Chapter 2
Geo-Environmental Setting

Location and Extension

The Himalaya is the youngest and the highest mountain system of the world. It extends about 2400 km as a massive arc, covering an area of about 612021 km^2; from the Pamir's Knot to the Arakan-Yoma mountain ranges of Myanmar and it covers the parts of Afghanistan, Pakistan, India, Tibet (China), Nepal, Bhutan and Myanmar (Fig. 2.1). The Tibetan plateau, known as the roof of the world, forms the northern boundary of this magnificent mountain system while lower extensions of it branch off from eastern and western frontiers of the mountains. Its largest spread is in the Indian Territory and is called the Indian Himalaya Region. It is located in the north part, known as the crown of India. The Himalayan system is very important strategic location—natural, economic and geo-political; it separates the Indian subcontinent from the Central Asia and China. The Himalaya protects the Indian sub-continent from the severe impact of cold waves, blowing from the Tibetan highland. It is believed that if there were no Himalayan ranges, the north part of India would have converted into cold desert. The Himalaya has tremendous economic importance to India as the major rivers originate from it and flow through almost all the northern states of India. The northern plain is nomenclature as 'the Ganges plain', a most fertile, feeds the highest number of population (approximately 50 % population of the Indian sub-continent), and is made of debris deposited by the Himalayan Rivers. Geo-strategically, the Himalaya is relatively important as it protects the Indian subcontinent from the military invasion of the neighbouring countries—China and Pakistan. The Himalaya is divided into three vertical divisions—the Great Himalaya, the Middle Himalaya and the Lesser Himalaya or the Shivalik Ranges; horizontally, it is divided into five divisions—the Jammu and Kashmir Himalaya, the Himachal Himalaya, the Uttarakhand Himalaya, the Nepal Himalaya and the Assam Himalaya (also known as the Eastern Himalaya) (Fig. 2.2). Uttarakhand Himalaya is further divided into the Garhwal and Kumaon Himalayas. The snow clad peaks of the Himalaya present a picturesque and panoramic view and the Himalaya is one amongst the richest areas in terms of biodiversity resources.

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A case study of the two sub-watersheds—the Kewer Gadhera and Khanda Gad of the Alaknanda Basin was carried out. The Alaknanda Basin represents the eastern part of the Garhwal Himalaya and is extended between 30–31° N and 78° 45′–80° E; it covers an area about 10882 Km^2. Out of the total area of the basin, 433 km^2 is under glacial landscape and rest 288 km^2 is under fluvial landscape. The total number of villages is approximately 2,310. The land under agriculture is 644.22 Km^2, which is 5.9 % of the total geographical area while only 64.8 Km^2 (0.6 %) land is under cultivation of horticultural crops (Sati 2005a, b). This chapter deals with the geography of the Alaknanda Basin that comprises of physiographical divisions, climate and natural resources. Administratively, the four districts of the Garhwal Himalaya i.e., Chamoli, Rudraprayag, Pauri, and Tehri; and a district of the Kumaon Himalaya i.e., Bageshwar comes under the Alaknanda Basin. These districts have eighteen development blocks.

Physiographical Division

The Alaknanda Basin comprises of the hilly terrain, deep gorges and river valley terraces. This basin is broadly divided into four major vertical divisions—the Great Himalayan Ranges, Alpine pastureland, Middle Himalaya and the river valleys. Horizontally, it is divided into the Upper and Lower Alaknanda basins with its different geographical and socio-economic characteristics. Its upper basin covers the part of Bageshwar district, whole Chamoli district and Rudraprayag districts; while lower basin comprises of the parts of Tehri and Pauri districts. The whole basin ranges from about 500 m at Devprayag, where it confluences with the Bhagirathi river to above 8000 m. The physical characteristics of these vertical divisions are as follows:

The Great Himalayan Ranges: The Great Himalayan Ranges are located above 4000 m. Snowline starts at about 3600 m during the summer and at about 2800 m during the winter. The entire region remains snow covered throughout the year. The Alaknanda River and its numerous tributaries originate from the glaciers of the Great Himalayan ranges. The major mountain peaks in this region are Nandadevi (7816 m), Chaukhamba (7138 m), Kamet (7756 m) and Trisul (7120). Nandadevi is the second highest peak of the Indian Himalayan region.

The Alpine Grasslands: Below the snowline and above tree-line, between 2800 m to about 3600 m, alpine grasslands are extensively found. These grasslands are the nature's treasures, providing naturally grown medicinal plants to the local people. The major alpine grasslands are Bedni Bugyal (3354 m), Madhyamaheshwar (3497 m) and Khankharakhet (3100 m). These grasslands remain covered by snow during the winter and in summer, they are major tourists' attraction. The native people of the lowlands immigrate seasonally to these grasslands for summer pasture (Sati 2008a, b, c, d, e, f). The world famous pilgrimages of Badrinath (3100 m) and Kedarnath (3553 m) are located in these meadows.

The Middle Himalaya: This part of the Himalaya comprises of the highlands and mid-altitudes, elevated from 1000 m to about 2800 m. The highlands (2000–2800 m) are mainly covered by the dense forests, including oak and coniferous and remain snow cover during the winter. Mid-altitudes are located from 1000 to 2000 m, are characterised by the high concentration of human population. Agricultural land and human settlements are mostly found in this zone. Many summer resorts are located here where during the summers, climatic conditions remain feasible. These summer resorts play significant role in tourism development of the region. Gwaldam (1875 m), Gopeswar (1293 m), Joshimath (1875 m) and Srinagar (550 m) are the major towns.

