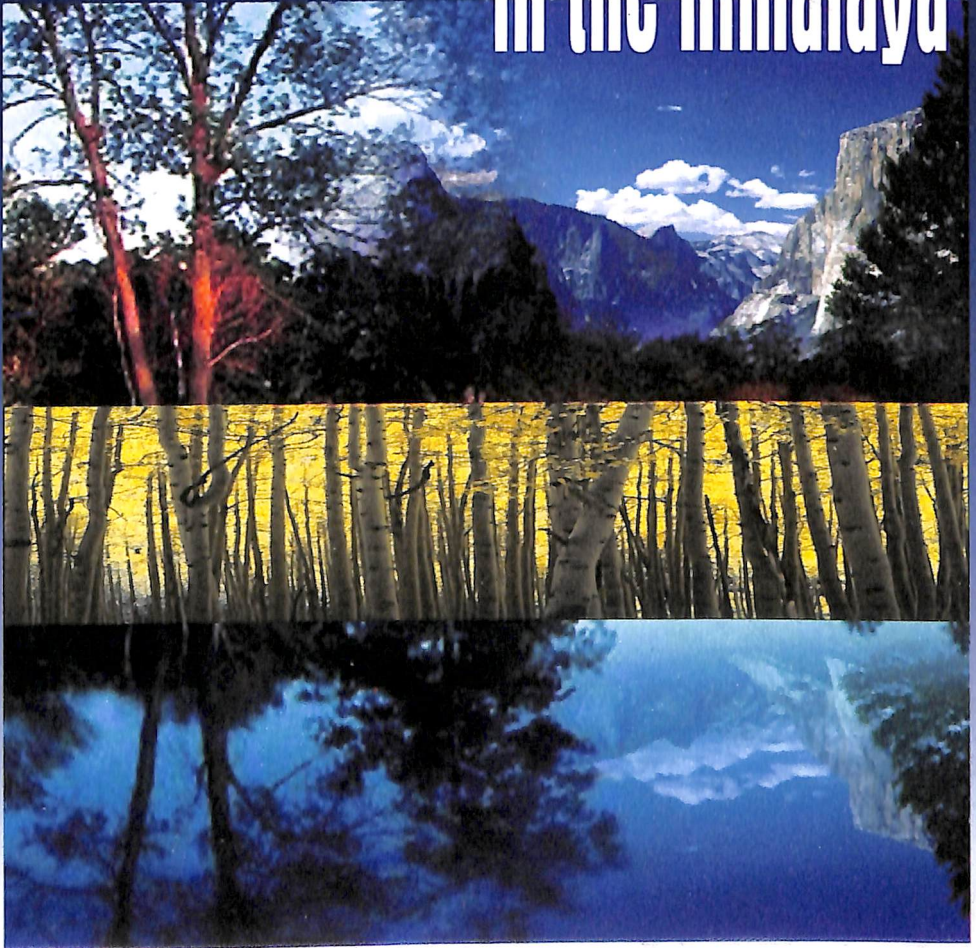


Natural Resource Management in the Himalaya



S.S. Negi

Land and Water and
Environmental Management



Natural Resource Management in the Himalaya

Vol.-1

Land, Water & Environmental Management



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Preface

Stretching for a length of about 2400 kms, an average width of 250 kms and rising to elevations of more than 7000 mts, the Himalaya are amongst the most imposing features on the face of the earth. This mountain system is a vast storehouse of natural resources, which includes water, ice, soil, rocks, minerals, forests, grasslands and wild animals. Infact, many of south Asia's largest rivers either rise or flow through this complex mountain system. These resources have been used by human beings for the past many centuries. Their sustainable use and management affects the lives of millions of people living in this mountain region and also in the plains.

This book, the first in a series of five on natural resource management in the Himalaya, deals with land, water and environmental management. It includes chapters on the Himalaya; land capability classification and management plan; geomorphology, geology and structure; soil management; soil erosion; soil conservation; water resources; fishes and fisheries; mining; landslides; geological processes and natural resource management problems; participatory approaches and integrated watershed management. It is meant as a handy reference book for natural resource managers, scientists, planners, students, researchers and also the layman interested to know more about natural resource management in the Himalaya. During the preparation of this book considerable published and unpublished literature has been consulted and hence no originality is claimed.

I am thankful to my well wishers for their encouragement, to my family for their support and to the publishers for bringing out

this book in a short time. This is my 100th book and I take this opportunity to once again thank all my friends, well wishers, publishers and my family for their constant support in all my writing endeavors and bring on record my deepest sense of gratitude towards them.

