinschede 1988, Penz 1988, Browman 1990, Randhawa 1996). In the mountainous regions, vegetation types, their phenologyand above ground biomass varies drastically according to gradients of climate and topography. Native people are tuned to adjust to such variations and manage the resource use over space and time (Pant 1935, Mann 1986, Hussain 1997). Transhumance, is derived from a latin word "transhumer" meaning " land that is situated across and beyond the cultivated land". It also refers to the seasonal movement of people from one ecological zone to the other. Transhumance in the Himalayan region is an age-old practice. Although different communities involved in the migratory activities have different lifestyle and economy, livestock is an integral part in all the transhumant communities of Himalaya (Chatterjee 1980). Different communities involved in the migratory practice in Himalayan region include *Gujjars, Bakerwals, Gaddis, Khadwals* and *Bhotiyas* (Grieve 1920, Shashi 1979, Rao & Casimir 1982, Hoon 1996).

According to Binghay (1899) *Gujjars* migrated to the tarai-bhabar area from Gujrat- Kathiawad region of western India centuries ago and were known to be the cow-herders but now the buffaloes constitute a major part of their livestock composition. But, according to Khati (unpublished), they initially came to lower parts of Himachal Pradesh (H.P.) as a part of the dowry with Kashmiri princess who was married to Prince of Nahan. *Gujjars* were originally Hindu but were converted to Muslims in the Mughal period (Binghay 1899). At present there are both Hindu and Muslim *Gujjar* populations in Northern India. Hindu *Gujjars* are mostly in the plains of Punjab and Haryana whereas the Muslim *Gujjars* inhabit the Himalayan region of Jammu and Kashmir, Himachal Pradesh and Uttaranchal. *Bakerwals* are the Muslim *Gujjars* who were traditionally the goat herders from Kashmir. Their goats are known as *Kagani.* Their ancestors came into Kashmir valley about 150 years ago from the Kaghan valley in Pakistan (Casimir & Rao 1985). Both *Gujjars* and *Bakerwals* migrate seasonally from the Tarai-Bhabhar region to alpine meadows of Garhwal, Himachal Pradesh and Jammu & Kashmir respectively. *Gaddis* are the true shepherds. They have their origin in the Bharmaur sub-district of Chamba situated in the Dhauladhar ranges of H.P. *Gaddis* rear mainly sheep and goats for wool, milk and meat though they also practice mixed farming in their permanent villages. During summers, they graze their livestock in the alpine pastures of H.P and Garhwal Himalaya and during winters they migrate to lower valleys between Himachal and Uttaranchal (Gairola 1947). Bhotiyas (inhabitants of *Bhot* region) include *Jads, Marchas, Tolchhas, Darmis, Byansis* and *Joharis. Bhot* region starts from the southern slopes of Greater Himalaya and extends upto Zansker ranges, which demarcate Indo-Tibetan border. They are descendents of an ancient grazier race called Mon-khmer or Bheel or Kirat, which entered this region from the East, along the northern slopes of outer Himalaya and spread over the entire belt. Presently, these communities inhabit narrow valleys of rivers Bhagirathi, Vishnu Ganga and Dhauli Ganga, which range from 2250m to 3600m in altitude (Bhandari 1981). Originally *Bhotiyas* depended on trade (barter system) with Trans-border communities of Tibet and for this they used sheep and goats as pack animal. However, after the closure of borders due to Indo-China war this trade has stopped completely and now they have switched on to trade of woollen garments and carpets within country (Hoon 1996). Similarly due to changed political scenario and landuse patterns, transformations in many traditional practices have been observed (Goldstein 1981, Manku 1985, Tucker 1986). In some other parts of the world also agriculture has totally displaced the transhumance activities (Go'mez Ibanez 1977) whereas in other places periodic livestock movements still constitute an economically viable activity (Widstrand 1975, Ruiz & Ruiz 1986). One such example of transitional transhumance is found in the Garhwal and Kumaon regions of Western Himalaya (Farooquee 1994). In this practice one or two members from the family migrate seasonally with livestock to the alpine meadows.

Thus transhumance has been an adaptation of native people to overcome the environmental constraints and was the basic requisite for animal herding. However, with the transformations coming up in the traditional migratory patterns and subsistence economy the sustainability of this practice is becoming questionable (Brown 1971, Shah 1988, Prins 1992, Rawat & Uniyal 1993, Fox *et al.* 1994). The sustainability of this practice can be assessed if the socio-economic status and resource use pattern of transhumant communities is quantified. Literature perused shows that though several workers have conducted sociological and anthropological studies e.g., Bhasin 1996, Verma 1996, Farooquee & Nautiyal 1996, Negi 1998 on these transhumant communities, very little ecological work (Edgaonkar 1995, Saberwal 1999) has been carried out to quantify and analyze the resource use pattern of these communities. A need to study the lifestyle and resource use pattern of these communities in the seasonal camps and their impact on the surrounding vegetation is long awaited for the conservation and management. Thus, the present work was initiated in the Bhagirathi valley, in an attempt to bridge this gap. Following were the broad objectives of this study:

- To compare lifestyle and migratory patterns of different forms of transhumance in the upper catchment of river Bhagirathi.
- To quantify and compare resource use pattern of different transhumant communities.

5.2 Methods

5.2.1 Field Methods: After extensive survey of the villages in the upper catchment of river Bhagirathi, different patterns of transhumance followed by different communities were identified. In the present study the term **transhumance** has been used for all forms of seasonal movements of people or livestock from one place to other. Four communities, which follow transhumance in the study area, were *Gujjars*, *Gaddis*, *Jads* and resident *Garhwalis*. To study the lifestyle and resource use pattern of these communities at their summer settlements following methods were followed:

- *Questionnaire survey*: In the two intensive study sites (ISS) there were 12 temporary settlements locally known as *kharaks* used seasonally by *Gujjars* and villagers. Of these, six (6) *kharaks* were selected for quantification. In these *kharaks* there were a total 169 chhans (temporary huts) of *Garhwalis* and 7 *Deras* (temporary huts) of *Gujjars*. In each kharak, 20% of the *chhans* and all the *Deras* were selected for intensive questionnaire survey and monitoring of resource use. For collecting information on *Jads* and *Garhwalis* following transmigration, their summer villages (n=4) were surveyed. Structured questionnaires were used to gather information on population size, livestock composition, income, time of migration and residence time in the summer settlements. Displacement method (chapter-4) was used to quantify the amount of fuelwood and fodder consumed.

  However, in case of *Gaddis,* only interviews along with the personal observations were recorded. This was because *Gaddis* do not stay in the alpine areas of the two ISS for the entire season. Instead, they just use this area on their way to summer camping sites at much higher altitudes.
- *Secondary information*: Secondary information on the number of *Gujjars* and *Gaddi* herders arriving at the upper catchment of river Bhagirathi, the taxes charged from them and their historical account was collected from the records (Forest Working Plans, District Gazetteers and reports) of State Forest Office at Uttarkashi.

5.2.2 Analyses: Data collected in the field were subjected to preliminary analyses using Microsoft Excel. Statistical tests such as Paired t-test, ANOVA and Correlation Coefficient were applied to determine the significance of differences in resource use patterns of different communities.

5.3 Results:

In the upper catchment of river Bhagirathi four different communities follow transhumance. The pattern of transhumance followed by these communities can be categorized into following four forms:

Plate-5.1: A *Gujjar* family in temporary hut

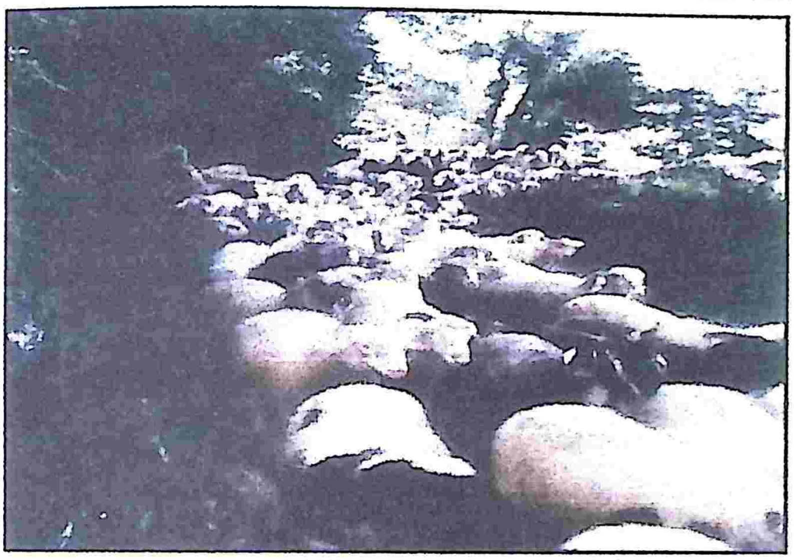


Plate-5.2: Livestock herd of *Gaddis* on way to summer camp

Plate-5.3: Summer village of Transmigrants

Plate-5.4: Temporary hut of Nuclear Transhumants

i) *Nomadism (N):* a form of migration in which entire family moves from one place to another. In the present study area, *Gujjar* community follows this practice **(Plate-5.1)**.

ii) *Semi-nomadism (SN):* a transitional form between sedentary and nomadic mode, in which one or two male members of the family migrate with livestock whereas the remaining family members stay back in the village. The shepherd community or *Gaddis* follows this practice in the present study area **(Plate-5.2)**.

iii) *Transmigration (TM):* a form of transhumance in which the entire village migrates from winter to summer settlements and vice-versa (**Plate-5.3**). Two villages of *Garhwali* community and two villages of *Jads* follow this practice in the present study area.

iv) *Nuclear transhumance (NT)*: a form of transhumance in which one or two members from each family migrate to local alpine meadows situated at higher altitudes (Farooquee 1992). *Garhwali* villagers follow this practice in the present study area **(Plate-5.4)**. A comparative account of the four forms of transhumance practices is shown in Table-5.1.

Table-5.1: Forms of transhumance in the upper catchment of river Bhagirathi

Parameter	Nomadism	Semi-nomadism	Transmigration	Nuclear transhumance
Community	*Gujjars*	*Gaddis*	*Jads & Garhwalis*	Other *Garhwalis*
Settlement	Temporary at both places	One temporary, one permanent	Permanent at both places	One temporary, one permanent
Altitudinal range covered	600-3600 m	600-4500 m	1500-3000 m	1700-3200 m
Altitude of summer camps	3200-3600 m	3600-4500 m	2700-3000 m	2700-3200 m
Economy	Milk based	Pastoral & agriculture based	Trade & agriculture based	Agriculture based
Livestock composition	Buffaloes & horses	Sheep & goats	Sheep, goats cows & buffaloes	Cows & buffaloes
Resource use	Alternate	Simultaneous	Alternate	Simultaneous

5.3.1 Nomadism amongst *Gujjars*: The study revealed that nearly 50% of the *Gujjars* from the foothills of Uttaranchal, *viz.,* Dehradun, Haridwar and Saharanpur districts migrate to the alpine meadows of Bhagirathi catchment during summer season. The *Gujjars* take on an average, 25 days to cover a distance of about 200kms on foot. The migratory route selected by different families is determined by the location of destination point. Few summer camping sites of *Gujjars* in Bhagirathi catchment are Dayara, Bakariya, Dodital, Ranthali, Belak, Kush-Kalyan, Khera Taal, Sukhi, Gangnani and Harsil. They do not traverse horizontally beyond Harsil in Bhagirathi valley. The altitudinal gradient covered by them during transhumance varied from *ca.* 600m to 3600m. However, in the alpine meadows they were confined to 3200m-3600m asl. The composition of forests these people occupy varied from moist (mixed) deciduous forests dominated by Sal (*Shorea robusta*) of Bhabhar and Shiwaliks tracts in winter (mid October to mid April) to alpine meadows and sub-alpine forests of birch-rhododendron (*B. utilis* and *R. arboreum*) and brown oak (*Q.semecarpifolia*) which form natural timberline towards upper limit during summers (mid May to mid September). In both the areas, they live in settlements called "*dera*". Each *dera* comprise of two to three hutments. The average distance between two *deras* is generally not less than 1km. Their huts are made up of wooden logs, hill bamboo (*Thamnocalamus spathiflorus*), mud and tarpaulin. A questionnaire based socio-economic profile of *Gujjars* (Table 5.2) revealed that each family had more or less equal proportion of male and female members and a higher number of children. As the economy of these people is milk based, they had a high proportion of buffaloes in their livestock and used horses/mules as pack animals during their migration. Average income per family from the sale of milk was *ca.* Rs. 170/day. During their stay in the alpine meadows they also faced livestock losses either due to natural calamities such as thunderstorm, diseases or old age or predation by wild animals.

Table-5.2: Socio-economic profile of a *Gujjar* Dera (n=7)

Parameter	Mean ± S.E
Population (number)	
Male	4.57±0.9
Female	4±0.8
Children	6.14±1.9
Total/dera	14.71± 3.12
Livestock (number)	
Buffaloes	16.29±3.6
Cow	0.57±0.3
Calves	4.14±1.7
Horses	2.14±0.9
Others	0.7±0.4
Total/dera	23.86±4.27
Economy	
Milk (kg/day)	15.29±3.4
Rate(Rs./kg)	11.14±0.4
Mawa (kg/week)	4± 1.3
Rate(Rs./kg)	65.8 ±0.2
Income/family/month (Rs)	*ca.* 5000
Livestock loss (#/season)	
Predation by leopard	2.0±0.5
Natural cause	2.83±0.7
Total livestock lost	3.86±0.6

± S.E= Standard error, # = number

A comparison of *deras* of the two ISS also revealed (Table 5.3) that *Gujjars* of Duggada watershed (DWS) sold milk at higher rates than those of Bhatwari watershed (BWS). This could be probably because they had to cover more distance to transport the milk from their *deras* than *Gujjars* of BWS. Livestock loss due to predation by leopard was more in DWS while predation was reported to be lower in BWS. This could be because DWS had good forest cover and less disturbances providing good habitat to wild animals compared to BWS.

Table-5.3: A comparison of *Gujjar deras* of two watersheds

Parameters		BWS (n=3)	DWS (n=4)
Population	Male	5.33±1.6	4±1.2
(mean ± S.E)	Female	4.33±1.45	3.75±1.03
	Children	5±3	7±2.7
	Total	14.67±5.55	14.75±4.3
Livestock	Buffaloes	14.67±2.67	17.5±6.3
(mean ± S.E)	Cow	1±0.6	0.25±0.25
	Calves	5.67±3.8	3±1.1
	Horses	2.3±1.2	2±1.4
	Others	1±0.6	0.5±0.5
	Total	24.7±7.1	23.25±6.2
Economy			
Production (kg/day/dera)	Milk	20.7±7.2	11.25±1.3
Rate (Rs./kg)		10±0	12±0
Production (kg/week/dera)	Milk product	3.3±3.3	4.5±0.3
Rate (Rs./kg)		66±0	65.75±0.3
Livestock loss/season			
Killed by leopard		0.33±0.3	2.25±0.6
Natural cause		4.3±0.3	1.3±0.3
Total		4.7±0.5	3.25±0.9

± S.E= standard error

5.3.2 Semi-nomadism by *Gaddis*: A general profile of the *Gaddis* prepared after interviews (Table- 5.4) revealed that they come from Dhauladhar ranges in Himachal Pradesh. They move with their livestock (sheep and goats) to alpine meadows of Bhagirathi catchment.

Table-5.4: A general profile of *Gaddi* herds (n=6)

Parameter	Mean ± S.E
Journey time (in months)	2.17±0.1
Herd size(# of livestock/ herd)	366.67±42.2
Wool production /sheep (kg)	1.33±0.2
Market value of a goat (Rs.)	2266.67±241.75
Fuelwood consumed(kg/day)	25.5± 2.27
Fodder fed (kg/day)	12±1

± S.E= standard error

During their journey, *Gaddi* shepherds cover a distance of over 400 kms and an altitudinal range of 600m-4500m. It takes them about two months to reach alpine zones (3600-4500m). Some of the important *Gaddi* camps in the study area were alpine areas Gidara, Harsil, Gaumukh, Tapovan, Kedartaal and Nilang. All of them stay in tents or caves during transition and at summer camping sites. The tents are made up of plastic tarpaulin. Their economy is based mainly on rearing of sheep and goats. An average of 366.66± 42.2 sheep and goats constituted a herd. Sale of an adult goat (female) fetched them Rs. 2000 to 3500 depending on the health of the animal. Besides this, wool obtained from sheep was sold at a rate of Rs. 50 to 70 per kg to the local villagers. Average production of wool per sheep according to *Gaddis* was *ca.* 1.33±0.2 kg. Each herd is accompanied by 2-3 watchdogs, which assist in keeping away the wild animals such as leopard, fox and jackal. The *Gaddi* livestock (sheep and goats) mainly grazed or browsed the herbaceous plants and shrubs. Occasionally, *Quercus* and *Ilex dipyrena* were also lopped (*ca.* 10kg/day) to feed the herd while on way to alpine zones. In *Gaddi* camps fuelwood was burnt whole night to scare away wild animals and also for warmth. Some of the *Gaddi* shepherds reared their own herds while rich *Gaddis* hired other shepherds for taking their herds to the alpine areas. Though these people migrate with livestock from winter to summer grazing grounds back and forth, their families stay permanently at the villages in H.P. and practice agricultural activities.

5.3.3 Transmigration (TM): Four villages in the Bhagirathi catchment followed transmigration. People of *Jad* community inhabited two villages Baghori and Harsil (2600m) and Garhwali community occupied the other two villages *viz.*, Dharali and Mukhba (2700m) as their summer settlements. The winter settlements of *Jads* were Dunda and Nakuri whereas in case of *Garhwalis* different families migrate to different villages such as Saura, Lata, Netala and Gangori situated at an altitudinal range of 1500-1700m. Both Garhwali villagers and *Jads* migrated on bus, jeep or truck from one settlement to other. It takes them few hours to cover a distance of about 70-100km and an altitudinal gradient of 1500 to 2700m. A questionnaire based general profile of

TMs (Table 5.5) showed that approximately equal number of families had both agriculture and trade based occupation.

Table-5.5: Socio-economic profile of Transmigrant villages (n=4)

Parameter	Mean ± S.E
Population/village	
Male	457.5±168.7
Female	367.5±119.9
Children	200±72.2
Total	**1025±349.7**
# of Households/village	147.5±45.02
Income/year/village (Rs.)	41500±7632.17
Occupation (# of families/village)	
Agriculture + Daily wages	65.5±31.1
Agriculture + Service	20.5±6.7
Agriculture + Other	61.5±39.6
Livestock (# per village)	
Cows	158.75±59.5
Oxen	133.75±78.4
Goats/Sheep	12575±7987.3
Others	1±1
Horses	137.5±137.5
Total	**13006±8084.9**
Fuel use (# of families/village)	
Firewood	147.5±45.02
LPG	58±18.2

± S.E= standard error

A comparative account (Table-5.6) of two TM communities i.e. *Jads and Garhwalis* revealed that former had more of ovine livestock whereas latter had more of bovines. The reason behind this could be the difference in economic base. *Jads* had trade-based economy whereas *Garhwalis* had agriculture based economy. Before the closure of borders due to Indo-China war, *Jads* of Bhagirathi valley were involved in trans-border trade (barter system) with Tibet. They inhabited the border villages Jadhung and Nilang situated at a height of ca. 3400m and were in fact transhumant traders who kept sheep and goats as pack animals. They cultivated crops such as amaranth(*Amranthus hybridus*), potato (*Solanum tuberosum*) and mustard (*Brassica juncea*) as a supplement to their needs. During winters they migrated to area between Rishikesh and Dehradun. After 1960's both the summer villages of *Jads* were rehabilitated to Harsil and Baghori due to security reasons. This completely stopped their trade with Tibet. Now most of the *Jad* families in Bhagirathi valley are involved in trade of woollen items and rear sheep and goats to get raw material for these items. Another source of income is the sale of locally prepared liquor (*personal observation*) about which they did not tell much when inquired.

Table-5.6: Comparison of Transmigrant villages of two communities

Parameter	*Garhwalis* (n=2)	*Jads* (n=2)
Population (per village)		
Male	450±150	465±385
Female	402.5±122.5	332.5±262.5
Children	247.5±127.5	152.5±102.5
Total	**1100**	**950**
# of Households/village	162.5±12.5	132.5±107.5
Income (Rs./year/h.hold)	29000±1000	54000±6000
Occupation (# of families/village)		
Agriculture + Daily wages	118±13	13±11
Agriculture + Service	20.5±5.5	20.5±15.5
Agriculture + Others	24±6	99±81
Livestock (# / village)		
Cow	162.5±12.5	155±145
Ox	267.5±32.5	0
Goats/Sheep	1150±850	24000±11000
Others	2±2	0
Horses	0	275±275
Total	**1582**	**24430**
Fueluse (# of families/ village)		
Firewood	162.5±12.5	132.5±107.5
LPG	72.5±27.5	43.5±28.5

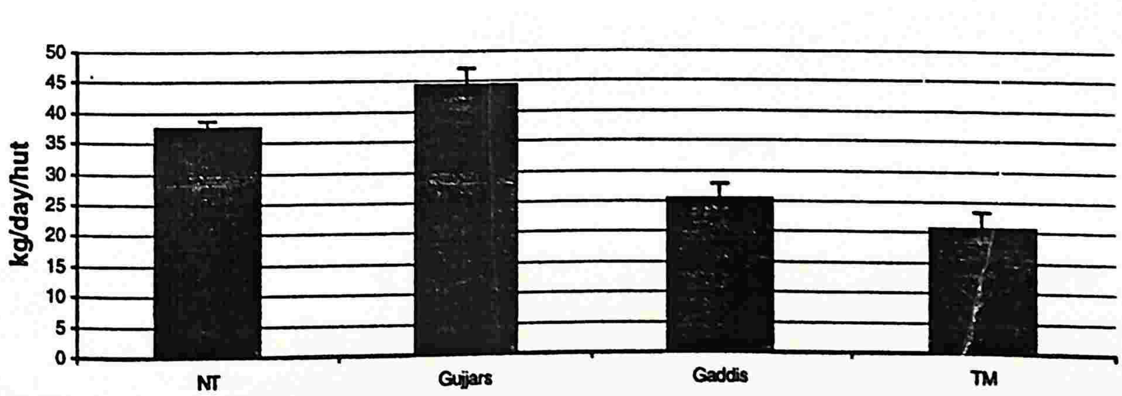
± S.E= standard error

Garhwalis migrated from the summer settlements to winter homes due to harsh weather conditions. Agriculture has been the traditional subsistence of these people and it is for the requirements of agriculture only that they kept livestock such as cows, oxen and buffaloes. Their source of income was the cultivation of cash crops such as kidney bean, potato and apple. In their winter settlements both communities followed the same occupation patterns i.e. *Garhwalis* were involved in agricultural activities whereas *Jads* were involved in activities such as cleaning and spinning of wool and weaving the woollen items such as shawls, pullovers, carpet, *Thulma* and *Pankhi* (blankets) and jackets. At both the settlements they depend on surrounding forests for fuelwood and fodder requirements. In the summer villages, surrounding forests are mainly composed of species such as *Pinus wallichiana*, *Cedrus deodara*, *Picea smithiana*, *Acer spp.* etc whereas around winter village's forest of *Pinus roxburghii*, *Quercus leucotrichophora*, *Rhododendron arboreum* and various others are found (Uniyal & Awasthi 2000).

5.3.4 Nuclear transhumance: Almost all the villages in the upper catchment of river Bhagirathi except those, near towns, followed nuclear transhumance. A detailed socio-economic profile of each village following NT in the ISS was presented in Chapter-4 (Table-4.2). It shows that of the six villages, five followed NT to alpine meadows during summers. Two villages of BWS and three villages of DWS followed this practice. Migratory distance of NTs varied from 6 to 15 km. The altitudinal range covered by them varied from 1600m to 3200m. It takes them 3 to 4 hours to reach alpine camps. However, they did not cover this distance in a day instead first they move to *kharaks* in the middle altitudinal zones (2400-2500m) and after staying there for fifteen to twenty days they move further to alpine meadows (2700-3200m). In the sub-alpine and alpine meadows NTs stay in temporary huts locally called *chhans*. The *chhans* are constructed from wooden logs, stones, hill bamboo (*Thamnocalamus falconerii*) and grass (*Chrysopogon gryllus*). It was known from the questionnaire surveys that one or two members per family moved with livestock to alpine zones after the cropping work was over. This not only prevented crop damage by livestock but also provided livestock with nutritious fodder at alpine meadows. Since main source of income (82.6%) for this community was cash crops such as potato and soyabean, which are cultivated in permanent villages, the other members of the family stayed back in the permanent villages to take care of the crops. Local festivals such as *Papri Sankrant* in April and *Selaku* in September regulated their movement. At alpine meadows the livestock were left free for grazing and only calves and milching animals were stall-fed at night. At both the settlement people extracted fuelwood and fodder from the surrounding forests (chapter-4, section-4.3.3). Per capita consumption of fuelwood at temporary huts was significantly higher from that in the permanent villages (chapter-4, Figure-4.14). Also, the leaf-fodder requirement of livestock at the temporary huts and permanent villages varied significantly (chapter-4, Figure-4.26). Besides fuelwood and fodder, people also extracted bamboo (*Thamnocalamus falconeri*) from forests to make articles such as baskets and mats for self-use. They collected medicinal herbs from alpine meadows for their self-use.

5.3.5 Resource use by different communities: All the four transhumant communities depended on surrounding forests for their resource needs such as fuelwood, fodder and timber. It was revealed that all transhumant communities used firewood as the source of fuel at their summer camps. Approximately 39% of TM families also used LPG as a supplement to fuelwood at their summer villages. Significant difference was found in the fuelwood consumption by different communities during their stay at summer camps (Figure-5.1). Per day fuelwood consumption was highest in case of nomadic *Gujjars* and least in case of TMs.

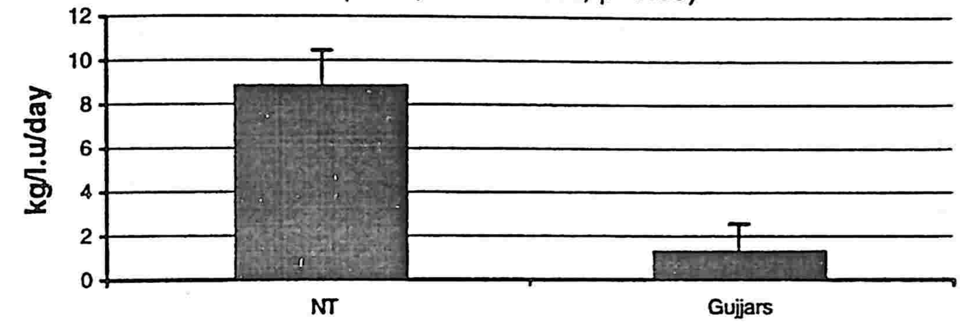
Figure-5.1: Fuelwood burnt by different communities
(1 Way ANOVA, F-value=16.876, $p<0.001$)



Similarly, composition and quantity of fodder requirements of livestock also varied among different communities. In case of *Gaddis*, most of the time animal herds either grazed or browsed on available resources whereas livestock herds of NTs and TMs were also supplemented with lopped fodder. It was found that lopped fodder requirement was higher in case of NTs when compared to *Gujjars* (Figure-5.2).

Figure-5.2:Leaf-fodder requirement per livestock unit by different communities

(t-test, t-value=0.24, p>0.05)



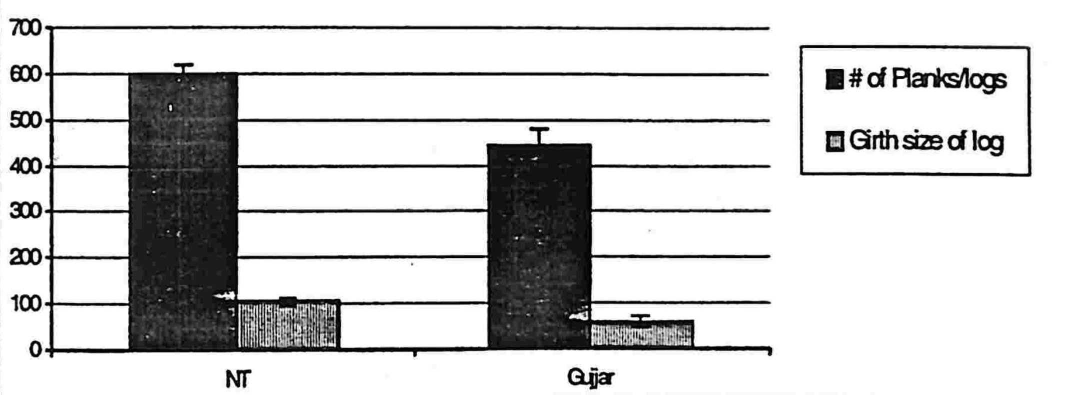
The reason for this could be that *Gujjars* left their livestock free for grazing at night whereas NTs stall-fed them at night. Transmigrants on the other hand fed their livestock with agricultural by-products (95%). The reason for this could be the unavailability of fodder yielding species in the surrounding forests (*Cedrus deodara -Pinus wallichiana* forests). Species lopped for fodder and cut for fuelwood also varied among different communities (Table-5.7).

Table-5.7: Species used by different transhumant communities

Nuclear Transhumant	*Gujjars*	Transmigrants	*Gaddis*
Fuelwood			
Q. semecarpifolia	*B. utilis*	*C. deodara*	*Juniperus spp.*
T. baccata	*R. campanulatum*	*P. wallichiana*	*Rosa spp.*
V. cotinifolium	*Q. semecarpifolia*	*J. regia*	*Artemisia spp.*
A. pindrow	*T. baccata*	*P. malus*	
Fodder			
Q. semecarpifolia	*B. utilis*	Grasses	Grazed only
Thamnocalamus spp.	*Q. semecarpifolia*	Agr. By-products	
Acer spp.			

The differential use of species could be the result of confinement of different communities in different ecological zones and the availability of the species in the surrounding areas. *Gaddis* burnt *Juniperus* spp. in the alpine zones (>3600m) whereas *Gujjars* mainly used *B. utilis and R. campanulatum* as fuelwood (3200-3600m). On the other hand NTs and TMs burnt *Q. semecarpifolia* and *C.deodara* respectively as fuelwood. The quantity of wood used in the construction of temporary huts also differed between *Gujjars* and NTs. In case of *chhans* (NT) more number of planks that too of higher girth class were used to construct walls and floor of the hut. On the other hand in case of *chappars* (*Gujjars*), logs of medium girth class were more used in the construction of huts (Figure-5.3). Besides wooden logs/planks *Gujjars* also used mud and bamboo (*T. spathiflora*) while NTs also used grass (*C. fulvus*) and bamboo (*T. spathiflora*) as thatch for their huts. Barks were peeled off from the trees for using it in cattleshed by both NTs and Gujjars.

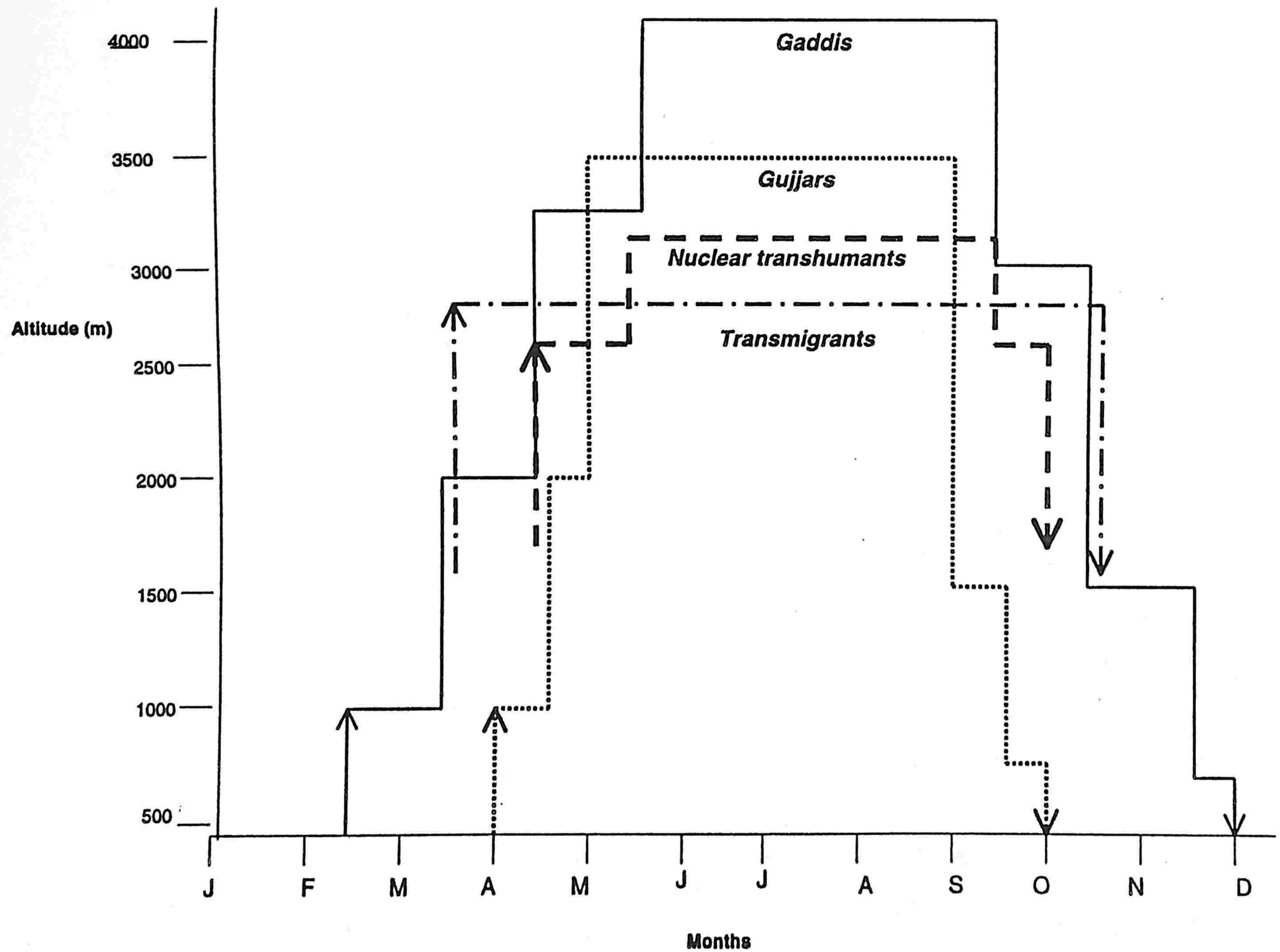
Figure-5.3: Wood used in constructionof temporary huts
(t-test, t_1=3.83, P_1<0.005; t_2=3.39, P_2<0.05)



5.4 Discussion and Conclusions

5.4.1 A comparative account of different forms of transhumance: Utilization of the different biomass resources at various altitudes seems to be the most important economic strategy of various communities in the upper catchment of river Bhagirathi. It was found that almost all the zones above 2700m were used seasonally by one or the other form of transhumant community. All the transhumant communities had one thing in common i.e. the **seasonal migration.** However, these communities differed in their lifestyle, resource use patterns community composition and socio-economics (Table-5.1). The time periods of journey were related to the spatial range covered and herd-

Figure-5.4: Seasonal movements of different transhumant communities



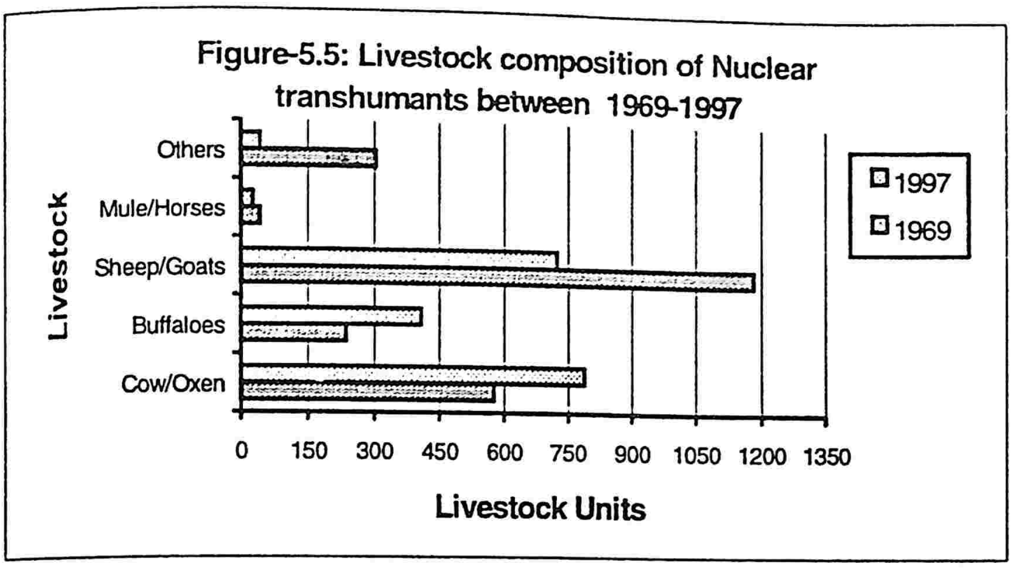
size managed (Figure-5.4). It was found that resources used during journey and energy expenditure in the form of human labour during transhumance were probably higher in case of Nomadic (*Gujjars*) and Semi-nomadic (*Gaddis*) communities compared to NTs and TMs. This could be due to differences in the economic basis. People with dependence only on livestock (*Gujjars)* spent more time and covered wider altitudinal ranges than those, which had agricultural based economy (NT). In case of NTs and TMs agricultural activities determined their movements. Their upward movement started after completing all the cultivation work and returned back to lower villages before the harvest of *kharif* crops. Individual communities also differed in their movement both horizontally and vertically. *Gaddis* and *Gujjars* moved horizontally in space for quite a long distance to fulfill the resource needs of their livestock before moving vertically to alpine zones. This could cause wider impact on the natural resources. On the other hand NTs and TMs had vertical and horizontal movements only to reach their summer settlements. A difference in livestock composition and their stratification in the alpine region was also seen. *Gaddi* herds (sheep and goats) were confined to higher zones (>3600m) compared to cattle and buffaloes of *Gujjars* and NTs (2700-3600m). This stratification was either based on the relationship of body sizes of animals and ecological features of the areas (Gonzalez *et al.* 1990) or due to resource scarcity in a particular zone. Either of the two or both reasons might have allowed dispersion of different communities in different zones. Negi (1998) discussed that resource depletion was an important factor in the movement of *Gujjars* from Jammu & Kashmir to parts of Punjab, H.P and hills of U.P. Main factor regulating the seasonal movements of *Gujjars*, *Gaddis* and TMs was change in the climate leading to resource scarcity in the lower valleys, however, in case of NTs agricultural activities guided the movement. In some parts of the world (Perez & Saez 1990) the seasonal movement is regulated by the date on which pastures are leased.