Valley Regions: It consists of the river valleys characterised by steep slopes and river terraces; located between about 500 m and 1000 m elevation. The river meeting points, popularly known as *prayags*, are situated in this zone. During summers, the valleys receive high temperature and during winters, the cold waves, which are blowing from the high Himalaya, are present here. Their presence reduces the air temperature. Roads are traversed along the rivers sides and service centres are located on the road heads.

Major Rivers and Their Tributaries

The Alaknanda Basin is source of origin for a number of rivers. Among the major rivers of India, the Alaknanda River and its numerous tributaries (Dauli Ganga, Vishnu Ganga, Nandakini, Pindar, Mandakini, and other perennial streams) make a large river system. Detail descriptions of these rivers are given below:

The Alaknanda River: The Alaknanda River originates from the Alkapuri Bank (Glacier) flows through Badrinath, Vishnuprayag, Nandprayag, Karnprayag, Rudraprayag and finally inlets into the Baghirathi River at Devprayag, where it is called the mother Ganga. Its total length is 195 km and drainage area is 534 crore cubic meter. In the Hindu mythology, it is considered as bridegroom and mother-in-law is the Bhagirathi River. It is also called 'Vishnu Ganga' at 'Badrinath', a famous pilgrimage devoted to the Lord Vishnu.

The Saraswati River: It is a small tributary of the Alaknanda River, originates from the Great Himalayan Ranges, confluences with the Alaknanda near Mana, a last village of Chamoli district. The meeting point of the two rivers is called 'Keshavprayag' which is the first prayag in the Alaknanda River.

The Dhauli River: It outlets from the Niti Pass in Joshimath block (Chamoli District) and inlets into the Alaknanda River at 'Vishnuprayag' about 10 km down from Joshimath town towards Badrinath.

The Nandakini River: It outlets from the Nanda Ghunti, flows through the Ghat block (Chamoli District) and inlets in the Alaknanda River at 'Nandprayag'.

The Pindar River: The Pindar River originates from the Pindari Glacier in Kapkot block of Bageshwar district, flows about 120 km (20 km in Bageshwar

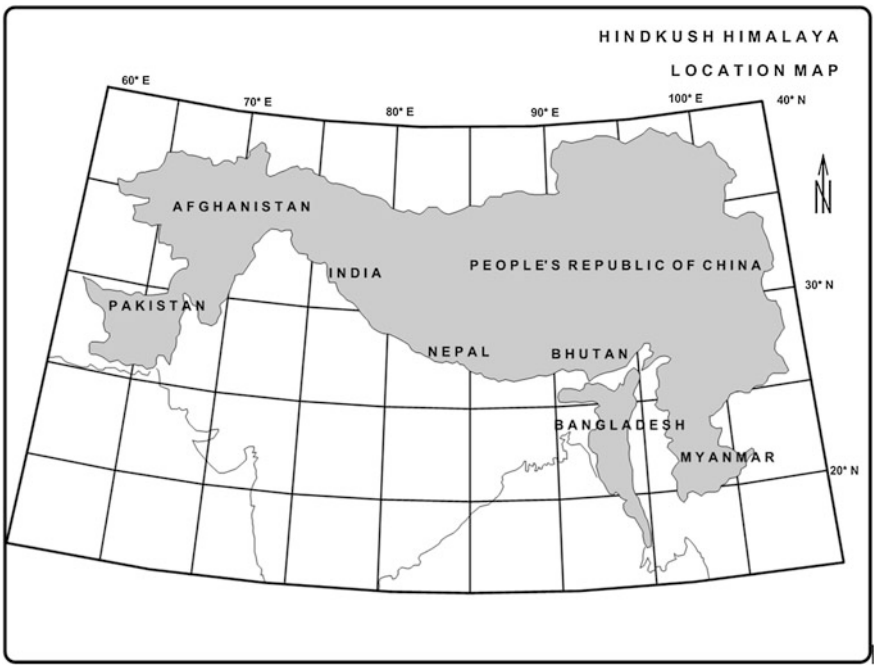

Fig. 2.1 Location map of the Hindkush Himalaya

district and 100 km in Chamoli district), and confluences with the river Alaknanda at 'Karnprayag'.

The Mandakini River: It originates from the Chaura-Bari glacier (Chamoli District) and meets in the river Alaknanda at 'Rudraprayag'. It has numerous small tributaries such as Madhyamaheshwar, Kali and Son rivers (Fig. 2.3).

There are many other perennial streams from small to medium sizes that flow in the Alaknanda River, make this region potentially rich in water resources. Mainly, during the monsoon season, these rivers and perennial streams become very violent; it causes severe damage to agriculture/settlements and to loss of lives.

Climatic Conditions

Climatic conditions are determined by the altitudes, slope aspects, climatic seasons and the presence of the Great Himalayan ranges. The altitudinal differences coupled with varied physiographic divisions, contribute to climatic variations in the Alaknanda Basin. The climate varies from the valley regions (sub-tropical) to the highlands (alpine). Despite diverse physiographic characteristics, sub-regional

