



**Environment
and
Sustainable
Development
in the Himalaya**

S.S. NEGI

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Preface

The Himalayan region comprises of the western, central and eastern Himalaya. This region is ecologically very sensitive, though development is taking place at a very fast rate. The socio-economic condition of the people living in some of the far-flung areas is very poor, and appropriate measures are needed to be taken for their upliftment.

It is a well-established fact that sustainable development must go on with environmental stability. This book deals with environment and sustainable development in the Himalaya. It covers chapters on Environmental problems and their management, Participatory natural resource management, Forest resources and their sustainable use, Sustainable management of grasslands, Sustainable agriculture development, Sustainable horticulture development, Sustainable livestock and fodder development, Sustainable water use and management, Sustainable tourism development, Integrated watershed development, Wildlife management, Natural disasters and their management, and Sustainable land development.

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The Himalaya

The Himalaya has been described as the most magnificent feature on the face of the earth, stretching in an arcuate shape for a length of about 2400 km from the Indus gap in the north-west to the Brahmaputra gap in the north-east (Negi, 1990). This mountain chain can be divided into three regions, viz. the western Himalaya comprising of Jammu & Kashmir, Himachal Pradesh and Uttaranchal; the central Himalaya consisting mainly of Nepal; and the eastern Himalaya comprising Sikkim, North Bengal and Arunachal Pradesh.

The Himalaya is a melting pot of diverse races and cultures, vegetation, ecosystems, rivers, lakes, glaciers and natural resources. It consists of a complex system of high mountains, deep river valleys, fast-flowing rivers and streams, and flat alluvial terraces.

This western part of the Himalayan mountain system is the most densely populated part of the mountain chain and perhaps the most developed in terms of standard of living and economic condition of the people. However, this is putting a severe strain on the natural resources and the environment. Population in the central and eastern Himalaya is less dense.

PHYSIOGRAPHIC DIVISIONS

The Himalaya has diverse physiography, varying from the Shiwalik hills on its boundary with the Indo-Gangetic plains to

the cold desert tracts along the Tibetan plateau (Bose, 1972 and Gansser, 1964). The western Himalaya may be divided into the following physiographic divisions.

1. Shiwaliks

The Shiwalik hills consist of a series of low hills that lie more or less parallel to the main Himalaya mountain system. It is believed that these hills were formed during the last phase of Himalayan orogeny. They are well-developed in the western Himalaya and gradually become narrower and merge with the lower Himalaya in the eastern part of this mountain chain.

The highest tops of the Shiwalik hills have an elevation of about 1000 m while in the south they merge with the Indo-Gangetic plain. Longitudinal valleys have been formed between the Shiwalik hills and lower Himalaya. These are very fertile and densely populated and are referred to as Doon valleys e.g. Kiarda dun and Dehradun.

The Shiwalik hills are rich in natural resources including forests and water. The main Himalayan rivers originating from glaciers flow through these hills. Many smaller rain-fed streams and rivers originate from these hills and flow to the plains or join the major rivers.

Agriculture is the main occupation of the people living in this region, mainly because of the flat valleys, relatively fertile soils and ample water supply.

2. Lower Himalaya and Middle Himalaya

The lower and middle Himalayan range is another series of mountains, which lie to the north of the Shiwalik hills and have evolved as a part of main Himalayan orogeny. The highest peaks of this range tower to more than 3000 m. In Jammu & Kashmir, the Pir Panjal range forms the lower Himalaya and it enters Himachal Pradesh where it is known as the Dhauladhar range.

The zone formed by mountains of the lower Himalaya and middle Himalaya is very wide in the north-west and becomes

narrower in Garhwal and Kumaun. The tops of the Pir Panjal and Dhauladhar range remain under a permanent snow cover.

A large part of the population of the western Himalaya lives in this physiographic zone formed by the lower and middle Himalaya. Agriculture is the main occupation of the people living in this region. The slopes are steep and fields narrow and terraced.