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The Himalaya

The Himalaya or abode of snow, stretching from the Nanga Parbat massif in the northwest to the Namche Barwa massif in the east constitutes one of the most imposing land features on the face of the earth. It forms a part of the Hindu Kush. Himalayan mountain region and extends in an arc shape for a length of about 2400 kms and a width varying from 150 to 300 kms. This imposing mountain range forms a part of a complex system of fold mountains radiating in different directions from the Pamir knot. The other mountain ranges include the Kun Lun, Hindu Kush, Sayan and Ling Shan

The boundaries of the Himalaya are taken as either between the Indus and Brahmaputra gaps or between the Nanga Parvat and Namche Barwa peaks. In the south, they merge with the plains of the Indus and Ganga rivers and in the north with the Tibetan plateau and its offshoot ranges.

The sage Nagsena described these mountains as, “the king of mountains, five and three thousand leagues in extent at the circumference, the source of five hundred rivers, the dwelling place of multitudes of mighty creatures, the producer of manifold perfumes, enriched with hundreds of magical drugs is seen to rise aloft like a cloud, the center of the universe.” Describing this mountain range, the great poet Kalidasa wrote, “Stretching from east to west coasts, it is located on the earth as a measuring rod.”

This mountain chain includes some of the highest mountain peaks in the world including Mount Everest, Makalu, Nanda Devi,

Nanda Kot and Kanchunjunga. It is also the source of major rivers of the Indian sub-continent viz. the Ganga, Yamuna, Ravi, Beas and Chenab. Three large rivers originate on the fringes of the Tibetan plateau and flow across the Himalayan mountain system before entering the plains of India. These are the Indus, Satluj and Brahmaputra. Large parts of the catchment of these trans-Himalayan rivers lie in the Himalaya, while most of their tributaries originate in the Himalaya. .

The Himalaya have been the destination of countless of sages, pilgrims and travellers for the past thousands of years. Important places of religious interest are located in the Himalaya. These include Badrinath, Kedarnath, Gangotri, Yamunotri, Vashno Devi, Amarnath, Chamunda, Chintpurni, Jwalaji, Naina Devi, Manimahesh, Kinner Kailash, Hem Kund, Tabo, Kee, Ghoom and Pashupatinath. People belonging to many religions revere these places. In recent decades, the Himalaya have also become an important tourist destination for people from all over the world. This mountain range is also of immense interest to nature lovers, mountaineers, trekkers conservationists, wild lifers and the lay man. The ecology and environment of this mountain chain has a bearing on the lives of the people living in the Indo-Ganga plains.

Physical Set Up

Geologists agree that the Himalaya lie where there was once a large sea, between Gondwana land in the south and Angara land in the north. Rivers deposited millions of tons of sediments in this geosynclinal basin. The movement of the Indian plate towards the north has led to the upliftment of the Himalayan mountain system from under the sea. This has occurred in several phases and is believed to be continuing to this day. It has been estimated that the Himalaya are about 40 million years old. In the southern part of this mountain chain, a young range is developing. This is known as the Shiwalik range.

The mountain building forces, which have acted upon the Himalaya, have resulted in the development of folds and faults. Several thrusts in the Himalayan region extend all along the mountain chain from west to east. These include the main boundary thrust and the main central thrust.

Besides mountain building activity, rivers too have been responsible for influencing the physical set up of the Himalaya. They drain vast catchments and have formed valleys forming river cut and river built valleys. .

Physiographic Divisions

The Himalaya have been divided into the following four physiographic divisions or units from south to north.

1. Shiwaliks or outer Himalaya—The Shiwalik hills extend along the southern periphery of the Himalaya, occurring in a wide zone in the northwest and gradually merging with the lower Himalayan ranges in the east. They are believed to be the youngest range of the Himalayan system and continue to be in a formative stage. The rocks forming the Shiwalik hills are made up of unconsolidated sediments, boulder beds, sandstone and other sedimentary rocks. They are rich in vertebrate and plant fossils indicating a younger age. These mountains have also been referred to as the outer Himalaya. In Nepal, they are known as the Churia or Churia Muria hills.