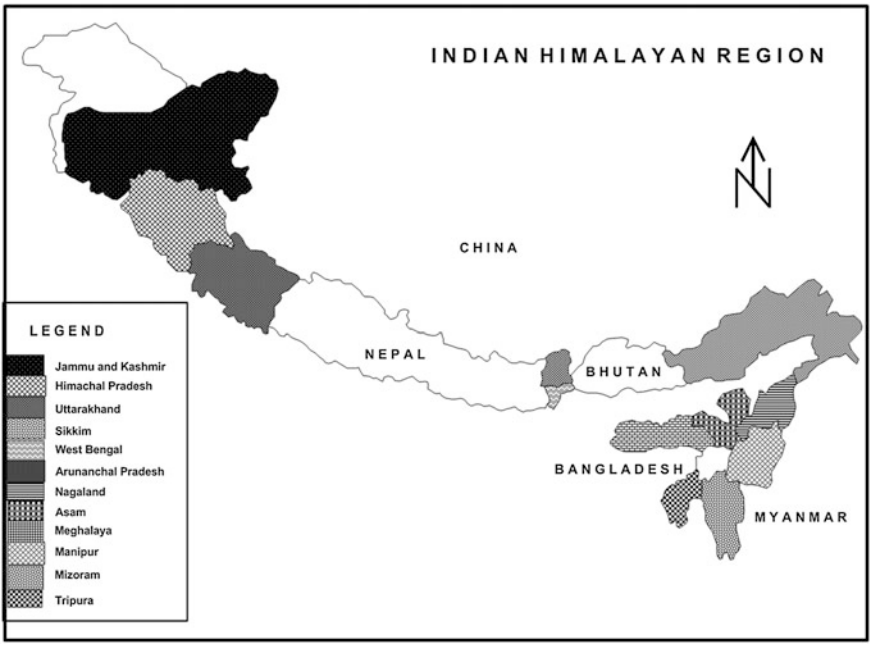

Fig. 2.2 Location map of the Indian Himalayan Region

variations in the average seasonal temperature are not so high. Details of the climatic conditions are presented in the following paragraphs:

Temperature: Temperature varies based on (i) season i.e., summer, monsoon, and winter; (ii) altitudes i.e., from the valley regions (low-lying areas) to the highlands and alpine meadows. The highest temperature was recorded in Srinagar (550 m) in the month of June (30° C) and lowest in Tungnath (3600 m) in the month of Jan (0.5°). Srinagar is a wide valley, covered by the two mountain ranges from the north and the south and between these two ranges, the Alaknanda River flows. It has very contrast climatic conditions. During the summer, it receives high temperature and during the winter, extreme cold waves hit the whole region. As shown in Table 2.1, the whole Alaknanda Basin receives average to low temperature during the entire year. The areas, located above 2000 m, receive heavy snowfall during the winter. Heavy snowfall was observed in Jan 1993, when the low-lying areas (about 900 m elevation), were also covered by snow. Summers are very conducive for health in the mid-altitudes. The valley regions, between Karnprayag and Devprayag, are very warm during summers as monthly temperature averaged about 30° C. During this period, the farming communities migrate to the highlands for summer pasture. Heavy tourist-flow can be observed in the towns of the basin along the Alaknanda River. The large number of pilgrims also visits the two pilgrimages i.e., Badrinath and Kedarnath during the summers.

Table 2.1 Mean monthly temperature in the Alaknanda basin

Name of place	Altitude (m)	Mean monthly temperature ° C											
		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Srinagar	550	14	18	20	25	25	30	29	28	25	27	17	15
Mastura	1800	4	6	12	14	15	20	20	18	17	14	8	4
Joshimath	1875	2	3	7	11	14	17	18	17	16	10	7	4
Tungnath[a]	3600	0.5	1	3	6	7	12	12	11	5	4	2	1

Sources [a] HAPPRC Srinagar Garhwal (Uttaranchal)
India Meteorological Department, Pune, 1990
Sati (2004a, b, c, d)

Rainfall

Rainfall occurs during the two different seasons—summer and winter. Heavy rainfall occurs during the summer from June to October due to monsoon winds. It is known as orographic rain. The entire region gets intensive rain that varies from the valley regions (low rain) to the highlands (high rain) and from north-facing (leeward) to south-facing (windward) slopes. Due to high and long mountain ranges, leeward and windward phenomenon takes place. Cloudbursts, debris-flows, landslides, landslips, mass movements and flashfloods are very intensive as well as frequent. The entire region is worst affected due to these catastrophes during the monsoon season. During heavy rains, there are many instances where the low-lying river valleys were swept away, causing loss of lives and property. During the winter, rainfall occurs due to western disturbances. The wind that originates through the western disturbances makes the entire region cool and as a consequence, cold waves blow. Mostly during December–January months, precipitation occurs in the forms of snow in the higher reaches above 2000 m and rain in the mid-altitudes and the valley region.

Rainfall data were recorded from the four rainfall data recorded stations of the basin (Table 2.2). These stations are located in different altitudes that ranges from 550 to 3600 m. Highest rainfall was recorded in Okhimath (199.4 cm) followed by Karnprayag (147.1 cm) while lowest rainfall was recorded in Srinagar (92.5 cm). This data reveals that in the high altitude rainfall is higher than the valley regions rainfall. However, there are the regions where low rainfall occurs; for example as Joshimath, which is located at 1875 m, received only 107.5 cm annual rainfall because it is located in the leeward direction.