Hoon (1996) also observed similar differences in time and space utilization among shepherds (pastoralists) and *Kunchas* (transhumant villagers) while studying sociological aspects of Bhotiyas of Kumaon. Similarly Bakerwals of Jammu & Kashmir also utilized different ecological belts in their annual cycle of movements (Casimir & Rao 1985). Though in case of transhumant Bhotiyas of Kumaon, a direct link was found between livestock and land ownership patterns (Farooquee & Nautiyal 1996), no such relationship was evident among the *Jads* inhabiting Bhagirathi valley. However, such relationship was found in case of NTs, where villages with more agricultural land had more livestock units (chapter-4). Communities following NT in Pithoragarh and Almora had primary occupation based on agriculture similar to the NTs of present study but it only fulfilled their subsistence needs so they reared cattle to earn liquid cash from the sale of milk products (Farooquee 1992). On the other hand in the present area NTs had market-oriented agriculture and people reared animals to supplement their needs and manage agricultural activities.

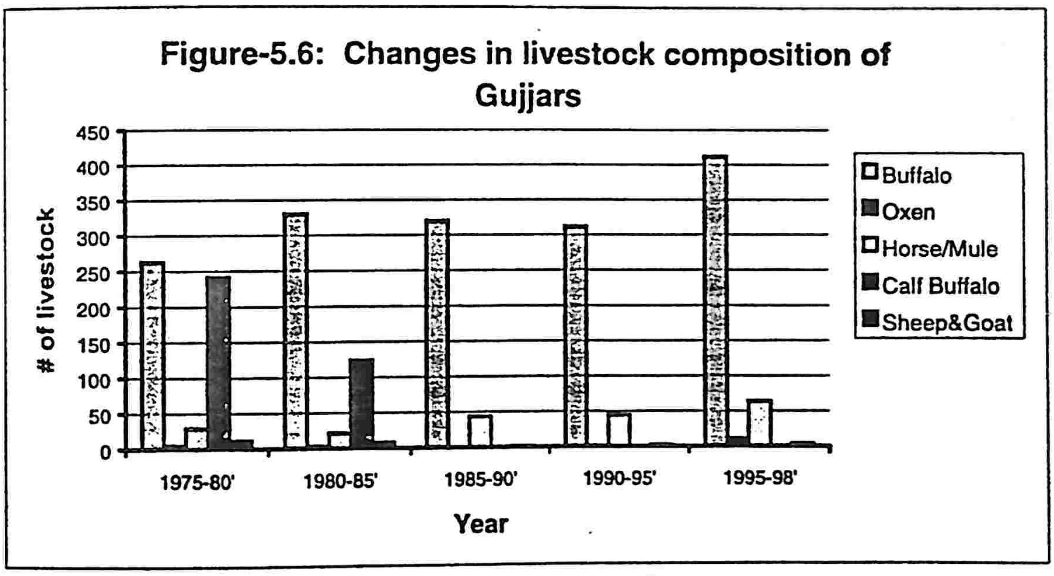
The different transhumant communities also differed in their resource use patterns. It was found that *Gujjars* and TMs used the rescurces of their summer and winter homes alternately but *Gaddis* and NTs had simultaneous resource use at both permanent (villages) and temporary (*chhans* or tents) camps. The alternate pattern of resource extraction was in accordance with the traditional form of migration, which allowed time for the regeneration of surrounding forests. But in the case of simultaneous resource use, forests around both permanent and temporary settlements were disturbed. This is complementary to the results of Schmidt-vogt (1990) in case of Nepalese people. In the present study it was also observed that *Gujjars* had highest fuelwood consumption compared to other three communities (Figure-5.2) because they generally had two hearths; one for cooking and other for heating the huts and were totally dependent on forest resources for fulfilling their daily needs. A comparison of *Gujjars* with *Taungya* villagers in and around Rajaji National Park also revealed that resource use was higher in case of former (Berkmuller *et al.* (unpublished). On the other hand in case of fodder, NTs had higher per livestock unit consumption of leaf-fodder compared to *Gujjars* (Figure-5.2). This could be because they kept their herds inside *Chhans* at night and were stall-fed whereas *Gujjars* left their livestock out in the open even at night and only calves were fed on leaf-fodder. Also, wood used in the construction of temporary huts was higher in case of NTs compared to *Gujjars* (Figure-5.3) because *Chhans* of NTs were generally bigger in size and had space for animal herds also while *Gujjar* huts had single room, which was partitioned, as kitchen. *Chhans* were repaired only after two or three years, while *Gujjar* huts were renovated every year.

Confinement of different communities in different ecological zones in the alpine area also justified the composition of species they utilized as fuelwood or fodder (Table-5.7). Thus different transhumant communities do have overlap in the route that they used to migrate to alpine ranges but once in the alpine region they were confined to different altitudes. Though this had decreased the concentration of herds at a particular zone but had certainly widened the region of influence of anthropogenic activities. This would put more pressure on the ecologically sensitive sub-alpine forests and alpine meadows.

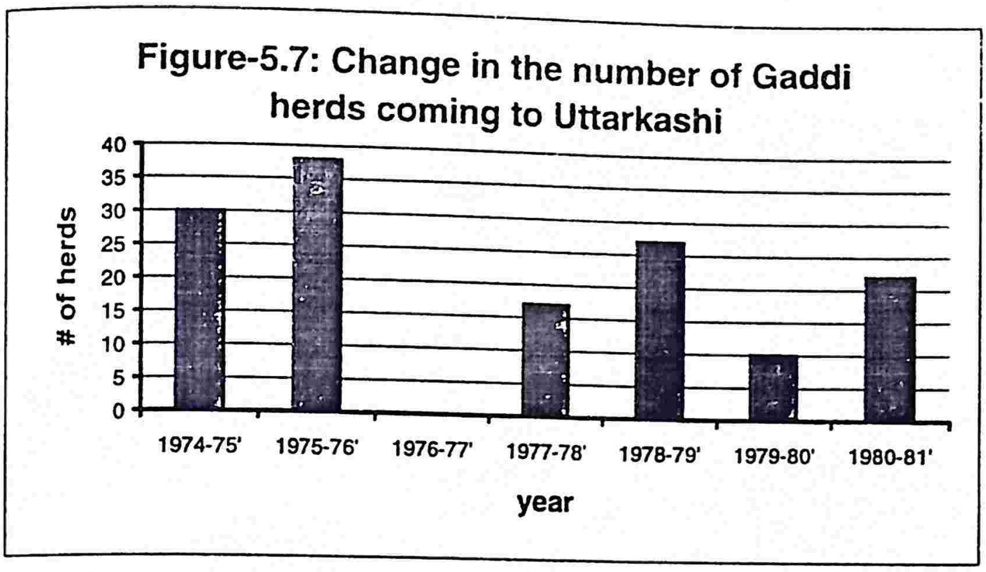
5.4.2 Transformations in the transhumance practices and their impact: Traditional ways of life are being vitally effected by the changing circumstances such as the growth of both human and livestock population, invasion of modern civilization and coming up of developmental projects. These effects alter the traditional lifestyle and landuse practices. Reduced rotation cycle in the *Jhum* (slash & burn) cultivation in the North-east, replacement of subsistence economy with market oriented agriculture in many parts, monoculture plantations and clear felling of forest patches for tea gardens and orchards are some of the examples of such transformations. Transhumance is no exception to such changes. Traditional form of nomadism or "true form of nomadism" i.e. to roam from one place to another without having fixed destination has been replaced by the present type of nomadism (as followed by *Gujjars*) with fixed summer and winter destinations. The routes and the areas of usage are now well defined. Nuclear transhumance and semi-nomadism are themselves an interphase of nomadism and sedentarism (Farooquee 1992, Tucker 1986). Traditionally these transitions would have taken place to supplement subsistence but now these seasonal movements have become a part of their market-oriented economy. This change was also evident in the livestock composition of different communities. Earlier, in case of NTs sheep and goats constituted the herds as the economy was based on pastoralism but now number of bovines has increased due to shift towards agriculture based economy (Figure-5.5).



Whereas *Gujjars* have now almost stopped keeping sheep and goats and population of buffaloes and horses has increased in their herds (Figure-5.6).



This again is an indication of commercialized pastoralism. Impact of market-oriented economy was also observed in the *Gujjars* of other parts of Himalaya. *Gujjars* inhabiting tarai area of Kumaon have almost ceased to visit Pindar valley now perhaps due to its remoteness from the market (Nand & Kumar 1989). In parts of Punjab, *Gujjars* have almost stopped transhumance and have adapted sedentary lifestyle (Manku 1985). This is because with increasing population, pastoralists tend to become agriculturist to fulfill their biological as well as economical needs (Brown 1971). *Gaddi* herds arriving in alpine areas of Bhagirathi catchment have also reduced (Figure-5.7) due to problems encountered during these long journeys and also because of increasing resource scarcities and conflicts with other communities (Bhandari 1981).



In case of *Jads*, collapse of Indo-Tibet trade led to sudden disruption of the economic main-stay (trade with Tibet) and stability of their socio-cultural life (Hoon 1996). Alternative sources of livelihood were sought and they modified their socio-cultural life in conformity with the changed conditions (Dube and Singh 1997). Their trading instincts helped them in establishing wool-based trade and this further increased their livestock holdings, which resulted in more resource extraction from the surrounding forests. Now a change is visible in this trade also. With recognition of the benefit of reservation as scheduled tribes more and more *Jad* people are now inclined towards seeking employment in government services. In case of *Garhwali* transmigrants, younger generation (*ca.* 32%) are getting more inclined towards other modes of livelihood such as tourism. The reason for this could be better transport network, increased tourist number in this area and roadside location of the village (*Personal observation*). Inclination towards other modes of economy might lead to decline in transhumance practice but as tourism generates seasonal income, their mainstay would remain agriculture only. Technological and economical changes have not only reshaped practice of transhumance but also outmoded on foot migration, which is now undertaken by bus, truck or taxi in case of TMs and some times *Gujjars*.

This shift in traditional transhumance practice, by no means, was a smooth transition but it might have taken several decades to come to the present status. The negative impact of transhumance in the surrounding areas comes up as overgrazed pastures eroded lands and proliferating weeds

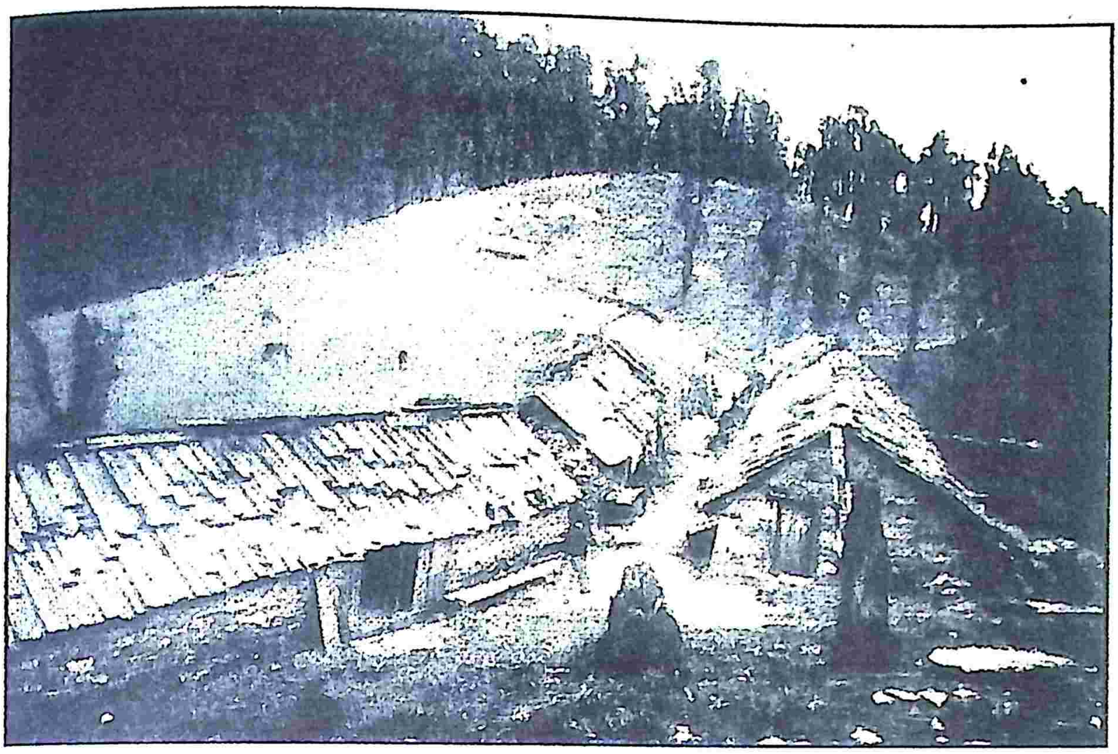


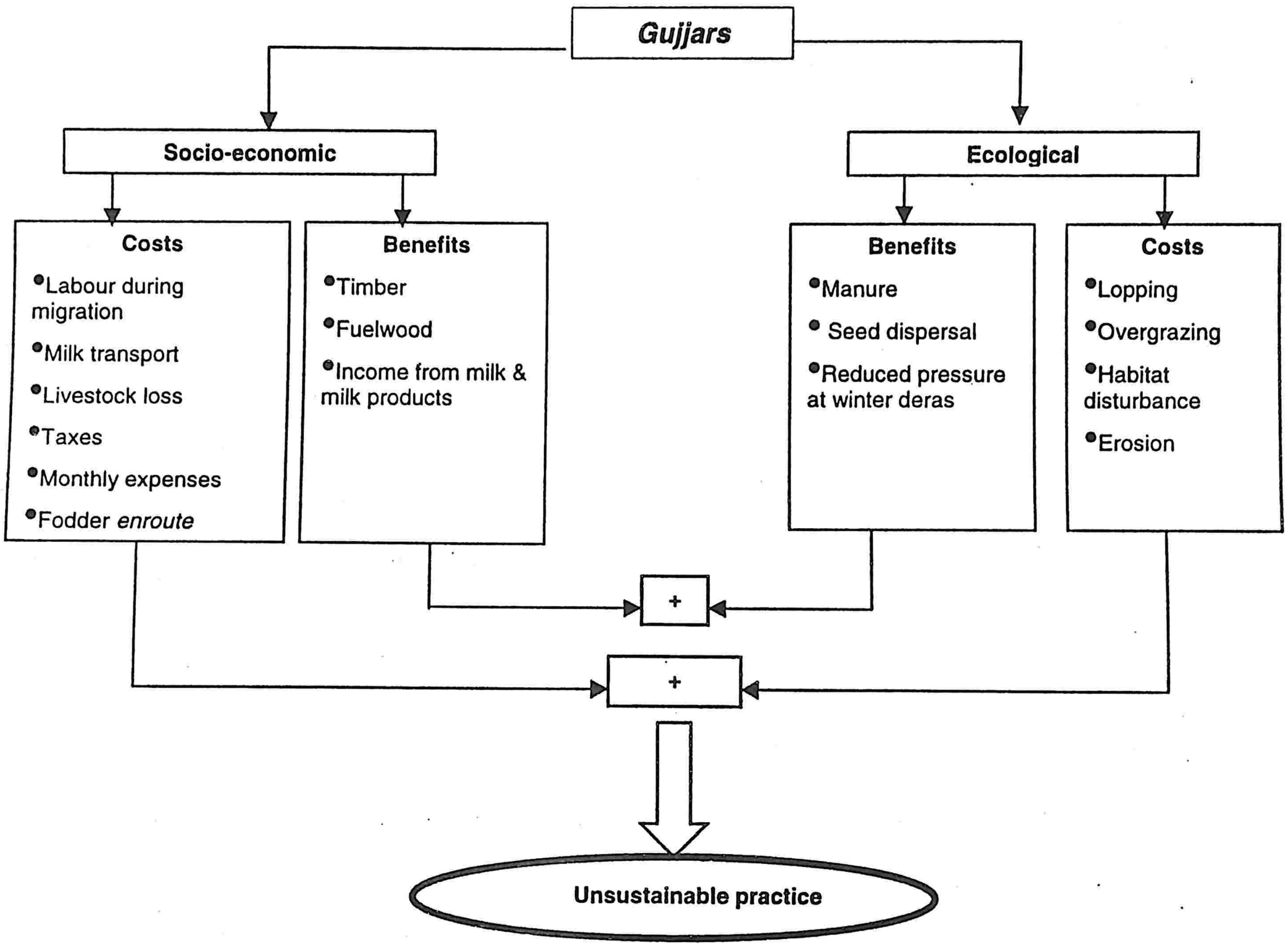
Plate -5.5: Degradation of sub-alpine forests

Plate-5.6: Debarking for cattle sheds

(Casimir & Rao 1985, Shah 1988, Rawat & Uniyal 1993). At several places in Himalaya, forests are in a poor state of regeneration due to overgrazing and burning (Pirazizy 1992). The problem of overstocking in sensitive sub-alpine and alpine zones has led to the degradation of alpine meadows in the present study area *too*. The intensity of lopping of trees increased in the sub-alpine and alpine zones during rainy season. The forests surrounding temporary settlements are severely lopped and debarked (**Plates 5.5 & 5.6**) to turn into pole or bushy appearance (Chapter-7). Regeneration status of preferred species was also poor and canopy loss has resulted in the coming up of secondary species (Uniyal *et al.*, 2000). In the winter *deras* of *Gujjars* also regeneration of fodder tree utilized by buffaloes was very low (Edgaonkar 1995). In the future this could result in fodder shortages. Excessive resource use by *Gujjars* in their winter settlements has also led to depletion and transformation of vegetation (Das *et al.* 1996). Cases of transhumant herds destroying crops on their way to alpine meadows have also been highlighted (Chatterjee 1980) and observed during this study. Besides, while traversing through the forest, livestock herds also disturb the habitat of many wild fauna resulting in increased wildlife-human conflicts (Mishra 1997). This was also observed in the present study (Chapter-8). It is due to these ecological impacts that the practice of transhumance is highly questionable.

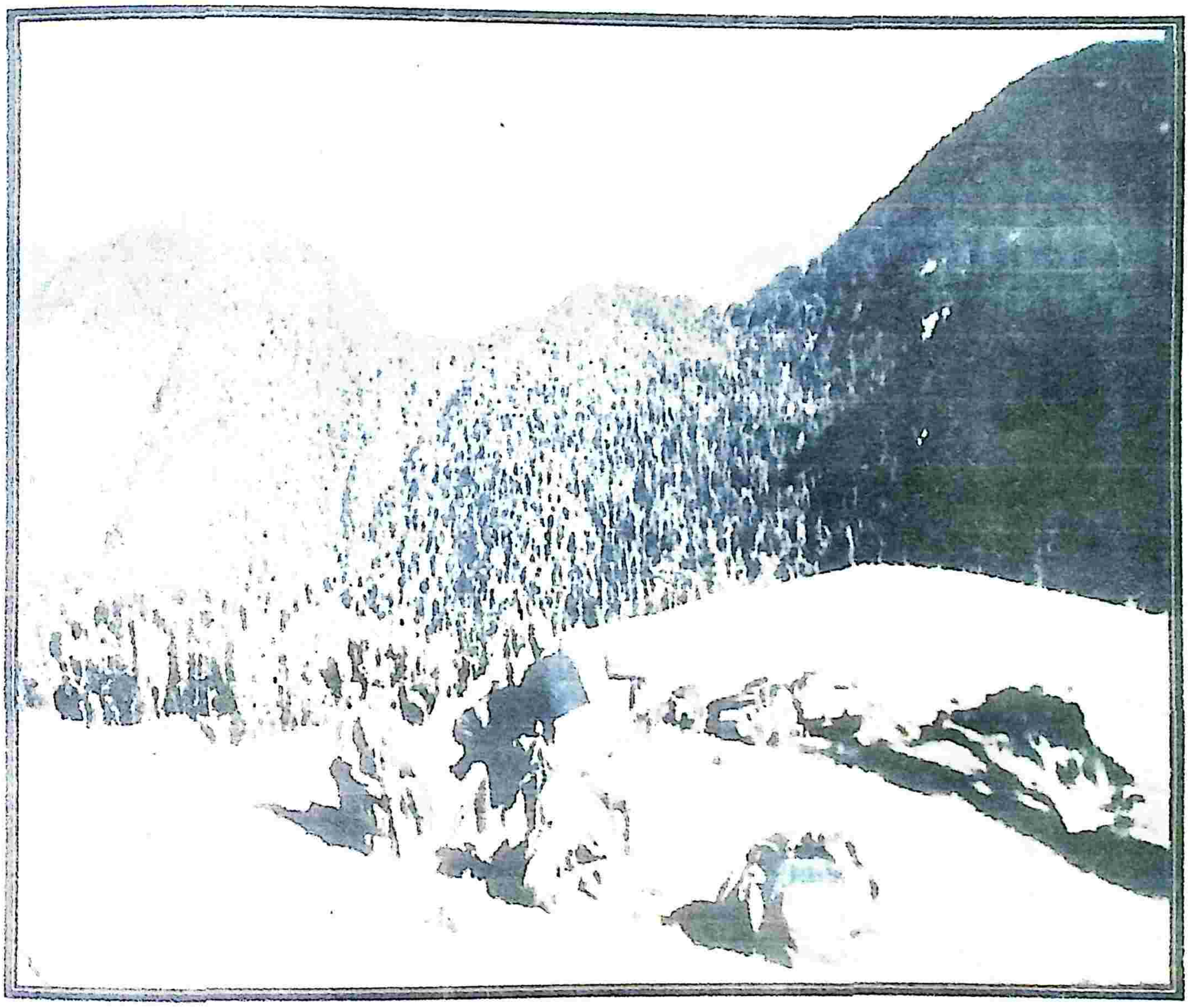
Now the question is **whether this practice is still economically viable to transhumants?** In case of NTs, TMs and *Gaddis* it might be viable as it is their supplementary source of income and their primary occupation is either agriculture or trade. With better socio-economic conditions in the future this practice might stop completely as has been seen in one of the six study villages and other parts of the Himalaya (Dube & Singh 1997). But what is the status of nomadism by *Gujjars*? On evaluating the livestock losses during their stay at alpine settlements, taxes paid to forest department, energy expenditure and problems (mental as well as physical) faced during seasonal migration by *Gujjars* their benefits seemed to be meagre. The economical costs coupled with ecological costs in transhumance practice of *Gujjars* were found to be more than the total benefits (Figure-5.8). Hence, this practice as determined from the present study is neither sustainable for the economical upliftment of *Gujjars* nor for the recuperation of high altitude forests.

Figure-5.8: Costs and benefits from nomadism



Widening of region of influence of anthropogenic activities in the alpine zones coupled with transitions in the traditional landuse practices such as subsistence based agriculture to commercialized agriculture might increase pressures on the surrounding forests for their resource needs. The expansion of agricultural land at the cost of surrounding forests in the permanent villages and degradation of timberline forests due to increased pressure by transhumant communities might lead to shrinkage of relatively undisturbed mid-elevation forests.

CHAPTER-6



Current Level of Tourism and it's Impact

CHAPTER-6

Current Level of Tourism and Its Impact

6.1 Introduction

Tourism has acquired the status of second largest industry of the world in terms of direct and indirect employment generation. Though the concept of travel is very old, the term 'tourism' as we know today is of relatively modern origin (Tewari 1994). In India, tourism in the form of pilgrimage is an age-old phenomenon, however, after the enactment of Indian constitution, tourism received a greater impetus. In 1958, a separate department of tourism was created under the Ministry of Transport. Later a presidential order of 1967 brought the Department of Tourism and Civil Aviation formally into being with the objects of developing and promoting tourism in the country (Pillai 1985).

Distribution of major shrines and natural landscapes in the Garhwal Himalaya provided it a prominent place in the tourism industry. Four distinct forms of tourism viz., pilgrimage, elite tourism, mass tourism and wildlife or nature tourism have been identified in the Garhwal Himalaya (Singh 1980). Pilgrimage has been an important feature of this region (Bhardwaj 1973). Every bit of land in Garhwal is considered sacred and thus have the latent potential of religious tourism. The *Panch Prayags*, *Panch Badris*, *Panch Kedars* and a number of holy places abound this region (Prasad 1994). Simplicity, austerity and morality were the main traits that characterized the pilgrims' progress to these shrines. The concept of 'Tirth' (pilgrimage) intertwined the spirit of religion and tourism (Dabral 1960). Modern tourism or mass tourism, which is the innovation of the 20th century, entered Garhwal Himalaya after the construction of metalled roads and the opening of Garhwal for visitors in 1974 (Singh 1977). This influx of visitors has now become interminable and is exerting immense socio-economic influences resulting in social transformations (Pirazizy 1993, Singh 1983). Since past few decades there has been a rapid increase in number of visitors to Garhwal mostly due to disturbance in Kashmir Himalaya. Resorts such as Mussoorie, Dehradun, Badrinath, Kedarnath, Yamunotri and Gangotri are the main tourist centers which have attracted 3/4th of the total tourist flow to Garhwal Himalaya and still show a rising trend (Kayastha & Rai 1990). The unmanaged influx of mass tourism in the fragile zones of Garhwal Himalaya has led to rapid degradation at several places. Deterioration of fragile ecosystems and attractive landscapes through unplanned construction, excessive trampling and unsustainable resource use has been highlighted in several parts of the Garhwal Himalaya (Singh & Kaur 1980, Singh 1983, Kaur 1985, Khadkha 1992, Berkmuller *et al.* (unpublished). Despite its long-term negative impacts, tourism has some potential for positive socio-economic benefits from improved opportunities for jobs and education, improved civil amenities, transport network and environmental awareness. For incorporating appropriate planning strategies for tourism at micro-level, analysis of ecological profiles of different tourist centers and lifestyle of visitors becomes essential. Impacts of tourism in varied socio-economic and ecological conditions should be evaluated to reduce conflicts between development and conservation goals (Parsons 1986).

The upper catchment of river Bhagirathi is.not an exception to all that is described above. It has been an important religious center and now the number of nature lovers has also increased since past few decades. Recent increase in the influx of tourists has led to increased construction around Gangotri. Deforestation and unplanned construction around Gangotri temple (a famous Hindu shrine in the Bhagirathi catchment) and Gaumukh (source of river Bhagirathi) has resulted in ecological degradation of the area (Nand & Kumar 1989). Keeping this in view, the Government of India banned all kind of construction in and around Gangotri (UNI, 1991). Many workers have highlighted the impacts of increased and ill-conceived tourism in and around Gangotri but no systematic quantitative studies have been carried out to study the attitude and behaviour of visitors and its impacts on the surrounding environment, which is a major prerequisite for proper planning. This aroused the need for present study in the upper catchment of river Bhagirathi. Broad questions framed for the study were:

- What are the impacts of tourist activities on forests surrounding the tourist centers?
- Are there any differences in the behavioural characteristics and resource use patterns of domestic and international tourists?
- Are there any differences in the behavioural characteristics and resource use patterns of nature tourists and pilgrims?

6.2 Methods

6.2.1 Field Methods: The reference of the records of Regional Tourist Office (RTO) at Uttarkashi and discussions with the Officer on Special Duty (OSD) adventure tourism, established that there were two peak tourist seasons in a year. These were summer (mid-May to mid-June) and autumn seasons (mid-September to mid-October). These two seasons were therefore selected for studying the above mentioned objectives. Following different tools were used to elicit information:

- *Pressure assessment:* Two trails (1.0 km each) were selected in the vicinity of Gangotri (a religious shrine of Hindus) to study the impact of visitors (lopping of trees and disposal of garbage) on the surrounding environment. Of the two trails one was less visited trail and the other was more visited. In each trail, at every 250m, a circular plot of 10m radius was laid to record the tree species, number of individuals of each species, their CBH above breast height and number of cut/lopped trees (Sale & Berkmuller 1988). Garbage inside each plot was also weighed after sorting.
- *Questionnaire surveys:* Gangotri being one of major tourist centers was selected as an observation point. Besides Gangotri, observations were also recorded in the two intensive study sites (ISS). The information was gathered from the visitors and hoteliers through structured questionnaires and interviews. At Gangotri, three days each in two major tourist season (summer and autumn) were selected randomly for distribution of questionnaires over a three years period of study (Oct. 1996-July 1999). Hence, data for a total of three summer and three autumn seasons was compiled. In each season 100 copies of questionnaires (Appendix-3.4)

were distributed to the tourists (parties, families, and individuals) randomly. For illiterate respondents interviews were conducted to obtain answers to the questionnaires. For trekking parties in the ISS, a different questionnaire was structured to incorporate all difference in the field conditions (Appendix-3.5). A random method was adopted for the interviews because of no set pattern of visitation in these ISS. In all, fifteen parties were interviewed in both the ISS. The information gathered from these questionnaire surveys was related to the lifestyle of visitors, aim of visitation, resource use pattern and their views about the place and environment.

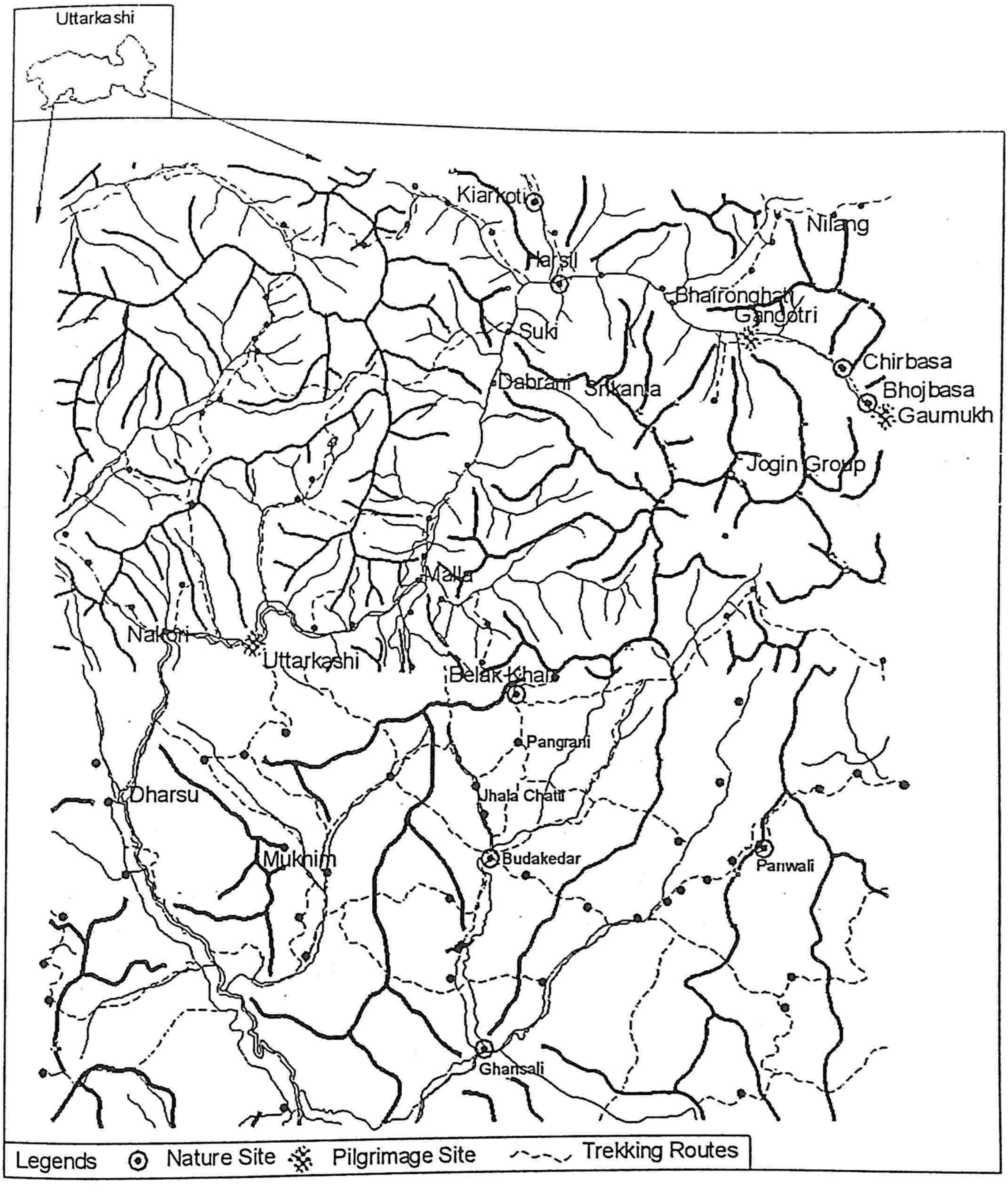
- *Secondary sources:* Secondary information regarding trends of tourists and number of registered hotels was gathered from the records of tourist department. Some information was also elicited from the local trekking and mountaineering agencies and OSD.

6.2.2 Analyses: Data gathered using different tools was analysed to understand different types of visitors, their behaviour and direct and indirect impact of tourist activities on the surrounding forests. From the information collected through questionnaires, tourists were classed into four types viz., domestic and international, pilgrims and nature lovers. A comparison of characteristics and resource use patterns of all the four types of tourists was made to determine the status of different forms of tourism. Different trails were compared for garbage load and frequency of lopping of trees to delineate the pressure zones based on wood extraction and litter load.

6.3 Results

The places of tourist's interest in the upper catchment of river Bhagirathi can be divided into two zones (Figure-6.1). Pilgrimage zone consist of sites of famous Hindu shrines such as Uttarkashi, Gangotri (**Plate-6.1**) and Gaumukh and Wilderness zone comprising trek routes to Kedartaal, Nandanvan, Tapovan, Gaumukh, Saat-Taal, Dodi-Taal, Kheda-Taal, Nachiketa-Taal, Dayara Bugyal (**Plate-6.2**), Belak Khal, Kush Kalyan and Chawraungi Khal. Gaumukh is also visited by nature-lovers.

Figure-6.1: Map depicting pilgrimage and nature sites in Bhagirathi valley



6.3.1. *Attitude and behavioural characteristics of domestic and international tourists:* The analyses of questionnaires provided information on profession, aim of visit, group size and residency time. There was an obvious overlap in the response percentages in different classes due to preference for more than one option by the visitors. Some of the salient features as analyzed are specified below:

Profession of tourists: Categorization of tourists based on their profession revealed that of the five hundred domestic tourists interviewed, 33.3% were in government service and 29% in business. About 13% of the visitors were agriculturists, about 9% students and 3% doctors. People such as painters, journalists and artists were kept under "others" and they consisted of about 12% visitors (Table- 6.1). On the other hand, of one hundred international tourists interviewed, 44% were workers in different sectors and 44% were either painters or musicians. Only 6% of them were students.

Table-6.1: Profession wise distribution of domestic and international visitors

Tourists	Service	Business	Doctor	Student	Agriculturist	Others*	Total
Domestic	167 (33.3)	143 (28.6)	16 (3.2)	48 (9.5)	63 (12.7)	63 (12.7)	500
International	44(44)	6 (6)	0	6 (6)	0	44(44)	100

Values in parentheses represent percentage of total, *others include painters, journalist, player's etc.

Purpose of Visit and period of stay: Purpose of visit of most of the domestic visitors was pilgrimage (82.54%) whereas those of international tourists were either trekking (81%) or meditation (50%). About 31% of domestic tourists also preferred trekking to places such as Gaumukh and Tapovan whereas just 5% had meditation as their purpose of visit. About 11% also preferred wildlife viewing and photography and 6% were a part of educational tours (Table-6.2). Most of the domestic tourists (35%) stayed in Gangotri for less than 24hours because most of them were a part of Package tours and had their night halt at hotels/dharmshalas in Uttarkashi. Only those interested to trek to Gaumukh and adjacent areas stayed for more days. In case of International tourists most of them (50%) stayed there for about a week or fortnight (38%).

Table-6.2: Purpose of visit and period of stay of domestic and international visitors

Tourists	Purpose of visit						
	Trekking	WV	EDT	Photography	Pilgrimage	Meditation	Total
Domestic	159 (31.75)	56 (11.1)	32 (6.4)	56 (11.1)	413 (82.5)	24(4.8)	500
International	81(81)	38 (38)	19 (19)	25 (25)	31(31)	50 (50)	100

Tourists	Duration of stay						
	< 1 day	1 day	2days	2<7days	7-15days	>15 days	Total
Domestic	175(34.9)	87(17.5)	63(12.7)	144(28.9)	16(3.2)	0	500
International	0	0	6(6)	50(50)	6(6)	38(38)	100

Values in parentheses represent percentage of total, WV= wildlife viewing, EDT = educational tour

Group size of the tourists: Most of the domestic tourists had a group size of 5-8 people followed by those with 9 to 12 people in a group (Table-6.3). On the other hand more of the International tourists were either single individuals or in a group of 2-4. Most of the domestic tourists visiting Gangotri were from eastern parts of India especially West-Bengal followed by Western India (including people from Gujrat, Rajasthan and Haryana). Number of visitors from the state of Bengal increase in autumn due to Durga Puja vacations and hence autumn is often termed as "season of Bengali tourists". Most of the International tourists (60%) visiting Gangotri were from Germany and France.

Table-6.3: Number of people in a group

Tourists	Group size					
	Individuals	2 to 4 people	5 to 8 people	9 to 12 people	>12 people	Total
Domestic	24(4.8)	119(23.8)	214(42.9)	127(25.4)	16(3.2)	**500**
International	56(56)	44(44)	0	0	0	**100**

Values in parentheses represent percentage of total

Source of Information and frequency of visitation: Based on the information provided by the respondents about their source of knowledge about the area, it was found that 67% of domestic tourists learnt about the place through word of mouth followed by books (44%) (Table-6.4). On the other hand books were the main source of information (75%) in case of international tourists followed by word of mouth (69%). Brochures (14%) and films (3%) were a minor source of information in the present area. As regards their earlier visits to this place most of the domestic tourists visited the place for the first time (75%) and just 11% had visited it more than once. Only 19% of the international tourists visited the place once.

Table-6.4: Source of information and frequency of visitation of domestic and international visitors

	Source of information				
Tourists	**Books**	**Brochures**	**Films**	**Friends**	**Total**
Domestic	222 (44.44)	71(14.29)	16(3.2)	333(66.7)	**500**
International	75(75)	6(6)	0	69(69)	**100**

	Frequency of visitation			
Tourists	**Not visited**	**Once**	**More than once**	**Total**
Domestic	373(74.6)	71(14.3)	56(11.1)	**500**
International	81(81)	19(19)	0	**100**

Values in parentheses represent percentage of total

Mode of transport and accommodation: Most of the domestic as well as International visitors preferred bus as the mode of transport to visit Gangotri (Table-6.5). However, to visit Gaumukh about 2% of the domestic visitors preferred ponies/mules and another 2% preferred trekking whereas almost all the international tourists preferred to go on foot. In Gangotri most of the domestic (62%) as well as International (81%) visitors staying overnight chose to stay in hotels/lodges. But in Gaumukh they either used tents or stayed in ashrams. During the stay most of the domestic and international tourists depended on local restaurants/hotels for food and only few persons prepared food themselves.