Towards the southern part, the lower Himalayan range towers over the Shiwalik hills and forms longitudinal valleys between them. The major Himalayan rivers flow through this physiographic zone in their journey to the plains.

3. Main or Great Himalaya

The main or great Himalayan mountain wall stretches in an arcuate shape in the north and north-eastern part of this region, with its peaks towering to over 6000 m in elevation. This physiographic division is comprised of very high mountains, steep slopes, deep gorges and glaciated upper slopes that remain under a permanent cover of ice.

North and north-east of this mountain wall have the peripheral zone of the Tibetan plateau while to its south and south-west are the lower and middle Himalayan mountains. Major Himalayan rivers like the Chenab, Ravi, Beas, Ganga and Yamuna rise from the glaciers located on the upper slopes of the main or great Himalayan range. However, some rivers that rise in Tibet and flow across this mountain wall have cut deep gorges. These rivers include the Indus, the Satluj and Brahmaputra, which enter Indian territory from Tibet.

Dense forests of deciduous and evergreen species occur on the lower and middle slopes of these mountains. Towards higher elevations, the trees give way to pastures and finally to the zone of perpetual snow.

4. Trans-Himalayan Region

Also known as the cold desert region or the Tibetan zone, this physiographic region lies to the north and north-east of the main

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Himalayan mountain wall. It is a rain shadow area where the monsoon winds are unable to reach and hence extremely dry conditions prevail in this tract.

The topography consists of U-shaped valleys formed by glaciers and glacial deposits and steep mountains whose peaks rise to elevations of over 6000 m. The average elevation of this vast tableland is more than 3000 m.

Many rivers and lakes drain the cold deserts of Lahaul, Spiti and Ladakh. Amongst them are the rivers Indus, Shyok, Chandra, Bhaga and Spiti and lakes like the Tso Moriri and Chandra Tal.

GEO-POLITICAL REGIONS

The western Himalaya is comprised of the three states of the Indian union, viz. Jammu & Kashmir, Himachal Pradesh and Uttaranchal, and the Shiwalik hills of Punjab and Haryana. These have been described in brief in the points below.

1. Jammu & Kashmir

1. Karakoram range: The Karakoram range lies to the north of the main Himalayan range and the Zaskar range in the Ladakh region of Jammu & Kashmir. Many peaks rise to an altitude of over 7000 m while the average elevation is more than 3000 m. Some of the highest glaciers of the world form a part of this range e.g. Siachen glacier having a length of about 72 km.

2. Ladakh plateau: This is a vast highland or tableland lying to the north of the main Himalayan range in Jammu & Kashmir, with an average elevation of about 3500 m. A number of prominent rivers flow from different parts of the Ladakh plateau and drain into the Indus river or inland salt lakes. Amongst the main physical features of the Ladakh plateau are the Soda plains and Aksai Chin.

3. Zaskar range: Another trans-Himalayan range of the Ladakh regions is the Zaskar range which is made up of high mountains and glaciers. The eastern part of this range is known

as Rupshu in which occurs the famous salt encrusted lake of Tso-Moriri.

4. Great Himalaya: The great or main Himalayan range arises from the Nanga Parbat complex and runs across the state of Jammu & Kashmir, north of the Kashmir valley and south of the Zaskar range before entering Himachal Pradesh. Many rivers like the Jhelum and Liddar rise from the main Himalayan range in Kashmir.

5. Kashmir valley: This broad open valley lies between the main or great Himalayan range in the north and the Pir Panjal range in the south. It is a large valley drained mainly by the rivers Liddar and Jhelum. It is believed that a vast lake once covered the entire valley and now its remnants are left in the form of the Dal, Wular and Nagin lakes after a large part of the old lake drained out.

6. Pir Panjal range: The Pir Panjal range forms part of the lower and middle Himalayan regions and runs in an arc shape along the southern periphery of the Kashmir valley. Its mountain tops rise to elevations of over 3000 m and may be covered under a permanent snow cover. The river Jhelum has cut across this range near Baramula and the river Chenab near Kishtwar.