The cold chilly winters of the highlands and humid monsoon climate in the valley regions characterise the climate. This consequently has effect on the farming system and working potential of the populace. Leeward and windward direction of the slopes determines the amount of rainfall places receives. In this basin, Devprayag is located at 500 m (lowest elevation) while Nandadevi peak (7817 m) is the highest point. The physiographic characteristics also determine the climatic conditions. This basin can be divided into five physiographic zones; the low-lying river valleys, the mid-altitude, the highlands, the alpine pastures and the

Table 2.2 Rainfall data in the major towns of the Alaknanda Basin, 2008

Station	Altitude in m	Annual rain in cm	Seasonal rainfall %			
			Winter	Pre-monsoon	Monsoon	Post-monsoon
Srinagar	550	92.5	16.0	17.7	58.8	8.5
Karnprayag	883	147.1	10.5	13.4	15.9	10.2
Okhimath	1578	199.4	8.8	11.3	71.3	8.6
Pauri	1630	130.3	14.8	14.7	61.5	9.0
Joshimath	1875	107.5	15.4	10.3	53.1	12.2

Source Forest Working Plan, Nainital Working Circle (2010)

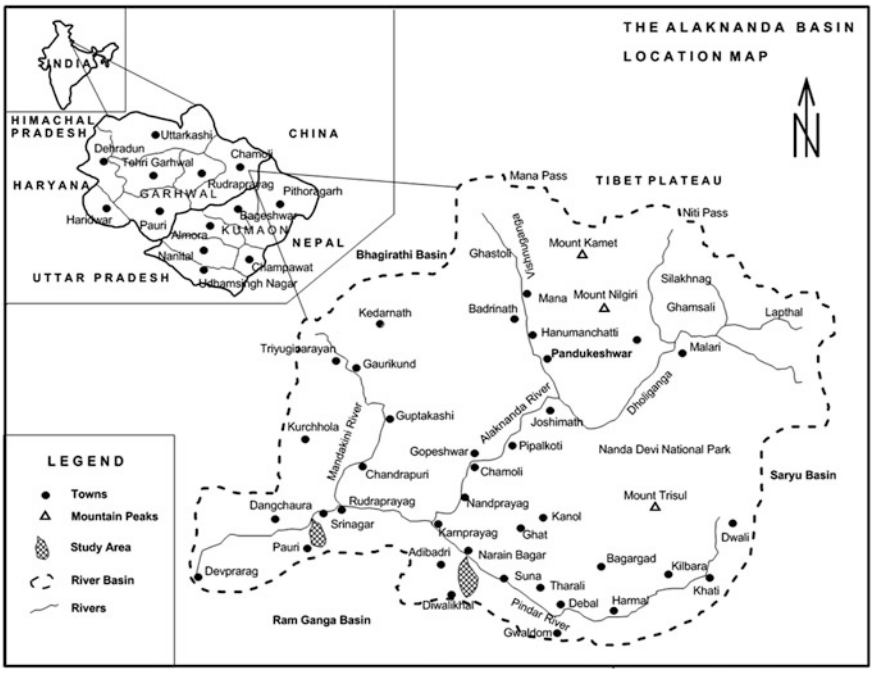

Fig. 2.3 Location map of the Alaknanda Basin showing case study areas

snow-capped mountain peaks. Temperature varies from the valley regions to the highlands and from winter to summer. It reaches down to minus zero degree level in the highlands during the winter. The areas, which are located above 2000 m, receive heavy snowfall during the 4 months of winter. Summer is hot and humid in the valley regions. Meanwhile, mid-altitudes remain mild during the summer and receive heavy downpour. The highland pilgrimages and natural locales are the major attraction for pilgrims and tourists respectively.

Table 2.3 shows rainfall data of the Alaknanda Basin between 1999 and 2004. As the table shows, rainfall intensity and frequency has been changing from year

Table 2.3 Average rainfall from 1999 to 2004

Months	Average rainfall (cm)	1999–2000	2000–2001	2001–2002	2002–2003	2003–2004
May	49	28.9	70.47	93.03	55.87	30.23
June	172.96	135.94	242.65	235	136.36	121.58
July	419.38	314.02	323.99	337.31	183.69	343.48
August	417.41	275.22	374.47	248.84	334.34	347.63
September	201.67	246.6	111.41	40.88	266.9	239.94
October	34.98	39.91	12.97	2.51	10.16	0
November	6.78	0.88	1.36	0.23	3.93	1.8
December	21.92	4.78	13.3	2.56	11.64	13.42
January	51.9	23.54	30.86	30.8	39	45.45
February	59.9	56.15	17.48	39.11	29.69	5.95
March	43.52	24.84	66.82	16.46	16.12	0
April	28.51	28.67	19.09	42.11	30.16	26.33
Total (Average)	125.7	98.23	107.1	90.7	91.1	97.9

Source Compiled by the author from the different sources

to year. It also varies according to (i) the direction of slopes i.e., leeward and windward; (ii) the altitudes i.e., from the lowlands to the highlands. Joshimath, Karnprayag, Okhimath and Srinagar are located in the leeward direction. Therefore, these places receive comparatively less rainfall in comparison to other places that are located in the windward direction as Mandal, Gopeshwar, Gwaldom, Diwalikhal and water dividing regions, facing towards east slopes. Mandal region receives highest rainfall (400 cm) and locally known as Cherrapunji of Garhwal. Average annual rainfall is 125.7 cm. November and December months receive minimum rainfall of 6.78 and 21.92 respectively. During the monsoon period, mainly 2 months of July and August, highest rainfall (above 400 cm) was noticed in the entire region and because of high rainfall, humidity was recorded up to 100 %. The valley regions remain covered by fog during the winter for example, in the months of December-January dense fog occurs in Srinagar Garhwal, a stretch valley of the Alaknanda River and it reduces visibility.

Humidity

This region is characterised by high humidity throughout the year; but the percentage of humidity differs depending upon season and altitude. During the rainy season humidity remains high throughout the whole region whereas, where as, during the summer, humidity decreases especially in the valley regions. Presence of high humidity in the atmosphere provides suitable conditions for growing crops even during the droughts. The drought of 1987, which affected the entire land of India and led to the situations of starvation and food insecurity, did not affect the

Alaknanda Basin (Sati and Kumar 2004). This was predominantly because of the presence of high humidity in the atmosphere. The Great Himalayan Ranges occupy 433 km^2 land of the Alaknanda Basin and the perpetual snow clad ranges of these ranges regulate the climatic conditions viz. temperature, rainfall and moisture.