Table-6.5: Mode of transport and accommodation preferred by visitors

	Mode of transport				
Tourists	**Bus**	**Car**	**Taxi**	**On foot**	**Total**
Domestic	292(58.37)	111(22.22)	95(19.05)	24(4.76)	500
International	81(81)	13(13)	13(13)	25(25)	100

	Accommodation				
Tourists	**Hotel**	**Tents**	**Ashrams**	**In transit**	**Total**
Domestic	310(61.9)	32(6.35)	159(31.75)	151(30.16)	500
International	81(81)	25(25)	38(38)	0	100

Values in parentheses represent percentage of total

Resource use: Most of the domestic (83%) as well as international (81%) tourists had negative reply regarding resources used in Gangotri and *enroute* Gaumukh (Table-6.6). However, about 13% international and 40% domestic visitors used fuelwood for cooking and for heating requirements. None of the visitors extracted medicinal herbs though few (2%) collected ornamental plants.

Table-6.6: Resources used by domestic and international visitors

	Resource use			
Tourists	**Yes**		**No**	**Total**
Domestic	48(9.52)		413(82.54)	500
International	13(13)		81(81)	100
	Kind of resource			
Tourists	**Fuelwood**	**Medicinal Plants**	**Ornamental Plants**	**Total**
Domestic	40(7.94)	0	8(1.59)	500
International	13(13)	0	0	100

Values in parentheses represent percentage of total

Garbage disposal and disturbances: Of the total five hundred domestic visitors interviewed about 67% reported of disposing off garbage in the dustbins whereas most of the international visitors packed their garbage with themselves (69%). When asked about the kind of disturbances observed around Gangotri, most of the international tourists reported of unmanaged litter/garbage and too much of construction but domestic visitors highlighted more on the problem of deforestation and crowd (Table-6.7).

Table-6.7: Garbage disposal and disturbances observed by visitors

	Garbage disposal options						
Tourists	**Dustbin**	**Pit**	**Burning**	**Pack out**	**Throw**	**No reply**	
Domestic	333(66.67)	8(1.59)	8(1.59)	87(17.45)	48(9.52)	24(4.76)	
International	56(56)	0	0	69(69)	0	0	
	Disturbance sources						
Tourists	**None**	**Crowd**	**Litter**	**Trampling**	**Lopping**	**Urbanisation**	**No reply**
Domestic	151(30.16)	175(34.9)	159(31.75)	16(3.17)	222(44.44)	95(19.05)	16(3.17)
International	25(25)	6(6)	63(63)	0	38(38)	44(44)	0

Values in parentheses represent percentage of total

<u>Satisfaction from the tour</u>: Though most of the visitors both domestic and international were satisfied with the visit to this place in terms of peace of mind, natural resources and fresh air. However, few domestic tourists were dissatisfied and complained about local transport facilities (3.2%) and hike in fare during peak tourist season. Many others were unhappy with bad sanitation arrangements (19%) and accommodation (12.8%). In case of international tourists most of them were dissatisfied with the heaps of garbage in and around rivers and forest trails (50%) others were unhappy with the bad sanitary facilities (31%). Some of them (13%) also raised concern about fuelwood burnt in the hotels and ashrams, which being the main cause of deforestation.

6.3.2. Attitude and behavioural characteristics of pilgrims and nature tourists: Of the total five hundred visitors interviewed it was found that about 183 had come there to enjoy the wilderness and natural beauty of the area (nature tourists) and about 429 had come there for pilgrimage (Pilgrims). Trekking, wildlife viewing and nature photography were the main aims of nature tourists while worship in the temple and take holy dip in the Bhagirathi was the main aim of pilgrims. Of the 429 pilgrims visiting Gangotri, about 112 were also interested in the wilderness zones. These were included under the category of both pilgrims and nature tourists and hence there would be some overlap in the percentages. In addition to interviews at Gangotri, 15 trekking parties to ISS were also classed as nature tourists (Table-6.8). Analyses of information revealed salient characteristics of both nature tourists and pilgrims in Gangotri and other wilderness zones.

Table-6.8: Attitude and behavioural characteristics of nature tourists in the two nature trails

Parameters	Lata to Belak	Bhatwari to Dayara
# of groups	7	8
# of people/group	25±6.9	17±4.2
Minimum # of people	1	2
Maximum # of people	50	35
Source of Information		
Guide	5	6
Books	2	2

Brochures	0	0
Frequency of visits		
Never	6	6
Once	0	1
Twice	0	0
more than twice	1	1
Mode of transport		
Foot	7	8
Horses/mules	2	2
Accommodation		
Hotels	1	0
Tents	3	6
Chhans	3	2
Period of stay		
7days	3	3
2-6days		4
1day	3	1
<1day	1	0
Food		
Packed food	5	6
Prepare yourself	7	8
Fuel used		
Kerosene	6	7
Fuelwood	4	6
Gas	2	2
Equipment taken along		
Camera	7	8
Binocular	3	3
Tape recorder	4	6
Garbage disposal		
Pack out	4	4
Throw	0	0
Dig a pit	2	2
Burn	3	6
Sighting of wild animals		
Yes	5	2
No	2	6

Profession of tourists: Of the 183 nature tourists maximum number represented the category of service based occupation (56%) while those visiting wilderness zones (Lata to Belak Khal & Bhatwari to Dayara) mostly represented groups of students (61%). Of the pilgrims to Gangotri, service based occupation was represented by the highest proportion (46%) (Table-6.9).

Table-6.9: Profession wise distribution of pilgrims and nature tourists

Tourists	Service	Business	Student	Others	Total
Pilgrim	199(46.3)	143(33.33)	24(5.55)	63(14.8)	**429**
Nature tourist	103(56.5)	24(13.04)	56(30.43)		**183**

Values in parentheses represent percentage of total

Purpose of visit and duration of stay: Most of the nature tourists preferred trekking (83%) compared to pilgrims whose motive during the stay was to offer prayers and have a dip in Holy river (100%). Besides trekking, nature lovers were also interested in photography (40%) and wildlife viewing (40%). Nature tourists and pilgrims also differed in their period of stay. Most of the pilgrims (30 to 33%) stayed at Gangotri just for few hours or a day. Most of nature tourists (70%) preferred to stay for a period of two to seven days to enjoy the wilderness and trek to surrounding peaks and alpine meadows (Table-6.10). Nature tourists in the ISS (40%) also preferred to stay for about seven days in the forests and meadows (Table-6.8).

Table-6.10: Purpose of visit and period of stay of pilgrims and nature tourists

				Purpose of visit			
Tourists	**Trekking**	**WV**	**EDT**	**Photography**	**Pilgrimage**	**Meditation**	**Total**
Pilgrim	80(18.64)	13(3.03)	0	2(0.5)	429(100)	0	**429**
Nature tourists	151(82.6)	40(21.7)	16(8.6)	40(21.74)	0	0	**183**
				Period of stay			
Tourists	**<24hr**	**24 hrs**	**2 days**	**2<7 days**	**7-15 days**	**>15 days**	**Total**
Pilgrim	143 (33.3)	127 (29.6)	64 (14.8)	95 (22.2)	0	0	**429**
Nature tourists	0	24(13.04)	16(8.69)	127(69.56)	16(8.69)	**0**	**183**

Values in parentheses represent percentage of total, WV= wildlife viewing, EDT = educational tour

<u>Group size of the tourists</u>: Most of the nature tourists to Gangotri were in a group of 2 to 4 individuals (48%) while most of the pilgrims (41%) were in groups of 5 to 8 individuals (Table-6.11). On the other hand, in the 15 trekking parties interviewed at wilderness zones average group size was 21 people/group and the minimum and maximum range was of 1 to 50 person per group (Table-6.8).

Table-6.11: Number of visitors in different group sizes

	Group size					
Tourists	**Single**	**2 to 4**	**5 to 8**	**9 to 12**	**>12**	**Total**
Pilgrims	16(3.7)	135(31.5)	175(40.7)	48(11.11)	55(12.96)	**429**
Nature tourists	8(4.3)	87(47.8)	48(26.08)	16(8.69)	24(13.04)	**183**

Values in parentheses represent percentage of total

<u>Source of information</u>: Most of the nature tourists to Gangotri learnt about the place through books (Table-6.12) while those visiting wilderness zones were informed about these nature trails by their local guides (73%) and rest got the information through brochures of tourism department (27%) (Table-6.8). On the other hand most of the pilgrims (67%) got the information through words of mouth i.e. through friends and relatives.

Table-6.12: Source of information for visitors

	Source of information				
Tourists	**Books**	**Brochures**	**Films**	**Friends**	**Total**
Pilgrims	135(31.48)	48(11.11)	16 (3.7)	286 (66.66)	**429**
Nature tourists	111(60.86)	40(21.74)	16(8.69)	111(60.86)	**183**

Values in parentheses represent percentage of total

<u>Mode of transport and accommodation</u>: Mode of transport used by most of the tourists whether nature tourists or pilgrims to reach Gangotri was bus. For visiting other areas around Gangotri, nature tourists preferred trekking, whereas about 2% of pilgrims depended on ponies or mules to visit Gaumukh. On the other hand nature tourists to wilderness zones used bus or taxi to reach last road head village and from there trekked (100%) on foot to

reach their destination, but of the total fifteen parties, four carried their luggage on mules and ponies also. Most of the visitors (56%) to Gaumukh both pilgrims and nature tourists stayed in ashrams and about 30% of the nature tourists carried their own tents. In case of visitors to wilderness zones most of them (60%) carried their own tents and rest stayed in the temporary huts and hotels in the Dayara and Belak respectively (Table-6.8).

Resource use: About 35% of the nature tourists used wood as the source of fuel during trek and camping while none of the pilgrims used any natural resource from the surrounding forests. On the other hand about 67% of nature tourists to wilderness zones burnt fuelwood to cook food and lit campfires. Most of the sub-alpine tree species such as birch (*Betula utilis*) and rhododendron (*R. campanulatum*) are preferred as fuelwood by the trekking parties in the Gangotri-Gaumukh zones whereas in the ISS, brown oak (*Q. semecarpifolia*) is the most frequently burnt species by both (trekking parties and hoteliers). An average of 20 kg of wood is burnt per day by a trekking party of 5 to 6 individuals and varies according to the group size and period of stay. In case of hoteliers an average of 35 kg of wood is burnt per day per hotel. It also varies with weather conditions and number of visitors.

Garbage disposal and disturbances observed: When asked about disposal of garbage and disturbances observed around Gangotri and forests in the wilderness zones, most of the nature tourists and pilgrims (60%) reported of using dustbins to throw the garbage. Regarding disturbances, nature tourists emphasized on problems of litter (65%) especially polythene bags and plastic bottles and deforestation especially in the Bhojbasa and Chirbasa areas whereas 46% of the pilgrims complained of too many people during peak season. Of the fifteen groups interviewed, most of the nature tourists (60%) generally burnt the garbage and rest others (53%) packed it out. They complained of heavy lopping (82%) in the surrounding forests and soil erosion (80%) in the alpine and sub-alpine meadows.

Satisfaction from the tour: Most of the pilgrims (89%) were satisfied with the tour, though few reported of accommodation problems. Wanderers on the other hand enjoyed the beauty of peaks and forests but most of them were unable to see any wild animals. In the wilderness zones about 47% of the groups could see some or the other kind of wild animal but they emphasized on development of good camping and resting sites.

6.3.3. Anthropogenic pressures on the forests surrounding tourist sites: Two types of anthropogenic pressures *viz.*, lopping and cutting of trees and presence of garbage on the trails to forests surrounding the pilgrimage zones were quantified.

It revealed that more visited trail (MVT) had a total of 41 trees/0.1ha, of which 56% were lopped. On the other hand, less visited trail (LVT) had 69 trees/0.1ha, of which about 14% were, lopped (Table-6.13). The difference in densities of woody vegetation could also be due to different aspects but differences in lopping were only due to anthropogenic activities. On the MVT most of the trees were cut below the breast height while those on the LVT were just lopped. The reason for this could be that on the MVT more lodges have been constructed recently, which might have required land whereas on the LVT most of the trees were lopped for fuelwood and hence were not cut below breast height.

Table-6.13: Lopping pressure on forests around Gangotri

Pressure parameters	Less visited trail	More visited trail
Total trees/0.1 ha	69	41
Trees lopped/0.1 ha	10	23
Lopping intensity (%)	14.49	56.09

After the survey of the area surrounding the Gangotri temple, it was found that more garbage was disposed off along forest trails and riverbanks than on the main road or market. Though an incinerator has been kept by Gangotri Conservation Project (GCP) at the entrance of the temple area, still an average of ten heaps of garbage composed of polythene bags, pouches, plastic bottles and cans were counted on different trails in Summer season. The number of garbage heaps increased to an average of fourteen in autumns. Analyses of the garbage quantified in the trails also revealed that more of garbage was found during autumn (38.37kg/ha) season than summer (13.49kg/ha). Of the two trails, it was found that the LVT had more garbage compared to MVT in both the seasons (Table-6.14).

Table-6.14: Quantification of garbage in the forest trails around Gangotri

	Less visited trail	More visited trail
In summers		
Polythene (gm)	68.75±26.73 (20.5)	46.67±24.9 (52.8)
Bottles (gm)	266.67±222.62 (79.5)	41.67± 23.7(47.2)
Total(gm/0.03ha)	335.42 ±241.5 (100)	88.33 ±37.7(100)
Total (kg/ha)	**10.68**	**2.81**
In autumn		
Polythene (gm)	175.83±52.22 (17.73)	111.67±38.43(52.3)
Bottles (gm)	815.83±670.05 (82.27)	101.67±51.5 (47.7)
Total (gm/0.03ha)	991.67 ± 662.13(100)	213.33±74(100)
Total (kg/ha)	**31.58**	**6.79**

Values in parentheses represent percentage of total, ± = standard error

In the wilderness zones of Belak and Dayara, trails had less refuse but litter comprising of fruit juice cans, mineral water bottles and candy wrappers were spread sparsely in the camping sites (**Plate-6.3**). Garbage was also found spread around hotels in the sub-alpine Belak–Khal area. Most of the garbage was non-biodegradable.

6.4. Discussion

Development of tourism has taken different shapes and magnitudes in different environmental situations (Cole & Marion 1986, Joshi 1992, Wilson & Seney 1994). In the Himalayan region it has transformed from the age-old Hindu 'Tirtha' concept to the modern or 'mass tourism' (Singh 1993). One of the main reasons behind this transition is the development of roads and infrastructure facilities, which allowed easy access into higher Himalaya. In Bhagirathi catchment also, the number of visitors has increased after the construction of road upto Gangotri temple. Gangotri temple, which was not easily approachable till the beginning of the 20th century, became a full-fledged tourist center in the late seventies. Since past few years the influx of domestic (Figure-6.2) as well as international visitors has gone up (Figure-6.3). The decline in visitor numbers during 1992 and 1994 was due to earthquake of 1991 and Uttaranchal movement for the new statehood respectively.

Figure-6.2: Influx of domestic tourists in the upper catchment of river Bhagirathi

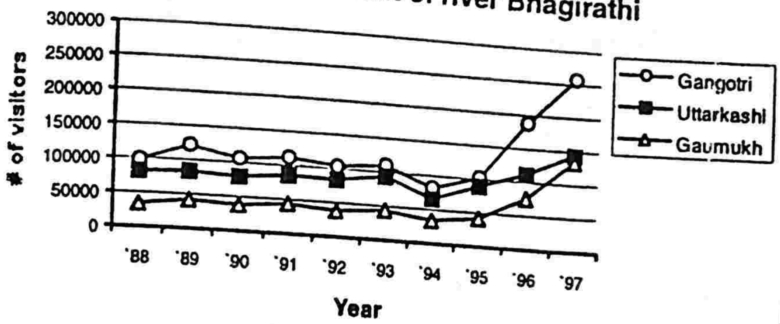
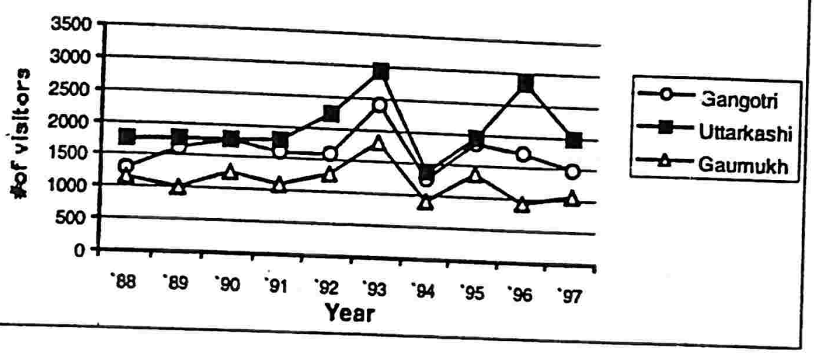


Figure-6.3: Influx of international tourists in the upper catchment of river Bhagiarthi



Earlier visitors to Gangotri were either explorers or the saints who took lots of pain and followed a strict code of conduct while traversing through fragile Himalayan ranges. But now, the behavioural pattern of visitors has changed. Their behaviour depends very much on their purpose of visit, which in turn regulates the sustainability of the surrounding resources.

6.4.1. Affinities and differences in the behaviour of different visitors: It was evident that though different visitors had different lifestyle and attitude while on tour, they also had few similarities. Though most of the people visited the tourist centers of Bhagirathi catchment for pilgrimage, others came to relax and enjoy the wilderness of the area. Pilgrims period of stay was shorter compared to the nature tourist tourists because their purpose of visit was also different. Similar behavioural differences were found between nature tourist and pilgrims in other parts of the Himalaya (Kaur 1985, Singh 1989). Peak visitation period of pilgrims was during summer season, which led to overcrowding of the sensitive sub-alpine zone during that period (**Plate 6.4**). Pilgrims from different parts of the country came mostly in the form of package tour, which defines their larger group size compared to the nature tourists who had a smaller group size. Nature tourists preferred to come during autumn when there was less crowd and vehicular pollution. Professionally both the pilgrims and nature tourist had service-based occupation. Most of the pilgrims were motivated by the word of mouth heard from friends and relatives whereas books and brochures prompted nature tourists. Almost all the pilgrims stayed either in hotels or ashrams but many nature lovers (especially those trekking to surrounding areas) carried tents with them. Most of the nature seekers were not luxury conscious and they loved to live in harmony with the nature. In the two trekking routes most of them enjoyed their stay in the temporary huts of locals. However, they were more worried about poor sanitary conditions. On the other hand pilgrims complained of less varieties in food, overcrowding and transport problems. Most of the comfort conscious pilgrims even suggested of motor road upto Gaumukh. Though most of the pilgrims were indirect user of the natural resources few nature-lovers were directly dependent on wood as a source of fuel during camps. Most of the visitors both domestic and international, whether pilgrims or nature lovers were satisfied with the visit and many of them wanted to come again. Nature-seekers found the place peaceful and inspiring. Many of them had a 'lifetime' experience. Experience conscious visitors were disappointed with the lack of any local souvenir or gifts that they would have liked to carry home. Many people who had come earlier too, were happy to see better transport facilities, better roads and availability of basic facilities such as first aid and STD, however, they complained of vanishing cultural and aesthetic values of the hills. They were unhappy with the construction of concrete buildings instead of traditional wooden cottages, fast food replacing traditional vegetables and increasing number of rubbish dumps. The attitude and behaviour of different visitors thus need different management implications. It is necessary to develop other neglected trails for nature tourists and more information should be spread about them through brochures, books and magazines. Good camping sites should also be developed. For pilgrims good sanitary facilities in the pilgrimage points and *en-route* is essential and for them proper halting facilities should be developed not only in the main townships but also *en-route*.

6.4.2. Impact of tourism on the surrounding environment: The rapid expansion of tourism as one of the largest and fastest growing industries in the world and a major economic activity has resulted in varied environmental and social impacts on the host area (Mathieson & Wall 1980). Some of the positive impacts of tourism include rise in income of local hoteliers, shopkeepers and transporters, improved infrastructural facilities, increased consciousness among several visitors to conserve the wilderness of hills and recognition of the cultural diversity of the region. On the other hand negative impacts include deforestation for construction of lodges and hotels, lopping of trees for fuelwood, increased rubbish dumps, waste disposal, overcrowding of the ecologically sensitive sub-alpine zones and increased vehicular pollution during peak seasons. Interviews with the local hoteliers revealed that most of the hotels and shops were hired for a period of six months. Thus most of them had seasonal income from tourism (95%) and a large portion of their income went in paying the rent. The distribution of these benefits is also concentrated at few townships or road head villages whereas earlier the contribution of tourism in terms of economic benefits was more or less evenly distributed in all the villages falling along the routes (Nand & Kumar 1989). It was also found that of the eleven trekking agencies working in the district headquarters almost 50% were at loss because of competition with other agencies working at metropolitan cities. Thus a large part of the income in these centers and similar other areas outflows (Singh 1983) and locals have very less benefits. Besides economic conditions, ecological balance of the area is also under threat due to increased unplanned tourism. It was found that most of the new lodges and ashrams were constructed at the expense of forest land besides the ban on construction activity in the vicinity of Gangotri. In the 19th century there was no human habitation and sages lived mostly in the rocky caves and whole area was surrounded with Deodar-Kail forest (Atkinson 1882-84). With time the situation changed, in the late 1980s there were three tourist bungalows, one hotel and two simple restaurants (Nand & Kumar 1989) but now the number of both restaurants and hotels has increased to more than twenty five. Besides these many ashrams have also come up in the recent past. A research programme undertaken by OECD also identified "construction " activities as one of the major source of stress on

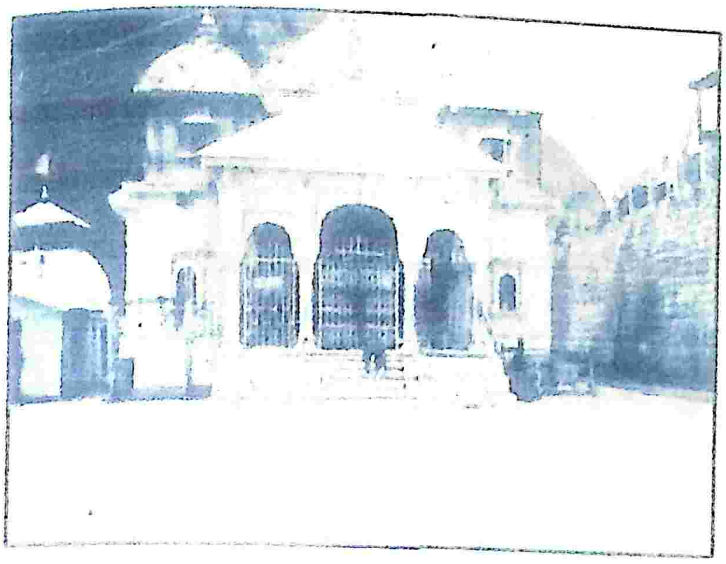


Plate-6.1: A view of Gangotri shrine

Plate-6.2: Dayara bugyal- visited by nature tourists

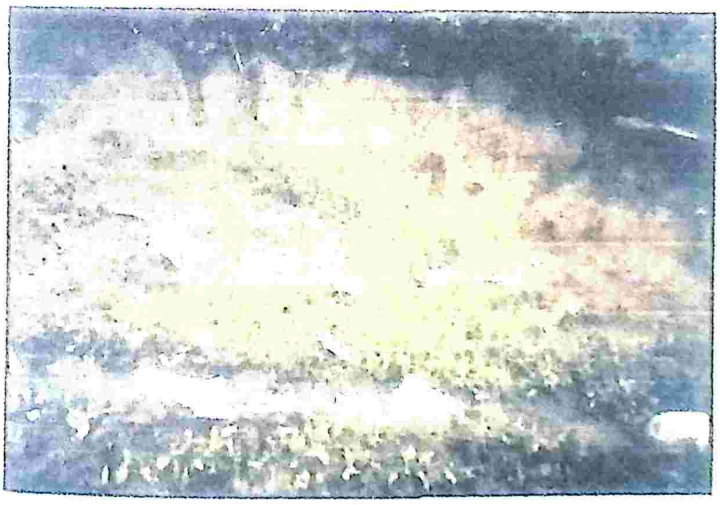


Plate-6.3: Garbage in the alpine camping sites

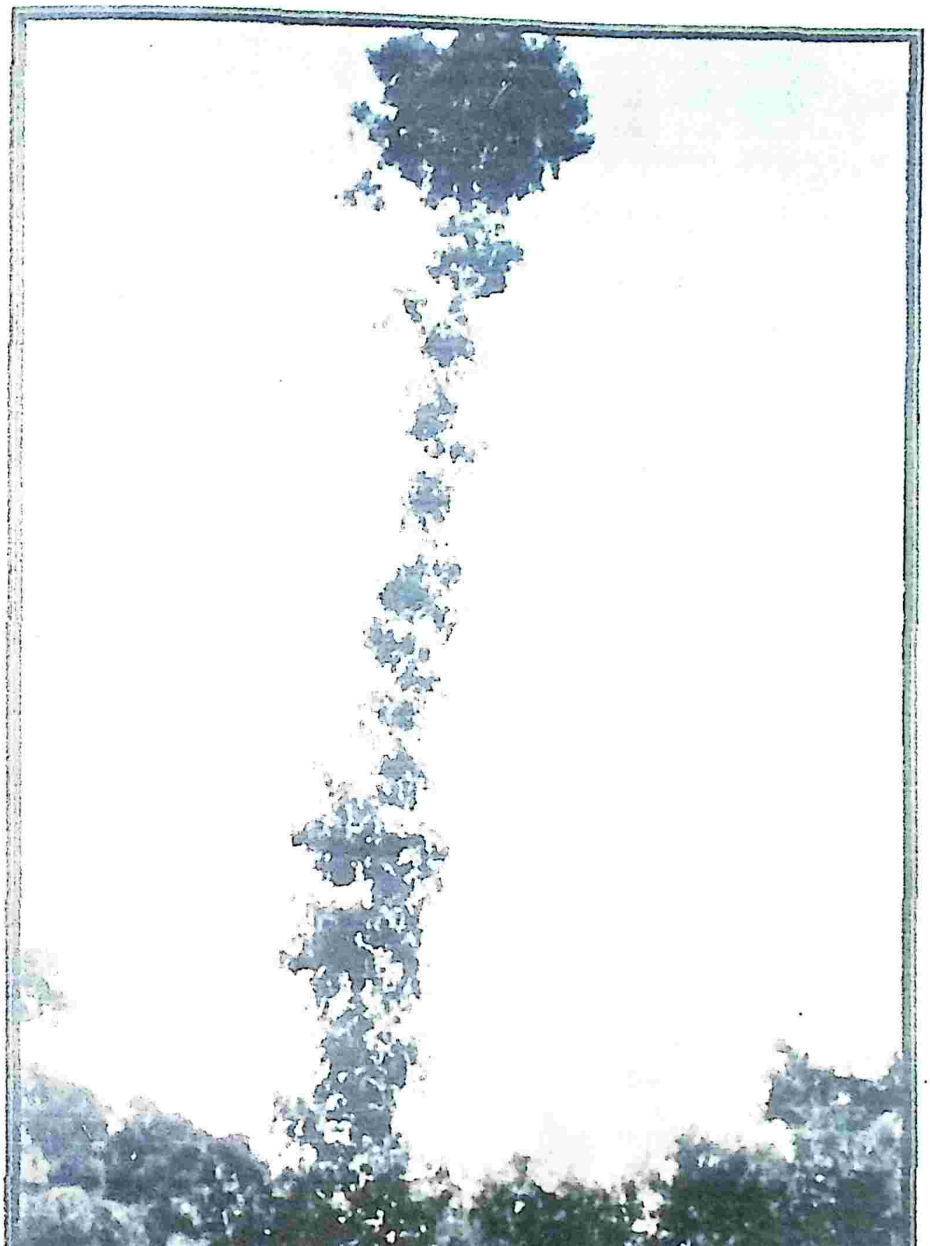
Plate-6.4: Influx of tourists in Gangotri environment. It not only causes changes in the visual amenity but also has far reaching effects on the ecology of the area. Another cause of stress is the increased tourist densities in a particular season, which results in increased demand for natural resources (OECD 1980). This was also observed in the present study area where demand of fuelwood increased during peak tourist influx. Though, fuelwood is made available by the forest corporation at the rate of Rs. 125/quintal (to cardholders) and Rs. 165/quintal (to non-card holders), still many people were seen collecting fuelwood from the forests. For hotels and ashrams at Gaumukh, an NGO, Gangotri conservation Project (GCP) provided free cooking gas cylinders during summers but during autumn season such facility was not available which caused excessive lopping of trees for fuelwood in Chirbasa and Bhojbasa areas (Singh 1980). Most of all, the aesthetics of the area was spoiled due to the presence of rubbish dumps on forest trails and backyard of the hotels and lodges. A spatio-temporal difference in the disposal of garbage and resource use was also found. In the autumn season, more garbage accumulation was seen compared to summer. It was also observed that off-route forests (Table-6.13) were dumped with more garbage, which was in contrast with the observations of Berkmuller *et al.* (Unpublished) in the VOF area. The reason for this was that during summers the present area is visited by a number of VIPs and Ministers that makes temple authorities more cautious but in the lean period no body is there to take care of the surroundings. On the other hand, those who (nature-seekers) trekked through these trails complained of these trails being converted into "garbage trails". Although an incinerator has been kept by the GCP at the entrance of the area but due to its distance from the lodges and hotels, most of the lodge owners and sweepers dispose off garbage in the nearby forests. Also it was found that the incinerator worked only during summer and no body was there in autumn season (*personal observation*). Compared to the pilgrimage zone 'Gangotri' and wilderness zone 'Gaumukh', nature trails of Belak and Dayara were in better conditions. The design of lodges (temporary huts-*chhans*) and bridle paths amidst forests were in harmony with the nature. The number of visitors was less and most of them were environment conscious. However, plastic bags, fruit juice cans, pouches and other garbage around temporary huts and few camping sites ruined the beauty of the area.

Wood extracted from the surrounding forests is the main source of fuel in the temporary huts. Besides hotel owners, local villagers also depend on the surrounding forests for their fuelwood and fodder needs. Though most of the trekking parties carried their own LPG cylinders or kerosene but they also burnt fuelwood both for cooking and campfires. Rai and Sundriyal (1997) had similar observations while studying the impact of tourism in Sikkim Himalaya. Thus most of the trees around temporary huts and campsites in the sensitive sub-alpine zones were heavily lopped, leading to the degradation and lowering of tree line forests (Uniyal 2001).

Similar impacts have also been reported in other parts of the Himalaya. In the Khumbhu region of Nepal though tourism has transformed a subsistence society to a cash economy but the physical environment has paid the price. In Ladakh too, a unique cultural heritage has been ravaged by the sudden tourist invasion (Eppler 1981, Singh & Kaur 1985). In the neighbouring areas of Garhwal too similar trends were found. Holy shrines of Badrinath, Kedarnath and Hemkund faced resource crisis during peak tourist season (Kaur 1985, Kayastha & Rai 1990). It is due to the ill impacts on the ecology and environment of tourist centers that the need of sustainability in tourism has arisen. Recently, many workers have emphasized that conservation of natural resources is an indispensable condition for the sustainable tourism (Dabrowski 1994, Schulze 1998, Cochrane 1996). In response to this, concept of "eco-tourism" has gained importance in many parts of the world (Boo 1990). Eco-tourism not only promotes environment friendly tourism but also leads to upliftment of the indigenous communities of the area besides preserving their cultural identity (Wearing & Larsen 1996, Gurung 1998). In India eco-tourism has been implemented mostly in the Protected Areas (Anon. 1994) but fragile ecosystems of Himalaya, which are important pilgrimage and wilderness centers also need such approach. To conserve the natural resources of highly fragile Gangotri and Gaumukh areas it is necessary to develop other neglected nature trails for nature tourists and spread information about these through brochures and books. Local villagers can be trained as nature guides because they are fully aware of area. This will not only improve their economic status but will also raise consciousness among them to protect the forests and wildlife. In the Gangotri and Gaumukh areas number of visitors should be regulated during peak seasons and not more than a fixed number of vehicles should be allowed to visit the area in a single day. People should be made aware of the ecological fragility of the alpine and sub-alpine areas at the Regional tourist office. A tourist information center should also be maintained at Gangotri itself, which would not only take care of the visitors but will also guide people regarding different nature trails. Several halt stations *en-route* Gangotri should be well maintained to attract the visitors.

Hence, it could be concluded that it is not so much the number of visitors that will prove a danger. Instead their behaviour at and *en-route* tourist centers, along with the negligence of lodge owners and authorities would cause more damage to the ecosystem.

CHAPTER-7



Impact of Anthropogenic Pressures on Forest and Wildlife

CHAPTER- 7

Impacts of Anthropogenic Pressures on Forests and Wildlife

7.1 Introduction

Anthropogenic pressures may be defined as the disturbances caused by human induced activities on the surrounding environment. Since the dawn of human civilization, man-induced pressures in the form of fire, grazing, logging and lopping have influenced the forest ecosystems of the world (Dorst 1976). Excessive pressures negatively influence the climax assemblages and bring instability in the ecosystem (Clements 1936) or at moderate level such activities may increase species diversity in the community by preventing competitive exclusion by dominant species (Huston 1979). Reduction in total forest cover, conversion of natural forest ecosystem to simplified and often even-aged monoculture plantations and fragmentation of remaining forests into smaller patches are some consequences of uncontrolled anthropogenic activities (Barnes *et al.* 1998). Some indirect effects of forest degradation include impoverishment and regression of many wild species (Mukherjee 1974) and increased human-wildlife conflicts (Studsrod & Wegge 1995, Sukumar 1996). These human induced impacts at both global and local scales have aroused concern among ecologists, conservationists and forest managers (Ives and Messerli 1989, Johnsingh *et al.* 1991, Mc Neelay *et al.* 1995, Vitousek *et al.* 1997).

Ecological impacts of fuelwood and fodder extraction at the local level may be difficult to assess but effects of such pressures on the individual species can be quantified as these hamper the regeneration and normal forest growth (Sousa 1984) further affecting the distribution of wild animals and resource availability for them. Information on such pressures not only helps in predicting regional patterns of vegetation and wild animal distribution but also help in evolving area specific conservation measures (Stapanian *et al.* 1997). Many studies in other parts of the world have documented the responses of plants and animals to human induced disturbances (Shackleton *et al.* 1994, Vermeulen 1996, Skarpe 1990, and Sullivan 1999). Need to evaluate the local level impacts of anthropogenic pressures on forests and wildlife of Himalaya has also been felt by several authors (e.g., Sundriyal and Sharma 1996, Negi *et al.*1999, Dang 1969, Green 1978, Nainwal 1994).

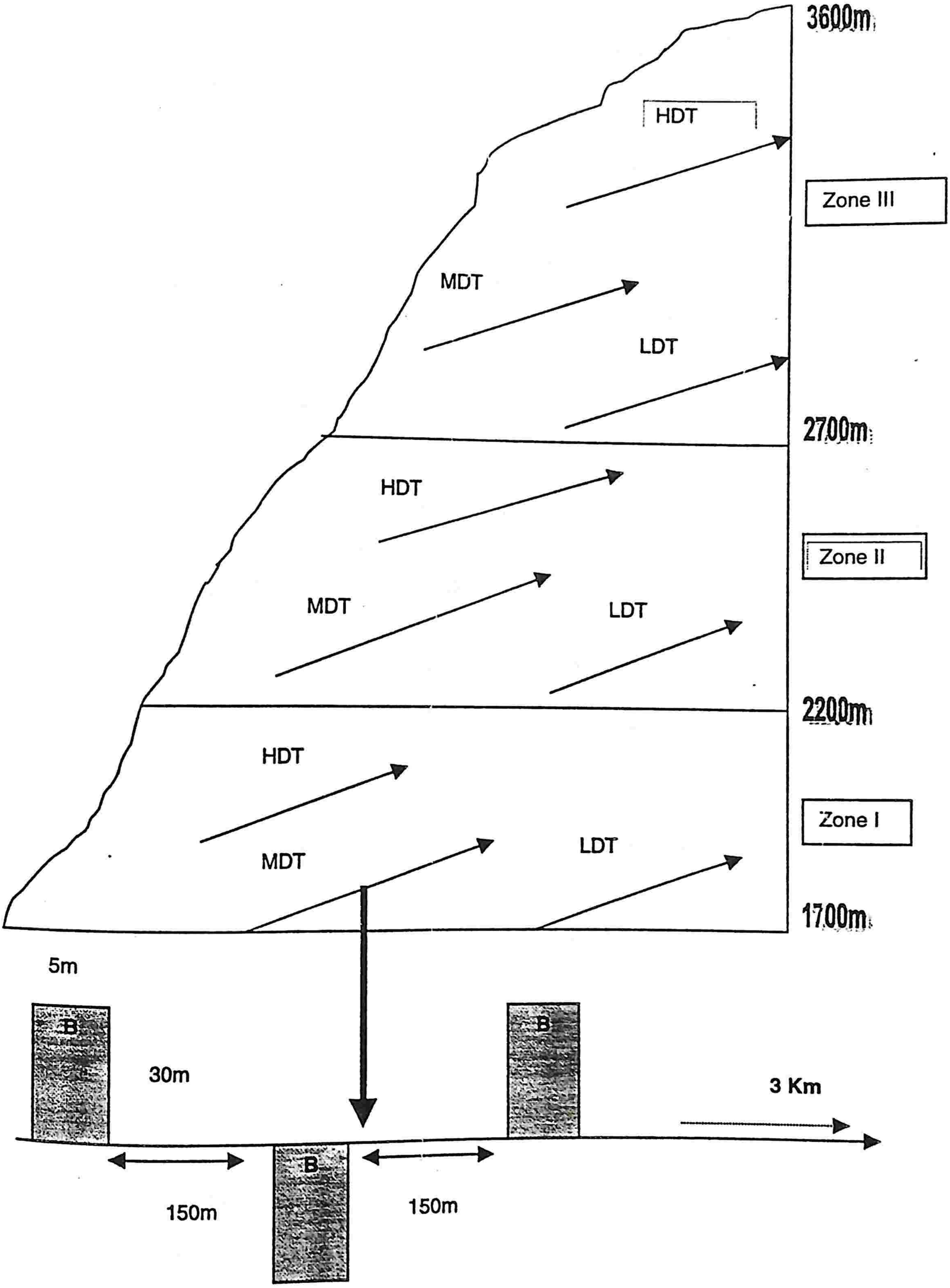
As in other parts of the Himalaya, local people, transhumant communities and tourists in Bhagirathi valley also depend on the surrounding forests for their resource needs (Chapters-4, 5 and 6). Patterns of resource extraction affect the status and availability of preferred species and interaction with wild animals. To assess the impacts of resource extraction and related disturbances on forests surrounding the study villages and temporary huts, following questions were addressed:

- Are there any spatial and temporal variations in resource extraction along the gradients of disturbance?
- Are there any differences in the distribution of wild animals along the gradients of disturbance?
- Are there any spatial and temporal patterns of human wildlife conflicts?

