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Wild Edible Vegetables of Lesser Himalayas

Ethnobotanical and Nutraceutical
Aspects, Volume 1

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Preface

Major populace in the world does not have sufficient food, and millions of people are deficient in one or more micronutrients. Wild edible plants have played an important role in human life since time immemorial and a greater part of the rural communities depend on wild food resources including wild edible fruits and vegetables to meet their food requirements in the periods of food disaster. The diversity in wild plant species offers variety in family diet and contributes to household food security. Wild edible food species are known to be an excellent source of nutrients and serve as a food supplement and an appetizer. Throughout the world wild plants make an important contribution to the life of local communities. They play a significant role in a wide range of agricultural systems and have an important socioeconomic position through their use in medicines, dyes, poisons, shelter, fibers, and religious/cultural ceremonies. Ethnobotany deals with natural relationships of the plant kingdom with man and animals. It relates past and present interrelationships between human cultures and the plants, animals, and other organisms in their environment. Nutraceuticals are the substances that may be considered as food or part of food and provide health benefits to the consumers. Consumption of the fruits and vegetables has been strongly associated with reduced risk of cardiovascular disease, cancer, diabetes, Alzheimer disease, cataracts, and age-related functional decline.

This book provides a brief introduction of ethnobotanical and nutraceutical aspects of wild edible vegetables used in the region of Lesser Himalayas. A total of 50 wild edible vegetables species are included in this volume. A detailed description of each species is provided including photographs, botanical name, English/local name, family, flowering/fruitletting period, status/habitat, parts used, distribution, ethnobotanical uses, cultural aspects, medicinal uses, and nutraceutical aspects. Medicinal uses include mode of preparation, way of application, and diseases cured; cultural aspects show species cultural index; nutraceutical aspects comprise proximate analysis of fats, proteins, fibers, carbohydrates, ash, moisture content, dry matter, and energy value; elemental analysis includes various essential and toxic metals; phytochemical screening involve total phenolic, flavonoids,

flavonols, and ascorbic acid; and antioxidant potential in terms of DPPH scavenging activity, hydroxyl radical scavenging activity, H_2O_2 scavenging activity, Fe^{2+} chelating activity, ferric reducing antioxidant power, and phosphomolybdenum assay are also assessed for each species. The analytical data pertaining to the statistical distribution, correlations, and multivariate analyses of the nutrients, phytochemicals, selected metals, and antioxidant activities are also provided.

It was our intention to best convey maximum knowledge regarding ethnomedicinal and nutraceutical aspects in minimum words. Further work is desirable to assess detailed phytochemical profiling and mechanisms of antioxidant properties of these vegetables based on modern techniques. There is always space for improvements and perfection. The readers are best adjudicators to evaluate this effort. We would be very grateful for any comments and suggestions as to improvement in terms of clarity, vigor, and coverage of subject matter. It would be our greatest achievement if this book could attract the students/scientists of food science, agriculture, nutraceutical science, bioscience, biodiversity, applied ethnobotany, ethnoecology, ecology, wild life naturalists, tourists, and others who have some lovely feeling for nature.

Islamabad, Pakistan

Arshad Mehmood Abbasi
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Chapter 1

Pakistan and Pakistani Himalayas

1.1 Pakistan

1.1.1 *Geo-Climate*

Pakistan has a long history of human settlements. Evidence of early civilizations dating from 3000 B.C. has been found in Harappa and Mohenjodaro. Pakistan is located in the north-west part of the Indo-Pakistan subcontinent about in the middle of the South Asian region. It lies between 24° and 37° north latitude and between 61° and 78° east longitude and stretches from the coast of Arabian Sea near the Delta of the river Indus so far north of the mountain ranges of Himalayas and Karakoram. From the deserted deserts of Thar to the forested valleys of Dir and Kohistan Pakistan, it covers a land area of 803,940 km² (0.67 % area of the world). About 58 % of the total land of Pakistan consists of mountain and plateau, whereas about 42 % are plains and deserts. Pakistan is surrounded by the neighboring countries; Iran to the west, Afghanistan to the north, China to the northeast, and India to the east and southeast, with about 1,000 km long coastline along the Arabian Sea (Food and Agriculture Organization of the United Nations 1987).