Climate Change Phenomenon in the Himalaya

Climate change phenomenon is not only a global issue; it also has regional and local dimensions. It has tremendous impact on the land, the oceans and the atmosphere. Meanwhile, mountain regions are worse affected as they are most fragile and vulnerable. This vulnerability is due to the fact that mountains have three dimensional landscapes where high biodiversity—faunal and floral is found. The highly elevated mountain ranges are always covered by perpetual snow. Further, mountains are the major sources of the perennial rivers. Some of the biggest river systems of the world originate from the Himalayan Ranges and more than half of India's population is dependent upon these river systems.

Climate change is observed in the Himalayan region during the past decades. The major changes are seen in the agricultural and horticultural farming along with changing pattern of forest distribution. For example, apples were grown at an altitude of 1600 m during the summer; this is now shifted to the elevation of above 2000 m. This has led to a situation where the cultivation is completely vanished. Similarly, citrus fruits, traditional cereal crops etc., have disappeared from the areas where they were cultivated. As a result, the agricultural land is abandoned.

During the past few decades, simultaneously, changes in the forest distribution pattern were also noticed in the Himalayan Region. The rich diversity of these forest areas is noticeable and it is dominated by the three forest species in the different altitudinal zones. Pine forest lies between 700 and 1600 m, oak forest is found between 1600 and 2200 m and evergreen coniferous forests are located between 2200 and 2800 m. Finally, Alpine meadows are spread above 2800 m. Now, warming of the valleys and the mid-altitudes has resulted in shifting of pine forest to the higher elevation. Consequently, most of the oak forest has been disappeared from their dominating areas (Sati 2006a, b, c, d, e, f).

Potentials of Natural Resources and Their Distribution Pattern

Mountains provide water, biodiversity resources and magnificent landscape. They are the prominent sources of key natural resources—minerals, forests and agricultural products; are storehouse of biological diversity and endangered species;

also caters to great recreational values. As a major ecosystem, representing the complex and interrelated ecology of the planet earth, mountain environments are essential to the survival of the global ecosystem. However, they are rapidly changing. The changes in climate are having its impacts and it is manifested in the form of accelerated soil erosion, landslide, rapid loss of habitat and genetic diversity. As a result, most global mountain areas are experiencing environmental degradation. Further, there is widespread poverty among mountain inhabitants which is accompanied by the loss of their indigenous knowledge. Proper management of mountain resources and socio-economic development of people deserves attention in the wake of global changes.

The Himalayan ecosystem is fragile and diverse. Here, over 51 million people are practicing hill agriculture under high risk and vulnerability. The Himalayan ecosystem is vital to the ecological security of the Indian landmass, as it is providing forest cover, feeding perennial rivers and conserving biodiversity. It also provides a rich base for high value agriculture, and spectacular landscapes for sustainable tourism. It is vulnerable and susceptible to the impacts and consequences of (i) changes on account of natural causes; (ii) climate change resulting from anthropogenic emissions; and (iii) developmental paradigms of the modern society. The Himalaya having largest resources of snow and ice and its glaciers form source of fresh water for the perennial rivers such as the Indus, the Ganga and the Brahmaputra.

Sustainability of the Himalayan ecosystem is crucial for the livelihoods of about 1.3 billion people in Asia. The Himalayan region is rich in biodiversity resources, mineral and power resources, water resources—glaciers and rivers and agricultural resources; yet, high fragility of terrain does not permit to utilise them optimally. Further, any unscientific changes in the ecosystem will lead to ecological degradation. The perennial rivers of north India are largely dependent upon the sustainability of glaciers and the ecosystem of the Himalayan region. In the Himalayan Region, development should be in congruence with the sustainability of the prevailing ecosystem. As mentioned earlier, natural hazards such as terrestrial and atmospheric, are very intensive and frequent throughout the Himalayan region. This restricts and creates hurdles to the development activity.

In the whole world, natural resource management and food security are the prime concerns; this is particularly in the wake of globalization, high growth of population and changing livelihood options. This remains major concern as well as priority for the third world countries where livelihood is dependent on the subsistence agriculture. The Himalayan region is rich in terms of presence of natural resources i.e., flora, fauna and water. Further, rich agro-ecological conditions provide suitability for cultivation of various kinds of crops- subsistence and cash. Water resource has abundance as the major rivers originate from the Himalayan glaciers and flow through this region. These abundant natural resources and suitable agro-climatic conditions are not harnessed sustainably to tackle issues like food insecurity and malnutrition. Lack of infrastructural facilities further accelerates this problem. The economy of the region is largely dependent upon traditional agriculture and on remittances. Meanwhile, the optimum utilisation of these

abundant natural resources can enhance livelihoods and the people of the region can have food security. A case study of the natural resources potentials and distribution pattern in the Alaknanda Basin was carried out. The major findings are as follows:

Soil Resources

Soil pattern and texture varies from the Greater Himalaya to the mid-altitudes and the valleys, and accordingly, soil fertility is varied. Landscape of the greater Himalaya is consisted by very steep to steep slopes, are dominantly occupied with very shallow to moderate shallow, excessively drained, sandy-skeletal and loamy skeletal, neutral to slightly acidic, with low available water capacity soils, without profile development in association with rock outcrops. In the Lesser Himalaya, soil can be seen on steep to moderately steep slopes, is shallow to moderately shallow, excessively drained, sandy/loamy-skeletal/loamy with moderate erosion and moderate to strong stoniness. In the side slopes or terrace slopes, soils are moderately deep to deep, excessive drained, fine loamy slightly too moderately acidic with slight to moderate erosion and stoniness. Soils in glacio-fluvial valley consist of moderately shallow excessive drained, coarse loamy, slightly acidic and moderately stony. Fluvial valley's soils are deep well drained, moderately acidic, slightly eroded, and Typic Dystrochrepts.