In their north they form longitudinal valleys known as the dun valleys e.g. Dehradun, Kiarda dun and Chitwan dun valleys. These are fertile valleys lie between the lower Himalayan ranges in the north and the Shiwalik hills in the south. However, such valleys have developed prominently only in the western and central Himalaya. The Shiwalik hills have steeper southern faces and relatively gentler northern faces. They merge with the Indo-Ganga plains.

Numerous rivers, most of which rise in the main Himalayan glaciers have cut across the Shiwalik hills. They bring with them millions of tons of sediments that are deposited in the valleys are tracts where the rivers enter the plains of India.

2. Lower Himalaya— The lower Himalaya are made up of a number of ranges extending in a northwest- southeast direction, parallel to the main Himalayan mountain wall. They rise above the dun valleys or the northern fringes of the outer Himalayan ranges. A deep-seated tectonic lineament known as the main boundary thrust separates the lower Himalaya in the north from the outer Himalaya or Shiwalik ranges in the south. It has brought the older lower Himalayan rocks over the younger rocks of the Shiwalik ranges. This physiographic unit is very wide and also includes the tract, which has been referred to as the middle Himalaya. In the north, it gives way to the main or higher Himalayan region.

The lower Himalayan ranges either extend parallel to each other or may be in the form of offshoot ranges to the main range. A number of prominent ranges form the lower Himalaya in the western part of this mountain range. They include the magnificent Pir Panjal and Dhauladhar ranges in Jammu and Kashmir and Himachal Pradesh. The upper peaks of these Pir Panjal and Dhauladhar ranges are under a permanent cover of snow. The lower Himalaya form a number of high ridges such as the Mussoorie, Pauri and Shimla ridges. In Nepal, the Mahabharat Lekh is the main mountain range of the lower Himalaya.

The slopes vary from gentle to very steep, with rivers and streams forming V-shaped valleys and gorges. All major Himalayan rivers except those rising in the Shiwalik hills drain the lower Himalaya. The main rocks include limestones, shales, slates, phyllites, boulder beds, quartzites, granites and metabasics. Fossils are rare in the lower Himalaya.

3. Higher or Central or Main Himalaya—The higher or central or main Himalayan region is comprised of the great or main Himalayan range that stretches from west to east. It is made up of

very high peaks including Mount Everest, Makalu, Shivling, Bandarpunch, Chowkhamba and Kanchanjunga. The slopes are very steep with the upper tracts being covered under a permanent blanket of snow. The peaks are rugged and jagged often having razor sharp edges. Glaciers are located in the upper slopes of these mountains. The southern boundary of the main Himalaya is marked by the main central thrust, a deep-seated tectonic lineament that separates this zone from the lower Himalaya.

The rocks are highly metamorphosed and are known as the central crystallines. They are folded and deformed, often being intruded by granites associated with migmatites and pegmatites.

The main Himalayan mountain wall has a profound impact on the climatic conditions prevailing in this region. They act as a barrier for the moisture laden monsoon winds resulting in a rainshadow area in the tracts beyond. Due to these high mountains, inner dry tracts or rain shadow areas occur within this unit.

4. Trans-Himalaya—This is the northern most physiographic unit of the Himalayan mountain system. It occupies a position to the north of the main or central Himalaya and is considered to be a transition between the main Himalayan range and the Tibetan plateau to the north. The trans-Himalayan tracts include Ladakh, Spiti, Lahaul, Pooch and some smaller tracts along the northern fringe of Uttaranchal, Nepal and Sikkim. It has also been referred to as a cold desert due to the extremely dry conditions prevailing in this tract. The trans-Himalaya lies in the rain shadow of the main Himalayan ranges and hence, rainfall is very low.

A combination of the dry and extremely cold conditions coupled with the high average elevation has created conditions similar to deserts. The larger valleys are broad and open, with the slopes covered with aeolian and glacial deposits. The vegetation is very sparse and with trees being either absent or having a stunted growth.

The main rocks are shales, slates, limestones, phyllites, greywackes, conglomerates etc. They are extremely rich in invertebrate fossils belonging to different geological ages.

Drainage

Hundreds of rivers and streams drain the Himalayan mountain system to reach the Bay of Bengal, Arabian sea and some lakes. These form a part of the Indus, Ganga and Brahmaputra river systems. The drainage systems in this mountain range have been discussed in the text below. A detailed description forms part of the chapter on Water Resources.