7. Shiwalik hills: The Shiwalik hills form a wide belt in Jammu & Kashmir, forming the Jammu region of this state. They lie parallel to the Pir Panjal range and form wide valleys drained by various rivers like the Chenab, before they reach the plains.

2. Himachal Pradesh

The state of Himachal Pradesh borders Jammu & Kashmir and Uttaranchal. It is made up of a number of geo-physical units (Kayastha and Mishra, 1971 and Srikantia and Bhargava, 1998). These are:

1. Lahaul and Spiti valleys: The Lahaul and Spiti valleys lie in the cold desert region of the trans-Himalayan tract of the state. These are two separate valleys, with the former being drained by the Chandra and Bhaga rivers and the latter by the Spiti river. As

both the valleys fall in the trans-Himalayan tract, they receive very little rainfall, particularly in the case of the Lahaul valley. Population is very sparse as the land cannot support more human beings. The main occupation of the people is agriculture and animal rearing.

2. Great Himalaya: The main or great Himalayan range extends in an arc shape in the northern and north-eastern part of the state and contains snow-clad peaks, glaciers and deep valleys. Many rivers like the Beas and Ravi rise from these mountains, while the trans-Himalayan river Satluj has cut a deep gorge across this mountain wall.

Agriculture & animal husbandry is the main occupation of the people.

3. Dhauladhar range or lower Himalayan ranges: The Dhauladhar range is a part of the lower Himalayan region, being an extension of the Pir Panjal range of Kashmir which extends into Himachal Pradesh from Chamba and rises abruptly above the Kangra valley and finally merges with the main Himalayan range in north-central part of the state. The rivers Ravi and Beas have cut gorges across this range.

Eastern extensions of this range include the Shimla ridge and Churdhar range. Agriculture and animal rearing is the main occupation of the people.

4. Kullu valley: The Kullu valley lies in the middle Himalayan ranges and is a broad valley formed by the Beas river. In the north are the high Himalayan mountains that remain under a blanket of snow for many months in a year.

The valley is very fertile and supports both agriculture as well as horticulture.

5. Shiwalik hills: The Shiwalik hills are well-developed along the southern and south-western part of the state, right from parts of Chamba district to Kangra, Hamirpur, Bilaspur, Una, Solan and Sirmur districts. They show extensive development in this region. There occur broad valleys within these hills and also between them and the lower Himalayan valleys, e.g. the Kiarda dun valley in Paonta and Swan valley in Una.

The hills are low and have steep south-facing slopes. The population density is more as compared to other parts of the state. Agriculture is the main occupation of the people, with livestock rearing being a supplementary source of income.

3. Uttarakhand

The state of Uttarakhand lies between Himachal Pradesh and Nepal. Most of this state is located in the western Himalaya except the two districts of Haridwar and Dehra Dun. It can be divided into the following geo-physical units.

1. Main or great Himalaya: The main or great Himalayan range forms the northern boundary of the state, across which lies the Tibetan plateau. The tops of these mountains remain under a permanent cover of snow and may rise to elevations of over 6000 m. The prominent peaks of this range include the Dhaulagiri, Annapurna, Nanda Devi and Nanda Kot.

Many glaciers lie in this mountain range and they give rise to major rivers like the Yamuna, Gomti and Alaknanda.

2. Yamuna valley: The Yamuna river rises from the snout of the Yamunotri glacier in Dehra Dun district and flows to enter the plains near Allahabad. It forms a V-shaped valley formed by interlocking spurs, gorges and terraces.

Agriculture is the main occupation of the people of this valley. The people living in the upper reaches depend on animal husbandry for their livelihood.

3. Gomti valley: The Gomti river, one of the main channels of the Ganga river rises from the snout of the Dhaulagiri glacier at the base of the Dhaulagiri peak in Dehra Dun district. It forms a V-shaped valley and flows past spurs, terraces and gorges to merge with the Alaknanda river at Allahabad to form the river Ganga.