Water Resources

Water resources of this region remain mostly underutilized; at the same time it is the most abundant resource of the Himalaya. It is estimated that about 11,00,000 million cubic meter water flows every year down the Himalaya which has a potentiality of generating electricity to the tune of 28000 MW; as much as 247000 million cubic meters water is available for irrigation in the Indo-Gangetic plains (Valdiya 1985). Per capita fresh water availability in the Himalayan Region is calculated to range from 1757 m^3/yr in Indus, 1473 m^3/yr in Ganges, 18417 m^3/yr in Brahmaputra with an all India average of 2214 m^3/yr. The Alaknanda Basin is endowed with bounty of water resources accounting for about 8 % of the total water resources in the country. Unfortunately, this vast potential has not been rationally exploited. Endowed with huge water resources potential, it has also the worst water resource problems rendering untold sufferings to millions every year. The region experiences excessive rainfall and high floods during monsoon months and also suffers from acute shortage of drinking water in many areas due to lack of management. The Alaknanda river and its numerous tributaries (like Dauli Ganga, Vishnu Ganga, Nandakini, Pindar, Mandakini and their sub tributaries) together, which are perennial and glacial fed, presents huge water resources reservoir (Sati 2006a). In many areas, the tributaries

Table 2.4 Water resource potential in the Ganges system

Name	Origin	Confluences	Length in km	Annual drainage (Crore cubic m)
Tons	Har-Ki-Dun	Dakpathar	148	484.4
Yamuna	Yamunotri	Dhalipur	136	165.1
Bhagirathi	Gaukukh	Devprayag	205	253.3
Alaknanda	Alkapuri bank	Devprayag	195	534.2
Nayar	Dudhatoli	Vyasghat	87	162.6
Kosi	Kausani	Sultanpur Patti	168	187.0
Saryu	Tungbhadra	Pancheshwar	146	135.0
Ram Ganga	Dudhatoli	Kalagarh	155	97.2
Kali	Lipulekh	Tanakpur	252	238.7

Source Primary data collection with the help of 'Survey of India Toposheeds'

and sub-tributaries provide ideal sites for micro-hydropower projects. The area of unlimited water resources is facing acute water shortage of drinking and irrigation facilities; sustainable utilisation of water through construction of micro-hydropower projects would definitely solve the duo problems (Sati 2008a). The basic issues underlying the water resources problems are: recurring floods, drainage congestion, soil erosion, human influence on environment etc., and this call for its integrated management so that water requirement for drinking, irrigation, hydropower and recreation can be ensured.

Water, a joint product of land and forest, is the third largest resource of the Himalayan region. The major rivers of India i.e., the Ganga, the Yamuna, the Saryu, and the Kali along with their numerous tributaries, originate and flow from this region. There are 238 glaciers in the Central Himalayan region. Water from these perennial sources can meet the requirements of the whole country, provided it is properly managed. The river Ganga itself can meet the 42 % of the national water need according to estimation. It flows through the eight states of India and meets the demands of tremendous water requirement. Meanwhile, the Central Himalayan region faces severe water crises through out the year. Here, about three thousand villages have acute water scarcity. The Ganga River irrigates only 4 % land. It is estimated that this region receives 663 billion KL water every year from rain. This plenty of water can be used for drinking, irrigation and industrial purposes. Furthermore, if water potential is to be linked with other industries such as packed water, cold water, tourism (water sports) and electricity generation, and if a considerable amount of tax to be paid to the government by the lowlands users, it can become a major resource and can change the economic scenario. There is a potential of generating 30,000 MW electricity. Until now, only 3000 MW electricity is being generated and it serves the lowland areas mostly (Table 2.4).

Management of water resource is a crucial issue because of the undulating terrain and fragility of landscape, which does not permit for construction of macro-level dams. Developmental interventions at micro-level considering drinking water, irrigation and hydroelectricity generation in an integrated manner, have yet to be properly designed and tested. Traditional management of water resource as a

form of *gharat* (water mills) and *gools* (small canals) did not involve any advance technology, while they are absolutely appropriate for this ecologically fragile mountain terrain (Sati 2006b).

Forest Resources

Among the other natural resources in the Alaknanda Basin, forests are most important, both economically and environmentally. The geographical area covered by forest is reported to be 10,21,156 ha, which accounts for around 42.2 %. Ownership of the forest in the state is mainly shared between the forest department (69.1) and Civil and Soyam (community forest (23.4). Forest Panchayats (6.9) and private forests (including cantonment) are other two stake holders and they manage the remaining area. The alpine, temperate and sub-temperate forests that cover most parts of the basin are the natural habitats for some of the best-known wildlife creatures. Alpine forests in the region include Valley of Flowers National Park (known for its amazing variety of flowers), Nanda Devi National Park and Govind Ghat National Park.