7.2 Methods

7.2.1. Field methods: Anthropogenic pressures were quantified at the two intensive study sites (ISS) during October 1996 to February 1998 and March 1998 to July 1999 respectively. For the pressure assessment, permanent plots were marked within ISS. Based on altitude, both the ISS were stratified into zones *viz.,* 1700-2200m (Zone I), 2200-2700m (Zone II) and >2700m (Zone III). However, in the BWS the first Zone was mostly agricultural land so only two zones *viz.*, zone II and III were available for the study. In each zone three trails (3 km each) *viz.,* highly disturbed (HDT), moderately disturbed (MDT) and least disturbed (LDT) were identified based on disturbance indices such as distance from village, cut/lopped signs, cattle signs and presence of weedy species. Trails were selected as substitute of the line transects because it is difficult to lay line transects in the Himalayan terrain. Because of its continuity through an area, the trail can be used to relate changes in vegetation along an environmental or disturbance gradient (Smith 1974, Kershaw 1973). Thus, trails were used instead of quadrat or circular plot method. In each trail, alternate belt transects of 30x5m were marked

Figure-7.1: General lay out of the trails and belt transects marked for monthly monitoring



B= Belt transect (B=20), HDT, MDT and LDT = highly, moderately and least disturbed trails perpendicular (using compass and measuring tape) to the trail at every 150m, i.e., 20 belt transects in 3km trail (Figure- 7.1). To avoid overlapping and observe heterogeneity, alternate belt transects were preferred. Belt transects have been preferred by many workers as these equalize microhabitat variation better than circular or square plots and are considered more suitable for permanent monitoring (Muellar and Dombois 1974, Sale and Berkmuller 1988). Belt transects have been used in similar studies elsewhere (Berkmuller *et al.* 1990, Shackleton *et al.* 1994, Hall and Rodgers 1986).

In the initial survey, all the trees in each belt were mapped on a graph paper. The number, species, GBH (girth at breast height i.e. 1.33 m above ground) of each tree was noted. Initial signs of cutting, number of cattle dung piles and wildlife signs were also recorded. Wildlife signs such as droppings were used as an index to estimate the relative abundance and habitat use following Neff (1968), Eisenberg & Lockhart (1972) and Sathyakumar (1994). In the present study, dung counts were used to estimate the relative use of various forest areas by large mammals. New signs of tree cutting and number of new dung piles were counted on monthly basis in each belt for complete one year. Cutting intensities were classed into different percentages following Sullivan (1997) as: Class I = tree cut 25% (only twigs lopped and less than half of the canopy disturbed) **(Plate-7.1)**, Class II = tree cut 50% (secondary branches also lopped and half of the canopy disturbed) **(Plate- 7.2)**, Class III = tree cut 75% (primary branches also lopped and tree appearing like bush or pole) **(Plate-7.3)**, Class IV= tree cut 100% (only the stump of the tree present) **(Plate- 7.4)**.

The conflicts of local people with wildlife such as attack on human beings, livestock depredation and crop damage were assessed through questionnaire survey and personal observations. All the six villages in intensive study sites (ISS) were surveyed and incidences of attacks on livestock or human beings and crop damage were recorded. Information was collected on type and quantity of loss, area where the incidence took place, species of wild animal involved in the conflict and measures taken to overcome the problem. Records of Divisional Forest Office, Uttarkashi were also used for supplementing the information.

Plate-7.1: A 25% cut tree

Plate-7.2: A 50% cut tree

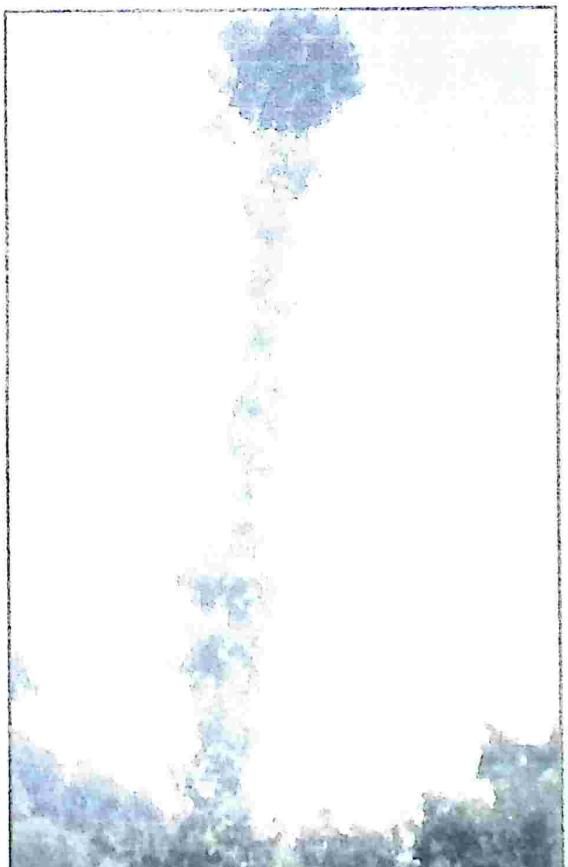


Plate-7.3: A 75% cut tree

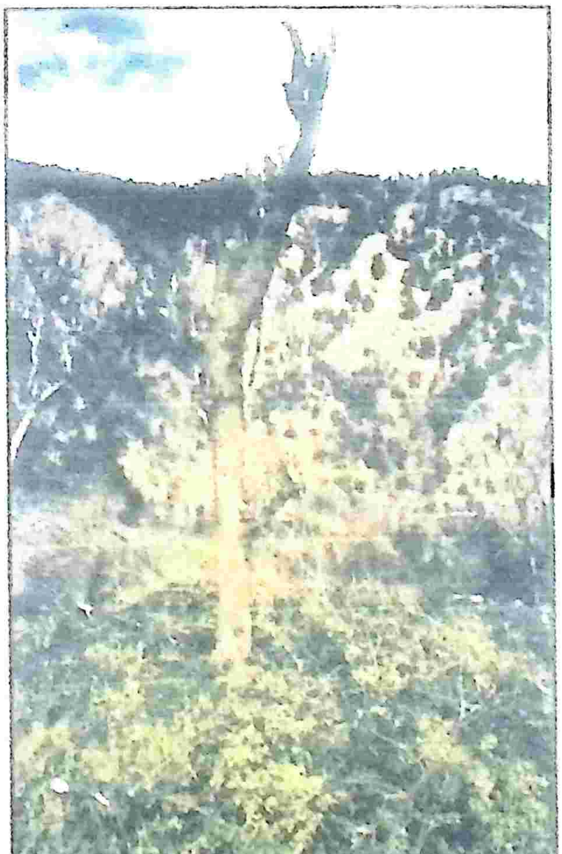


Plate-7.4: A 100% cut tree

Limitation: Trails in the highest zone (>2700m) could not be sampled due to heavy snowfall during two winter months (mid January to mid March). The use of dung counts was restricted to dry seasons since dung disintegration and decay is rapid during the rainy season.

7.2.2. Analyses: Data collected from field were entered in Microsoft Excel and analyzed using Analysis Tool Pack. Density and basal area of trees in each belt transect was calculated following Mishra (1968). To see differences in lopping intensities between disturbance gradients, seasons and zones, Kruskal-Wallis one way analysis of variance (ANOVA) was run (Zar 1984). The dung density was estimated using the formula D=N/A; where 'N' is the number of pellet groups or scat counted and 'A' is the area of the belt transects (Rodgers 1991). Data from different trails in each zone was pooled for estimating the relative abundance of animals in different altitudinal and disturbance gradients. Spatial and temporal patterns of wildlife-human conflicts were also analyzed.

7.3 Results

7.3.1 *Spatial and temporal variation in resource extraction along the gradients of disturbance:* In DWS, 1004 trees were marked within 180 belts. The distribution of tree species and categories under fuelwood, fodder and multipurpose are given in Table 7.1 and 7.2. In the zone I (1700-2200m), 31 and in zone III (>2700m), 14 tree species were found. Of the total 31 species in zone I, 18 were used exclusively as fuelwood, two as leaf-fodder. In zone II, of the 21 species, 12 were used as fuelwood and five for multipurpose and in zone III, 6 species were used as fuelwood and one as leaf-fodder. In the BWS, 1322 trees were marked within 120 plots. In the zone II (2200-2700m), 24 and in zone III (>2700m), 13 species were found. Of the total 24 species in zone II, 18 were used exclusively as fuelwood and two as leaf-fodder and in zone III, six species were used as fuelwood and 2 as leaf-fodder.

Table-7.1: Distribution of trees in different zones of DWS

Zone	Total trees	Total species	Fuelwood	Leaf-fodder	Multipurpose
I	361	31	18(58.06)	2(6.45)	7(22.58)
II	352	21	12(57.14)	1(4.76)	5(23.81)
III	291	14	6(42.86)	1(7.14)	4(28.57)

Values in parentheses represent percentage of the total

Table-7.2: Distribution of trees in different zones of BWS

Zone	Total trees	Total species	Fuelwood	Leaf-fodder	Multipurpose
II	510	24	18 (75)	2 (8.33)	3 (12.5)
III	812	13	6 (46.15)	2 (15.38)	1 (7.69)

Values in parentheses represent percentage of the total

Distribution of trees varied with different zones and in each zone along different disturbance gradients. In DWS, 361,351 and 291 trees were recorded in zones I, II and III respectively while in BWS 510 and 812 trees were recorded in zone II and III respectively. Density (# of individuals/ hectare) and basal area (cm^2/ha) of trees per hectare was significantly different between three disturbance gradients of zone II and zone III in DWS and zone III in BWS (Figures 7.2, 7.3 and 7.4) but did not vary significantly between three transects of zone I in DWS and zone II in BWS . It was found that basal area was significantly higher in the moderately and least disturbed trails in all the zones of DWS and BWS except zone III of DWS.

Figure-7.2 : Variation in basal area and density of trees in Zone-II of DWS (1 WAY-ANOVA, n=20, p<0.05)

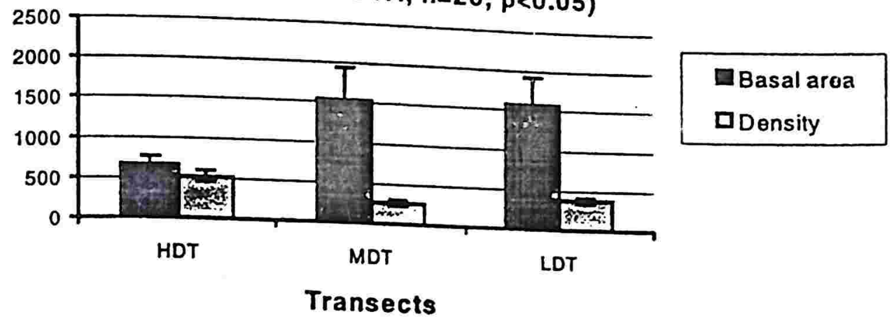


Figure-7.3 : Variation in basal area and density of trees in Zone-III of DWS (1-Way ANOVA, n=20, p<0.05)

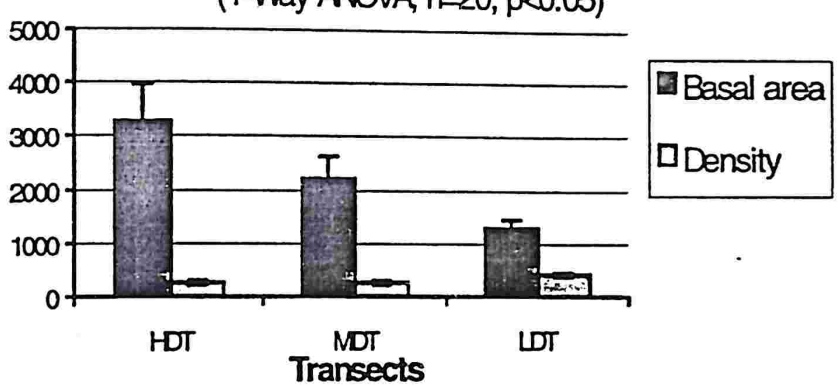
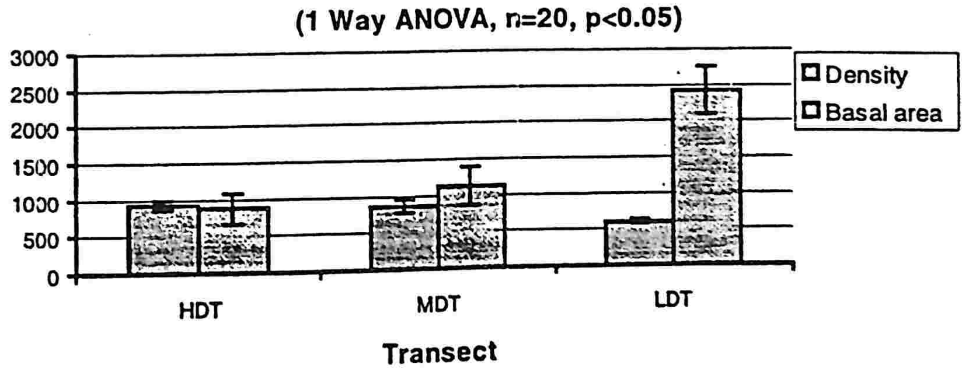


Figure-7.4: Variation in basal area and density of trees in zone-III of BWS (1 Way ANOVA, n=20, p<0.05)



* where HDT, MDT and LDT are the highly, moderately and least disturbed trails

In DWS, highly disturbed trail (HDT) of zone III had lowest density of trees per hectare (266.64± 38.38) whereas highly disturbed trail (HDT) in zone II had maximum number of trees per hectare (523.28±70.46). Basal area of trees (cm^2/ha) was highest (3271.65±714.47) in HDT of zone III and least in highly disturbed trail (HDT) of zone I (635.96± 83.34). In BWS, moderately disturbed trail (MDT) of zone I had least density of trees (533.28±52.31) whereas highly disturbed trail (HDT) in zone II had highest number of trees (923.24± 70.29). Basal area (cm^2/ha) of trees was highest (2431.41±325.03) in least disturbed trail (LDT) of zone II and least in highly disturbed trail (HDT) of zone II (875.56±211.83).

Of the total 1004 and 1322 trees marked within the trails of DWS and BWS respectively, 193 and 339 were lopped respectively in a period of one year. The lopping intensity of trees per belt transect varied significantly (1 Way ANOVA, $p<0.05$) between different disturbance gradients of both the watersheds (**Figure- 7.5 and 7.6**). Lopping intensity per belt was more in BWS (south facing slopes) than DWS (north facing slopes).

Figure-7.5: Lopping pressure along disturbance gradients in DWS

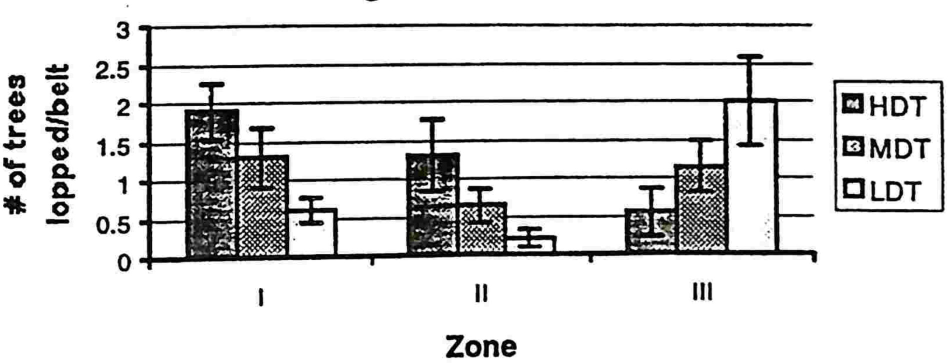
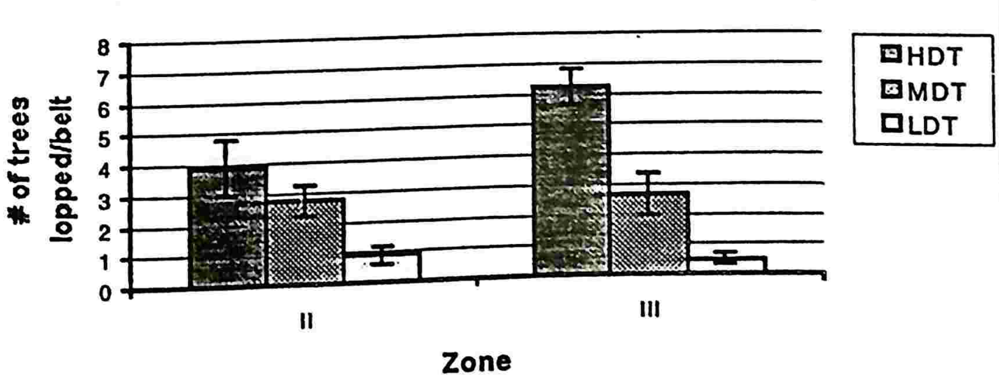


Figure-7.6: Lopping pressure along disturbance gradients in BWS



Pooled data for all the zones in DWS and BWS revealed that highest number of trees were lopped in HDT and least in the LDT (Table-7.3). The lopping pressure also varied among different zones. Highest number of trees were lopped in zone I and least in zone II in case of DWS whereas zone III in BWS, had more number of trees lopped when compared to zone II.

Table-7.3: A comparison of lopped trees in different disturbance gradients

Zone	DWS					BWS				
	T T	HDT	MDT	LDT	TL	T T	HDT	MDT	LDT	TL
I	361	38	26	12	76	-	-	-	-	-
II	352	26	13	4	43	510	78	55	18	151
III	291	11	23	40	74	812	125	53	10	188
Total	**1004**	**75**	**62**	**56**	**193**	**1322**	**203**	**108**	**28**	**339**

TT= total trees recorded, TL= total trees lopped

Lopping of trees differed with seasons in all the zones of DWS and BWS (Table-7.4 and 7.5). However, it was significantly different ($p<0.05$) only in zone III of DWS and zone II of BWS. In the zone I and II of DWS and BWS respectively, maximum trees were lopped in winter season whereas in zone III lopping pressure was highest in rainy season.

Table-7.4: Seasonal variation in lopping of trees (number/ trail) at DWS (K-W 1 Way ANOVA)

Zone	Transects	Summer	Rainy	Winter	p-value
Zone I	HDT	9	9	20	
	MDT	14	0	12	>0.05
	LDT	3	0	9	
	Mean	**8.67±3.18**	**3±3**	**13.67±3.28**	
Zone II	HDT	18	4	4	
	MDT	8	5	0	>0.05
	LDT	0	4	0	
	Mean	**8.67±5.21**	**4.33±0.33**	**1.33±1.3**	
Zone III	HDT	0	10	1	
	MDT	5	17	1	<0.05
	LDT	2	38	0	
	Mean	**2.33±1.45**	**21.67±8.4**	**0.67±0.3**	

± = Standard Error

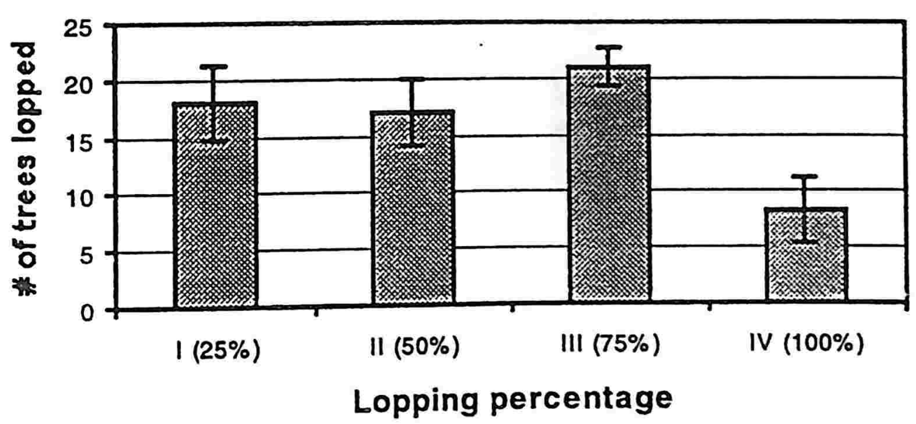
Table-7.5: Seasonal variation in lopping of trees (number/ trail) at BWS (K-W 1 Way ANOVA)

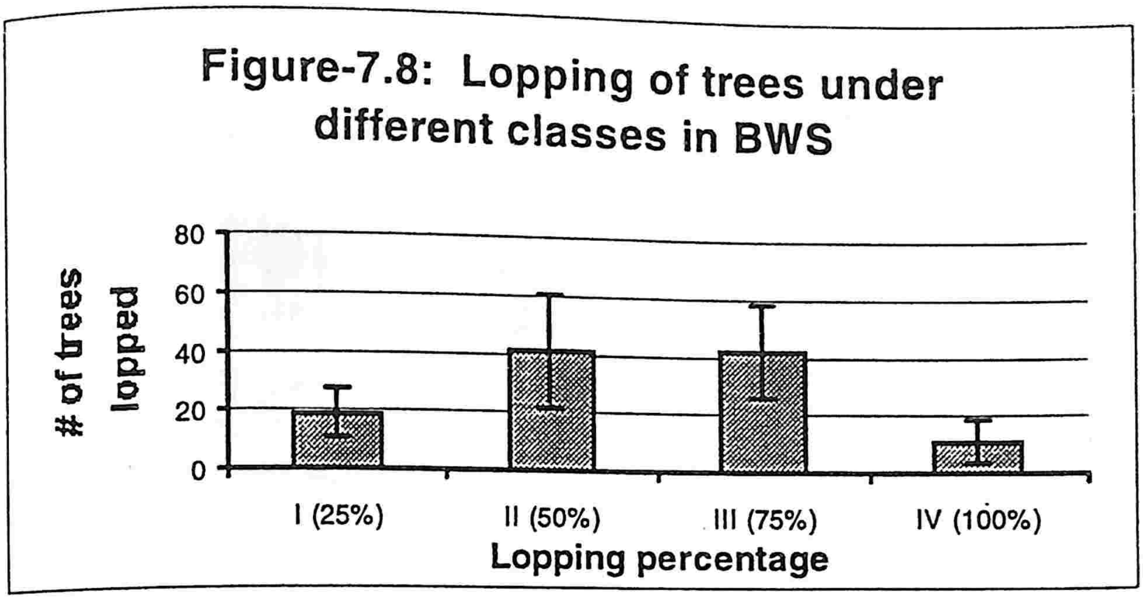
Zone	Transect	Summer	Rainy	Winter	p-value
	HDT	23	7	48	
zone-II	MDT	15	2	38	<0.05*
	LDT	3	1	14	
	Mean	**13.67± 5.81**	**3.33± 1.86**	**33.33± 10.09**	
	HDT	36	89	0	
Zone-III	MDT	19	34	0	>0.05
	LDT	1	9	0	
	Mean	**18.67± 10.11**	**44± 23.63**	**0**	

± = standard error

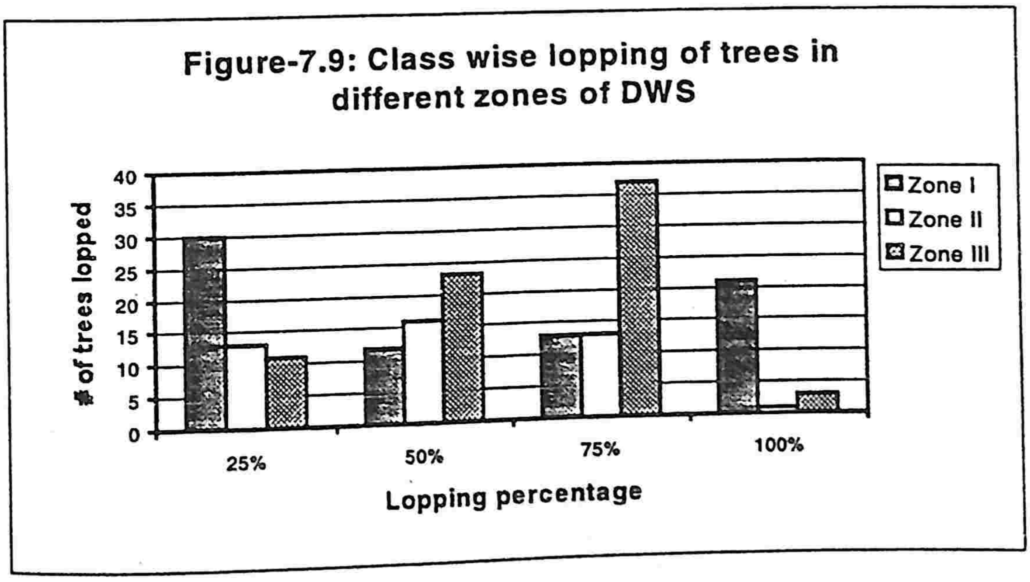
Lopping of an individual tree was classed into four percentages (Section 7.2.1). A significant difference (One way ANOVA, $p<0.05$, $n_{DWS} = 180$, $n_{BWS} = 120$) was found in the number of trees lopped under different classes in both the watersheds (Figures- 7.7 and 7.8).

Figure-7.7: Lopping of trees under different classes in DWS





Most of the individuals were lopped under class III followed by class I and least under class IV. This could be because most of the trees lopped repeatedly were considered a good source of foliage fodder and most of the trees lopped 25 or 50 % were lopped for fuelwood. In the lower zone (close to villages) more number of individuals were lopped 25 or 50% while most of the individuals in zone III were lopped 75% (Figures 7.9 and 7.10). This could be due to lopping of trees for fuelwood in zone I (chapter-4) and for leaf-fodder in zone III (chapter-5). Number of trees lopped under different girth sizes differed significantly in both the watersheds (Figures- 7.11 and 7.12).



Highest number of individuals were lopped in lower girth classes (31-60cm and 61-90cm) and least in the higher girth classes (151-180cm and > 180cm). The reason behind this could be that most of the trees were lopped repeatedly and therefore could nct attain full growth.

All the species of oaks *viz., Q.leucotrichophora, Q. floribunda* and *Q. semecarpifolia* were preferred mostly both as fuelwood and as leaf-fodder (chapter-4). Hence, these were under highest lopping pressure in both the watersheds. But *Q. glauca, Prunus cornuta, Carpinus viminea, Ulmus wallichiana, Desmodium* spp, *Debregeasia longifolia* and *Acer* spp. were lopped for both fodder and fuelwood. However, *Rhododendron arboreum, R. campanulatum, Pinus roxburghii, Taxus baccata, Aesculus indica, Cedrus deodara* and *Lyonia ovalifolia* were lopped exclusively for fuelwood. Few shrubs such as *Berberis* spp., *Cotoneaster* spp., *Caesalpinia* spp., *Arundinaria falcata, Thamnocalamus spathiflorus, Viburnum cotinifolium* and *Desmodium* spp. were also found cut especially in zone I and zone II of DWS and BWS respectively. In the lowest zone of DWS, of the total 76 lopped trees, 19 were of *R. arboreum* followed by *Q. leucotrichophora* (17) and *P. pashia* (10). In zone III, of the total 74 lopped individuals, maximum number of lopped rees were of *Q. semecarpifolia* followed by *T. baccata* **(Table-7.6).**

Table-7.6: Lopping preference for different species

Species	**DWS**	**BWS**
Rhododendron arboreum	19	20
Acer spp.	3	16
Qurecus semecarpifolia	61	110
Symplocos chinensis	3	11
Quercus floribunda	22	35
Taxus baccata	12	9
Viburnum cotinifolium	3	30
Quercus leucotrichophora	17	0
Pinus roxburghii	2	0
Toona sinensis	4	0
Pyrus pashia	10	0
Carpinus viminea	6	3
Alnus nepalensis	4	0
others	27	6

Buxus wallichiana	0	62
Salix spp.	0	6
Prunus cornuta	0	15
Pyrus lanata	0	9
Cotoneaster spp.	0	5
Cedrus deodara	0	2

In BWS, *Buxus wallichiana* was the highly lopped species (62) followed by *Quercus floribunda* (35) in zone II whereas *Q.semecarpifolia* was the highly lopped species (110) followed by *V. cotinifolium* (30) in zone III. Repeated lopping of *B. wallichiana* for fuelwood has prohibited its growth and it now occurs mostly in the lower (<30 cm) girth classes (Uniyal 2001).

7.3.2 Distribution of wild animals in different gradients of disturbance: In the present study, most of the indirect evidences of wild animals were recorded from the zone II (mid elevation) in DWS and zone III (upper elevation) in BWS which are relatively undisturbed and had good forest cover (Uniyal 2001). In BWS, most of the dung piles were observed in the least disturbed trails in zone I and moderately and least disturbed trails in zone II (Table-7.7). However, the frequency of dung piles varied with seasons. Barking deer pellets were most frequent in both the zones however, in zone II Sambar pellets were also recorded frequently.

Table- 7.7: Relative use of forest by wild mammals along different gradients of disturbance in BWS

Zone	Species	HDT (n=20)	MDT (n=20)	LDT (n=20)
I (2200-2700m)	Asiatic black bear	-	-	**
	Wild pig	-	**	-
	Barking deer	*	*	***
	Goral	-	-	-
	Sambar	-	-	*
	Himalayan musk deer	-	-	-
II (>2700m)	Asiatic black bear	-	*	***
	Wild pig	*	-	-
	Barking deer	**	**	***
	Goral	-	-	-
	Sambar	-	**	***
	Himalayan musk deer	-	-	*

HDT, MDT & LDT= highly, moderately & least disturbed trails, - = no evidence, * = <10% frequency, ** = 11-50% frequency, *** = >50% frequency

An estimate of the animal dung density in the BWS revealed that overall dung density increased during winter season in both the zones (Table 7.8 & 7.9). The highest dung density was recorded of wild pig in zone I in both the seasons, of barking deer in zone II in winter and black bear in summer. Presence of Himalayan musk deer pellets in zone II during winter season indicated its presence in the area.

Table-7.8: Estimates of animal dung or scat density/ha in BWS during winter season (n=4)

Species	Zone I (2200m-2700m)	Zone II (>2700m)
Asiatic black bear	0.83±0.53	1.11±0.8
Wild pig	10.83±0.94	0
Barking deer	6.39±0.28	13.61±1.84
Goral	0	0
Sambar	1.94±1.14	10.28±2.6
Himalayan musk deer	0	1.11±0.6

±= standard error

Table-7.9: Estimates of animal dung or scat density/ha in BWS during summer season (n=3)

Species	Zone I (2200m-2700m)	Zone II (>2700m)
Asiatic black bear	0.74±0.4	1.85±0.4
Wild pig	1.85±0.9	0.37±0.37
Barking deer	1.48±0.74	1.48±0.4
Goral	0	0
Sambar	0	0.74±0.7
Himalayan musk deer	0	0

±= standard error

In case of DWS most of the dung piles were observed in least disturbed trail in zone I, moderately and least disturbed trails in zone II and highly disturbed trail in zone III (Table-7.10).

Table-7.10: Relative use of forest by wild mammals along different gradients of disturbance in DWS

Zone	Species	HDT (n=20)	MDT (n=20)	LDT (n=20)
I (1700-2200m)	Asiatic black bear	*	*	**
	Wild pig	*	-	-
	Barking deer	-	-	***
	Goral	-	-	-
	Sambar	-	-	-
	Himalayan musk deer	-	-	-
II (2200-2700m)	Asiatic black bear	**	***	**
	Wild pig	-	**	***
	Barking deer	*	**	***
	Goral	*	***	-
	Sambar	-	**	***
	Himalayan musk deer	-	-	-
III (>2700m)	Asiatic black bear	*	-	-
	Wild pig	-	-	-
	Barking deer	-	-	-
	Goral	-	-	-
	Sambar	**	*	-
	Himalayan musk Deer	-	-	-

HDT, MDT & LDT= highly, moderately & least disturbed trails, - = no evidence, * = <10% frequency, ** = 11-50% frequency, *** = >50% frequency, ±= standard error

Dung densities of various mammals in all the areas were higher during winter season compared to summer (Table-7.11 & 7.12). Highest scat density was found for black bear in zone I, and for black bear and barking deer in zone II in summers. On the other hand in winters, dung density of barking deer was highest followed by sambar in zone II. No evidence of musk Deer was found in this ISS, however, evidences of goral were recorded mostly in the mid elevation zone.

Table-7.11: Estimates of animal dung density/ha in DWS during winter season (n=4)

Species	Zone I (1700-2200m)	Zone II (2200-2700m)	Zone III (>2700m)
Asiatic black bear	0.56±0.3	1.39±0.8	0.28±0.2
Wild pig	0	6.67±2.0	0
Barking deer	2.5±0.5	6.67±0.9	0
Goral	0	3.9±1.8	0
Sambar	0	4.2±0.8	1.4±0.5
Himalayan musk deer	0	0	0

±= standard error

Table-7.12: Estimates of animal dung density/ha in DWS during summer season (n=3)

Species	Zone I (1700-2200m)	Zone II (2200-2700m)	Zone III (>2700m)
Asiatic black bear	1.48±0.4	3.7±0.9	1.11±0.6
Wild pig	1.11±0.6	2.96±0.9	0
Barking deer	1.11±0.6	3.7±0.4	0
Goral	0	1.11±0.6	0
Sambar	0	1.85±0.4	0.74±0.7
Himalayan musk deer	0	0	0

±= standard error

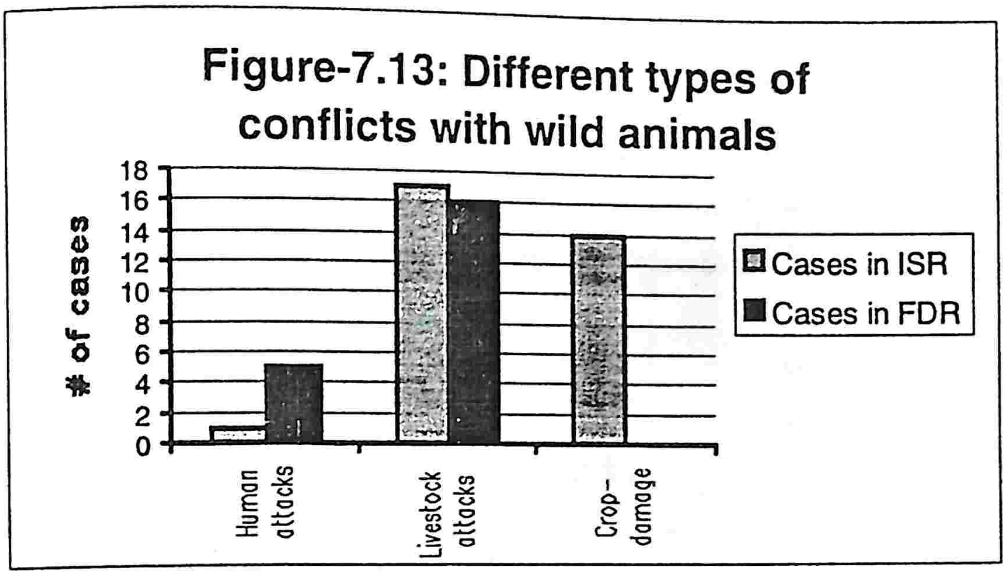
Besides indirect evidences, most of the direct sightings occurred in the mid-elevation forests or zone II (Table-7.13). Himalayan yellow throated marten and Pale weasel were very common in few localities and were sighted frequently. On the other hand, sightings of other animals were very low.

Table- 7.13: Direct sighting of mammals during the study period

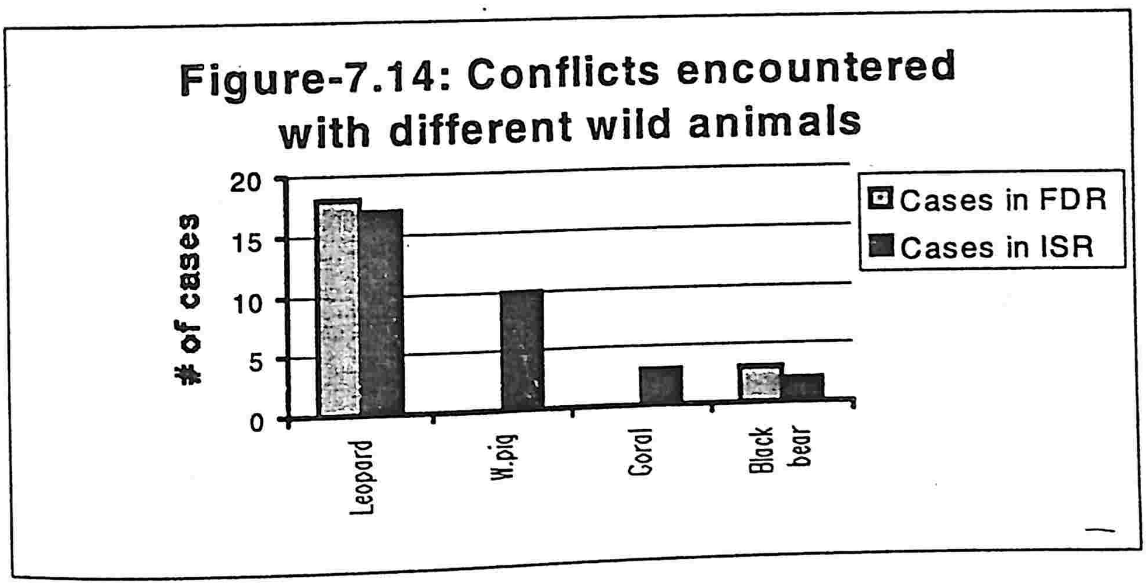
Species	# of sightings	Altitude (in m)	Habitat features	Month
Asiatic black bear	4	1700, 2300, 2500 , 2700	MOF	A, J, D & O
Wild pig	2	2400	MOF, Ag.fld	Ap. & M
Barking deer	1	2500	MOF	O
Goral	2	1900 , 2000	GS	J
Sambar	1	2700	MOF	JY.
Common leopard	1	1700	V	O
Weasel	5	2400	V	Ap. & My.
Himalayan yellow throated marten	6	1800, 2000 , 2400	MOF	Ap., My. & D
Rhesus macaque	10	1700, 2300, 2500 , 2700	V, MOF	Ap., My. O & N
Pika	6	2800	B	My., J, O & D

MOF=Mixed oak forest, Ag.fld= Agricultural field, GS= Grassy slopes, V= Village, B= Bouldery area, A=August, J=June, D=December,O=October, Ap.=April, M=March, Jy.= July, My.= May, N=November, ±= standard error

7.3.3 Patterns of human-wildlife conflicts: Between December 1996 and June 1999, a total of 32 cases of conflicts with wild animals were recorded in the ISS (Intensive Study Records =ISR). Only 21 cases of such conflicts from the entire forest division had been recorded with the Forest Department (FDR). Three types of conflicts *viz.*, livestock depredation, attack on human beings and crop damage were found in the area. An analysis of the conflict types (based on FDR and present survey) revealed that livestock depredation was the most serious problem followed by crop-damage (Figure-7.13).