1. Indus System—The main channel of the Indus river system rises from near lake Mansarovar in Tibet and drains through Ladakh before entering the plains and ultimately reaching the Arabian sea. The Himalayan catchment of this river forms part of Jammu and Kashmir and most of Himachal Pradesh. Its five main tributary systems are listed below:

- **Jhelum River System.**
- **Chenab River System.**
- **Ravi River System.**
- **Beas River System.**
- **Satluj River System.**

Of these, the Satluj river is the largest tributary of the Indus river system.

2. Ganga System—The main channel of the Ganga river rises from the snout of the Bhagirathi glacier upstream of Gangotri in Uttaranchal. It is known as the Bhagirathi river and drains across the middle Himalayan ranges to reach Deoparyag where it is joined by the Alaknanda river. The Ganga river system drains a very large catchment, which includes the eastern parts of Himachal Pradesh and whole of Uttaranchal and Nepal. Its main tributary systems are:

- **Yamuna River System.**
- **Kali River System.**
- **Ghagra River System.**
- **Gandak River System.**
- **Kosi River System.**

3. Brahmaputra System—The main channel of the Brahmaputra river rises from near lake Mansarovar in Tibet and drains a considerable area in Tibet, where it is known as the Tsang Po, before entering Indian territory. Its Himalayan catchment includes north Bengal, Sikkim, Bhutan and Arunachal Pradesh. The main Himalayan tributary systems of the Brahmaputra are:

- Teesta River System.
- Manas River System.
- Raidak River System.
- Torsa River System.
- Kameng River System.
- Subansiri River System.

Regional Set-up

The regional set of the western, central and eastern Himalaya is given in the table below :

Western Himalaya	● Jammu and Kashmir
	● Himachal Pradesh
	● Uttaranchal
Central Himalaya	● Nepal
Eastern Himalaya	● North Bengal or Darjeeling hills
	● Sikkim
	● Bhutan
	● Arunachal Pradesh

Climate

Wide variations occur in the climatic conditions prevailing in different parts of the Himalaya, from Ladakh in the northwest to

Arunachal Pradesh in the east and from the Shiwalik hills in the south to mount Everest in the north. Extremely cold and dry conditions are experienced in Ladakh, Lahaul and Spiti, while very high temperatures prevail in the sub-Himalayan belt and very heavy rainfall is experienced in most parts of Arunachal Pradesh.

The factors affecting climatic conditions in the Himalaya are-

- Altitude.
- Latitude.
- Physiographic features such as mountain ranges.
- Aspect and slope.

Climatic Zones

The Himalaya may be divided into the following broad climatic zones on basis of altitude.

Altitudinal Range (in mts.)	Climatic Zone
Below 800	Warm sub-tropical
800 to 1200	Cool sub-tropical
1200 to 1800	Sub-temperate
1800 to 2400	Cool temperate
2400 to 3600	Sub-arctic
Above 3600	Arctic

However, due to the influence of other factors, the climatic conditions prevailing in these zones may differ or there could also be variations in the altitudinal ranges given in the above table.

Seasons

Three main climatic seasons are experienced in different parts of the Himalaya. These are summer, monsoon and winter. The

autumn season occurs between monsoons and winter, while the spring season marks the transition from winter to summer. The duration of autumn and spring depends on altitude, latitude and local climatic conditions. The cycle of seasons experienced in the Himalaya is discussed below.

1. Summer—The summer season in most parts of the Himalaya is in May and June, though at lower elevations, summer begins in mid-April. The maximum temperature in the lower regions may soar to over 40°C, while in the higher reaches the maximum summer temperatures are about 25°. Due to the heat, the snow in the high hills melts faster, causing the water level in the snow fed rivers and streams to rise. However, in many parts of the Himalaya, high temperatures in summer may give rise to local rains.

2. Monsoon—The hot spell of summer is broken with the arrival of the monsoon rains, which cause heavy and widespread rains in most parts of the Himalaya from late June to mid-September, accounting for bulk of the total annual precipitation. This season starts earlier in the eastern Himalaya, where the monsoon rains begin in early June. The SW monsoon reaches parts of the western Himalaya in late June or early July. Infact, the Himalaya act as a barrier for the moisture laden SW monsoon winds, forcing them to cause heavy and widespread precipitation. During the monsoon season, rainfall may occur for several days at a stretch and mountains may be covered with a blanket of fog or mist.

However, some parts of the higher Himalaya and the trans-Himalayan tracts lie beyond the reach of the SW monsoons as they fall in the rain shadow area.

3. Winter—The monsoon season is followed by an autumn season when the skies largely remain clear. At higher elevations, the winter season may set in as early as in later October or early November, while in lower tracts, the winter season is from early December. This season extends till March and is followed by the spring season, which marks the transition between winter and summer.