The slopes have been terraced to support agriculture while forests and grasses cover the slopes where agriculture is not practiced.

4. Alaknanda valley: The Alaknanda river is another main channel of the Ganga river which rises from the base of the main Himalayan mountain wall near Badrinath and flows down to merge with the waters of the Bhagirathi at Deoprayag. This valley has many holy places like Badrinath, Kedarnath, Nandprayag, Karnaprayag, Vishnuprayag, Sonprayag, Rudraprayag and Deoprayag.

5. Lower and middle Himalaya: The lower and middle Himalaya of Uttaranchal comprises of a series of mountain ranges that are dissected by valleys of rivers like the Yamuna, Bhagirathi, Alaknanda, Ramganga and Kali. They are made up of various ridges such as the Nag Tibba ridge, Mussoorie ridge, Pauri ridge and Pithoragarh ridge.

Agriculture is the main occupation of the people of this tract. They also depend on animal husbandry as an additional source of income.

6. Shiwalik hills: The Shiwalik hills of Uttaranchal extend from the Paonta river in the west to the Kali river in the east, in an alignment parallel to the lower Himalayan range. The south facing slope is steeper than the northern slopes. The hills rise to elevations of over 1000 m.

These hills surround longitudinal valleys in the south with the lower Himalaya in the north. Such valleys are known as the dun valleys, e.g. Dehradun.

4. Nepal

Nepal occupies the central Himalaya and is known for its unique natural beauty, snow-clad peaks, raging torrents, conifer-covered slopes, terraced fields and friendly hill-folk. It can be divided into the following geo-physical units:

1. Main or Great Himalaya: The main or great Himalaya mountain wall in Nepal has a width of 25 to 30 km. It includes major peaks like Mount Everest, Makalu, Cho Oyu, Lhotse, Ganesh Himal, Annapurna and Dhaulagiri.

2. Middle Himalaya: The middle Himalayan tract of Nepal lies to the south of the main Himalayan mountain wall. It includes

many mountain ranges like the Humla-Jumla mountains, Baitadi mountains, Dialekh mountains, Beglung mountains and valleys of major rivers.

3. Lower Himalaya: In Nepal, the lower Himalaya has a width of about 85 km and average elevation of 1500 mts. This tract is also known as the Mahabharat Lekh. The famous Kathmandu valley also lies in this tract.

4. Outer Himalaya or Shiwalik hills: This is the southernmost physiographic unit of Nepal and is comprised of low rolling Shiwalik hills. It may further be sub-divided into the following:

- a) Terai-bhabar tract
- b) Shiwalik or Churia-Muria hills
- c) Dun valley or Bhitri Madhesh

5. Eastern Himalaya

The eastern Himalayan region consists of north Bengal, Sikkim, Bhutan and parts of Arunachal Pradesh upto the Brahmaputra gap. It may be divided into the following geo-physical units:

1. Main or great Himalaya: The great Himalaya mountain wall separates the eastern Himalaya from Tibet. It is comprised of snow-capped peaks, glaciers and river valleys.

2. Lower Himalaya: The lower Himalaya occupies the central part of this region. It is made up of a number of ridges many of which are almost north-south trending. The sub-units of this region are:

- a) Darjeeling ridge
- b) Singalila and Donkhya ranges
- c) Thimpu ridge

3. Shiwalik hills: The Shiwalik hills are not well-developed in the eastern Himalaya as compared to the western and central Himalaya. In fact, they merge with the lower Himalaya. In many areas, there is no clear-cut demarcation between these two geo-physical units.

CLIMATE

The climate of the Himalayan region varies widely as the region has some of the wettest stations like Dharamsala and driest like Spiti and Leh (Mani, 1981). Based on elevation and latitude, this region may be divided into the following climatic regions.