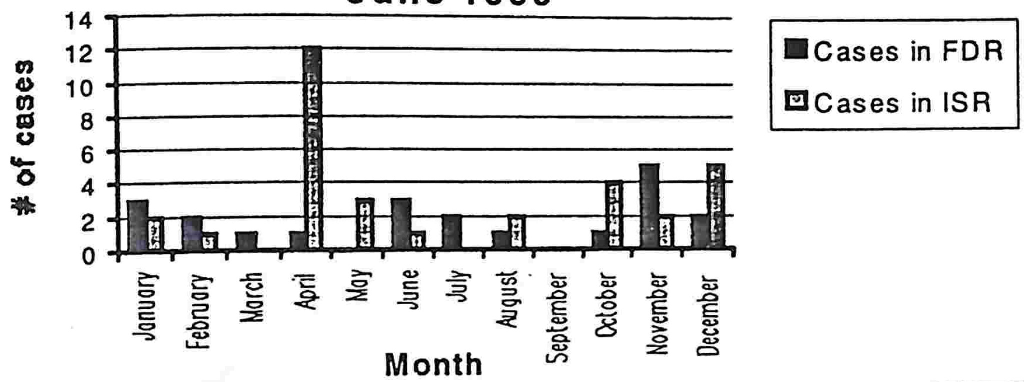


Attacks on human beings were occasional. As per records none of the attacks resulted in human deaths. Causal animals behind all these conflicts were Common leopard, wild pig, black bear and goral. Of the 21 cases reported in FDR, leopard was responsible for *ca.* 80% cases, which was complimentary with the ISR (Figure-7.14).



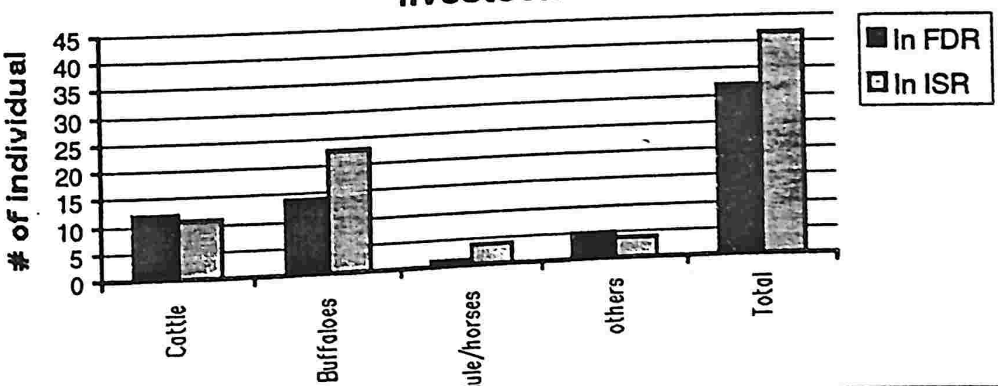
For most of the cases of livestock depredation common leopard was responsible, while the wild pig caused maximum damage to the crops. Goral was the only herbivore responsible for crop damage especially young crop of wheat. All the three cases of black bear conflicts recorded in FDR, were attack on human beings while in case of ISR in one condition it was damage to the crop and in other attack on human being. Cases of crop damage were not reported in the FDR. The reason for this could be that very few people know about the compensation scheme for these losses. A comparison of the seasonality of the conflicts in FDR and ISR revealed that most of the cases occurred during winter months (November) in the former. Most of cases in ISR occurred in April (37.5%) followed by December (Figure-7.15).

Figure-7.15 : Human-wildlife conflict cases between December 1996 and June 1999



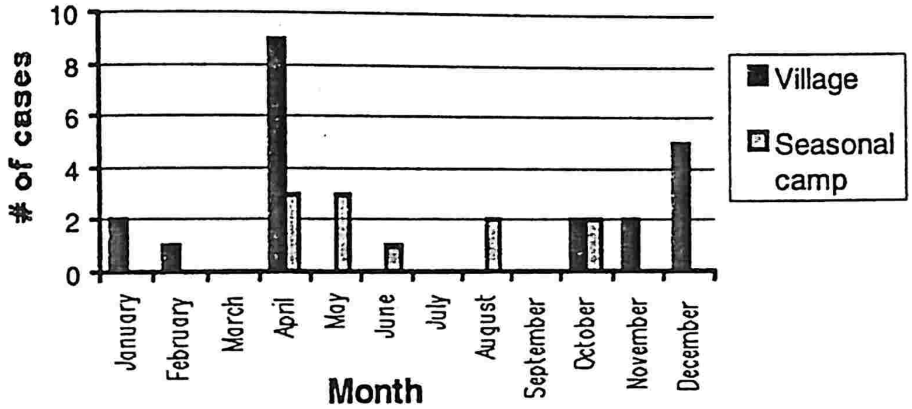
In the 21 cases reported in FDR and 32 cases reported in ISR there was a loss of about 32 and 42 livestock respectively. The loss ranged from 1 to 10 animal loss in an attack. According to both the records it was found that buffalo was most frequently attacked livestock accounting for the highest loss (Figure-7.16). Most of the attacks by black bear occurred on forest trails while leopard attacked even in the villages.

Figure-7.16: Depredation of different types of livestock



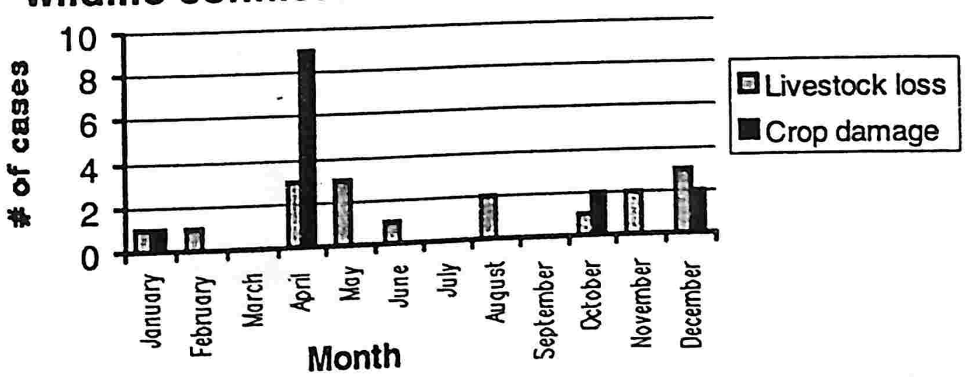
In ISR most of the attacks by common leopard occurred in villages surrounded by degraded or scrub forest. A majority of such attacks also took place during temporary migration to alpine and sub alpine meadows. A spatio-temporal variation in the human-wildlife conflicts was also found in the present study. In temporary huts, more number of such cases occurred during April to October whereas in villages and their vicinity most of the cases occurred during November to February (Figure-7.17).

Figure-7.17: Spatio-temporal pattern of human-wildlife conflicts in the ISS

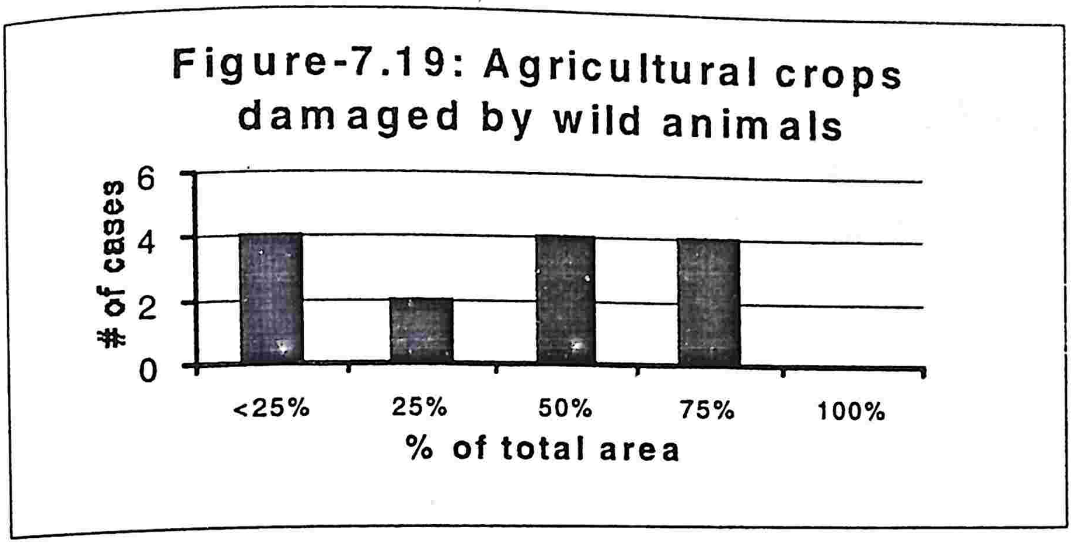


Most of the conflicts in seasonal camps or temporary huts were related to livestock depredation while those in the villages were related to crop damage. Maximum number of cases of livestock depredation and crop damage in the ISS occurred in the months of April, May and December (Figure-7.18).

Figure-7.18: Different types of human - wildlife conflict in Intensive study sites



Wild pig was responsible for damage to both potato and wheat crops while goral destroyed only the latter. In most cases, 50% of the cropland was destroyed (Figure-7.19).



Crop damage was in the form of uprooting, trampling and crop destruction during wallowing by wild pig. On the other hand goral destroyed crop by grazing and trampling on young plants. Due to wallowing the crops such as wheat get knocked down which further affects the yield. It was observed that the fields near village were less damaged compared to those in the vicinity of the forest. It was also observed that disturbance or damage increased after a distance of 800m from the village. Local people followed different methods to scare away the wild animals, some of them include construction of stone walls around the field (especially the one with potato crop), whistling, beating drums and canisters.

7.4 Discussion

7.4.1 Resource extraction along gradients of disturbance: The levels of disturbance affect the structure and composition of plant species (Chesson and Huntly 1989, Lavorel *et al.* 1994). In the present study area, basal cover of trees was relatively higher in moderately and least disturbed trails (Figure 7.2 to 7.4). This shows that forests with fewer disturbances had better status, which is comparable to studies done by Shackleton *et al.* (1994) and Vermeulen (1996). They also found that basal area was high in the plots with low disturbances. However, the density of trees was relatively more in the highly disturbed trail. This could be due to invasion of secondary species subsequent to the decline of the climax species (Uniyal 2001). Sundriyal and Sharma (1996) also found that there was a loss of canopy species due to increased biotic pressures in Sikkim Himalaya. It has been emphasized that in the intermediate disturbance stage certain obligate sensitive species show a marked decline in abundance and these are compensated by the other species, which are invasive in nature (Rai 1985, Skarpe 1990, Shackelton *et al.* 1994). However, in the heavily disturbed situation there is a decline in the overall species diversity (Pickett *et al.* 1989, Rao *et al.* 1990, Kadman & Pulliam 1995 and Stapanian *et al.* 1997).

Within ISS, BWS (south facing slopes) was more disturbed and had higher lopping pressure compared to DWS (t-test $p<0.05$). Preference of southern warmer aspect by humans and animals in Himalaya is well known. In the BWS, the lowest zone (1700-2200m) has already been converted into agricultural zone (**Plate-7.5**). With the trends of increasing population and socio-economic changes in the lifestyle of locals as well as transhumant communities (chapter4 and 5) the forests in other zones are also under pressure. The scarcity of agricultural by-products and need of more land for cash crop cultivation has resulted in excessive lopping and cutting of trees (**Plate-7.6**). This in turn has affected the overall status of forest (Uniyal 2001).

Lopping of trees was related to accessibility and proximity to the settlements. Due to irregular distribution of temporary huts and agricultural fields amidst the forest land, a clear pattern of lopping with proximity to villages was not visible. However, the middle elevational zones, which were away from the human disturbance, had comparatively less pressure (**Plate-7.7**). Grundy *et al.* (1993) also observed that lopping had a much more local effect on woodlands and the impact was more in the vicinity of settlements. Rai (1985) reported that regeneration pattern of certain species was adversely affected in the areas disturbed due to excessive browsing and lopping of trees a trend expected and also found in the present study (Awasthi *et al.* 1998). There was a spatial and temporal variation in the trees cut in the different disturbance gradients. In the forests surrounding villages, the lopping pressure was more during winters whereas it was high near temporary huts in the rainy season (Table-7.4 and 7.5). During rainy season local as well as transhumant people migrate with their livestock to their temporary huts in sub-alpine and alpine meadows (chapter-4 and 5) thereby increasing the extraction of fuelwood and fodder. On the other hand, during winter season due to heavy snowfall in the upper zone they return to their permanent

Plate-7.5: Agricultural fields in 1700-2200 m zone

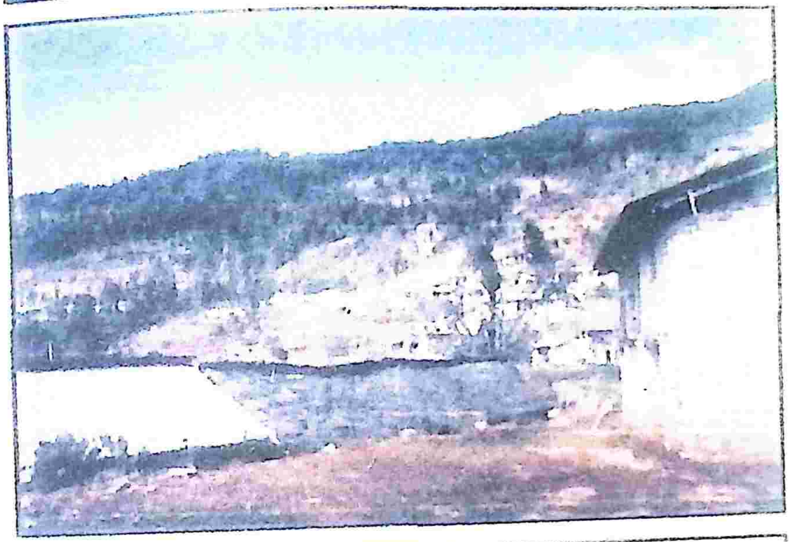


Plate-7.6: Degradation of forests near villages

Plate-7.7: Relatively undisturbed forests in the middle elevation

Plate-7.8: Degradation of timberline forests settlements. This causes an increased fuel wood and fodder extractions in zone I i.e. closer to permanent villages. Metz (1990) and Schmidt-Vogt (1990) also found similar differences in lopping intensities over space and time for high altitude forests of Nepal and highlighted temporary migration of locals to be an important cause for the degradation of timberline forests (**Plate-7.8**).

Cutting of selective species and girth size also influences the status and regeneration of certain species. Such a pattern of selective species and girth size lopping was also observed in the present study. Oak forests form the climax species in the present study area and these are the ones, which are highly preferred for lopping. This brings about a change in the structure and composition of forests which is an indication of changed ecosystem properties (Pickett *et al.* 1989). Though oaks have good coppicing property, the repeated lopping (>75%) for fodder has converted them either to stunted scrubs or poles **(Plate-7.3)**. The results of present study complement the findings of studies done in other parts of the Himalaya (Gupta 1978, Upreti *et al.* 1985 and Schmidt-Vogt 1997) which confirm that oak forests are most vulnerable to degradation. This has particularly been observed in the areas where resource extraction is more i.e near villages (zone I) and subalpine forests (zone III).

Species of low to mid girth class (31-60cm & 61-90cm) were mostly lopped for fodder and fuelwood. One reason for the lower girth sizes being more lopped could be that repeated lopping did not allow them to attain full growth. On the other hand, higher girth classes (151-180cm) were preferred for construction of temporary huts, cattle-sheds and hotels and generally cut in the sensitive timberline areas (chapter 5). Thus selective lopping of particular species and particular girth size leads to reduction in number of individuals of preferred girth class and affects their regeneration (Sousa 1984 and Schimdt-vogt 1990). In the present area also, it was found that preferred fuelwood and fodder species had low regeneration (Uniyal 2001) compared to species not preferred by the local people.

7.4.2 Distribution of wild animals along gradients of disturbance: Distribution and abundance of wild animals depends mainly on their adaptability and habitat conditions in an area (Dasmann 1982, Soule 1986). However, some times human induced disturbances in the form of poaching and hunting alter their population size and distribution (Halarnka 1998). Habitat destruction due to resource extraction, expansion of agriculture at the expense of forests, monoculture plantations and various construction works has also led to increased man-animal conflicts (Johnsingh 1991). The present study also revealed that there was a spatio-temporal variation in the distribution of animals in the area, which was regulated, not only by the seasonal variations in climate but also by the anthropogenic activities.

Abundance estimates for wild mammals based on indirect evidences showed variation in the dung density in different seasons as well as different altitudinal zones. It was found that mid-elevation zone had relatively higher dung density compared to the other two zones. Probable reason behind this could be that this zone had relatively good status of forest and is comparatively free from anthropogenic disturbance (Uniyal 2001). In the lowest zone, forests were interspersed with human habitations and agricultural fields and the upper zone (zone III; >2700m) was disturbed due to seasonal migration of villagers and transhumant communities with their livestock. It was also found that during winter season frequency of indirect evidences increased in these zones because of harsh climatic conditions and fewer anthropogenic disturbances. This seasonal increase of evidences and animals has also been reported in other parts of the Himalaya (Bhatnagar 1991).

It was found that most of the representative mammals of Western Himalaya inhabit the area but their densities were very low compared to protected areas (Sathyakumar 1994, Vinod 1999)(Table-7.14).

Table-7.14: Comparison of dung density/ha in different regions

Species	1 Bhagirathi catchment	2 Kedarnath WLS (Overall)	3 Kedarnath WLS (Disturbed)	4 GHNP
Barking deer	3.7	13.34	0.5	A
Himalayan musk deer	0.11	A	A	A
Sambar	2.12	37.73	A	A
Goral	0.5	35.14	9.6	8.36
Wild pig	2.38	A	A	A

1=Present study; 2 & 3= Sathyakumar 1994, 4= Vinod 1999

When the dung density estimates of present study were compared with the dung density estimates in the more disturbed sites of KWLS, both were comparable. A variation in the presence of indirect evidences due to human disturbances was also observed in the present study. One of the trails in the subalpine forest was heavily disturbed during summer and rainy season but due to unfavourable climatic conditions during winters human disturbance reduced drastically which explains an increase in dung density during winters in this trail. It was observed that besides physical and biological attributes, disturbance factors also played a major role in the distribution of animals in the present study area as has been observed for many other species in different parts of the world.

7.4.3 Nature of human-wildlife conflict: Human-wildlife conflicts in the areas adjoining forest are an age-old phenomenon. The man-eating leopard of Rudraprayag killed over 125 human beings and injured many more until Jim Corbett shot it dead in 1926 (Corbett 1981). With the ever-increasing demand for land, the human and wildlife conflicts have accelerated (Prakash 2001). The growing population has forced extension of cultivation till the periphery of the forest resulting in excessive deforestation. This has allured wild animals for crops, domestic livestock and sometimes-even human beings.

Present study reveals that though not many incidences of attack on human beings are reported, the depredation of livestock and agricultural crops by wild animals was prominent. Livestock depredation by leopard was mostly either in winters or summers. In the winter season livestock mostly grazed in the forests surrounding the villages and hence became an easy prey for the leopard. On the other hand, during summer season most of the incidences took place in the temporary settlements. This could be due to interspersion of people in the wilderness areas (Rodgers 1989) which disturbed the habitat of wild animals. Edgaonakar (1998) also found in a study conducted in Mumbai, that more number of human-leopard incidences took place in the seasons when human prey was easily available. While more attacks by lions in the monsoons were due to overlap in daily activity patterns of lions and humans and increased grass cover, which obstructed visibility resulting in accidental encounters (Saberwal *et al.* 1994).

Crop damage by wild animals was major problem in the study area. Cultivation of crops such as potato and wheat, which are preferred by wild pig and goral, attracted them for crop raiding. Goral generally damaged young crop of wheat in December and January. The protein content is highest and fibre content is lowest in this period as a result, preference by antelopes for wheat is higher in this nutritious phenophase (Jarman 1974). On the other hand wild pigs damaged potato crop. It was observed that land configuration had a major influence on crop damage. The agricultural fields that sustained more than 50% damages were located either in the periphery of the forest or amidst forest land. In some cases the loss per household quite high and villagers also spent considerable time and money guarding crops and protecting livestock as also reported by Butler (2000) and Sekhar (1998). It is evident that those villagers whose fields were near forest edges lost a part of their income due to severe crop damage. On the other hand, agitated victims kill many of the important wild fauna by poisoning the kill. This has also been reported by Rajpurohit & Krausmann (2000) for wolves whose dens were destroyed by the annoyed villagers.

Increased threat on wild animals due to these practices and need to overcome people-wildlife problems have gained the attention of both wildlife managers and scientists (Schultz 1986, Srivastava 2000) in the recent past. At different places different causes have been explained for these incidences. Some times the encounters are accidental and at the other, mistaken for the natural prey. Cases of deliberate attacks are occasional (Daniel 1996). Negi (1996) reported an increase in human-leopard incidences after 1988 especially in the areas where its prey has been eliminated. He also mentioned that villages around Corbett Tiger Reserve or dense forests of Dudhatoli where there was abundance of prey animals such incidences were rare. In case of large mammals such as elephants, human interference in the forest corridors (which are used by them in search of food) has been the main cause of human killings by elephant (Ranjitsinh 1991). On the other hand in some places legal protection of wildlife has increased their number above the carrying capacity of the forests leading to attacks in human habitations (Tov *et al.* 1995). A transition from subsistence based economy to market oriented economy was the major factor responsible for livestock depredation in trans

Himalaya (Mishra 1997). In the present study, the main cause of behind such conflicts seem to be habitat destruction due to excessive resource extraction, creation of new agriculture fields and seasonal transhumance.

Increased anthropogenic pressures in the forests close to villages in the lowermost zone and forests close to temporary huts in the sub-alpine zone have adversely affected the status and distribution of both plants and animals. Presence of sambar, goral and barking deer in the study area which are all important prey species for carnivores such as leopard further highlight the importance of these forests lying outside PA for conservation.

CHAPTER-8

Recent changes in land-cover and land-use

CHAPTER-8

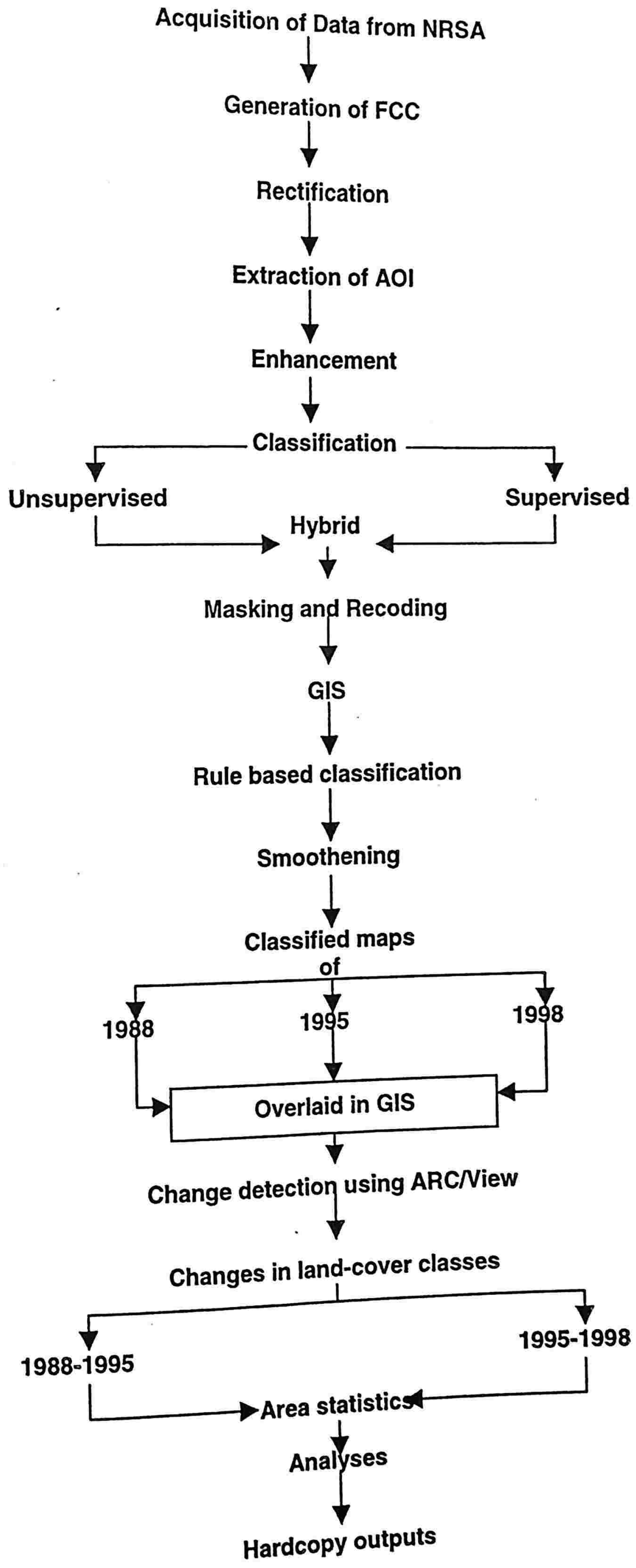
Recent Changes in the Land-cover and Land-use

8.1 Introduction

Land-cover denotes the physical state of the land including the quantity and type of surface vegetation, water and other features. Land-use, on the other hand defines the human employment of the land (Turner and Meyer 1991). It is now widely accepted that land-use and land-cover are closely linked. Diversity of different land uses should be understood to perceive and analyze changes in land-cover that links them to many aspects of global environment change. Changing land-use is the most important cause of land–cover change especially if the time horizon is limited to decades (Leeman and Zuidema 1995). Land-cover changes fall into two types *viz.,* conversion and modification. The former is a change from one class of land-cover to another whereas the latter is a change of condition within a land-cover category. Both conversion and modification occur at local as well as global scale and have significant environmental consequences (Turner *et al.* 1990). The increasing concern about the changes in land-cover and subsequent impacts on environment has recently been expressed through the signing of Climate Treaty, by *ca.* 150 countries at the United Nations Conference on Environment and Development (UNCED) in 1991. Article 2 of the treaty stresses the importance of an adequate description of land-cover and a good understanding of past, current and future status of land use. Information on the existing land-use and land-cover, its spatial distribution and changes over different time periods is prerequisite for proper planning and management (Richards 1984).

Historical approaches for documenting land-cover and its long- term changes used revenue and land records. These approaches were constrained by sparse sampling in space and time (Skole 1994). Recently, Remote Sensing (RS) coupled with Geographic Information System (GIS) has come as an efficient tool for mapping and monitoring land-cover (Lillesand & Keifer 1987, Burrough 1986). Applications of RS and GIS are wide ranging from simple inventorying and mapping of land classes to complex, modeling

Figure- 8.1: Outline of methods adopted for land-cover classification and change detection



(Schultink 1992, Innes and Koch 1998, Zhou 1998, Sen 2000, Behera *et al.* 2000). Satellite data of different years can be used to detect spatial and temporal changes in the land-cover (Byrne *et al.* 1980, Townshend *et al.* 1991, Tiwari *et al.* 1992, Fox *et al.* 1995, Roy *et al.* 1996 Ardo *et al.* 1997, Miller *et al.* 1998). Use of these techniques become even more important for mapping land-cover in mountainous regions where climatic and topographic conditions makes it difficult to survey several areas and update the information frequently (Sahai and Garg 1992, Adinarayan and RamaKrishnan 1996).

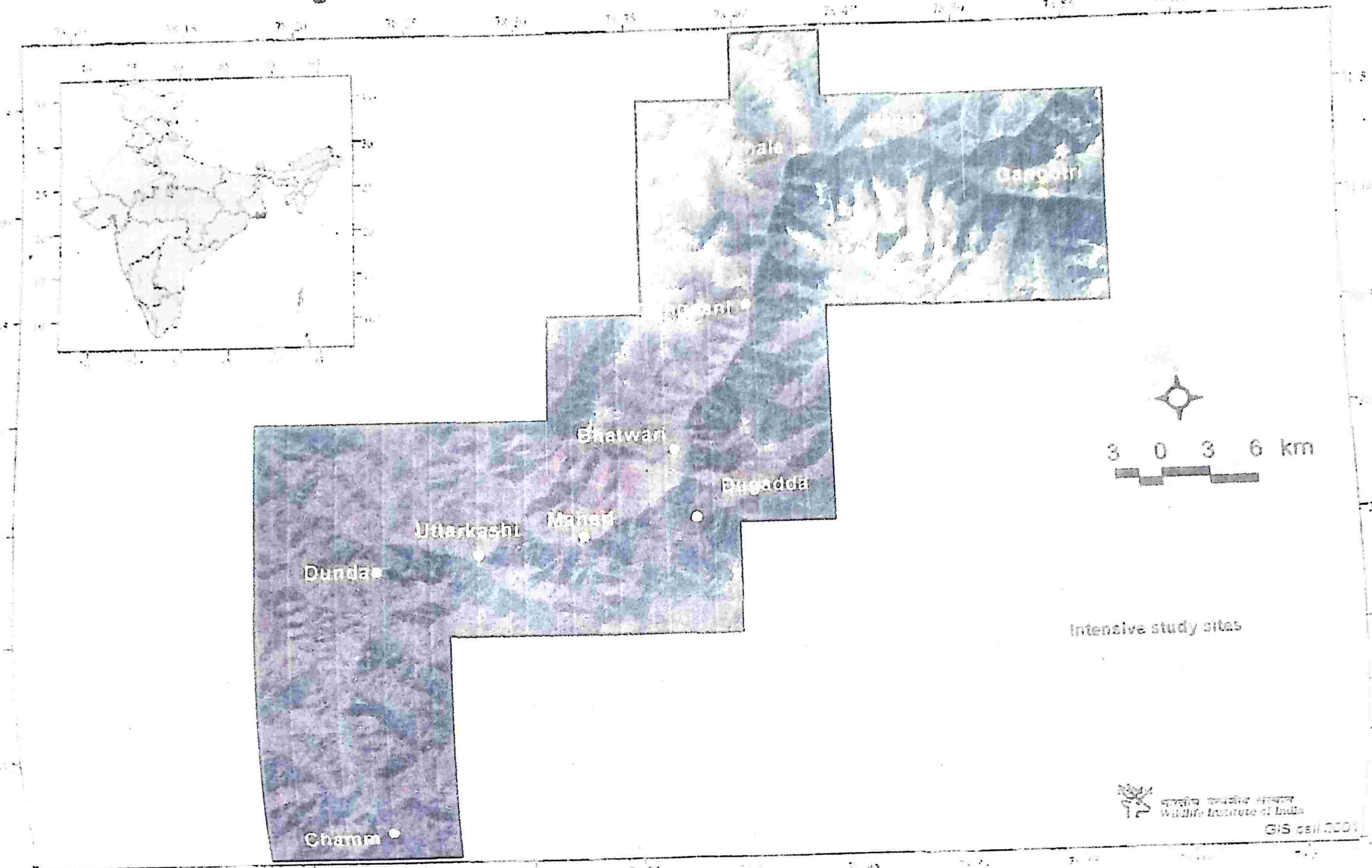
The upper catchment of river Bhagirathi is one such area where recent changes in land-use patterns have been observed. Construction of a hydroelectric project in its lower catchment and increased tourist activities in its upper catchment has put immense pressure on this fragile land. Thus, present study was initiated to map current status of different land-cover categories in the area and detect recent changes in these categories, which are influenced by the changed land-use practices, developmental activities and natural calamities. Broad objectives of the study were:

- To classify and map different Land-cover categories
- To detect changes in land-cover categories during different time periods viz., 1963-1988,1963-1998, 1988-1995 and 1995-1998.

8.2 Methods

Satellite data were acquired from the National Remote Sensing Agency (NRSA) Hyderabad, which were later used for Digital Image Processing (DIP) to yield classified maps of different time periods. These outputs were further used for change detection in GIS software: ARC/ VIEW ver. 3.1. An outline of methods is depicted in Figure-8.1.

8.2.1. Data used: Digital data for different time periods (Table 8.1) were acquired from NRSA. Digital data was preferred as it is less prone to human error and the analysis is less time consuming (Jensen 1996). In addition, it is very useful for detecting changes over time and space (Singh 1989). Survey of India (SOI) toposheets viz., 53J/5, 53J/6, 53J/9, 53J/10,53J/13, 53J/14, Figure-8.2: False Colour Composite of Bhagirathi catchment (AOI)



531/12 and 531/16 at the scale 1:50,000 were also used to extract Area of Interest (AOI) and creation of spatial database.

Table-8.1: Characteristics of satellite data used

Satellite	Sensor	Resolution	Bands	Month & Year
IRS-IA	LISS-II	36.25m	4 bands	November 1988
IRS-IA	LISS-II	36.25m	4 bands	November 1995
IRS-IC	LISS-III	23.5m	4 bands	November 1998

8.2.2. Software and Hardware used: Satellite data was loaded in SUN Microsystems workstations and digital image processing (DIP) of the data was carried out using ERDAS IMAGINE ver. 8.3. Various themes such as contours, drainage, land-use and road network were extracted from the toposheets and digitized in ARC/INFO ver. 7.0. Contours digitized at an interval of 80 m, were used to generate a digital elevation model (DEM) of the study area. DEM helps in solving terrain analysis problems and is very beneficial in image classification especially for high mountains (Miller and LaFlamme 1958, Ebner 1989). From DEM, slope and aspect maps were derived. Maps prepared after DIP were used for time series analyses in ARC/VIEW ver. 3.1. Area statistics was calculated using ARC/VIEW and hardcopies of the final maps were taken for presentation.

8.2.3. Digital Image Processing: After loading raw data in the hardware system, a false colour composite (FCC) was generated and it was put to different processes such as rectification, extraction of study area, enhancement, classification and smoothening.

Rectification: It is the process of projecting the data onto a plane and making it conform to a map projection system. Since all the map projection systems are associated with map coordinates, rectification involves 'Georeferencing'. For the rectification of raw data of present study, 40-ground control points (GCPs) were selected from the SOI toposheets. The GCPs were spread through out the study area so as to reduce the root mean square (R.M.S) error to 0.1. First order affine transformation was specified for the

Georeferencing process. After rectification, the image was resampled using Nearest Neighbourhood Algorithm. Resampling involves calculation of the file values for the rectified image and creation of a new file .

Mosaicking and Extraction of AOI: The present study area falls in two scenes of IRS satellite. After geo-referencing both the scenes to same coordinate system, they were mosaiced. Later a subset of the study area was created to extract area of interest *viz.*, area between 78^0 18' –78^0 57' longitude and $30^0$30'-$31^0$08'latitude (Figure-8.2). Subsetting involves breaking out a portion of a large file into one or more smaller files.

Enhancement: Initially after loading the raw data, Contrast Linear Stretch was applied. After the extraction of AOI, edge enhancement with a kernel size of 3X3 was used to sharpen the edges for better classification.

Classification: Enhanced image was put to classification. Unsupervised classification algorithm was used to generate the initial classified map. Later, a Supervised classification was performed and for the final classification a Hybrid of the two approaches was used.

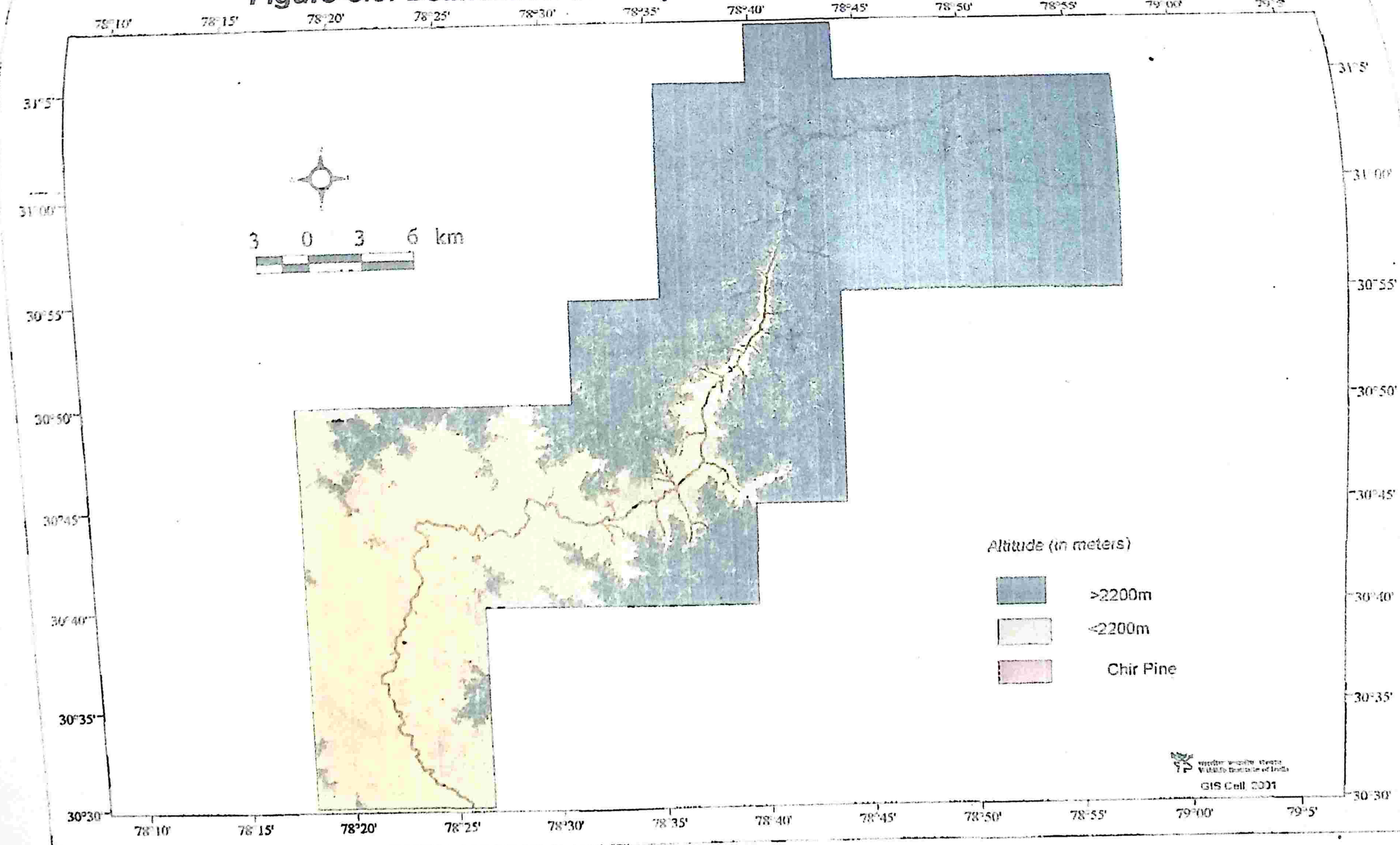
Unsupervised classification: The image of all the three time periods were classified using an unsupervised clustering algorithm (ISODATA). Number of classes and maximum iterations (number of times the ISODATA utility will recluster the data) specified in the unsupervised classification were 80 and 15 respectively. Convergence threshold i.e. the maximum percentage of pixels whose cluster assignments can go unchanged between iterations was set to 0.95. The image obtained after running the algorithm was classified into 80 different spectral classes. After analyzing the reflectance values, these 80 classes were merged into 10 distinct classes of which 6 were of different forest types viz., Chirpine (>75% area under 'chir' *Pinus roxburghii*), other conifers (>75% area under other coniferous species such as *P. wallichiana, Abies pindrow, Cedrus deodara, Picea smithiana* etc.) broadleaf (>75% area under broadleaf species such as *Quercus leucotrichophora, Quercus floribunda, Q.semecarpifolia, Rhododendron arboreum, Lyonia ovalifolia, Acer* spp., *Aesculus* spp. etc.) , broadleaf-conifer mixed (>75% area with intermingled broadleaf and conifer species), scrub (>75% area under scrub vegetation) and grassland (>75% area under grassland) and 4 were non-forest categories *viz.*, habitation (area under settlements, agriculture, wasteland near settlements), water bodies (area under river and rivulets, glaciers and lakes) rocks & boulders and snow (snow covered areas).