Pakistan has a great variety of landscapes with a diversified relief. It has all the majestic high mountain ranges, having enormous mass of snow and glaciers and 100 peaks of over 5,400 m in elevation. K-2 (8,563 m) is the second highest peak in the world. The great mountain masses the Karakoram, Himalaya and Hindu Kush form the watershed of the Indus River, which starts in the mountains of Ladakh, flows through Baltistan, bending southward through mountains into the immense plains of the Punjab, and falls into the Arabian Sea near Karachi. To the west, the Rocky Mountains which start from Chitral and extend through the Safed Koh in the Khyber Pakhtunkhwa (KPK) province converge with the semiarid Suleiman range in Balochistan. Torrential monsoon rains cause flash floods in some of these mountains. Their eastern drainage flows into the Indus. In the heartland of the country lies the flat alluvial flood plain which forms the drainage basin of this

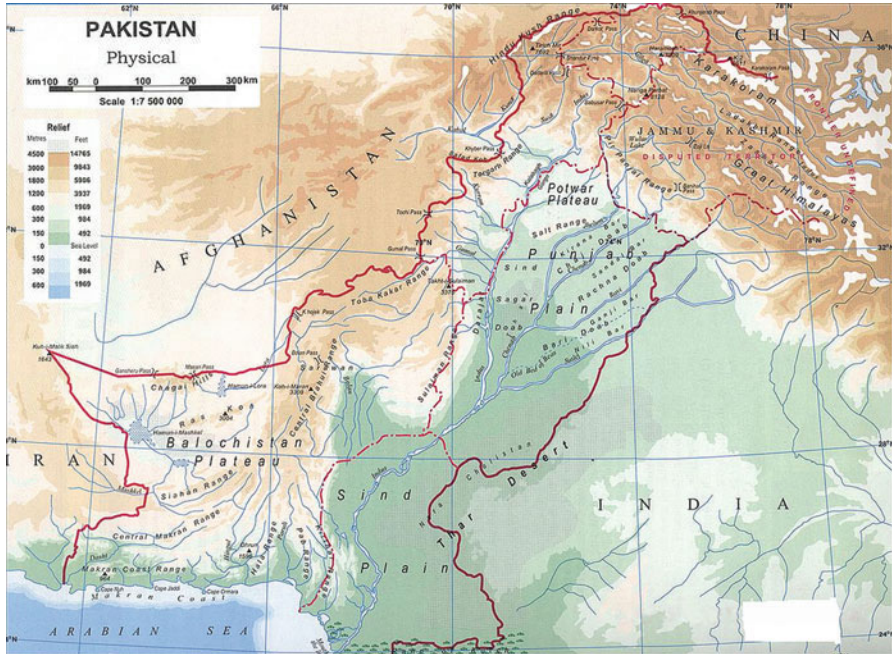


Fig. 1.1 Physical map of Pakistan (Source: [http://cn.bing.com/physical map of Pakistan](http://cn.bing.com/physical%20map%20of%20Pakistan))

mighty river. Summers are hot and dry, even in the lower mountain regions (Fig. 1.1).

The hot spell is interspersed by the monsoons which sweep into Pakistan from the Indian Ocean during early July to late September. The monsoon season is of immense importance to the biodiversity of the country. The moisture-laden winds end in heavy precipitation which is intense along the outer foothills of the great northern mountain barrier. The monsoon currents are blocked by the Nanga Parbat, after which a cold mountain desert emerges some 1,200 m above sea level. The direction of the monsoon largely bypasses the Baluchistan highland region, in particular the south-western corner of the province. This area is comprised of a vast desert plain called the Chaghai, which is an extension of the great Seistan depression, extending all the way into the Arabian Sea.