<i>Climatic region</i>	<i>Altitudinal range (in m)</i>
Arctic	more than 4000
Sub-arctic	3000 to 4000
Temperate	2000 to 3000
Sub-tropical	700 to 2000
Tropical	less than 700

1. **Seasonal Cycle**

The following seasons occur in the Himalayan region.

1. Summer season: This is the hottest part of the year and extends from mid-April to early July, depending on the location of the station. In the cold desert regions, this season is from mid-May to late August as there is no rainy season in this trans-Himalayan tract.

2. Monsoon season: The monsoon or rainy season begins with the arrival of the south-west monsoons in July and continues till September. Rains are very heavy in this period, though the cold deserts and inner dry valleys remain unaffected by the monsoon rains.

3. Winter season: The winter season starts after the rainy season though a brief autumn may be experienced in the sub-tropical and temperate regions. At higher elevations, the winter starts early and continues for several months till spring or early summer.

The occurrence of snowfall is a common phenomenon in the high altitude tract in this season. Snow covers the ground for long stretches.

NATURAL VEGETATION

The Himalaya is rich in natural vegetation which includes forests, grasslands and scrub lands. These range from the dense sal forests of the foothills to the sparsely vegetated slopes of the cold desert region.

A brief description of the natural vegetation of this region is given in the text below (Champion and Seth, 1968 and Negi, 1989).

1. Sub-tropical Forests

The sub-tropical forests occur in the sub-tropical zone of the Himalaya, where the climate is very hot in the summer season, while in winter the temperature drops to about 5°C. Rainfall is received both in the monsoon season, as well as in winter from the western disturbances. The main forest types of this tract are listed below:

1. Sub-tropical dry forest
2. Moist sal forest
3. Dry sal forest
4. Shiwalik sal forest
5. Dun and bhabar sal forest
6. Lower Himalayan or Shiwalik chirpine forest
7. Sub-tropical grasslands
8. Riverine forest or Khair and Shisham forest

2. Moist Temperate Forests

The temperate zone experiences warm summers and mild winters with snowfall occurring in the upper reaches of the temperate zone. Rainfall is received both from the south-west monsoons and from the western disturbances in winter. The main forest types of this tract are listed below:

1. Upper chirpine forest
2. *Ban*, *kharsu* and *moru* oak forests
3. Moist mixed coniferous forest
4. Moist deodar forest

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5. Fir and spruce forest
6. Moist mixed deciduous forest
7. Moist temperate grasslands.

3. Dry Temperate Forests

The dry temperate forests occur in the dry tracts of the temperate zone, mainly in the rain shadow of the main Himalayan mountain wall. Rainfall is low and bulk of the precipitation is received in the form of snow. The main forest types are listed below:

1. Dry broad-leaved and coniferous forest
2. Dry temperate coniferous forest
3. High level dry blue pine forest
4. Dry juniper forest
5. Neoza or Chilgoza pine forest
6. Dry temperate grasslands.

4. Sub-Alpine Forests

The sub-alpine forests are the highest tree forests in the Himalaya and no or sparse tree growth is found above this tract. They occupy an altitudinal position between the temperate and alpine vegetation. Winters are very cold in this tract and snow covers the ground for several weeks at a stretch in this season. The temperatures remain below the freezing point in winter. Summers are mild and heavy precipitation is received during the monsoon season. The main forest types of this tract are:

1. Sub-alpine birch and fir forest
2. Sub-alpine fir and spruce forest
3. Sub-alpine rhododendron forest
4. Sub-alpine grasslands or pastures

5. Moist Alpine Scrub

These scrub forests lie just below the snow line in the moister tracts of the Himalaya, usually above an elevation of more than

3300 m. Winters are very cold and heavy snowfall is experienced. The total growing period available to the plants is very short.

The tree species become stunted due to the harsh climatic conditions and may attain shrubby form. The vegetation comprises mainly of meadows or grasslands. These include the following vegetal types.