It becomes very cold in most parts of the Himalaya in winter, when the temperature in the higher reaches drops below the freezing point. During this period, heavy snowfall occurs at higher elevations and the ground may remain covered under a blanket of snow for several days at a stretch. Even, in the lower tracts, it becomes very cold in the winter season with the mercury dropping to around 0°C. Frost commonly occurs in the valleys and foothills.

Gravity Winds

Gravity winds blow in many parts of this mountain system every day due to variations in temperatures and pressure conditions. They may often attain very high speeds. At the break of day and during the earlier part of the day, gravity winds blow from the valley bottom to the top of the mountains, mainly due to changes in the temperatures and pressure conditions brought about by the rising sun, which warms the upper slopes first. The warming effect of the sun causes the mists in the valley bottom that have accumulated at night to rise and ascend in altitude.

In the afternoon and later, gravity winds blow from mountaintops to the valley bottom, mainly due to changes in temperature and pressure conditions. This results in the accumulation of mist in the valley at night.

Ecological Zones

Himalayan ecology is very complex, interesting and has a significant bearing on the life of the people living not only in this region but also in other parts of the Indian sub-continent. It is affected by the following factors:

1. Prevailing Climatic Conditions.
2. Altitude and Latitude.
3. Edaphic Factors or Soil Conditions.
4. Physiography, Aspect and Slope.

5. Forests, Grasslands and Wild Animals.
6. Biotic Influences.

The main ecological zones of the Himalaya have been described in brief below.

1. Dry Sub-tropical Zone—The dry sub-tropical zone covers parts of the Jammu hills and the southern tracts of Himachal Pradesh, where extremely dry conditions prevail. Rainfall is relatively less and very high temperatures are experienced in the summer season, when the temperature may soar to over 40°C. The soil is poor and harsh conditions prevail. The total annual rainfall is less with rains occurring both in the monsoon season and also in winter.

The natural vegetation found in this ecological zone includes:

- (a) Dry Thorny Scrub.
- (b) Khair and Sisham Forest.
- (c) Dry Tropical Forest.
- (d) Dry Grasslands.

2. Montane Sub-tropical Zone—This ecological zone covers the sub-tropical regions of Himachal Pradesh, Uttaranchal, Nepal, North Bengal, Sikkim, Bhutan and Arunachal Pradesh. It occurs along the southern periphery of this mountain chain, forming a part of the Shiwalik hills, dun valleys, lower and middle Himalaya, depending on the prevailing climatic and other conditions. Summers are very hot in this tract, though rainfall is also very heavy mainly during the monsoon season. Winters are cold with the occurrence of frost. Edaphic conditions vary from moderate to poor with thick soils in the valley areas.

The natural vegetation found in this ecological zone includes:

- (a) Dry and Moist Sal Forest.
- (b) Chir Pine Forest.
- (c) Sub-tropical Broad-leaved Forest.
- (d) Sub-tropical Broad-leaved Hill Forest.

- (e) Sub-tropical Wet Hill Forest.
- (f) Sub-tropical Dry Evergreen Forest.
- (g) Sub-tropical Savannah or Grasslands.

3. Moist Temperate Zone—The moist temperate zone covers the temperate tracts of the western and central Himalaya. Precipitation is very heavy with bulk of it being received as rain during the monsoon season. Summers are mild while winters are very cold. The mercury may drop to below the freezing point in winter. Snowfall occurs in the upper parts of this zone in the winter season.

The natural vegetation found in this ecological zone includes:

- (a) Moist Deodar Forest.
- (b) Ban, Kharsu and Moru Oak Forests.
- (c) Moist Mixed Coniferous Forest.
- (d) Moist Broad-leaved/ Deciduous Forest.
- (e) Blue Pine, Fir and Spruce Forest.

4. Dry Temperate Zone—The dry temperate zone covers parts of the inner dry valleys of the higher Himalaya and the trans-Himalayan tracts. Rainfall is very low as this tract lies in the rain shadow area. This zone experiences a very cold winter when the mercury remains below the freezing point for many days. Summers are mild.

The natural vegetation found in this zone includes:

- (a) Dry Deodar Forest.
- (b) Dry Temperate Broad-leaved Forest.
- (c) Dry Temperate Coniferous Forest including Chilgoza and Blue Pine.
- (d) Dry Juniper Forest.