The Alaknanda Basin is very rich in terms of forest and its diversity. Right from the valley region to the highly elevated Alpine meadows, locally known as *Kharak* or *Bugyal*, the diversity in plants is very rich and extensive. In the middle altitude, Pine (*Chir*) are found while in the upper reaches, temperate coniferous forest mainly *Kharsu* (*Quercus semicarpifolia*). *Tilonj* (*Q. dilitata*), *Rianj* (*Q. lanuginose*) and *Banj* oak (*Q. leucotricophora*) are abundantly found (Sati 2006a, b, c, d, e, f). Except these forest types, many other fodder plants like, *bhimal* and *khadik*, are also grown along with edges of agricultural fields. The main forests are (i) Deodar Forests (*Cedrus deodara*) are found between the heights of 1650 and 2300 m; (ii) Blue Pine Forests (*Pinus wallichiana*) are also known as *Kail* [These are found in Joshimath areas mostly mixed with Deodar Forests. The tree occurs between 1650 and 2300 m. Timber is used in making sturdy cupboards and pelmets in houses]; (iii) *Chir* Forests (*Pinus roxburghii*) are found in the whole region [Its forests exist mostly between the altitudes of 1000 and 1650 m. It is used for making packing cases and paneling in interior decoration. It is also used as fuel wood]; (iv) Oak Forests (*Quercus species*) [found in the basin between the heights of 1325 and 1625 m. It is used for fuel wood and charcoal manufacturing. It is the best firewood having high caloric value. It is a broad-leaved tree]; (v) Fir (*Abies pindrow*) and Spruce (*Picea smithiana*) Forests are found mostly between 2300 and 2950 m.

Altitude regulates diversity in flora in the Alaknanda Basin. According to altitudinal zones, various kinds of flora with great economic value are found. Most of the forests belts in the basin are inaccessible. Consequently, their economic use is just negligible. In the high altitude, these forests help to increase the soil fertility because soil is brought with rainwater and deposited in the lowlands. The entire basin is ecologically fragile. Landslides and landslips are very common,

particularly during the rainy seasons. Due to heavy rains (known as cloudburst) and steep slopes, this situation is further accentuated. Forests are the main tools for conserving soil and land. To conserve the soil and land, diversity in flora is required.

Diversity in flora is found in all altitudinal zones, dominated by oak and pine forests. Forest covers about 42.2 % of geographical land and it is increasing constantly. A study on land cover change shows that about 1.3 % forest cover increased in the last three decades (Sati 2008b). Forest is the main source of livelihood of the populace. It provides fodder, firewood, timber, non-timber products, herbs and environmental services. Altitudinal variations in forest types are due to changes in the climatic conditions. This region comprises of subtropical to temperate, alpine and cold climatic zones resulted in diversity in natural vegetation gradually from the valley regions to the uplands. Oak and pine forests are useful for firewood, fodder, and timber. The farming community of the region is highly dependent on forests for their livelihood. Pine forests are found mostly in the valley regions and the mid-altitudes patches while oak forests have monopoly over the highlands. The impact of global change can be noticed here as pine trees invaded oak in many areas.

The Himalayan region is amongst the 12 biodiversity hotspots of the world and it has forests ranging from sub-tropical to temperate to alpine. Here, the economic viability of the forest resources is tremendously high therefore, the populace of the region has been engaging in collection of timber and not-timber forest products. In the Indian Central Himalayan Region (ICHR), forest covers above 65 % land area. The economy of the region is based upon the cultivation of traditional cereal crops whose production and per ha yield is considerably low. Thus, the people largely depend on the forest resource for fodder, firewood, and food. Forests have the linkages with agriculture and crops production. For manure composition, most of the tree leaves are used to mix-up with cow-dung that enhances productivity. In the Himalayan region, oak and pine are largely used for firewood and construction of building. Oak leaves are also used as important fodder for the lactating animals. It enhances milk production thus, food security can be obtained. There are numerous forest products which are used as spices to food and medicinal plants and herbs for traditional health care system. The others are essential oils, fibers and silk, natural dyes and organic products, and bees and bee products. Wild fruits as *kafal, hensole, kilmode, bhamore* and many others substantially enhance livelihood options on which the local people are dependent. This illustration reveals that forests are the major source of livelihood thus, need attention for a comprehensive conservation measures. The traditional methods of harnessing non-timber forest products are sustainable that can be restored for the future use of forests.

In the Himalayan region, there are 2,300 guldar, 240 tigers, 1,350 elephant, 250 kasturi mrig, 10,800 sambhar, 10,500 kakad, 5,000 giddha, 53,000 chital and 400 bird's species found in twelve national parks and wildlife sanctuaries. Valley of Flowers, Asan Barrage, Nanda Devi and Gangotri National Parks are the main attraction. The revenue from the forest was Rs. 9150 lakh during 2001–2002 and 20316 lakh in 2007–2008 (Sati 2013). The attitude of the previous governments

and colonial rulers towards forest conservation and utilisation of its products was not very positive. Currently, the forest department is also following the same pathway. Local people have been raising the issues related to their forest rights and are agitating against the Forest Act (FA). The FA is a main hindrance to the construction of national highways, power lines, irrigation, and drinking water projects and the Act even prevents the establishment of schools and colleges. Around 200 development projects are pending due to the FA. The local people are unable to utilise forest resources let it be- timber, fodder or other forest products. From forestation to prevention of fire, the forest department has failed to ensure local people participation. This region has privilege of having some of the Worlds' pioneering Research Institutes such as the Wild Life Institute, the Forest Research Institute, the Forest Survey of India, the Botanical Survey of India, the Zoological Survey of India, the Wadia Institute of Himalayan Geology, the Survey of India, the GBPIHED, the Indian Institute of Petroleum, and the Oil and Natural Gas Commission. But, these institutes could not do much in livelihood enhancement of the local people mostly because of lack of coordination at different levels and between different stakeholders. Forest fire is a major manmade disaster here. In the month of May 2009, there were about 1400 incidences of forest fire. These incidences had greater intensity than the historical forest fire of 1921 and 1995. Forest fire spread about 3000 ha land, killed eight people, and injured two dozen people. Due to implementation of the Wild Life Act (WLA), number of wild animals has shown a remarkable increase, and consequently, man-animal conflict and human deaths also has shown increase. About 200 people died and more than 500 people were injured from the last 9 years (Times of India 2009).