1. Birch-Rhododendron scrub forest
2. Deciduous alpine scrub
3. Alpine pastures

6. Dry Alpine Scrub

This is the alpine vegetation of the cold desert areas and the inner dry valleys, e.g. Ladakh, Lahaul, Spiti and Kinnaur. Precipitation is very low as this region lies in the rain shadow area of the main or central Himalayan mountain wall. As a very short growing period is available, the vegetation appears only after the snow melts in the summer season and dies with the onset of winter. It is mainly semi-xerophytic in nature.

DRAINAGE SYSTEM

The Himalaya is drained by a complex system of streams, lakes and rivers, some of which rise in Tibet and enter into this region from the north. A number of rivers are older than the Himalayan mountains. This region is drained by the Indus and Brahmaputra river systems (Negi, 1998).

1. Indus River System

The Indus river rises from near the lake Mansarovar on the Tibetan plateau and enters the Himalaya in Ladakh. Thereafter it flows through the Ladakh region of Jammu & Kashmir before entering the plains of Pakistan. The main tributaries of the Indus river in Ladakh are:

- the Shyok river rises in the Despang plains.
- the Shigar river originates from the glaciers on the southern face of the Karakoram range.

- the Gilgit river rises near the north-western boundary of the Himalaya.
- the Astor river rises near the Burzil pass.
- the Shigar (south) river drains the northern slopes of the Himadari.
- the Zaskar river originates from the north-facing slopes of the great Himalaya.
- the Hanle river is a short left-bank tributary of the Indus river.

Besides the above tributaries, other important tributaries of the Indus system draining the western Himalaya are:

1. Jhelum: The Jhelum river rises from the northern slopes of the Pir Panjal range. It drains the Kashmir valley before cutting a deep gorge through the Pir Panjal range near Baramula. Its major tributaries are:

- the Liddar river originates in the snowy wastes at Chandanwari near the mountain resort of Pahalgam
- the river Sindh originates on the southern slopes of the great Himalayan range that hems the Kashmir valley. It flows into the Jhelum river near Srinagar
- the river Kishenganga also originates on the south-facing slopes of the great Himalayan range.

2. Chenab: The river Chenab is another major tributary of the river Indus. It rises from the Lahaul valley of Himachal Pradesh and enters Kishtwar after flowing through the Pangi valley of Himachal Pradesh. Thereafter it flows along the base of the Pir Panjal range and enters the plains.

3. Ravi: The Ravi river is the third of the five major tributaries of the Indus river. It originates in the Bara Banghal tract between the Dhauladhar range in the south and the Pir Panjal in the north. This river flows in a more or less westerly direction before it cuts across the Dhauladhar range downstream of which it flows towards south-east to enter the plains of Punjab.

4. Beas: The river Beas is another important tributary of the river Indus. It rises from the snowy wastes on the south-facing slopes of the Pir Panjal range near the famous Rohtang pass. It

drains past the famous holiday resort of Manali and through the Kullu valley south of which it has cut across the Dhauladhar range at Larji. The main tributaries of the Beas river are:

- the Parbati river which joins the Beas river near Shamshi
- the Harla river which joins the Beas near Bhuntar
- the Sainj river which joins the Beas near Larji
- the Tirthan river which rises in the snows of an offshoot of the Pir Panjal range. It joins the Beas near Larji
- the tributaries rising from the Dhauladhar range which flow into the Beas river are Uhl, Suketi, Luni, Awa, Banganga, Gaj and Chaki.

The river enters the plains of Punjab near Pathankot after cutting a gorge across the Shiwalik range.

5. Satluj: The Satluj river rises from near the lake Mansarovar in southern Tibet. It enters India (Himachal Pradesh) near Shipki La. Thereafter it flows, through the trans-Himalayan areas of Himachal Pradesh. It cuts a spectacular gorge across the main Himalaya, flows at the base of the Shimla ridge and enters the plains of Punjab downstream of the Bhakra dam. The main tributaries of the Satluj are the river Spiti and Baspa.