Supervised Classification: The output of unsupervised classification at the scale of 1:50,000 was taken to field for ground truth. Seven homogeneous training sets were selected for each class and their locations were recorded using GPS (Global Positioning System). Of the total 70 training sets collected from field, 35 were used for defining the spectral signatures in supervised classification process and rest were used for accuracy assessment. Maximum likelihood parametric rule was used for the supervised classification. The classes so generated were evaluated and used further for hybrid approach.

Hybrid Approach: This approach involves the integration of supervised, unsupervised clustering and field knowledge as it has been preferred by many workers (Deekhshatulu 1992) in classification of digital data. In the present study also, it was found that neither of the above mentioned two approaches could give a true representation of the field conditions hence a combination of the two approaches i.e. Hybrid approach was used. To reduce the mis-classification noise and improve the classification, certain features such as shadows and clouds were masked and reclassed to the specific category found in field. Still there was problem in delineating chirpine and other conifers as both have similar reflectance. Similarly differentiation of alpine scrub and pastures from low valley scrub and pastures was also not possible. The map was therefore exported to GIS and certain ecological rules observed in field were used to overcome this problem.

Rule based classification: Refinement of classified maps using certain ecological rules in GIS domain has been well-appreciated (Bolstad and Lillesand 1992, Wilson 1997). In the mountainous terrain altitude plays a major role in plant distribution and in the present study it was found that chirpine did not occur above 2300m altitude and other conifers not below 2300m. Similarly alpine pastures and alpine scrub were restricted to alpine

Figure-8.3: Delineation of Chirpine and Other Conifers using DEM



zones *viz.*, above 3200m. Hence certain rules were developed taking into considerations the following as a criterion:

If, altitude >2200m, reclass chirpine to other conifers
altitude <2300m reclass other conifers to chirpine
altitude >3200m reclass grasslands to alpine pastures and scrub to alpine scrub

These rules were used to break DEM into two altitudinal zones and distribution of different forest types was overlaid on it (Figure 8.3). As a result, the above four forest types were reclassed and a final map with 12 different classes was generated.

Smoothening: The final map so obtained was very pixilated and could not be used for change detection in the GIS. Therefore, Nearest neighbour algorithm with a kernel of 3X3 was used for smoothening the maps. However, area statistics was calculated from the non-smoothened maps only. All the classified maps had an accuracy between 81 to 90%. The maps of different time-periods so generated were analyzed for change detection using GIS.

8.2.4 Change detection: The classified maps of the years 1988, 1995 and 1998 were overlaid in ARC/VIEW to generate maps depicting changes in the different Land-cover classes during two time periods (1988 to 1995 and 1995 to1998). As phenological changes in vegetation and weather conditions affect the quality of data and might lead to biases in results (Jensen *et al.* 1997), satellite data of corresponding month was preferred for the time series analyses.

For the year 1963, land-cover map was prepared from the SOI toposheets. The number of land-cover classes obtained was less and different forest types could not be therefore delineated separately. Hence for detecting changes between years 1963 to 1988 and 1963 to1998 and different forest types in the 1988 and 1998 maps were merged to one class forest. Similarly, in the 1963 map agriculture and habitation were merged to one class habitation so that the maps of 1963, 1988 and 1998 become comparable.

8.2.5. Analyses: Topographical maps (slope, aspect and altitude) generated from DEM were analyzed for area statistics in the ARC/VIEW. Slope was categorized into the following six classes, aspect into nine types and altitude into six zones:

Slope (in degrees)	Altitude (in meters)	Aspect
0-15 = Class I	279-981 =Zone I	Flat = F
15-30 =Class II	982-1683 = Zone II	North = N
30-45 = Class III	1684- 2386 = Zone III	North East = NE
45-60 = Class IV	2387- 3088 = Zone IV	North West = NW
60-75 = Class V	3089- 3790 = Zone V	South = S
>75= Class VI	> 3790 = Zone VI	South East = SE
		South West = SW
		West = W
		East = E

Land-cover map of the year 1998 was overlaid on these topographical maps to get area of different land-cover types in different topographical classes. Similarly maps of changes during both the time periods (1988-1995 and 1995-1998) were also overlaid on slope, aspect and DEM maps to obtain area statistics of changes in different slope, aspect and altitude categories. The area statistics so obtained was correlated to discuss various trends.

8.3. Results

The total geographic cover of the study area was 2050.66 sq. km while the area calculated in GIS domain came out 2051.7 sq. km. The difference in the area could be due to human errors in digitization.

8.3.1. Land-cover classification: River Bhagirathi is the main river, which drains the whole area. There are many small and large tributaries of river Bhagirathi . River Bhagirathi divides the mountain ranges into a narrow valley and AOI forms the catchment of Bhagirathi. It has an altitudinal range of 279-6600m and the terrain is rugged with steep slopes and different aspects.

Topographical distribution of area: For the present study, 9 categories of aspect, six of slopes and six of altitude were delineated. Of the six

Figure-8.4: Digital elevation model of Bhagirathi catchment

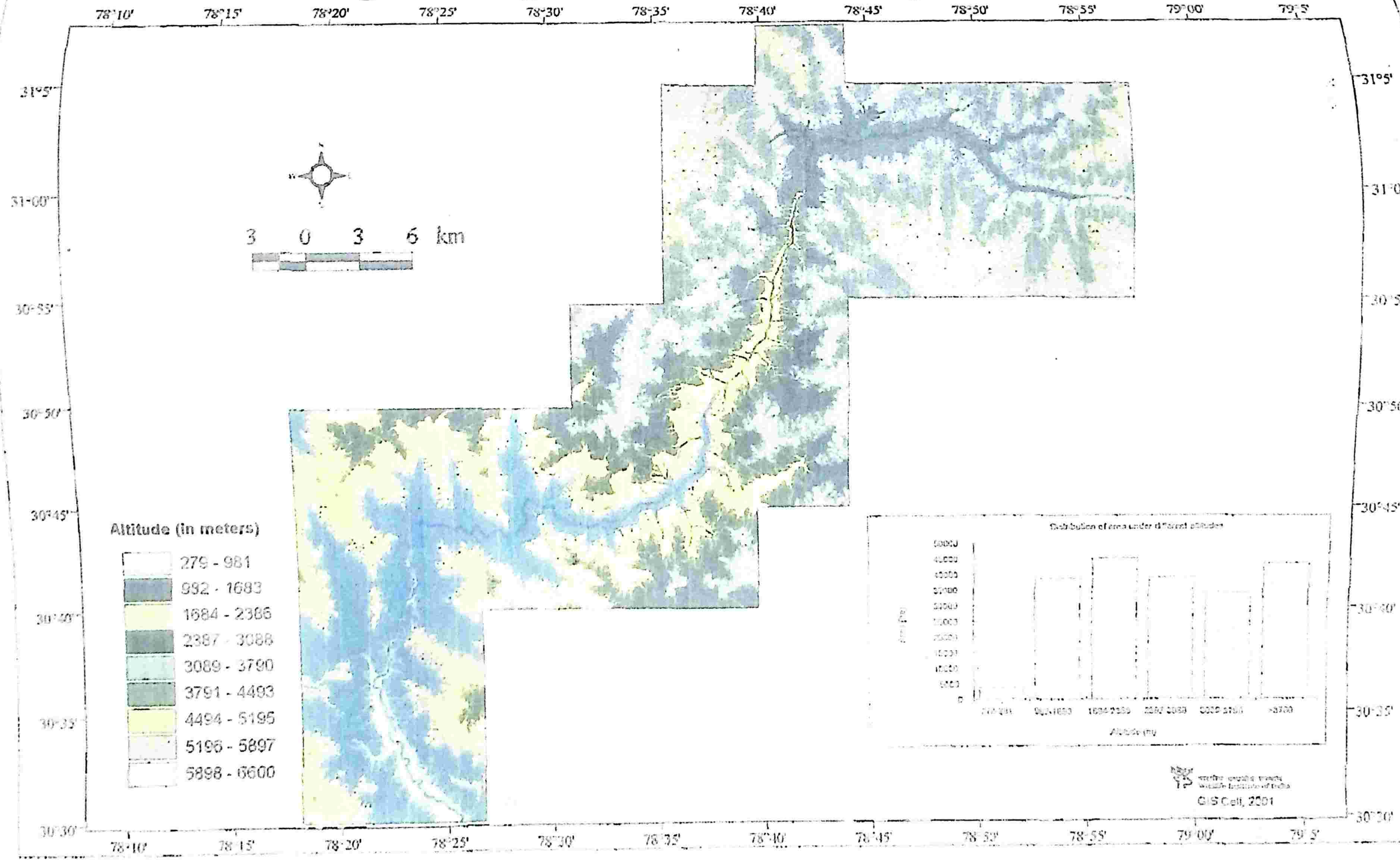


Figure-8.5: Aspect map of Bhagirathi catchment

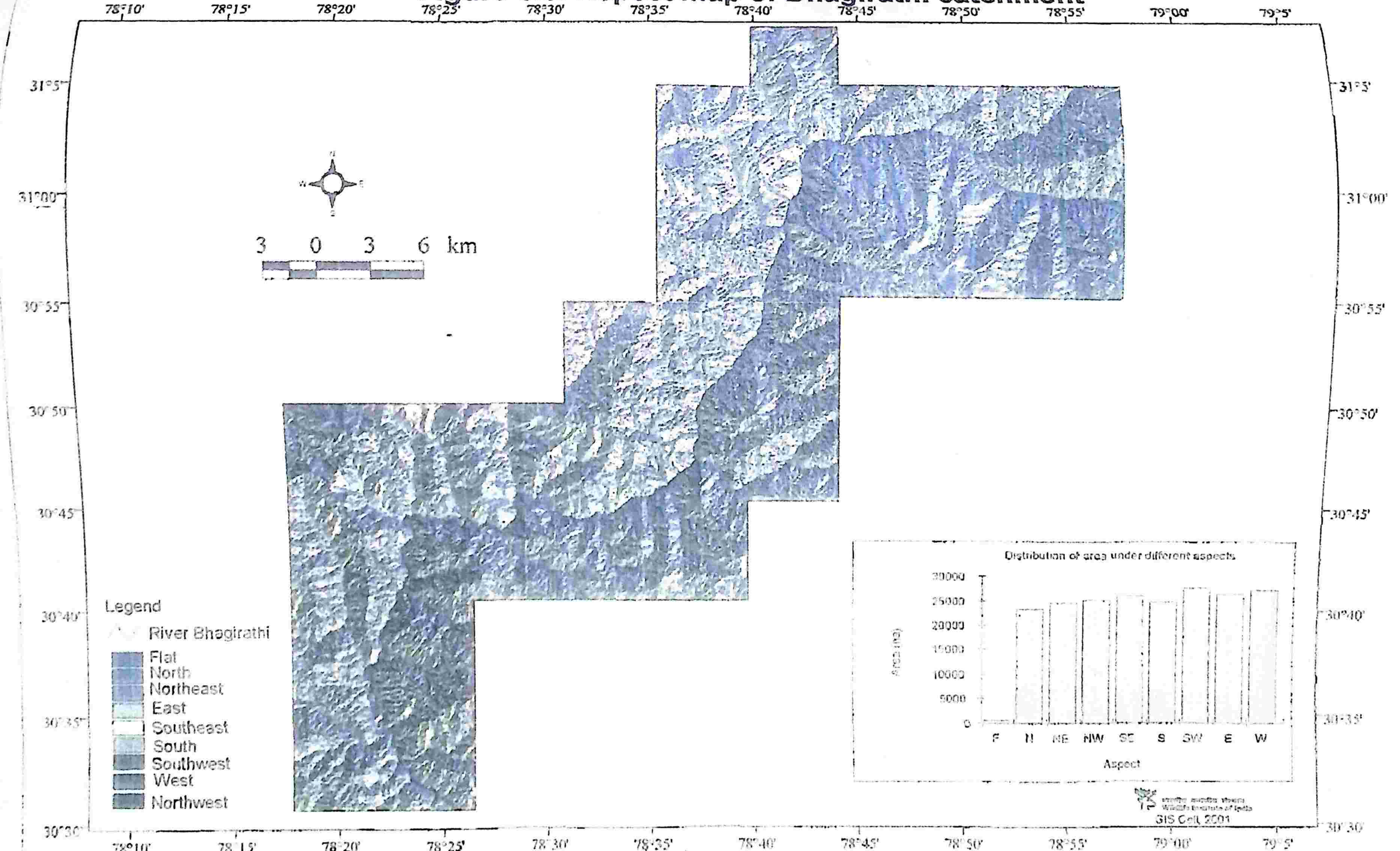


Figure-8.6: Slope map of Bhagirathi catchment

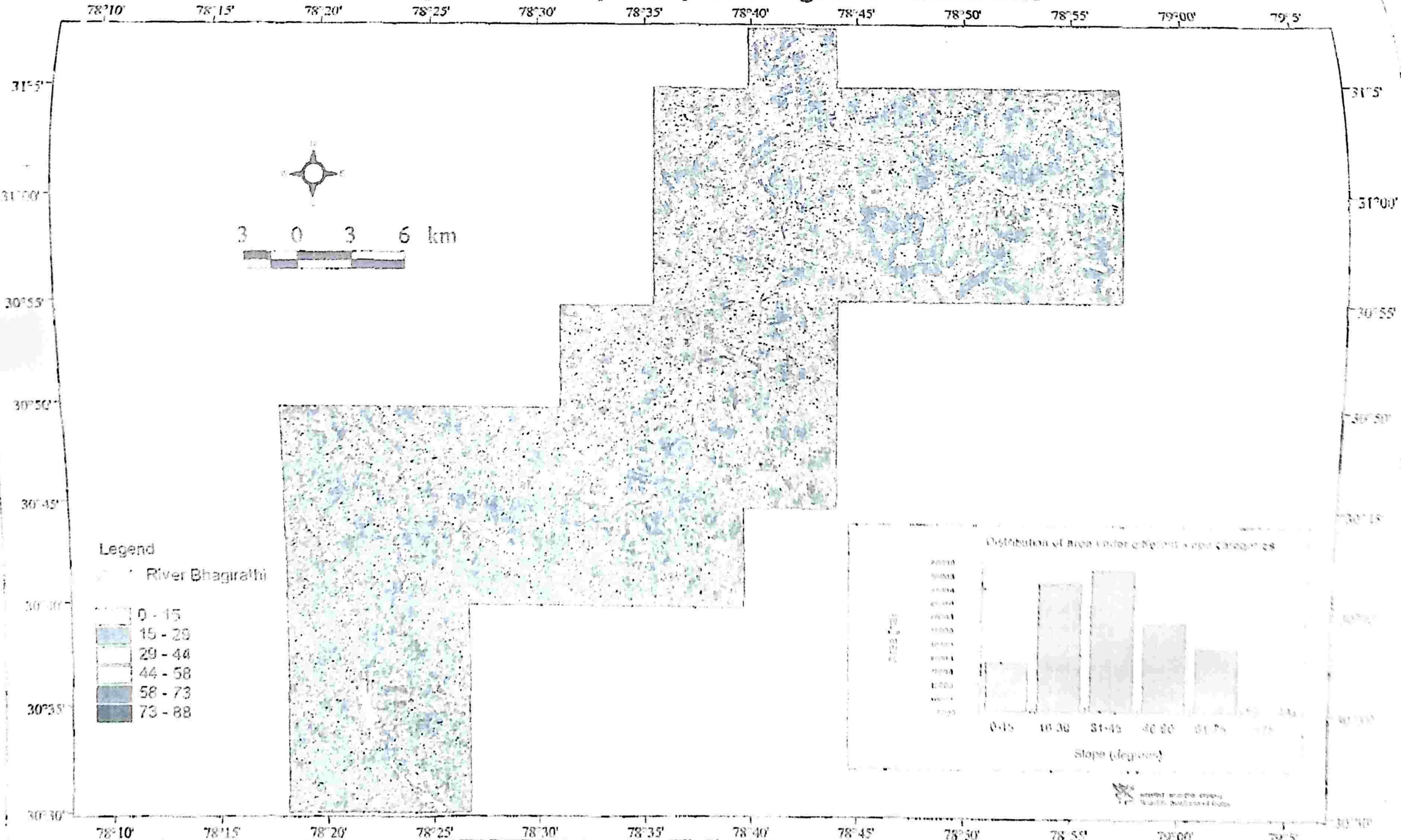
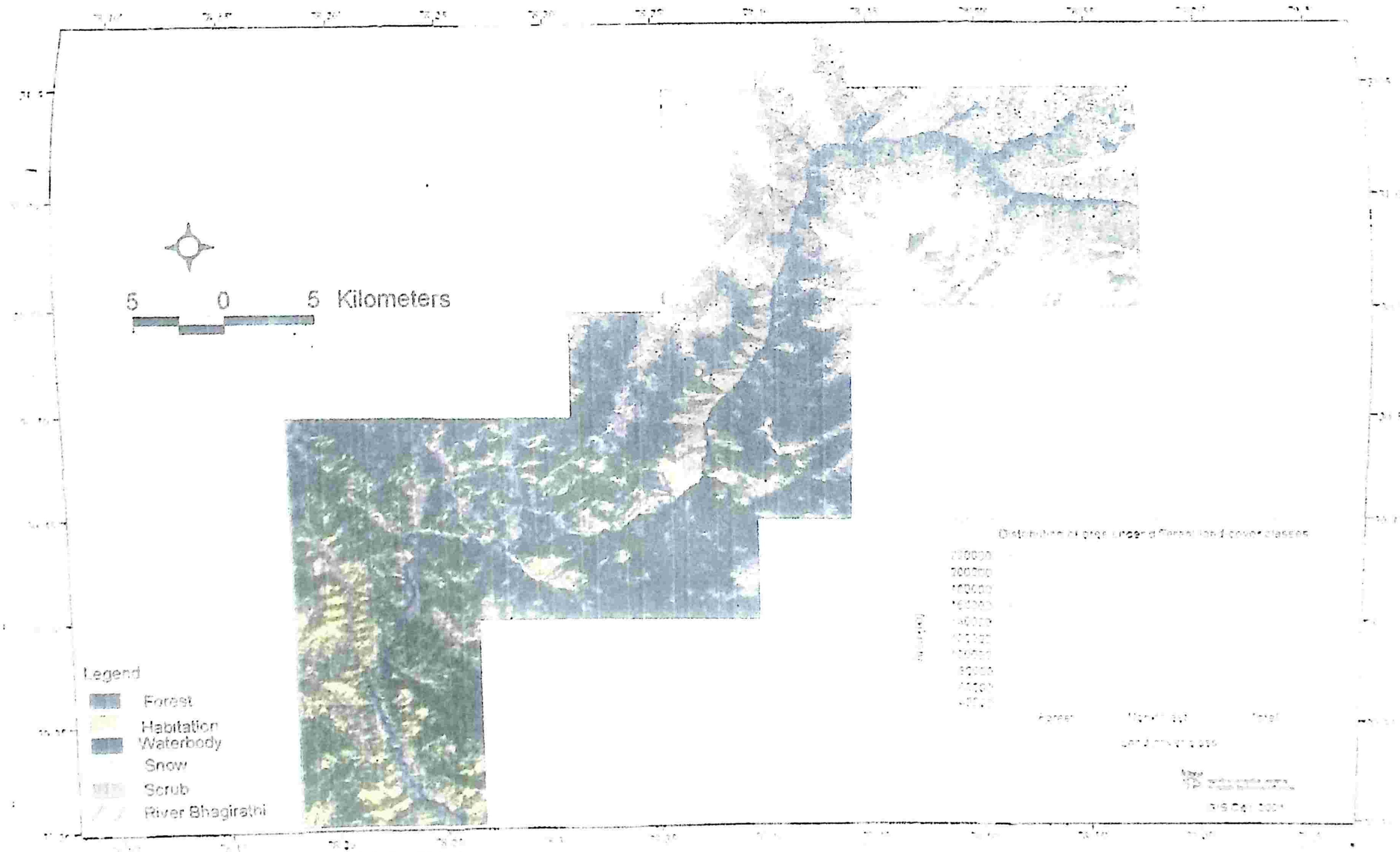


Figure-8.7: **Landcover classification of Bhagirathi catchment (1998)**



altitudinal zones, maximum area (22.03%) was under zone III (1683-2386m) followed by zone VI (> 3790m) and least was under zone I (279-981m) (Figure-8.4).

Of the nine aspects categories maximum area was under southwest aspect (13.46%) and least under flat areas (0.4%). When area for north, northeast and northwest was pooled together as northern aspect and compared with southern aspect (south, SE and SW pooled), it was found that southern aspect had comparatively more geographical area (Figure-8.5). Of the six slope classes maximum area (27.6%) was under slope class III (31-45^0) and least under slope class VI (>75^0) (Figure-8.6).

Distribution of different land-cover classes: In the study area 12 distinct land-cover classes were identified of which 8 were of different forest types and 4 of non-forest categories. It was found that more than 70% area was under forest cover and rest (27.66%) included non-forest categories such as habitation (including agricultural land), rocks/boulders, snow, river/ waterbody (Figure–8.7). The distribution of area under different forest types showed that maximum area was under broadleaf-conifer mixed forest and least under lower valley grassland. Of the non-forest classes, maximum area was under snow and least under river/water bodies (Table-8.2).

Table-8.2: Area under different land-cover classes in 1998

Land-cover	Area (in hectares)
Chirpine	11457.28
Other conifers	13640.96
Broadleaf	21612.16
Broadleaf-conifer mixed	50504.96
Grassland	6334.72
Scrub	21300.48
Habitation	16879.36
River/water body	3978.24
Snow	21989.76
Rocks/Boulders	13893.12
Alpine pastures	11402.24
Alpine scrub	12072.32
Total	**205065.6**

8.3.2. Change detection between different time periods: The Land-cover maps of different time period's *viz.*, 1963, 1988, 1995 and 1998 (Figures 8.8, 8.9,

Figure-8.8: Land cover classes in 1963

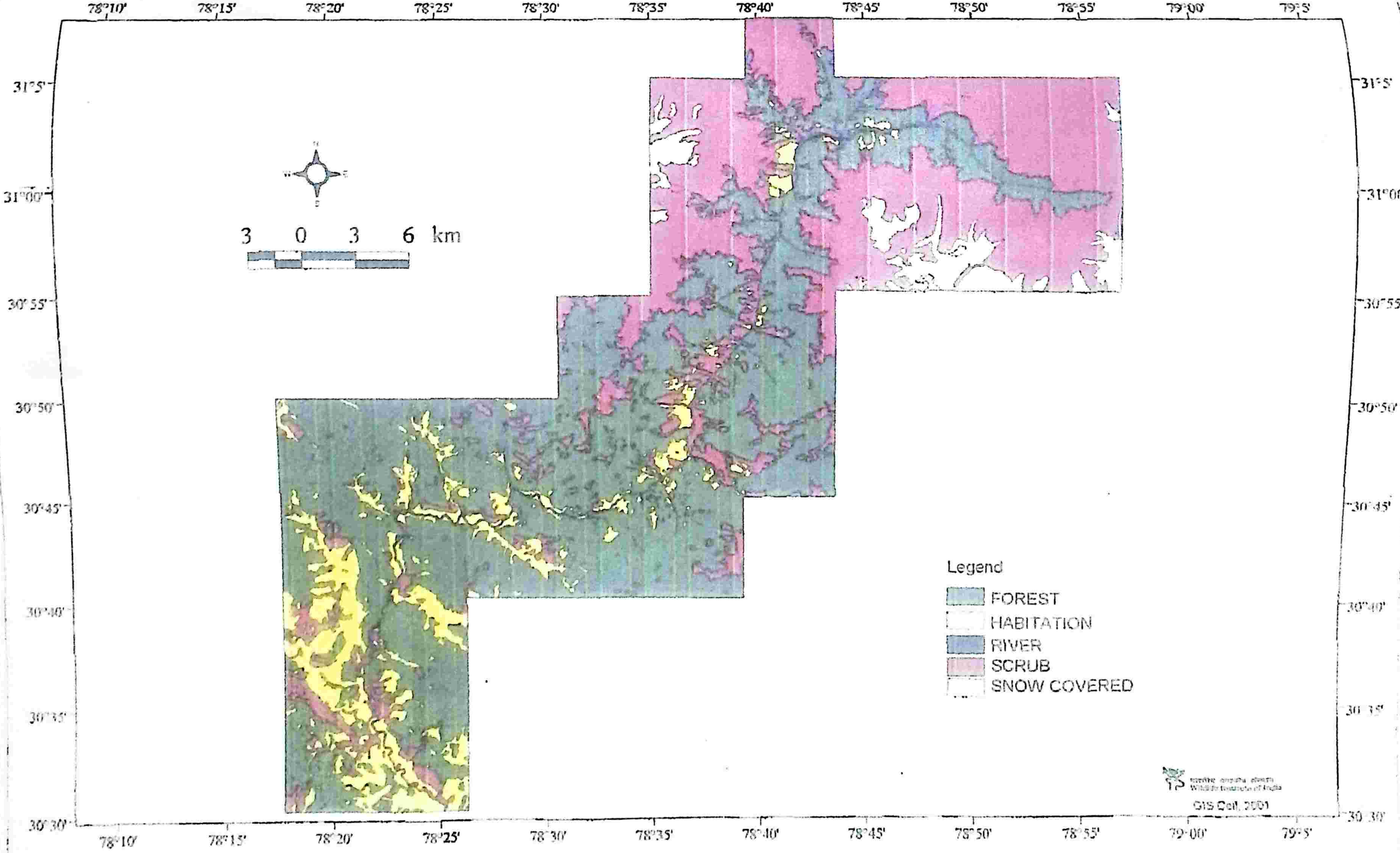


Figure-8.9: Land cover classification of Bhagirathi catchment (1988)

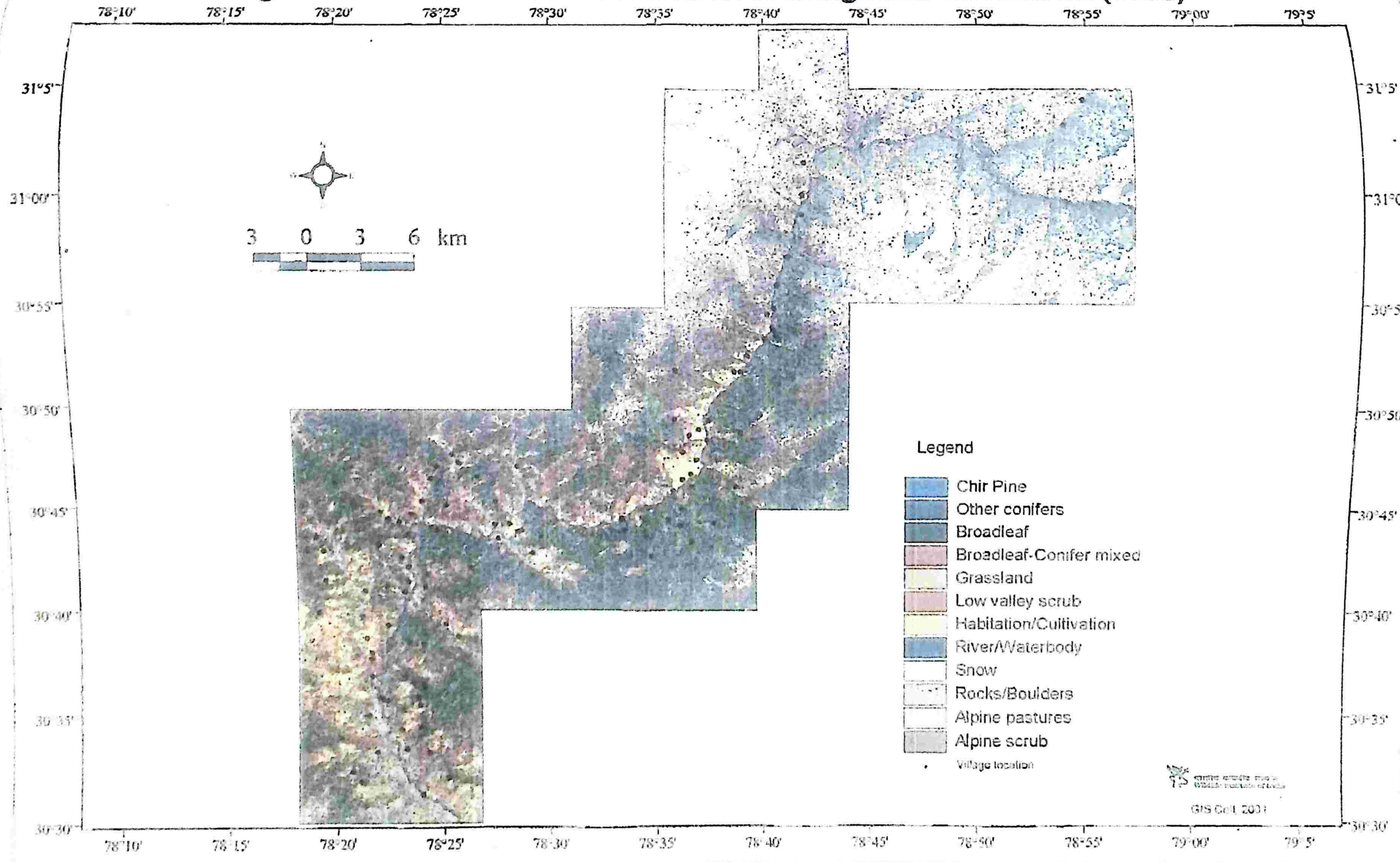


Figure-8.10: Land cover classification of Bhagirathi catchment (1995)

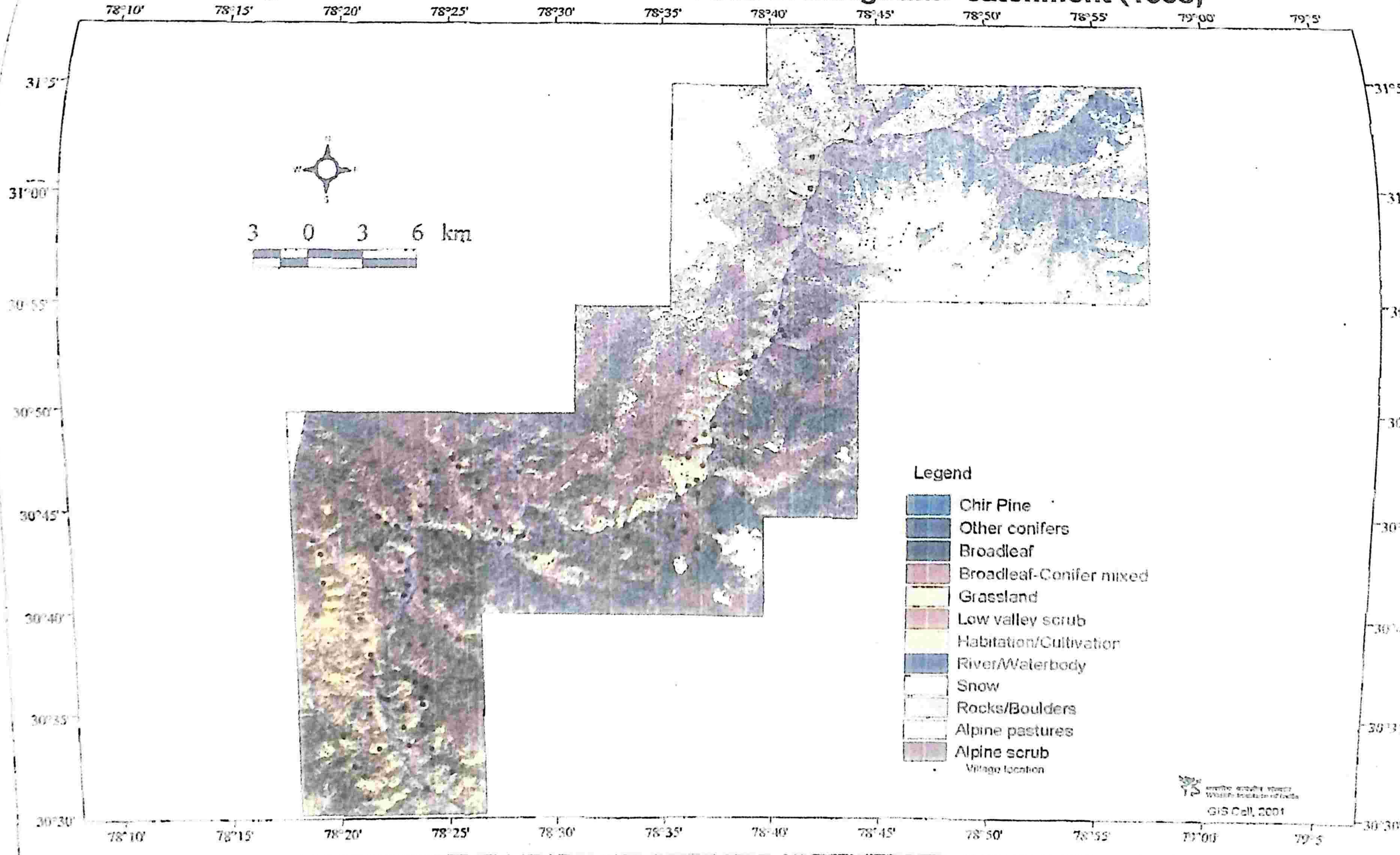
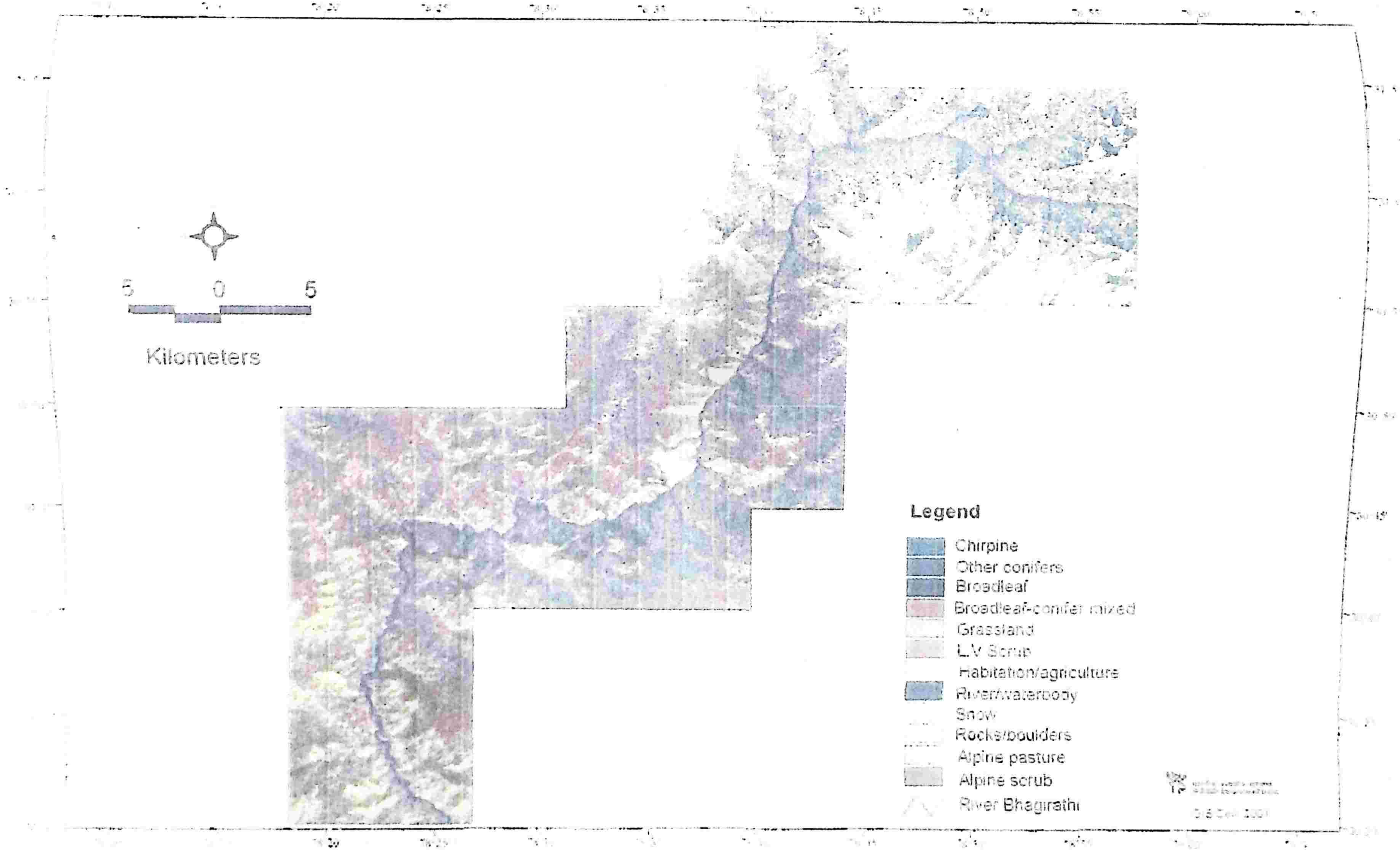


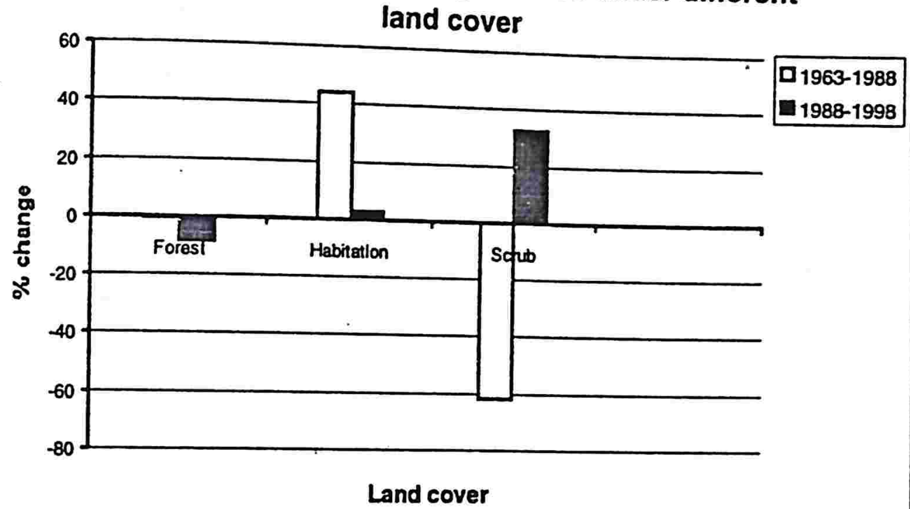
Figure-8.11: **Land cover classification of Bhagirathi catchment (1998)**



8.10, 8.11) revealed conversions and modifications in the above mentioned land-cover classes.