5. Wet Temperate Zone—This zone includes parts of the temperate region of the eastern Himalaya, receiving very heavy rainfall. Winters are fairly cold and snowfall may be received in the upper tract.

The natural vegetation found in this zone includes:

- (a) East Himalayan Wet Temperate Forest.
- (b) High Level Oak Forest.
- (c) Sub-alpine Forest.

6. Sub-alpine Zone—This ecological zone includes the sub-alpine tracts of the western, central and eastern Himalaya and may extend till the tree line or even the snow line. It also includes the sub-alpine parts of the dry areas. Winters are very cold and the ground may be covered under a thick blanket of snow for several weeks at a stretch. Sub-zero temperatures are experienced for long periods. Precipitation is both in the form of snow and rain. Summers are mild.

The main natural vegetation of this ecological zone is:

- (a) Sub-alpine Birch and Fir Forest.
- (b) Upper Oak and Fir Forest.
- (c) Sub-alpine Grasslands or Pastures.
- (d) Sub-alpine Coniferous Forest.
- (e) Sub-alpine Junipers Vegetation.

7. Moist Alpine Zone—This ecological region covers all the moist upper tracts of the western, central and eastern Himalaya including the areas above the line of perpetual snow. It experiences arctic type of climate with the temperatures remaining below the freezing point for long periods. Summers are short and mild, while winters are long and cold. Precipitation is received mainly in the form of snow.

The main natural vegetation of this ecological zone includes:

- (a) Birch-Rhododendron Scrub.
- (b) Deciduous Alpine Scrub.
- (c) Moist Alpine Pastures.

8. Dry Alpine Zone—This ecological zone covers the cold desert areas of Ladakh, Lahaul, Spiti, Pooh and other tracts which in the trans-Himalayan region. The climatic conditions are very dry

as this zone lies in the rain shadow of the main Himalayan mountain wall. Sub-zero temperatures are experienced for long periods in this zone. Summers are mild and short.

Vegetation is sparse and includes many xerophytic species. Dry alpine pastures occur in pockets. They become green in summer when the snow covering the ground melts. Trees are few and scattered, with shrubs forming the dominant natural vegetation in the cold deserts. The local communities have planted trees along watercourses.

People

People of diverse cultures, ethnic and religious backgrounds live in the Himalayan region. The population density in this mountain region is lesser than that in the plains. It is believed that human settlement in the Himalaya followed migration from the north (mainly Tibet and central Asia), east, west and south. Settlement took place due to any one or a combination of the following reasons:

- (a) Migratory grazer communities came with their flocks to various regions and settled there.
- (b) Pilgrims and sages came to the places of religious importance in the Himalaya and settled there.
- (c) Traders and agriculturists settled in these mountains.
- (d) People migrated from the plains to escape from wars and conflicts that took place in various parts of India, during the middle ages and even later.
- (e) Regular settlement took place once the availability of sustainable livelihoods began to develop.

Habitation zones

The Himalaya may broadly be divided into the following habitation zones based on altitude and main occupation of the people.

1. Lower Zone—This zone covers the Shiwalik hills, dun valleys and the lower Himalaya, usually upto elevations of about 1800 mts. It is relatively more prosperous than other zones and the main occupation of the inhabitants is agriculture, though trade and other means of livelihood are also well developed.

2. Middle Zone—This zone covers parts of the lower, middle and higher Himalaya, between elevations of 1800 to 2200 mts. The main occupation is agriculture with other sources of livelihood being horticulture, trade and animal husbandry.

3. Higher Zone—This zone includes the high altitude areas and the trans-Himalayan tracts. Agriculture and animal husbandry are the main occupations. The people migrate to the lower hills in winter and move with their flocks to high altitude pastures in the summer months.

Tribal Communities

Many tribal communities live in the Himalayan region; with most of them being graziers, who rear animals for their livelihood. They have either settled in permanent locations or move from one place to the other with their animals. These communities are:

1. Gujjars of Kashmir.
2. Gaddis of Kullu and Chamba.
3. Kinnauras of Kinnaur.
4. Jadhvs of Nilang, Uttaranchal.
5. Marchas of Mana, Uttaranchal.
6. Johris of Milam valley, Uttaranchal.
7. Thakalis of Nepal.
8. Lepchas of Sikkim.
9. Bhutias of Sikkim.
10. Lanchenpas and Lanchungpas of Sikkim
11. Wanchos of Arunachal Pradesh.