2. Ganga River System

The Ganga river system drains a major part of the Himalaya, from the south-eastern slopes of the Shimla ridge to eastern Nepal. There are a number of tributaries of the Ganga river system. These are:

1. Yamuna: The Yamuna river is the largest tributary of the Ganga river. It drains the westernmost part of the Ganga catchment. The main tributaries of the Yamuna river are:

- the Tons river which rises in the snows beyond the high altitude valley of Har-ki-dun
- the river Aglar which flows along the base of the northern slopes of the Mussoorie ridge
- the Giri river which drains the south-eastern corner of Himachal Pradesh

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- the Bata river which originates on the lower slopes of the Nahana ridge and drains the Paonta valley.

2. Bhagirathi: The Bhagirathi is one of the two rivers that merge to form the Ganga river at Deoprayag. It rises from the snout of the Gangotri glacier at the base of the Chaukhamba massif. It is joined by the Alaknanda at Deoprayag, downstream of which the channel is known as the Ganga river. Important tributaries of the Bhagirathi river are:

- the Janhvi river that flows into the Bhagirathi near Uttarkashi
- the Bhilangana river which flows into the Bhagirathi near Tehri.

3. Alaknanda: The river Alaknanda and its tributaries drain the central part of the U.P. Himalaya. It rises from the snowy wastes to the north of Badrinath and merges with the Bhagirathi river at Deoprayag. Main tributaries of the Alaknanda river are:

- the Mandakini river which rises from the snows to the north-east of Kedarnath. It joins the Alaknanda at Rudraprayag
- the Pindar river which rises from the Pindari glacier on the south-western slopes of the Alaknanda-Kali water-divide. It merges with the Alaknanda at Karnaprayag
- the Nandakini river is another important tributary of the Alaknanda. It joins the main river at Nandprayag
- the river Dhauliganga which rises from the snowy wastes on the southern face of the main Himalayan range.

4. Kali: The Kali river forms the border between India and Nepal. It flows in a more or less south-southwest direction along a narrow V-shaped valley. The main tributaries of this river are-

- the Kalapani river which is the eastern headwaters of the Kali river
- the Kuthi Yankti river which is the western headwaters of the Kali river. It rises on the southern slopes of the main Himalaya
- the Goriganga river which rises from the snow-bound slopes of the Alaknanda-Kali water-divide

- the Sarju river is another important tributary of the Kali river. It drains west-central Kumaun
- the Ladhiya river which rises from a number of spring-fed streams in the south-eastern corner of Kumaun.

5. **Ghagra:** The river Ghagra and its tributaries drain western Nepal. It has a number of large tributaries:

- the river Karnali rises in the springs of Mepha Chungo near Mansarovar in Tibet. Thereafter, it flows south of the Gurla Mandatta, cuts across the great or main Himalayan range to enter Nepal.
- The river Seti rises near Api and flows in an easterly direction to join the Karnali.
- The river Bheri rises in the snows of the Dhaulagiri massif and joins the river Ghagra in the foothills.

6. **Gandak:** The river Gandak and its tributaries drain central Nepal. The main river of this system is the Krishna Gandaki which rises in the trans-Himalaya tract beyond Manang Bhot. It has cut across the main or great Himalayan range through a spectacular gorge between the Dhaulagiri and Annapurna massifs. The other important tributaries of the Gandak river system are the Seti Gandak which rises from the base of the Ganesh Himal.

7. **Kosi:** The river Kosi and its tributaries drain eastern Nepal. The main river is known as the Sapt Kosi in its upper reaches as it is formed by the following seven major rivers:

- the river Sun Kosi which rises beyond the Gosainthan massif.
- The Indrawati which drains the eastern outer rim of the Kathmandu valley.
- The Bhola Kosi which takes away the snow-melt waters of the Cho Oyu and the Gauri Shankar massifs.
- The river Dudh Kosi drains the Mount Everest massif.
- The river Arun rises in the trans-Himalayan zone of Tibet. It has cut across the main Himalayan range through a fantastic gorge to the east of the Everest massif.
- The river Barun rises from the Barun glacier lying at the base of the Makalu peak. It drains into the river Arun.