Changes in land-cover classes between 1963-1988 and 1988-1998: Of the four broad land-cover classes, maximum changes were observed in scrub during both the time periods 1963-1988 and 1988-1998 (Figure-8.12). It was found that forest cover decreased by 0.8 % between 1963 and 1988 and by 8.65% between 1988 and 1998. On the other hand area under habitation increased by 44.03% during 1963-1988 and 2.8% during 1988-1998.

Figure-8.12: Percent change in area under different land cover



Changes in land-cover classes between 1988 and 1995: It was found that between 1988 and 1995 there was no change in the total geographical area however, the area under chirpine, broadleaf-conifer mixed, scrub and habitation increased. On the other hand area under conifer, broadleaf, grassland, alpine pasture and alpine scrub decreased (Figure-8.13). It was also revealed that of all the Land-cover classes, maximum changes took place in broadleaf-conifer mixed forest and least in the alpine vegetation (Table-8.3).

Figure-8.13: Changes in different land-cover classes during 1988 -1995

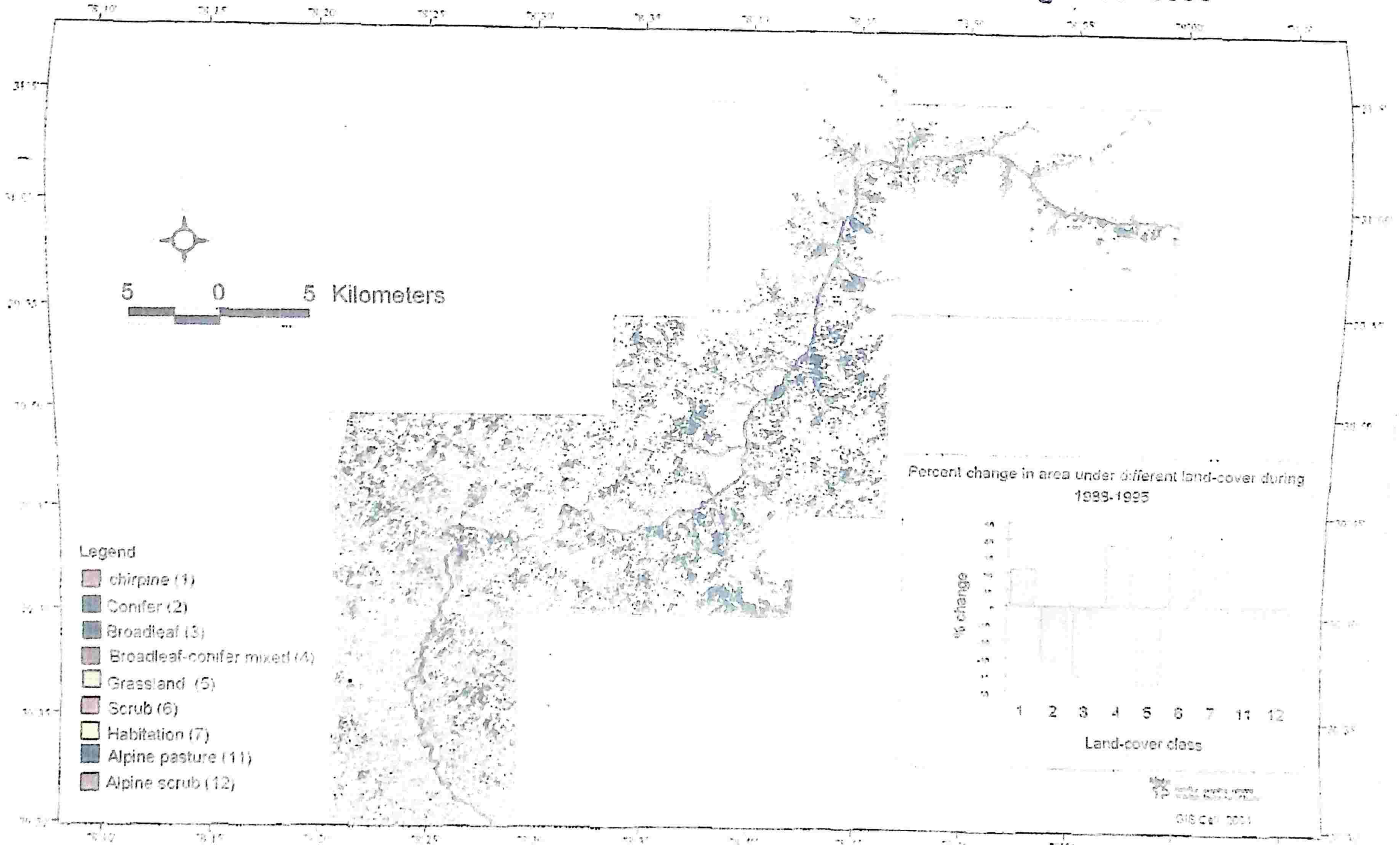


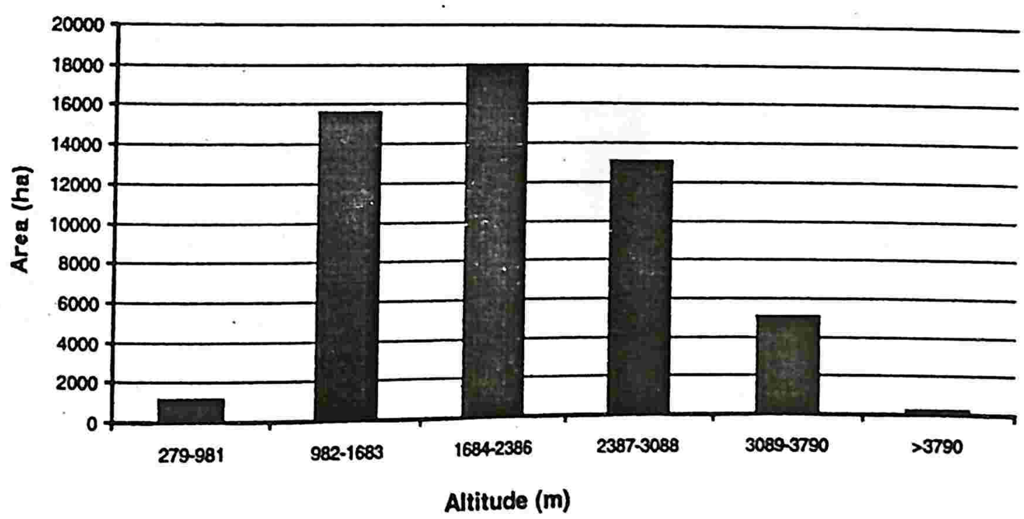
Table-8.3 Matrix showing changes in area (km^2) under different land-cover categories between 1988 and 1995

1995 → / 1988 ↓	1	2	3	4	5	6	7	11	12	Total
1	-	0.03	0	36.62	0	3.66	0.64	0	0	40.95
2	0	-	0	57.13	0	6.2	0.53	0	0	63.86
3	0	0	-	161.9	0	10.98	2.47	0	0	175.3
4	36.11	12	28.4	-	0	11.94	11	0	0	99.45
5	1.88	1.2	0	0	-	40.32	17.74	0	0	61.14
6	14.66	0.006	0	0	4.53	-	20.69	0	0	39.88
7	12	0	0	0	2.22	16.44	-	0	0	30.66
11	0	0	0	0	0	0	5.77	-	0	5.77
12	0	0	0	0	0	0	13.34	0	-	13.34
Total	**64.65**	**13.24**	**28.4**	**255.6**	**6.75**	**89.54**	**72.18**	**0**	**0**	**530.4**

1=chirpine, 2=other conifers, 3= broadleaf, 4= broadleaf-conifer mixed, 5= grassland, 6=scrub, 7= habitation, 11= alpine pasture, 12= alpine scrub

Changes in land-cover classes when correlated with altitudinal zones revealed that maximum changes took place in zone III and minimum in zone VI (Figure-8.14).

Figure-8.14: Land-cover changes during 1988-1995 in different altitudes



Chirpine, broadleaf and broadleaf-conifer mixed had maximum changes in zone III while grassland, scrub and habitation in zone II. Changes in coniferous forest and alpine vegetation occurred in zone IV and V respectively. In zone I grassland had maximum changes while in zone II, III and IV broadleaf forest had highest changes. On the other hand, in zone V and VI conifer had maximum transformations (Table-8.4).

Table-8.4: Changes in area (ha) under different land-cover classes in different altitudinal zones between 1988 and 1995

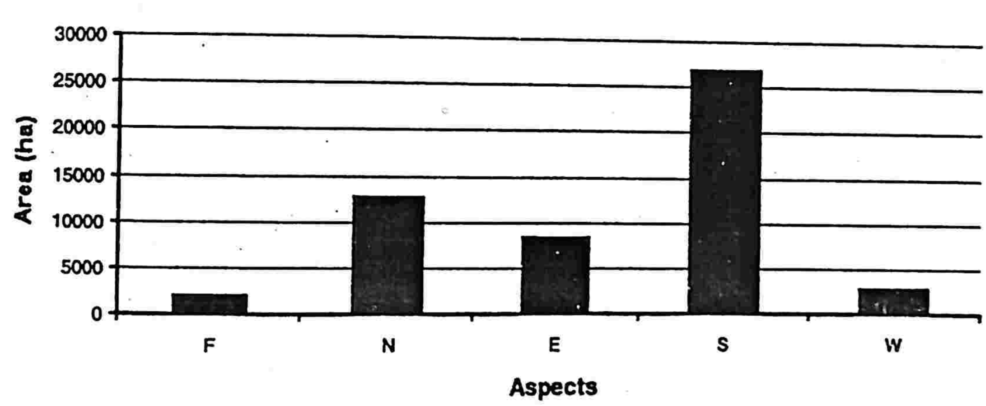
Land-cover	I	II	III	IV	V	VI	Total
1to2	0	0	3.2	0	0	0	3.2
1to4	100.48	1498.88	2058.24	5.12	0	0	3662.72
1to6	46.08	200.96	119.04	0.64	0	0	366.72
1to7	3.84	32	28.16	0.64	0	0	64.64
Changes in 1	**150.4**	**1731.84**	**2208.64**	**6.4**	**0**	**0**	**4097.28**
2 to 4	0	0	630.4	2999.04	1991.68	92.16	5713.28
2 to 6	0	0.64	26.88	488.96	103.04	0.64	620.16
2 to 7	0	0	8.32	29.44	15.36	0	53.12
Changes in 2	**0**	**0.64**	**665.6**	**3517.44**	**2110.08**	**92.8**	**6386.56**
3to4	60.16	3530.88	6842.88	4737.28	1004.8	12.8	16188.8
3to6	12.16	388.48	423.68	257.92	16	0	1098.24
3to7	1.28	92.16	115.84	33.92	3.84	0	247.04
Changes in 3	**73.6**	**4011.52**	**7382.4**	**5029.12**	**1024.64**	**12.8**	**17534.08**
4to1	86.4	1852.16	1671.04	1.92	0	0	3611.52
4to2	0	0.64	250.88	734.72	213.12	0.64	1200
4to3	16	590.72	968.96	983.04	289.28	0	2848
4to6	45.44	405.12	476.8	249.6	17.92	0	1194.88
4to7	32.64	374.4	391.68	229.76	71.68	0	1100.16
Changes in 4	**180.48**	**3223.04**	**3759.36**	**2199.04**	**592**	**0.64**	**9954.56**
5to1	16.64	128	42.88	1.28	0	0	188.8
5to2	0	0	7.68	99.2	13.44	0	120.32
5to6	255.36	1964.8	799.36	908.16	104.96	0	4032.64
5to7	80	777.6	444.16	414.72	57.6	0	1774.08
Changes in 5	**352**	**2870.4**	**1294.08**	**1423.36**	**176**	**0**	**6115.84**
6to1	108.16	928	430.08	0	0	0	1466.24
6to2	0	0	0.64	0	0	0	0.64
6to5	43.52	259.84	149.76	0.64	0	0	453.76
6to7	134.4	1188.48	740.48	5.12	0.64	0	2069.12

Changes in 6	**286.08**	**2376.32**	**1320.96**	**5.76**	**0.64**	**0**	**3989.76**
7to1	42.24	747.52	410.24	0	0	0	**1200**
7to5	3.84	82.56	94.72	39.04	2.56	0	**222.72**
7to6	52.48	574.08	714.88	284.8	17.92	0	**1644.16**
Changes in 7	**98.56**	**1404.16**	**1219.84**	**323.84**	**20.48**	**0**	**3066.88**
11 to 7	**0**	**0**	**0.64**	**16**	**504.32**	**56.96**	**577.92**
12 to 7	**0**	**1.92**	**118.4**	**550.4**	**602.88**	**60.8**	**1334.4**
Total Changes	**1141.12**	**15619.84**	**17969.92**	**13071.36**	**5031.04**	**224**	**53057.28**

1=chirpine, 2=other conifers, 3= broadleaf, 4= broadleaf-conifer mixed, 5= grassland, 6=scrub, 7= habitation, 11= alpine pasture, 12= alpine scrub; I=279-981m, II=982-1683m, III=1684-2386m, IV=2387-3088m, V=3089-3790m, VI=>3790m

Of all the nine aspects there was no change in the land-cover classes in northwest aspect. On the contrary, maximum changes were observed in the land-cover classes falling in southern aspect and minimum in the flat areas (Figure-8.15).

Figure-8.15: Land-cover changes during 1988-1995 in different aspects



Broadleaf forests observed highest and alpine vegetation least changes in all the eight aspects. Chirpine, broadleaf-conifer mixed forest, scrub and grassland had maximum changes in southwest aspect while broadleaf forest had maximum changes in northeast aspect. Changes in habitations and alpine vegetation occurred in southern aspects (Table-8.5).

Table-8.5: Changes in area (ha) under different land-cover classes in different aspects between 1988 and 1995

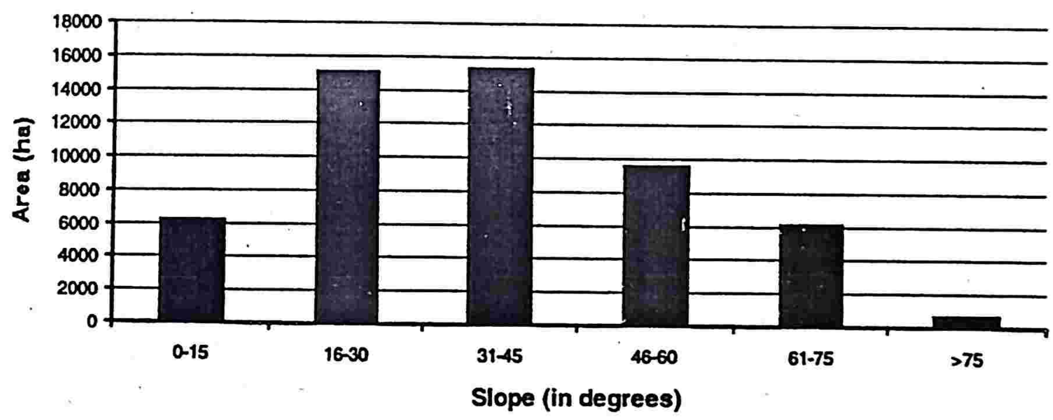
Aspect	F	N	NE	E	SE	S	SW	W	Total
1 to 2	0	0	1.6	0	1.6	0	0	0	3.2
1 to 4	152.32	305.92	583.68	682.88	497.92	513.92	721.92	204.16	3662.72
1 to 6	22.96	38.32	72.24	62.64	46	40.88	60.72	22.96	366.72
1 to 7	3.47	7.31	8.59	8.59	14.99	9.87	11.79	0	64.64
Changes in 1	**178.75**	**351.55**	**666.11**	**754.11**	**560.51**	**564.67**	**794.43**	**227.12**	**4097.28**
2 to 4	220.16	591.36	842.24	1093.1	882.56	815.36	976.64	291.84	5713.28
2 to 6	39.36	93.76	121.28	81.6	62.4	77.12	100.8	43.84	620.16
2 to 7	0	0	7.04	5.12	7.68	16.64	16.64	0	53.12
Changes in 2	**259.52**	**685.12**	**970.56**	**1179.8**	**952.64**	**909.12**	**1094.08**	**335.68**	**6386.56**
3 to 4	854.32	1950	3014.32	2502.3	1982.64	2002.48	2787.76	1094.96	16188.8
3 to 6	59.04	133.92	199.2	174.24	128.16	138.4	185.76	79.52	1098.24
3 to 7	11.36	26.72	35.68	30.56	43.36	30.56	54.24	14.56	247.04
Changes in 3	**924.72**	**2110.64**	**3249.2**	**2707.1**	**2154.16**	**2171.44**	**3027.76**	**1189.04**	**17534.08**
4 to 1	101.12	243.2	353.28	503.68	755.2	791.68	715.52	147.84	3611.52
4 to 2	48.8	99.36	187.68	171.68	176.16	213.28	234.4	68.64	1200
4 to 3	154.56	420.16	671.68	440	325.44	267.84	388.16	180.16	2848
4 to 6	44.24	93.52	159.44	201.68	201.68	176.72	246.48	71.12	1194.88
4 to 7	0	31.26	63.26	134.3	310.3	319.9	214.3	26.78	1100.16
Changes in 4	**348.72**	**887.5**	**1435.34**	**1451.3**	**1768.78**	**1769.42**	**1798.86**	**494.54**	**9954.56**
5 to 1	8.56	24.56	32.88	33.52	25.2	22	30.32	11.76	188.8
5 to 2	5.04	17.2	25.52	23.6	15.92	10.16	17.2	5.68	120.32
5 to 6	177.92	360.32	641.28	668.16	610.56	554.24	800	220.16	4032.64
5 to 7	39.84	65.44	148.64	275.36	425.12	401.44	361.76	56.48	1774.08
Changes in 5	**231.36**	**467.52**	**848.32**	**1000.6**	**1076.8**	**987.84**	**1209.28**	**294.08**	**6115.84**
6 to 1	36	65.44	148	236.96	292.64	280.48	355.36	51.36	1466.24
6 to 2	0	0	0	0	0	0.64	0	0	0.64
6 to 5	16.08	40.4	96.08	81.36	54.48	71.76	67.92	25.68	453.76
6 to 7	45.92	74.72	162.4	320.48	488.16	469.6	436.32	71.52	2069.12
Changes in 6	**98**	**180.56**	**406.48**	**638.8**	**835.28**	**822.48**	**859.6**	**148.56**	**3989.76**
7 to 1	17.92	35.84	65.28	160	340.48	336	215.68	28.8	1200

7 to 5	4.08	9.2	23.28	39.28	48.24	55.92	38	4.72	222.72
7 to 6	30.08	63.36	129.28	261.12	369.92	424.32	314.24	51.84	1644.16
Changes in 7	**52.08**	**108.4**	**217.84**	**460.4**	**758.64**	**816.24**	**567.92**	**85.36**	**3066.88**
11 to 7	**0**	**14.9**	**42.42**	**67.38**	**127.54**	**167.22**	**139.7**	**18.74**	**577.92**
12 to 7	**0**	**29.34**	**92.7**	**186.78**	**326.94**	**382.62**	**283.42**	**32.54**	**1334.34**
Total changes	**2093.2**	**4835.53**	**7928.97**	**8446.4**	**8561.29**	**8591.05**	**9775.05**	**2825.66**	**53057.28**

1=chirpine, 2=other conifers, 3= broadleaf, 4= broadleaf-conifer mixed, 5= grassland, 6=scrub, 7= habitation, 11= alpine pasture, 12= alpine scrub; F=flat, N=north, NE= northeast, NW= northwest, S=south, SE= southeast, SW=southwest, E=east, W=west

Changes in the different land-cover classes when overlaid on slope map showed that maximum conversions or modifications were observed in slope class II and III and least in category VI (Figure-8.16).

Figure-8.16: Land-cover changes during 1988-1995 in different slopes



Chirpine, grassland and scrub observed maximum changes in slope class II and all other categories in slope class III. In all the slope classes broadleaf forest had highest changes followed by grassland in class I, broadleaf-conifer mixed in class II, III, IV and V and least changes occurred in alpine vegetation in all the slope classes (Table-8.6).

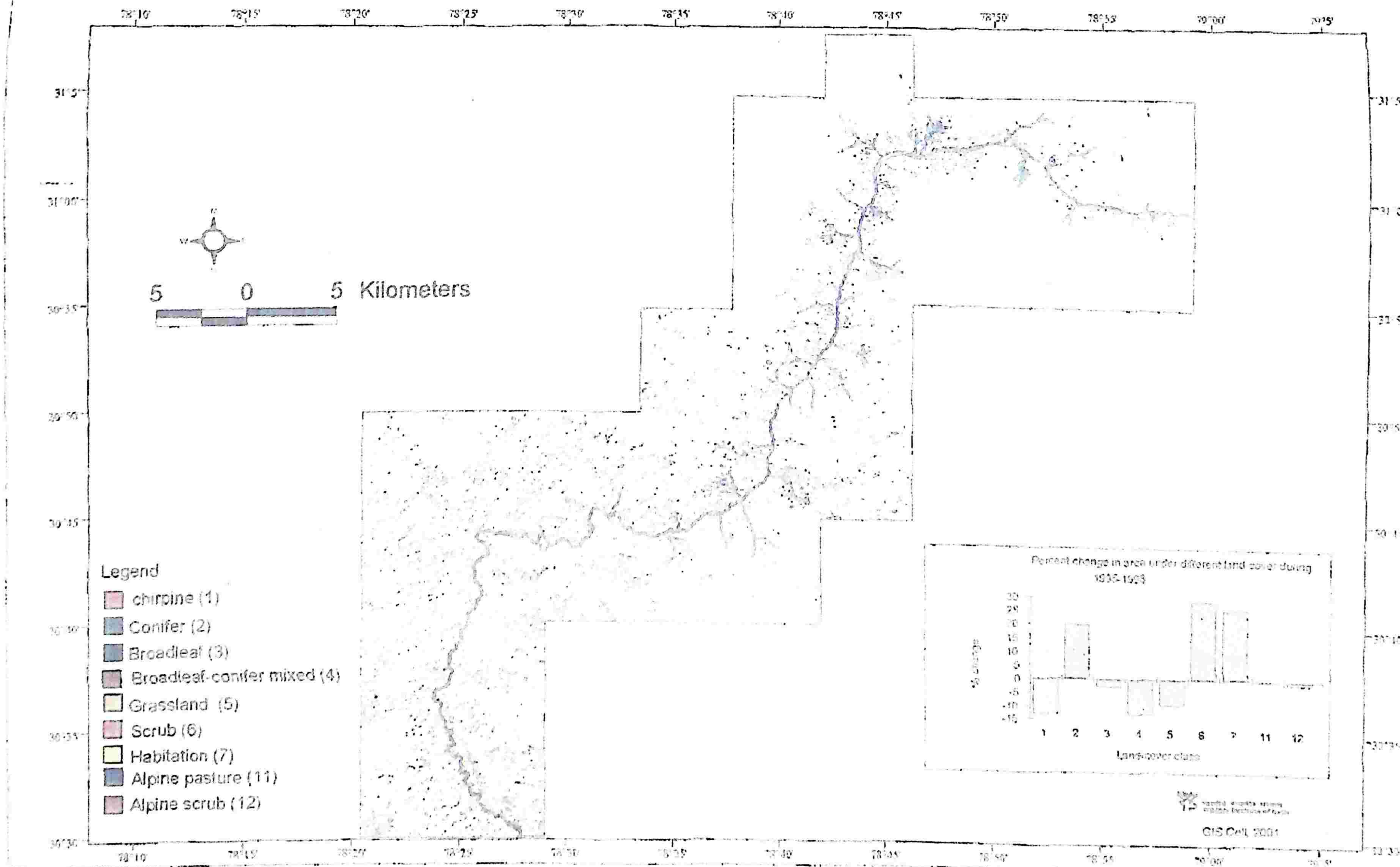
Table-8.6: Changes in area (ha) under different land-cover classes in different slopes between 1988 and 1995

Land-cover	$0\text{-}15^0$	$16\text{-}30^0$	$31\text{-}45^0$	$46\text{-}60^0$	$61\text{-}75^0$	$>75^0$	Total
1 to 2	0	0.64	1.28	0.64	0.64	0	3.2
1 to 4	481.28	1114.88	1066.88	609.28	363.52	26.88	3662.72
1 to 6	77.44	124.16	96.64	48	20.48	0	366.72

1to 7	12.16	23.04	15.36	10.88	3.2	0	64.64
Changes in 1	570.88	1262.72	1180.16	668.8	387.84	26.88	4097.28
2 to 4	535.04	1514.24	1692.16	1026.56	794.24	151.04	5713.28
2 to 6	94.72	180.48	161.28	108.8	65.92	8.96	620.16
2 to 7	5.12	15.36	16.64	11.52	4.48	0	53.12
Changes in 2	634.88	1710.08	1870.08	1146.88	864.64	160	6386.56
3 to 4	1646.72	4314.24	4652.8	3120.64	2206.72	247.68	16188.8
3 to 6	136.96	287.36	316.8	216.96	117.12	23.04	1098.24
3 to 7	27.52	65.92	80	35.84	33.28	4.48	247.04
Changes in 3	1811.2	4667.52	5049.6	3373.44	2357.12	275.2	17534.08
4 to 1	398.08	1090.56	1126.4	654.72	326.4	15.36	3611.52
4 to 2	112.64	337.28	380.8	215.68	144	9.6	1200
4 to 3	237.44	812.8	842.88	503.04	402.56	49.28	2848
4 to 6	160.64	341.76	341.12	227.84	113.92	9.6	1194.88
4 to 7	91.52	260.48	380.16	229.76	124.8	13.44	1100.16
Changes in 4	1000.32	2842.88	3071.36	1831.04	1111.68	97.28	9954.56
5 to 1	41.6	76.16	39.04	23.04	8.32	0.64	188.8
5 to 2	17.92	39.04	30.72	19.2	10.88	2.56	120.32
5 to 6	895.36	1285.76	963.2	578.56	279.68	30.08	4032.64
5 to 7	279.68	629.12	433.92	280.96	136.96	13.44	1774.08
Changes in 5	1234.56	2030.08	1466.88	901.76	435.84	46.72	6115.84
6 to 1	186.24	464	454.4	226.56	133.12	1.92	1466.24
6 to 2	0	0	0.64	0	0	0	0.64
6 to 5	84.48	153.6	99.2	81.28	33.92	1.28	453.76
6 to7	278.4	736.64	563.84	316.8	163.2	10.24	2069.12
Changes in 6	549.12	1354.24	1118.08	624.64	330.24	13.44	3989.76
7 to1	117.12	353.92	404.48	226.56	93.44	4.48	1200
7 to5	37.12	56.32	58.24	43.52	26.24	1.28	222.72
7 to6	193.92	388.48	515.84	339.84	187.52	18.56	1644.16
Changes in 7	348.16	798.72	978.56	609.92	307.2	24.32	577.92
11 to 7	42.88	160	178.56	112.64	69.12	14.72	1334.4
12 to 7	42.24	227.84	430.08	339.2	254.08	40.96	3066.88
Total changes	**6234.24**	**15054.08**	**15343.36**	**9608.32**	**6117.76**	**699.52**	**53057.28**

1=chirpine, 2=other conifers, 3= broadleaf, 4= broadleaf-conifer mixed, 5= grassland, 6=scrub, 7= habitation, 11=alpine pasture, 12= alpine scrub

Figure-8.17: Changes in land-cover classes during 1995-1998



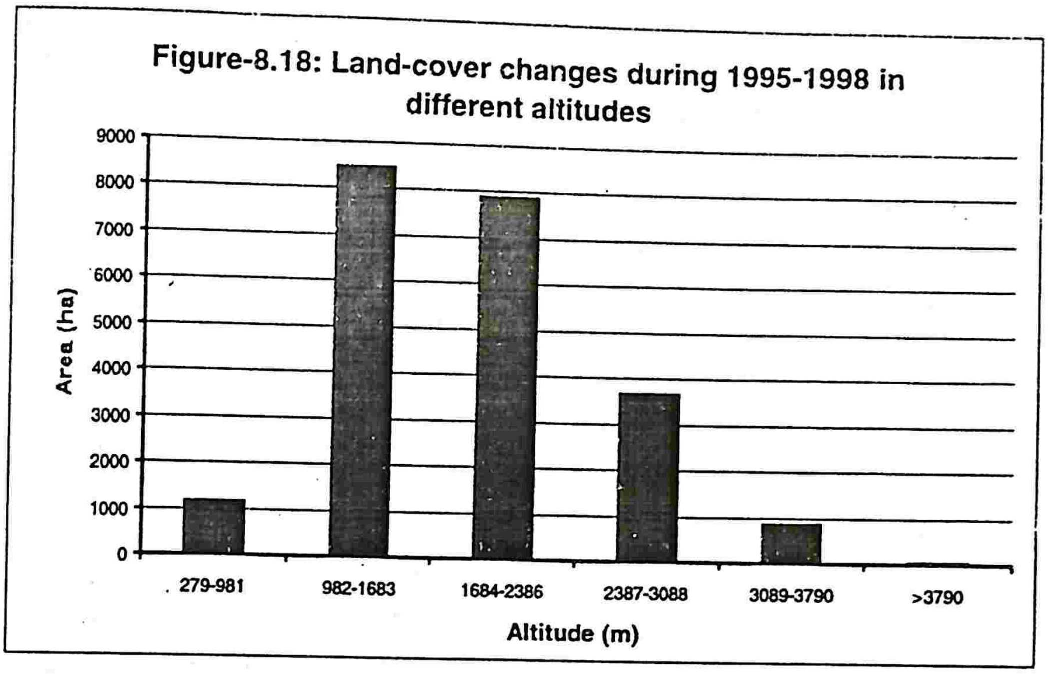
Changes in land-cover classes between 1995 and 1998: It was found that between 1995 and 1998 area under broadleaf, broadleaf-conifer mixed, grassland, alpine pastures and alpine scrub decreased while that under conifers, scrub and habitation increased (Figure- 8.17) leading to conversions or modifications of *ca.* 220 sq. km with the total geographical area remaining the same. Of all the changes in different land-cover classes, highest changes occurred in broadleaf-conifer mixed forest and least in the alpine vegetation (Table- 8.7).

Table-8.7 Matrix showing changes in area (km^2) under different land-cover categories between 1995 and 1998

1998 → / 1995 ↓	1	2	3	4	5	6	7	11	12	Total
1	-	0	0	0	0	9.12	15.11	0	0	**24.23**
2	0	-	0	0	0	2.07	1.56	0	0	**3.63**
3	0	0	-	0	0	3.08	2.61	0	0	**5.69**
4	0	26.4	0	-	0	29.31	18.7	0	0	**74.41**
5	2.48	0	0	0	-	21.73	3.52	0	0	**27.73**
6	4.77	0	0	0	11.02	-	29.77	0	0	**45.56**
7	0	0	0	0	10.3	27.84	-	0	0	**38.14**
11	0	0	0	0	0	0	0.22	-	0	**0.22**
12	0	0	0	0	0	0	1.33	0	-	**1.33**
Total	**7.25**	**26.4**	**0**	**0**	**21.32**	**93.15**	**72.82**	**0**	**0**	**220.9**

1=chirpine, 2=other conifers, 3= broadleaf, 4= broadleaf-conifer mixed, 5= grassland, 6=scrub, 7= habitation, 11= alpine pasture, 12= alpine scrub

Changes in different land-cover classes when correlated with different slope, aspect and altitudinal zones revealed interesting patterns. It was observed that maximum changes in land-cover classes occurred in the altitudinal zone II and minimum in zone VI (Figure-8.18).



Zone wise distribution of changes in land-cover classes revealed that in zone I, highest changes were found in the grassland and minimum in habitation whereas in zone II and III highest changes occurred in broad leaf-conifer mixed class. In zone IV and V habitation had maximum changes. Land-cover wise distribution of changes revealed that chirpine and broad leaf-conifer mixed had highest changes in zone III while broadleaf, grassland, scrub and habitation had maximum changes in Zone II (Table-8.8).

Table-8.8: Changes in area (ha) under different land-cover classes in different altitudinal zones between 1995 and 1998

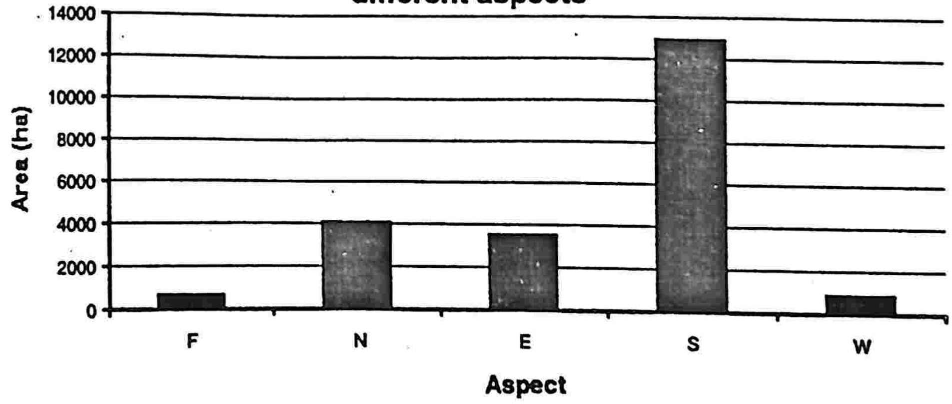
Land-cover	Area under different altitudinal zones						
	I	II	III	IV	V	VI	Total
1to6	56.96	443.52	411.52	0	0	0	912
1to7	66.56	767.36	676.48	0.64	0	0	1511.04
Changes in 1	**123.52**	**1210.88**	**1088**	**0.64**	**0**	**0**	**2423.04**
2to6	0	0	38.4	116.48	46.08	6.4	207.36
2to7	0	0	54.4	81.28	20.48	0	156.16
Changes in 2	**0**	**0**	**92.8**	**197.76**	**66.56**	**6.4**	**363.52**
3to6	11.52	96	103.68	78.72	18.56	0	308.48
3to7	16	136.96	74.88	19.2	14.72	0	261.76
Changes in 3	**27.52**	**232.96**	**178.56**	**97.92**	**33.28**	**0**	**570.24**
4to2	62.08	1431.04	1141.1	5.76	0	0	2640
4to6	62.72	867.2	1512.3	421.12	67.84	0	2931.2

4to7	35.84	588.8	901.76	236.8	106.88	0	1870.08
Changes in 4	**160.64**	**2887.04**	**3555.2**	**663.68**	**174.72**	**0**	**7441.28**
5to1	21.12	169.6	58.24	0	0	0	248.96
5to6	319.36	892.16	341.76	534.4	84.48	1.28	2173.44
5to7	40.32	171.52	70.4	61.44	8.32	0	352
Changes in 5	**380.8**	**1233.28**	**470.4**	**595.84**	**92.8**	**1.28**	**2774.4**
6to1	76.16	288.64	112	0.64	0	0	477.44
6to5	28.16	122.88	289.28	557.44	102.4	1.92	1102.08
6to7	255.36	1261.44	983.04	441.6	35.84	0	2977.28
Changes in 6	**359.68**	**1672.96**	**1384.3**	**999.68**	**138.24**	**1.92**	**4556.8**
7to5	7.68	183.68	264.32	484.48	89.6	0.64	1030.4
7to6	98.56	1064.32	870.4	623.36	128	0	2784.64
Changes in 7	**106.24**	**1248**	**1134.7**	**1107.84**	**217.6**	**0.64**	**3815.04**
11to7	**0**	**0**	**0**	**0**	**21.76**	**0.64**	**22.4**
12to7	**0**	**0**	**0**	**5.12**	**121.6**	**6.4**	**133.12**
Total changes	**1158.4**	**8485.12**	**7904**	**3668.48**	**866.56**	**17.28**	**22099.84**

1=chirpine, 2=other conifers, 3= broadleaf, 4= broadleaf-conifer mixed, 5= grassland, 6=scrub, 7= habitation, 11= alpine pasture, 12= alpine scrub; I=279-981m, II=982-1683m, III=1684-2386m, IV=2387-3088m, V=3089-3790m, VI=>3790m

Analyses of changes in land-cover classes in different aspects revealed that maximum change occurred in southern aspects and least in the flat areas (Figure-8.19).

Figure-8.19: Land-cover changes during 1995-1998 in different aspects



In all the aspects broadleaf conifer forest observed maximum changes and alpine vegetation the least. In flat areas besides broadleaf-conifer forests, grassland also depicted significant changes. On the other hand, in the southern aspects habitation underwent maximum changes. Chirpine, conifer, broadleaf, broadleaf-conifer mixed, habitation and alpine scrub have undergone maximum changes in southern aspects. Northern aspects had comparatively fewer changes in the land- cover classes (Table-8.9).