Land Resource and Environmental Services

Land management is a crucial issue in the Himalaya region. Only 8 % land is cultivable with high population pressure and cropping intensity. It is also used for diverse activities. During pre-independence period there were inter-relationship between land, forest and the people. The local people were fully dependent on land, animal and forest. Forest products were the major source of livelihood. In pre-independent India, agricultural land was around 20 %. First FA came into being with classification of forests in 1863. This led forest inaccessible to the local people and put peasants into severe trouble. In 1923, another FA came into force. Some amendments were made after rigorous opposition of the local people. Until independence, the montane people squeezed out to rehabilitate in the productive areas of Doon, Dwar, Tarai, and Bhabar. This was further accelerated by the UP Jamidari Emancipation Act of 1966. Under this Act, community land was converted into forestland. As a result of this, agricultural land could not get any support for extension even after getting the status of a separate state. The government announced to increase agricultural land up to 20 % but it could not do so.

Shrinking agriculture land and mounting population pressure put agricultural land unproductive. It was resulted in a large-scale emigration.

Himalaya Mountain regulates the climatic conditions. Forest sequestrates carbon. Since Uttarakhand Himalaya has abundance of forests, it helps to reduce carbon in the atmosphere. The issues of *Jal, Jangle*, and *Jameen* got attention to provide services to the sustenance of the local people. For the well being of local people, FA and WLA should be amended. Rights should be given to the local people to run their livelihoods from forest and its products. In all activity, participation of the local people should be ensured. Taxes should be imposed on water which runoffs to the plain region. Eco-tourism and cultivating medicinal plants with involvement of the local people will enhance livelihood. Unless agriculture could get a base for livelihood, out migration will be continued. There is need to re-think about the agriculture. Either the per capita land should be increased or the optimum utilisation of the arable land should be ensured using scientific innovation. The compensation for all these environmental service should be given to the people.

Livestock Rearing

Livestock plays foremost role in the livelihood as it is the second main occupation after farming of subsistence crops. On the other, it helps agriculture systems as plowing the field and providing manure. For centuries, organic fertilizer is used as manure, for production of crops. Besides, production of milk plays substantial role to run livelihood. Milk is mostly consumed domestically and is seldom sold in the nearby service centres. Draught animal constitutes the composition of domestic animal kingdom mostly uses in the field of agriculture as draught power. Cows and oxen are outnumbered followed by buffaloes. In the upland areas, goats are reared and used for wool and meat. Recent study on livestock farming reveals that the numbers of domesticated animals are decreasing (Sati and Singh, 2010). The households earlier had more than five cattle now have one or two each. However, the changes in rearing livestock vary from the valleys to the highlands. The valleys are connected by motorable roads. The households have changed their occupation from agriculture to tertiary sector. Consequently, the numbers of livestock reduced considerably. Contrary to this, in the upland areas, subsistence farming system is the main stay, which is based upon the mixed agriculture-livestock farming. Livelihood options have also changed in the uplands as outward migration is increasing and this creates a situation where the major source of income is from remittances. As a result of this, the agricultural practices and livestock are showing retardation.

The climate and agro-ecological conditions provide a base for rearing of high yield variety (HYV) of animals as temperate climate and alpine meadows are widespread in the region. During the 1980s, veterinary centres where established in each block headquarter and HYV lactating cows were given to the farming

communities. Nevertheless, this scheme could not meet with any success. A study carried out by the present author that this was due to mismanagement. The government distributed HYV animals to the poor farmers who were unable to manage them. *Murrah* buffaloes, reared in the upland areas, are high lactating animal. Meanwhile, their numbers are less as compared to draught animals. Rearing of *murrah* buffaloes and high lactating cows can contribute substantial household income. Livestock rearing constitutes major segment in the income and economy of the farming community. It received more significance, when high attention was paid to organic farming during recently. Keeping suitability of landscape, climate and agro-ecological conditions in mind, rearing of draught animals, and lactating cows and buffaloes for enhancing income and economy is inevitable.

Potential of Environmental Services

Water (*Jal*), forest (*Jungle*), and land (*Jameen*) are the three major life sustaining components in the ICHR. About 70 % population of the region are fully dependent on these components for their livelihoods. By and large, the benefits of ecosystem services to the people of the highlands are minimal as they do not receive any payments for these resources (mainly from the inhabitants of the lowland areas, who are noticeably benefitted). For the last many decades there has been debates and expectation that the people of the montane areas of ICHR will get their rights in terms of payment of ecosystem services. Such payment was to be made by the people of the lowland areas; but until now nothing has materialised and no policy is formulated. The natural and ecosystem services of the state can increase the annual turnover more than the annual turnover of the corporate companies and it has the capacity of providing sustainable livelihoods to the local people satisfactorily. It is the need of the hour that the issue of payment of ecosystem services should be raised at the national level so that the populace of the ICHR can enjoy their livelihood rights. The ICHR is the abode of rivers and forest resources. River water is still untapped and it directly runs-off to the Ganges plain, where it irrigates large agricultural land. The construction of micro-dams on these rivers will provide electricity and water not only to the local areas but also to the states of northern India.

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