- The river Tamur is the eastern tributary of the river Kosi. It rises from the snowy wastes on the western flank of the Kangchenjunga group of peaks known as the Kumbhkarān Himal.

3. Brahmaputra River System

The Brahmaputra system drains the eastern Himalaya. This river ranks amongst the longest rivers of the world. It rises in the great glacier of the Kailash range and flows for a distance of about 1700 km towards east in Tibet as the river Tsang po. Thereafter, it makes U-turn at the base of the Namche Barwa peak and enters India as the Brahmaputra.

1. **Teesta:** The river Teesta is a large tributary of the Brahmaputra. It rises from the Zemu glacier at the base of the Kangchenjunga massif. Thereafter, it flows towards south before merging with the Brahmaputra in the plains. The river Teesta has formed a deep valley which divides the Darjeeling and Kalingpong hills.

2. **Raidak:** The Raidak river drains western Bhutan. Its main tributaries include the river Thi Chhu which rises in the snows at the base of the great Himalayan range; the river Paro Chhu which is joined by the Thi Chhu at Confluence and the river Ha Chhu which flows in a south-easterly direction and joins the main river between Confluence and Chukho.

3. **Manas:** The Manas river and its tributaries drain parts of central and eastern Bhutan. The important tributaries of their river are: (a) the river Mangde Chhu which drains central Bhutan; (b) the river Chanka rises from the snows on the southern slopes of the main Himalayan range of Bhutan. It joins the river Mangde Chhu; and (c) the river Kurd.

4. Glaciers

Glaciers form a part of the drainage system as most major rivers of the Himalaya originate from glaciers located high up in the mountains. The melt waters from these glaciers form small streams that join to form rivers like the Ganga and Yamuna. A

majority of the glaciers lie on the main Himalayan mountain wall. In the Himalaya, the location of glaciers depends on aspects, like slope, latitude and total annual precipitation in the form of snow. The important Himalayan glaciers are listed below:

1. *Jammu & Kashmir*: Siachen, Hispar, Baltoro and Biafo.
2. *Himachal Pradesh*: Chandra Bhaga, Chandra-Nahan and Beas kund.
3. *Uttaranchal*: Yamunotri, Gangotri, Milam, Pindari and Satopanth.
4. *Nepal*: Khumbu.
5. *Sikkim*: Zemu.

In the past, major glaciations are believed to have occurred in the Himalaya and at least four glacial and corresponding interglacial periods have been identified from the Karewa sediments of the Kashmir valley.

SOCIO-ECONOMY

The socio-economic conditions of the Himalaya are diverse and there is a heavy dependence on natural resources by the people living in the rural areas. A high percentage of the total population depends on land resources for their livelihood, mainly in the form of agriculture.

1. Livelihood

The main sources of livelihood in this region have been discussed in the points below.

1. Agriculture is the main source of livelihood for the people. This is generally rainfed agriculture as irrigation facilities are lacking. Many farmers also grow fruits like apple and pears.

2. Animal rearing for wool, milk, meat and fur is another occupation, mainly for the people living in the higher reaches.

3. Other sources of livelihood include tourism, government service, business and trade.

2. Marketing

Small and large markets exist for marketing of the products, both in the rural as well as urban areas. These may be weekly or permanent markets.

3. Roads and Transport

Road transport is the chief means of transport in this region, though limited facilities exist for rail and air transport. The network or density of roads is more in the Shiwalik hills and lower Himalaya as compared to the high mountainous regions.

4. Power

Most areas in the Himalaya are electrified, except in the remote and inaccessible tracts. The main source of power is hydro-electricity.

5. Health

Most of the people depend on government-run hospitals and clinics for health services, though in the cities and towns private health facilities are also being used by the people.