Table-8.9: Changes in area (ha) under different land-cover classes in different aspects between 1995 and 1998

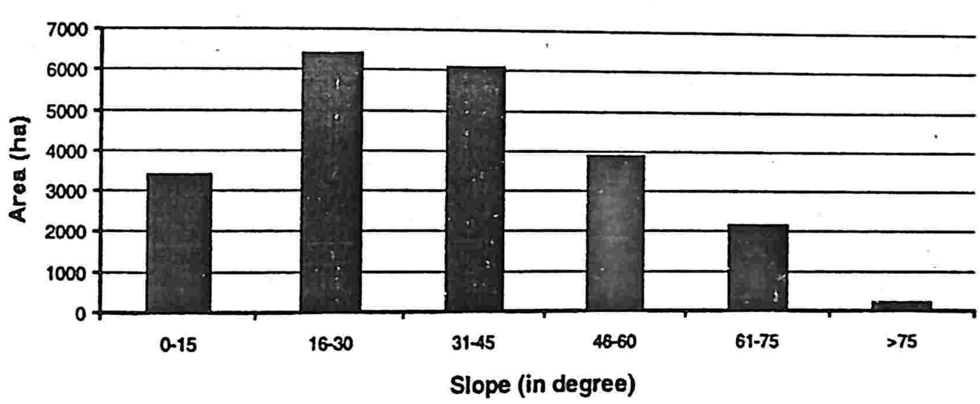
Aspect	F	N	NE	E	SE	S	SW	W	Total
1 to 6	26.88	40.96	70.4	152.96	203.52	185.6	193.28	38.4	**912**
1 to 7	30.08	53.76	83.2	199.68	374.4	391.04	331.52	47.36	**1511.04**
Changes in 1	**56.96**	**94.72**	**153.6**	**352.64**	**577.92**	**576.64**	**524.8**	**85.76**	**2423.04**
2 to 6	0	19.1	30.62	31.9	41.5	37.02	35.1	12.06	**207.3**
2 to 7	2	3.92	9.68	22.48	55.12	39.76	18	5.2	**156.16**
Changes in 2	**2**	**23.02**	**40.3**	**54.38**	**96.62**	**76.78**	**53.1**	**17.26**	**363.46**
3 to 6	20.88	38.8	43.28	40.72	49.04	42.64	54.8	18.32	**308.48**
3 to 7	9.04	21.84	28.24	41.68	63.44	47.44	39.12	10.96	**261.76**
Changes in 3	**29.92**	**60.64**	**71.52**	**82.4**	**112.48**	**90.08**	**93.92**	**29.28**	**570.24**
4 to 2	98.16	421.36	673.52	434.16	275.44	246	369.52	121.8	**2640**
4 to 6	100.16	168.64	340.16	522.56	561.6	523.2	586.56	128.3	**2931.2**
4 to 7	52.32	97.12	154.72	269.92	422.88	419.68	387.68	65.76	**1870.08**
Changes in 4	**250.64**	**687.12**	**1168.4**	**1226.64**	**1259.92**	**1188.88**	**1343.76**	**315.9**	**7441.28**
5 to 1	15.52	35.36	56.48	38.56	28.96	24.48	32.8	16.8	**248.96**
5 to 6	79.2	154.72	309.6	383.2	346.08	368.48	428	104.2	**2173.44**
5 to 7	10.48	22.64	39.92	54	78.32	71.92	61.68	13.04	**352**
Changes in 5	**105.2**	**212.72**	**406**	**475.76**	**453.36**	**464.88**	**522.48**	**134**	**2774.4**
6 to 1	22.72	40	88.64	61.76	67.52	79.04	90.56	27.2	**477.44**
6 to 5	33.2	66.48	122.8	145.2	229.04	263.6	206.64	35.12	**1102.08**
6 to 7	85.12	141.44	277.76	521.6	592.64	597.12	629.12	132.5	**2977.28**
Changes in 6	**141.04**	**247.92**	**489.2**	**728.56**	**889.2**	**939.76**	**926.32**	**194.8**	**4556.8**

7 to 5	15.2	29.28	51.04	131.68	290.4	314.72	172.64	25.44	1030.4
7 to 6	52.08	95.6	224.88	496.24	669.68	633.2	528.24	84.72	2784.64
Changes in 7	**67.28**	**124.88**	**275.92**	**627.92**	**960.08**	**947.92**	**700.88**	**110.2**	**3815.04**
11 to 7	**0**	**1.28**	**1.92**	**3.84**	**3.2**	**4.48**	**7.68**	**0**	**22.4**
12 to 7	**3.12**	**7.6**	**10.8**	**13.36**	**33.84**	**30.64**	**30**	**3.76**	**133.12**
Total changes	**656.16**	**1459.9**	**2617.7**	**3565.5**	**4386.62**	**4320.06**	**4202.94**	**890.9**	**22099.8**

1=chirpine, 2=other conifers, 3= broadleaf, 4= broadleaf-conifer mixed, 5= grassland, 6=scrub, 7= habitation, 11=alpine pasture, 12= alpine scrub; F=flat, N=north, NE= northeast, NW= northwest, S=south, SE= southeast, SW=southwest, E=east, W=west

Of all the slope categories, maximum changes in the land-cover classes were observed in 16-30^0 slope and minimum in >75 ^{0} slopes (Figure-8.20).

Figure-8.20: Land-cover changes during 1995-1998 in different slopes



In all the slope categories broadleaf-conifer mixed showed highest changes and alpine vegetation the least. Slope wise distribution of changes in land-classes revealed that in slope class I, grassland also had significant changes while in class II, III and IV, scrub had significant changes. It was found that chirpine, conifers and broadleaf had maximum changes in slope class III whereas broadleaf-conifer mixed, scrub and habitation showed maximum changes in class II. On the other hand, grassland and alpine pastures had maximum changes in slope class I and IV respectively (Table-8.10).

Table-8.10: Changes in area (ha) under different land-cover classes in different slopes between 1995-1998

CHANGE	0-15°	16-30°	31-45°	46-60°	61-75°	>75°	Total
1 to 6	133.12	283.52	275.2	147.84	71.04	1.28	912
1 to 7	176	429.44	490.88	270.08	135.04	9.6	1511.04
Changes in 1	**309.12**	**712.96**	**766.08**	**417.92**	**206.08**	**10.88**	**2423.04**
2 to 6	12.16	32	64	46.72	39.68	12.8	207.36
2 to 7	14.72	31.36	56.96	33.92	17.92	1.28	156.16
Changes in 2	**26.88**	**63.36**	**120.96**	**80.64**	**57.6**	**14.08**	**363.52**
3 to6	44.16	76.16	73.6	57.6	50.56	6.4	308.48
3 to 7	52.48	77.44	65.92	49.92	15.36	0.64	261.76
Changes in 3	**96.64**	**153.6**	**139.52**	**107.52**	**65.92**	**7.04**	**570.24**
4 to 1	332.16	785.92	782.72	455.68	265.6	17.92	2640
4 to 6	399.36	853.76	826.88	534.4	293.12	23.68	2931.2
4 to 7	210.56	530.56	557.44	359.04	193.92	18.56	1870.08
Changes in 4	**942.08**	**2170.24**	**2167**	**1349.12**	**752.64**	**60.16**	**7441.28**
5 to 1	34.56	86.4	65.92	39.68	20.48	1.92	248.96
5 to 6	730.24	607.36	394.24	262.4	160.64	18.56	2173.44
5 to 7	86.4	114.56	73.6	49.92	24.96	2.56	352
Changes in 5	**851.2**	**808.32**	**533.76**	**352**	**206.08**	**23.04**	**2774.4**
6 to 1	97.92	156.16	123.52	71.04	26.24	2.56	477.44
6 to 5	131.2	233.6	318.08	247.04	151.04	21.12	1102.08
6 to 7	479.36	913.28	832	479.36	251.52	21.76	2977.28
Changes in 6	**708.48**	**1303.04**	**1273.6**	**797.44**	**428.8**	**45.44**	**4556.8**
7 to 5	67.84	256	321.28	231.04	128	26.24	1030.4
7 to 6	371.2	882.56	734.08	497.28	278.4	21.12	2784.64
Changes in 7	**439.04**	**1138.56**	**1055.4**	**728.32**	**406.4**	**47.36**	**3815.04**
11 to 7	**3.2**	**5.12**	**3.2**	**5.76**	**4.48**	**0.64**	**22.4**
12 to 7	**7.68**	**27.52**	**35.2**	**34.56**	**21.76**	**6.4**	**133.12**
Total changes	**3384.32**	**6382.72**	**6094.7**	**3873.28**	**2149.76**	**215.04**	**22099.84**

1=chirpine, 2=other conifers, 3= broadleaf, 4= broadleaf-conifer mixed, 5= grassland, 6=scrub, 7= habitation, 11=alpine pasture, 12= alpine scrub

8.4. Discussion

8.4.1 Patterns of land-cover distribution: Land-cover distribution revealed that most of the area in the Bhagirathi catchment is inaccessible and rugged. Flat areas are confined to valleys or riverbeds. Mountain ranges towards north have altitude > 3790m and have steeper slopes. Here the river flows through deep gorges. On the other hand close to district headquarters, the area is comparatively flat. River Bhagirathi forms a divide line between two ridges running parallel to each other, the area under two major aspects *viz.*, northern and southern are almost equal. As most of the area is topographically unsuitable for agriculture and habitation, area under habitation is comparatively low and area under 'forest cover' is high (>70%). The lower elevation slopes are mostly under scrub vegetation or grassland whereas higher elevational zones are either under coniferous forest or alpine pastures. Land use patterns defined the distribution of area under different land-cover classes and it was observed in the present study that areas close to road head were more inhabited compared to those away from road and scrub vegetation was generally found intermingled with the habitation. Broadleaf forests comprising species of *Quercus*, *Rhododendron*, *Aesculus* and *Acer* are confined to the middle elevation zones. It is the mid-elevation zone, which is currently under human pressure because most of the flat land in the lower elevations has already been occupied and people are now encroaching these zones for agricultural and habitation purpose. Hence the importance of the area from conservation point of view increases manifold.

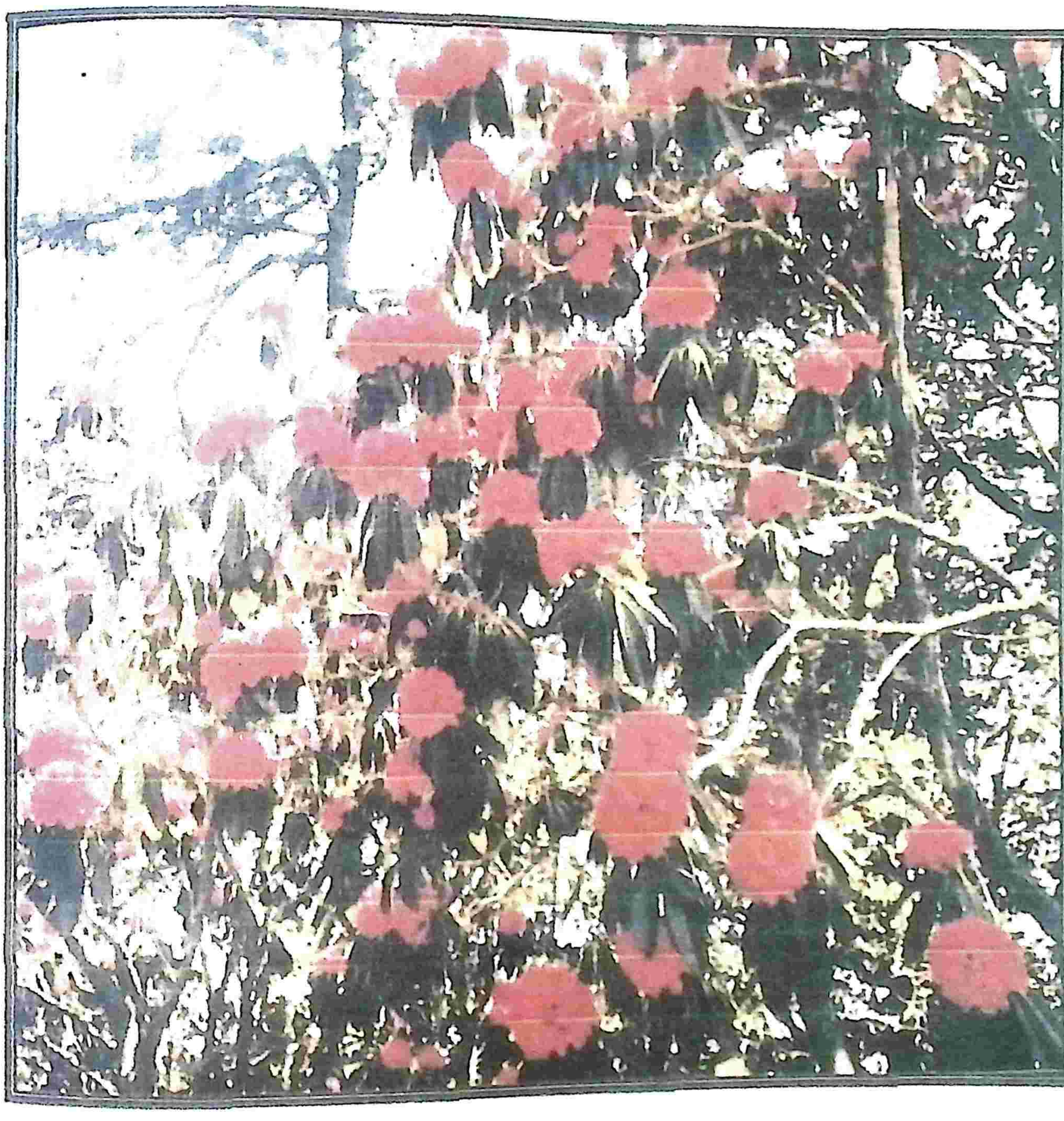
8.4.2. Causes of changes in land-cover: Transition in land-use patterns and natural calamities are the two major factors regulating the changes in different land-cover classes (Meyer and Turner 1994). In the present study too it was observed that natural calamities such as flood in river Bhagirathi in 1978, earthquake in October 1991 and frequent and recurring landslides played an important role in land-cover changes and modifications. Besides, changes in land use practices of villagers, increase in the tourist activities and developmental initiatives have also influenced significantly the land–cover in Bhagirathi valley. Increasing population coupled with influence of market-oriented economy has led to increased area under habitation since past few decades (Chapter 4). Broadleaf forests near the habitations have been converted to scrub forest (Chapter 6). Opening up of canopy of broadleaf forest results in encroachment by chirpine (Singh *et al.* 1984). This could be the one reason behind increased area under chirpine. Besides, another reason could be that forest department also prefers monoculture plantation of coniferous species at the cost of low commercial value broadleaf forest (Johari 1985). Forests in the sub-alpine areas have also been converted to scrub forest due to seasonal migration of local as well as transhumant communities. In the alpine areas, also area under habitation is on the rise due to construction of temporary huts and hotels (Chapter 5 and 7).

Comparison of land-cover classes with those three decades ago revealed drastic changes as expected. Most of the changes in land-cover occurred due to the construction of Gangotri road, after which certain villages such as Bhatwari and Harsil emerged as populated townships. Another plausible factor for increased habitation could be the rehabilitation of two border villages to Dunda and Harsil at the cost of scrub and forest land. Road to Gangotri has also resulted in mass tourism in the valley. Increased influx of tourists since past few years to Gangotri and Harsil has resulted in the increased construction activity not only in the district headquarters but also in the sensitive sub-alpine Gangotri and alpine Gaumukh areas (Chapter-6).

As reported in other parts of the Himalaya (Pant 1995, Ghosh 1996), most of the changes have taken place in the middle elevation zones (1000-2400m). In the present study area middle elevational zones with 30-45^0 slopes are highly fragile and prone to such changes especially increased construction and cultivation at the cost of forests. Lower elevation and sub-alpine forests are already degraded and therefore the pressure is now increasing on mid-elevation zones, which have relatively good forest cover. As observed during three years field work and discussed in preceding chapters (Chapters 4 to 7), RS also proved that major cause of recent changes in land-cover in the Bhagirathi valley is changes in land use practices. Keeping in view the trends of changes in land-cover classes, it is both imperative and urgent to initiate conservation-oriented management of these highly fragile mountain areas.

RS and GIS coupled with proper ground truth proved very helpful tools in time series analyses. This type of analyses would not only help in proper management and conservation of the area but will also be useful for future monitoring.

CHAPTER-9



Conclusions

CHAPTER-9

Conclusions and Recommendations

The forests in the Bhagirathi catchment, Garhwal Himalaya (Uttaranchal) are under the control of Uttarkashi Forest Division. Recent reorganization of the Forest Department in 1994 had led to decrease in area under Uttarkashi Forest Division from 4,78,793 ha in 1988 to 4,63,373 ha. Number of *chaks* (village land amidst forest) have also reduced from 438 to 325. Besides, an area of approximately 2,39,002.40 ha covering 51.58% of the total area under Uttarkashi Forest Division, has been notified as Gangotri National Park (Working Plan 1996). Gangotri National Park (GNP) lies in the Taknore range of block Bhatwari and is a home to several endangered animals such as Musk deer, Brown bear, Bharal and Tahr. Most of the area of GNP is inaccessible and very rugged. Parts of area under Gangotri and Gaumukh shrines has been excluded from the park. However, the forests outside GNP is under high pressure due to increasing anthropogenic pressures. From the present study various causes and processes of forest degradation were assessed. The findings of present study can also be used for conservation planning and future monitoring.

9.1 Causes

9.1.1 Transition from subsistence to market oriented economy: A change in the land use practices of villagers was observed in the valley since nineteen eighties. Villagers have generally stopped growing indigenous crops and have started promoting potato, soyabean and kidney bean as cash crops. Habitation and agricultural activities that were restricted upto 2000m in the beginning of 20th century have now reached even to the sub-alpine areas.

9.1.2 Increased dependency on forest resources due to population growth and transition in traditional transhumance practices: Several traditional practices are also under transformation, one of them is the seasonal migration to alpine meadows. The seasonal migration has become a part of their economy rather than just the traditional practice.

9.1.3 Attitude and behaviour of visitors: Since past few decades, there has been a rise in the number of tourists visiting Bhagirathi catchment. More than the visitor number, variations in attitude and behaviour of visitors influence the degradation of forests. Besides, the attitude of lodge managers and temple authorities is also responsible for the degradation of tourist sites.

9.2 Processes

Major processes of change which have been observed in the present study due to above mentioned causes include:

- Increased area under cultivation at the cost of fallow, abandoned and forest land
- Increased extraction of non wood and wood products
- Resource scarcity especially fodder for livestock (e.g. of agricultural by-products)
- Conversion of broadleaf forest to scrub and scrub to cultivation
- Increase in the number of temporary huts and hotels in the sub-alpine and alpine zones
- Increased non-biodegradable garbage dumps in the sub-alpine and alpine zones
- Increased human-wildlife conflicts
- Changes in the land-cover categories

As highlighted in other parts of the world (Rappaport 1971, Singh *et al.* 1984, Golley 1985, Singh 1995), it is evident from the present study also that the three practices *viz.,* agriculture, livestock rearing and forest resource extraction are interrelated and any alteration in one will certainly influence the other (Figure-9.1) which in turn may affect the structure and composition of surrounding forests.

9.3 Traditional pro-Conservation Practices

Traditionally the local people have their indigenous ways to conserve forests. However, with changing land use practices, this knowledge has vanished from many places. Shortage of forest produces has again made people to establish and follow certain regulations to conserve forests and forest products (Metz 1990, Zurick 1990). In the present area also, people in some villages still follow certain conservation-oriented practices such as community management of grasslands (*Rakeeta*). This not only improves the fodder base of local people for winter season but also protects the land from grazing until the seeds have been shed. Similarly, in one of the study village (Syaba), people have started using the same bamboo culms repeatedly for many years, reducing the annual extraction of bamboo. Such conservation practices have helped in the restoration of environment at some places in Garhwal Himalaya (Kumar *et al.* 1997). Having known the trends of transformation, the need to follow and promote such practices becomes very essential for the conservation of forests as well as the resource base of locals.

9.4 Future Implications of the conclusions

It is evident from the trends visualized in the present study that in the near future more ecologically sensitive areas might be brought under cultivation as most of the flat area in the lower altitudes have already been occupied. With more inclination towards cash crop cultivation, fertility and productivity of the land might decline leading to abandonment of many agricultural fields and creation of new fields at the cost of other landuse. Area under broadleaf forest might get converted to other categories such as scrub or broadleaf-conifer mixed due to encroachment of pine in degraded oak forest. Increased number of tourists might increase the demands of fuelwood and timber not only in the townships but also in the sub-alpine and alpine areas influencing the status of timberline forest which have restricted growth period. The present study being the baseline database on human-forest relationship for the Bhagirathi valley would certainly prove helpful in future monitoring and conservation of the forests.

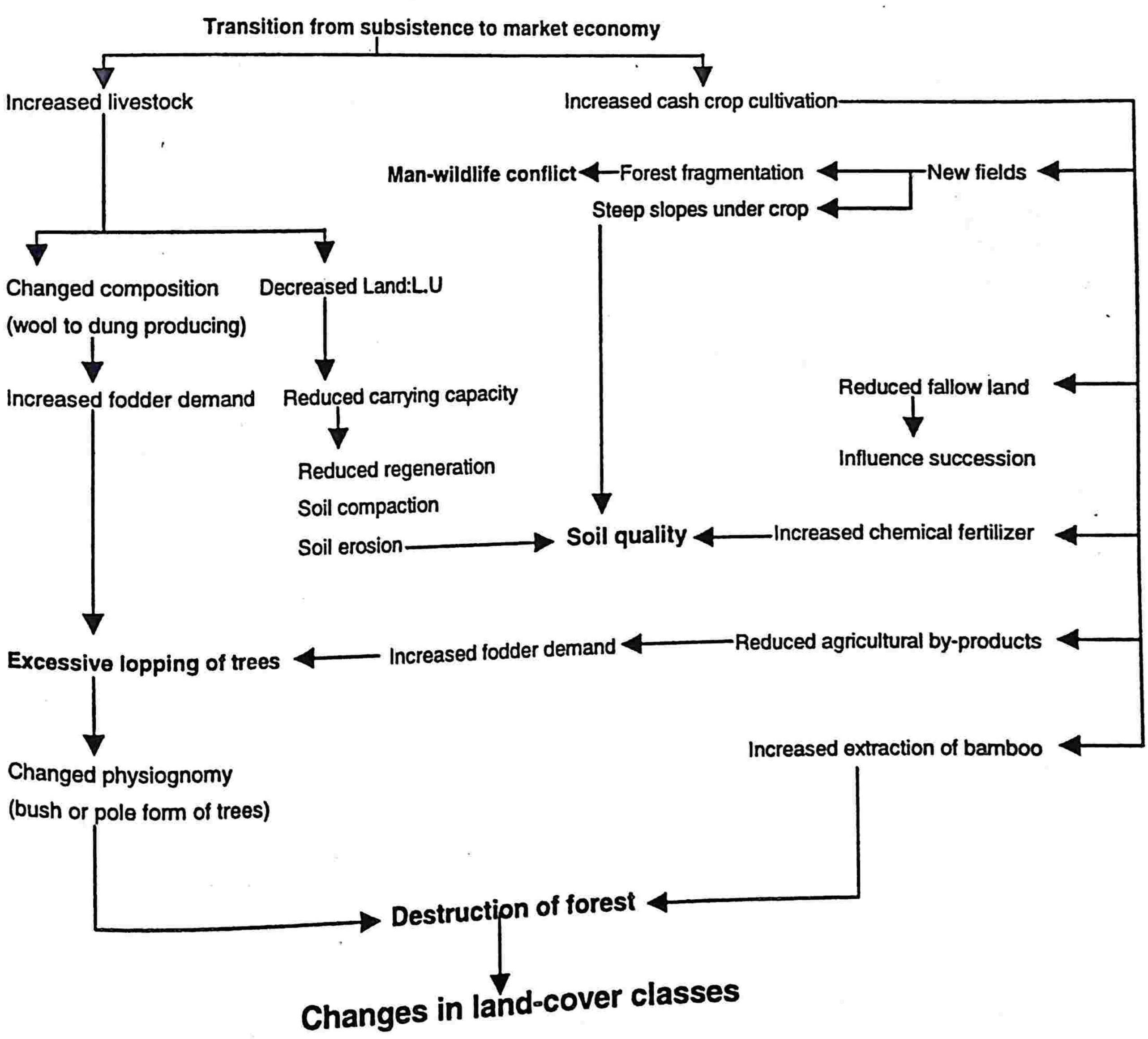
9.5 Recommendations

Based on the findings of present study few suggestions for the conservation oriented management of the area include:

- Promotion of traditional pro-conservation practices of villagers
- Plantation of multipurpose trees species by the villagers on their fallow land, seedlings for which should be provided free of cost by the Forest Department
- Before plantation proper training should be given to villagers

- Bamboo, a shrub preferred by locals for various household articles and also important for the ecology of mountains should be planted on the village wastelands and people should be encouraged to sell locally made bamboo handicrafts in local fairs and tourist sites
- Cultivation of medicinal plants can become a substitute for cash earning crops such as potato. Medicinal plant cultivation and apple orchards would not only solve the socio-economic problems but will also help in conservation of the forests.
- Nature trails which have been neglected should be developed for nature lovers. Local people should be encouraged to serve traditional and indigenous food and facilities in their huts, as has been done in states of Rajasthan and Gujarat.
- More lodging facilities should be provided *en route* so that there is less pressure in sub-alpine and alpine areas during peak tourist season.

Figure-9.1: Impact of change in one resource base on related resources



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APPENDIX-3.1

Village Profile Questionnaire

Date:

1. Village/block: Elevation:
2. Person Interviewed: Position:
3. When was village established?
4. Distance to the nearest forest:
5. Population:
   Total:
   Male:
   Female:
   Children:
6. Households:
7. No of Kaccha House: No .of Paccha house:
8. **Facilities:**
   Dispensary
   School
   Electricity
   D.water
   Gas
   Road
9. Occupation: Agriculture/Service/Business/Others
10. **Livestock:**
    Cattle:
    Buffalo:
    Goats:
    Sheep:
    Others:
11. Livestock: Stallfed /Graze
12. Any visiting graziers: Y/N
13. Any permit needed for grazing: Y/N
14. Preferred species of grasses/fodder:
15. Total land:
    Village:
    Panchayats:
16. Nearest town: Distance:
17. Any fuelwood depot: Y/N
    a. Place: b. Distance:
18. Fuelwood/Fodder collection from: Forest / Van Panchayats
19. No. of trails radiating from the village for forest and road:

20. Distance travelled to collect fuelwood / fodder:

21. Species preferred for fuelwood, timber, and fodder:

22. No. of people dependant on fuelwood only:

23. Most suitable season for collection:

24. Any other NTFP being collected: Y/N

    If yes, name of NTFP:

25. Wild Animals seen or heard:

26. Poaching: Y/N

27. People injured / killed by wild animals:

28. Any handicrafts: Y/N

29. Notes:

APPENDIX- 3.2
Household Schedule

1. Date:

2. Village: Block:

3. Name of respondent: Caste: Community:

4. Family composition:

Member	Age	Sex	Highest level of education	Occupation			Income
				Ag+ Dw	Ag+oth	Ag.+ser.	

5. Housing:

Type	Construction Material			Electric Current	Toilet		Drinking Water
K/P	Floor	Wall	Roof	P/A	K	P	P/A

6. Health:

Source of treatment: Home, Local vaidya, Pvt.Doctor, Hospital.

7. Domicile:

a. Original inhabitant or Migrant: O/M
b. If migrant, year of migration:
c. Place of migration:

8. Follow transhumance: Y/N, if yes then

a. When do you migrate:

b. Period of journey:

c. No. of family members accompanied:

d. Duration of stay at the high altitude:

e. Casualties of animals while migrating:

1.Natural Death:

2. Killed by Predators:

f. No. of halts/camps:

g. Resource use:

9. Land holding pattern

S.N	Particular	Area in local units (naali)
1	Cultivated	
2	Fallow	
3	Barren	

10. Irrigation facilities: Y/N

a. Sources of irrigation: Gul /Canal/ others

11.a. Cropping Pattern:

Season	Crops	Cropping Pattern		Area	Yield/unit last year	Do you sell?Y/N		Total income	Agency
		Sow	Harvest			Q.S kg.	Rate/ kg		
Summer									
Winter									

b. Fruit production: Do you own fruit trees? : Y/N

Sp.	No. of trees	Prod./yr (kg/no)	Own consumption	Selling of raw fruits		Process. items sold		Agency to Whom sold	
				Qua.	Rate	I	R	R	P

I=item,R=rate,R=raw,P=processed

12. Manuring Pattern: Cow dung/ Fertiliser/others

13. Livestock:

Animal Species	No.	Daily consumption (kg)	Days/year grazed	Fodder grown (kg)	Fodder purchased (kg)

14. Receipts from Livestock & Poultry:

Item	Q.Produ. or No.Produ.	Q.Sold/ month	Consum./ month	Cost/ unit	Total Income (Rs.)	Agency to Whom sold
Milk						
Milk Prod.						

15. Fuel & Fodder collection:

a. What fuel do you use for cooking? Fire wood/Kerosene/Gas/Others

b. Fuel Wood consumption:

Sp.	Sources*	Distance	Consumption/day			Preferred season	Head loads coll./day
			W	S	R		

* 1.market 2.forests 3.van panchayat 4.within village 5.agricultural fields.

c. Fodder collection pattern (perday in Kg):

Type	Sources*	People engaged	Distance	No. of trips/month	Head loads/trip	Sp. preferred	Season		
							S	R	W
lopped fodder									
grass									
others									

* market,forest,van panchayat,within village,agri.field

16. Extraction of minor forest products/medicinal plants

a. Do you collect MFP? Y/N

Name	Part used	Distance	Season	Quantity	Uses	Income	Remarks

b. Extraction of medicinal plants

Name	Source	Part used	Season	Quantity	Uses	Quantity Sold	Income/year

17. **Development Interventions:**

a. Are you aware of any rural development scheme launched by Govt.? Y/N

b. Direct benefit to household if any : Loan, Subsidy, Grant

c. .Are you aware of benefits received under other programmes (since1980-81)? Yes/No

1. Jawahar Rojgar yojana:
2. Social Forestry:
3. Adult Education:
4. Any other:

18 a. What are the developments in the village since past ten years?

b. What are the development problems of your village?

c. If there is degradation due to development? Y/N

If yes, kind of degradation :

19. Do any handicrafts exist: Y/N

20. Wild Life Status:

Wild animal	Last seen	Group/Single	Place	Poaching	Any Change in No./ behaviour

21. Tourist: Do trekkers and tourists pass through your village? Yes/No

If Yes, seasonal/non seasonal

a. No of tourist passing through per season:

b. If you earn something from them: Yes/No

c. Kind of earning:

d. Where do they halt:

e. What is your fuel wood consumption during the tourist season and in usual season?

22. Priority needs:

a. Employment
b. Fuel wood
c. Fodder
d. Fruits
e. Manure
f. Irrigation
g. Any other

23. What is the condition of nearby forest? Good/Bad/Worst

24. General remarks.

APPENDIX-3.3

Seasonal Migrants (*Gujjars*)

1. **Date:**

2. **Period:**

   a. Arrival month:
   b. Period of stay:
   c. Return journey:
   d. Time taken to reach:
   e. Route:
   f. Resource use during journey:
      i. Fuelwood:
      ii. Fodder:

3. **Settlement:**

   a. Place of stay in high altitude: In Plains:
   b. Do you change the settlement site each year? Y/N
   c. Settlement: Tents/ Channs/ any other
   d. Material used to construct Channs: Quantity/chann:
   e. Annual renovation: Y/N
   f. Permit: Y/N

No. of Deras	No. of Families/Dera	Population/Dera			
		Male	Female	Children (<15yrs)	Total

4. **Community:**

5. **Occupation:** Dairy/Agriculture/Other
Daily activity:

6. **Fueluse**
   a. Source of fuel: wood/kerosene/any other, if fuelwood
   b. Fuelwood:

Source	Distance (km)	Quantity collected (kg/day)	Quantity consumed (kg/day)	No. of trips/month	Plant Species	Purpose

   c. Permit: needed: Y/N

7. **Diet:**

8. a. **Livestock:**

Animal	Number	Dry	Milch	Stallfed/Grazed/Both

b. If Milch, **Dairy Products:**

Products	Quantity Produced/day	Self/Sale	Rate/Unit	Income/month	Total expenses	Agency

9.a. Fodder Collection:

Type	Species Preferred	Source	Distance	Quantity Collected (kg/day)	Quantity Consumed (kg/day)
Lopped Fodder					
Grasses					
Other					

b. Do you collect leaf litter for cattlesheds? Y/N If yes, how much per day?

10. Minor Forest Products

a. Do you collect any minor forest products? Y/N

If yes,

Product	Source	Use	Quantity (/trip)	Trips /month	Sale or Self use	Rate/ Unit	Total expenses

11. Wildlife:

a. Have you ever seen or heard of any wild animal during your stay? Y/N

If yes,

Animal	Location	Last Seen	Group/Single	Poaching	Behaviour of animals

b. Human Wildlife Conflict:

- **Livestock loss by wild animals:**

Any other loss:

12. Relations with local folk: Good/bad/worst

13. Tourist:

a. Do you get any benefit from tourist? Y/N

If yes, What kind of benefit do you get?

b. According to your past experiences how many tourists come each season?

c. What kinds of tourists come? Group/Single/Couple and Foreigners/Indian

d. Where do they stay?

14. What is your opinion regarding the status of forests surrounding settlements?

Excellent/Good/Bad/Worst

15. What are the changes in land use since past twenty years?

General Remarks:

APPENDIX-3.4

Questionnaire For Tourists

(WII has initiated a project in Bhagirathi catchment to assess the impact of tourism in this area and your co-operation by filling this format will be highly appreciated).

Date:

1 a. Name:
b. Address:
c. Occupation:

2 a. You are coming from:
b. You will be going to:

3. Did you come alone or with a group? A/G
If in group, no. of people in group:

4. How did you come to know about this place? Books/Brochures/Films/Friends

5. What is your purpose of visit?
Trekking/Wildlife viewing/Educational- tour/Photography/Pilgrimage/Meditation

6 a. How many times have you come here earlier? None/Once/Twice/More than twice
b. Did you notice any change in this trip? Y/N
If yes, Kind of difference:

7. What was your route and halting stations?

8. Do the local people have handicrafts or other items, which you bought or would have like to buy and carry? Y/N

9. What was the mode of transport used by you to reach this place?
Bus/Car/Taxi/Foot

10 a. Where did you stay in Gangotri? Hotels/Tents/Ashrams
b. Where did you stay in Gaumukh? Hotels/Tents/Ashrams

11. How long do you intend to stay in Gangotri and Gaumukh?

12. During your stay, you depend on: Packed food/Prepare yourself/hotels

13. Do you use forest resources while travelling through the forest? Y/N
If yes, what kind of resource? Fuelwood/Medicinal Plants/Ornamental Plant

14. Where do you throw the garbage? Dustbins/Dig a pit/Burn it/Take it back

15. Have you noticed any kind of disturbance in the surrounding forest or environment? Y/N
If yes, Kind of disturbance: Crowding/Litter/Trampling/Deforestation/Urbanisation

16. What did you like most in the area?

17. Was the purpose of your visit achieved? Y/N

18. Would you come to this place again? Y/N, if yes, why?

19. Are you satisfied with the facilities out here? Y/N

20. Suggestions for betterment of the area?

General Remarks:

Thank you once again for giving your valuable time and co-operation.

APPENDIX-3.5

Questionnaire For Tourists In ISS

1. Date:

2. Name:

3. Occupation:

4 a. You are coming from:
b. You will be going to:

5. Did you come alone or in groups? A/G
If in groups, no. of people in group:

6. How did you come to know about this place? Books/Brochures/Guide/Friends/any other

7. What is the purpose of your visit: trekking/wildlife viewing/educational –tour/photography/any other

8. How many times have you come here? None/Once/Twice/More than Twice

9. Did you notice any change in this trip? Y/N, if Yes, kind of difference:

10. What was the mode of transport used by you to reach this place? On foot/mule

11. Where did you stay? Hotels/Tents/any other

12. How long do you intend to stay here?

13. During your stay, do you take packed food/prepare your self/ hotels?
If prepare yourself, what fuel do you use?

Fuel	Source	Quantity/Food	Species

14. Where do you throw the garbage?

15. Do you use any resource of the forest via travelling? Y/N
If yes, Kind of Source: Purpose:

16. Have you noticed any kind of disturbance in the surrounding forests? Y/N
If yes, Kind of disturbance? Too many people/Litter/Noise/Vehicles/Trampling/Deforestation

17. Were you able to sight any wild animal? Y/N
If yes,

Animal	Location	Group/Single	Behaviour

18. Would you come to this place again? Y/N,
If yes, why?

19. Have you visited any other place similar to this one? Y/N
If yes, which one?

Thanks!

APPENDIX-7.1

List of mammals reported from district Uttarkashi (ZSI 1995, Johari 1985-1995)

Family	Species	Common name	Legal status
Bovidae	*Bos grunniens* Linnaeus✤	Yak	I, SI
Bovidae	*Naemorhedus goral* (Hardwicke)	Goral*	I, SIII
Bovidae	*Ovis ammon* (Linnaeus) ✤	Argali	I
Bovidae	*Capricornis sumatraensis* (Bechstein)	Serow	I, SI
Bovidae	*Hemitragus jemlahicus* (H. Smith)	Himalayan Thar	SI
Bovidae	*Pseudois nayar* (Hodgson)	Blue Sheep*	SI
Cervidae	*Muntiacus muntjak* (Zimmermann)	Barking Deer*	SIII
Cervidae	*Cervus unicolor* (Kerr)	Sambar*	SIII
Moschidae	*Moschus chrysogaster* Hodgson	Musk Deer*	I, SI
Suidae	*Sus scrofa* Linnaeus	Wild Boar*	SIII
Canidae	*Canis lupus* Linnaeus✤	Wolf	I, SI
Canidae	*Canis aureus* Linnaeus	Asiatic Jackal*	
Canidae	*Vulpes vulpes* (Linnaeus)	Common Red Fox*	
Canidae	*Cuon alpinus* (Pallas) ✤	Dhol or Indian Wild Dog	II, SII
Felidae	*Felis chaus* Guldenstaedt	Jungle Cat*	II
Felidae	*Panthera pardus* (Linnaeus)	Leopard*	I, SI
Felidae	*Panthera tigris* (Linnaeus)⇧	Tiger	I, SI
Felidae	*Panthera uncia* Schreber	Snow Leopard	I, SI
Felidae	*Felis bengalensis* Kerr	Leopard Cat	I, SI
Felidae	*Felis viverrina* Bennet	Fishing Cat	II
Hyaenidae	*Hyaena hyaena* (Linnaeus) ✤	Striped Hyaena	
Mustelidae	*Martes flavigula* Boddaert	Yellow throated Marten*	
Mustelidae	*Mustela siberica* Pallas	Siberian Weasel	SIV
Mustelidae	*Lutra lutra* Linnaeus	Common Otter	I
Ursidae	*Ursus arctos* Linnaeus	Brown Bear	I, SI
Ursidae	*Selenarctos thibetanus* (G. Cuvier)	Himalayan Black Bear*	I
Ursidae	*Melursus ursinus* (Shaw) ✤	Sloth Bear	I, SI
Viverridae	*Viverricula indica* (Desmarest)	Small Indian Civet	
Viverridae	*Paraoxurus hermophroditus* Pallas✤	Common Palm Civet	
Viverridae	*Paguma larvata* (Hamilton-Smith)	Masked Palm Civet	
Viverridae	*Herpestes edwardsi* Geoffroy	Indian Grey Mongoose	SIV
Pteropidae	*Pteropus giganteus* Brunich	Indian Flying Fox	II
Soricidae	*Suncus murinus* (Linnaeus)	House Shrew*	
Leporidae	*Ochotona royalei* (Ogilby)	Royale's Pika*	SIV

Leporidae	*Lepus nigricollis* Cuvier	Indian Hare	SIV
Cercopithecidae	*Macaca mulatta* (Zimmermann)	Rhesus Macaque*	II, SII
Cercopithecidae	*Presbytis entellus* (Dufrense)	Langur*	SII
Histricidae	*Hystrix indica* (Kerr)	Indian crested Porcupine*	SIV
Muridae	*Mus musculus* Linnaeus	House Mouse*	
Muridae	*Mus buduga* Gray	Little Indian Field Mouse	
Muridae	*Mus cervicolor* Hodgson	Fawn coloured Mouse	
Muridae	*Golunda ellioti* (Gray)	Indian Bush Rat	
Sciuridae	*Petaurista petaurista phillippensis* (Elliot)	Large brown Flying Squirrel	
Sciuridae	*Funambulus pennanti* Wroughton	Five stripped Pulp	

* direct or indirect evidences of these were also found in the present study, I & II : Appendix of CITES, SI,II,III, IV=schedules of Wildlife (Protection) Act 1972 , ✣=highly doubtful, ⇧= unconfirmed record