Rainfall in the country is highly erratic ranging from 30 mm annually in the Chaghai and Sibi deserts to as high as 1,350 mm in the Murree hills. In the Indus plain, the rain falls mainly during the monsoon season while the KPK is influenced by a Mediterranean climate with up to 60 % of the rainfall occurring in the winter months. In the foothill regions of the Hazara district and the Punjab, rainfall is more evenly distributed with a pronounced monsoon influence and only a quarter of the precipitation taking place during the winter months. Punjab and central parts of Northern Areas receive less than 250 mm of rainfall in a year. Northern Sindh, Southern Punjab, North-Western Balochistan, and the central parts of Northern

Areas receive less than 125 mm of rainfall. True humid conditions appear after the rainfall increases to 750 mm in plains and 625 mm in highlands. Pakistan can be divided into four broad temperature regions:

Hot summer and mild winter: 32 °C or more in summer and 10–21 °C in winter.

Warm summer and mild winter: 21–32 °C in summer and 10–21 °C in winter.

Warm summer and cool winter: 21–32 °C in summer and 0–10 °C in winter.

Mild summer and cold winter: 10–21 °C in summer and 0 and 10 °C in winter (UNEP).

1.1.2 Physiography

Pakistan has within its borders some of the world's highest and most stunning mountains such as Himalayas, Karakoram and Hindu Kush, Sulaiman, Toba Kakar, Kirthar, and Salt range. The Northern and Western Highlands produced by the mountain building movement extended from the Makran Coast in the south to the Pamir Plateau in the extreme north. The Northern and Western Highlands cover most of Balochistan, NWFP, Northern Areas, and parts of the Punjab. Five major physiographic entities of Pakistan are:

1. Mountainous North (The Himalayas, The Karakorams, and The Hindu Kush)
2. Koh-e-Safaid and Waziristan Hills
3. Sulaiman and Kirthar Mountains
4. Balochistan Plateau
5. Potowar Plateau (Salt Ranges, Kala Chitta Ranges, Margalla Hills)

1.1.3 Biodiversity

Pakistan has 225 Protected Areas (PAs), 14 national parks, 99 wildlife sanctuaries, and 96 game reserves. It is a world of rapidly shrinking wetlands, some of them of international significance of wondrous Juniper forests of Ziarat, Balouchistan province, and minute life forms. Pakistan covers a number of the world's eco-regions, ranging from the mangrove forests stretching from the Arabian Sea to the towering mountains of the western Himalayas, Hindukush, and Karakoram. One of the highest plateaus of the world "Deo Sai Plain" in Sakardu presents a unique plant diversity of alpine zone. The Fairy meadows of Gilgit also present a wide range of plant biodiversity. The Khunjrab Pass between China and Pakistan is a famous place of alpine flora, where several plants of family Asteraceae are yet to be identified a part from the members of Caryophyllaceae, Primulaceae, and grasses. The flora and fauna of the country are composed of a blend of Palearctic and Indomalayan elements, with some groups also containing forms from the Ethiopian region (Biodiversity Action Plan for Pakistan 2000).

1.1.4 Eco-Regions

Under the Global 200, ecosystems have been ranked to carry out conservation through comparative analysis. It covers all habitats on the land masses and in the ocean. The Earth has been divided into 238 ecoregions, by the United Nation (UN), the National Geographic Society (NGS) with WWF. Out of them five are in Pakistan. The Global eco-regions of Pakistan are:

1. Rann of Kunth grasslands
2. Tibetan Plateau
3. Western Himalayan Temperate Forests
4. Indus Delta Ecosystem
5. Arabian Sea

1.1.5 Agro-Ecological Zones

The climate of Pakistan varies with altitude. It has some of the world's highest cold areas that occur above 5,175 m in the Himalayas and the hottest low areas in the Indus Plains with many intermediate ecological zones. Pakistan has ten major ecological zones. In the Arid and Semi-Arid areas, most parts are bare of vegetation. On the basis of physiography, climate, soil type, and agricultural land use Pakistan is divided into ten main agro-ecological zones, which are:

1. Indus Delta
2. Southern Irrigated Plain
3. Sandy Desert
4. Northern Irrigated Plain
5. Barani (rainfall)
6. Wet Mountains
7. Northern Dry Mountains
8. Western Dry Mountains
9. Dry Western Plateau
10. Sulaiman Piedmont

1.1.6 Forest Types

Most recently, data of land use including forest area have been reported by Forestry Sector Master Plan (FSMP), with the help of Landsite Satellite Thematic Mapper Images at a scale of 1:250,000 covering the whole of Pakistan. Although the landmass of Pakistan offers varied soil conditions but the area under forests in spite of very pleasant climatic conditions is hardly about 4.587 million hectares which is 5.2 % of the total land area, including the farmland trees and linear

planting along roadsides, canal sides, and railway sides. Of the total forest area, about 3.311 million hectares (72.4 %) are managed and protected forests, while the rest 1.266 million hectares (27.6 %) are commercial forests (Hussain and Ilahi 1991; Sheikh 1987).

The type of forests that exist in Pakistan with relative share are moist and dry temperate: coniferous 40 %, scrub 28 %, tropical thorn 3 %, man-made irrigated 5 %, riverine 7 %, mangrove 8 %, and farm forests 9 %. At riverbanks and deltas, Riverain and Mangrove forests have emerged. On humid hills and mountains, pines and coniferous forests occur that change with altitude. The Dry sub-Tropical forests dominate up to an altitude of 1,000 m; the coniferous forests from 1,000 to 4,000 m. Above the tree line, dwarf alpine forests followed by the alpine pastures occur up to snow line.

The following forest types are found in Pakistan:

1.1.6.1 Tropical Forests

These forests are confined to the plain areas of Pakistan. They range from sea level to 300–400 m. These forests are divided into three subgroups (Beg 1975).

Tropical Littoral and Swamp Forests

These forests cover an area of 207,000 ha and occur in the Arabian Sea around the coast of Karachi and Pasni in Balochistan. The characteristics genera of these forests are *Avicennia*, *Rhizophora*, *Typha*, *Phragmites*, *Nymphaea*, *Nelumbium*, *Saccharum*, *Arundo*, *Tamarix*, *Acacia*, *Imperata*, *Paspalum*, *Sagittaria*, *Vitiveria*, *Salix*, *Potamogeton* and *Vallisnaria*, etc.

Tropical Dry Deciduous Forests

These are forests that occur at narrow strips in small areas of the Pakistan and mainly restricted to the Himalayan foothills and adjoining Siwalik and recent alluvial deposits. Such type of forests can be seen in the Rawalpindi foothills. The characteristics genera are *Salmila*, *Terminalia*, *Mallotus*, *Dalbergia*, *Carissa*, *Bauhenia*, *Lannea*, *Bombax*, *Sterculia*, *Flacourtia*, *Acacia* *Adhatoda*, *Gymnosporia*, and *Indigofera*.

Tropical Thorn Forests

These are low, open and pronouncedly xerophytic forests characterized by thorny, decedious, and hardwood species which occupy the whole of the Indus plain except

the driest parts. The major representative genera are *Prosopis*, *Capparis*, *Zizyphus*, *Tamarix*, and *Salvadora*.

1.1.6.2 Montane Subtropical Forests

These forests lie above the tropical zone and extend from 450 to 1,500 m in different parts of the country. They exist at a transitional zone between the tropical and temperate vegetation, therefore contain mixture of species from both types. According to Champion et al. (1965) these forests are divided into two main zones

Sub-Tropical Broad-Leaved Evergreen Forests

These are xerophytic forests of thorny and small-leaved evergreen species. This type occurs on the foothills and lower slopes of the Himalayas, the Salt Range, Kalachitta, and the Sulaiman Range. The typical genera of these forests are; *Olea*, *Acacia*, *Reptonia*, *Dodonaea*, *Mallotus*, *Carrisa*, *Justicia*, *Bauhenia*, *Pisticia*, *Maytenus* and *Sageretia*. Total area of these forests is estimated to be 1,191,000 ha.

Sub-Tropical Chir Pine Forests

These are open inflammable pine forests sometimes with, but often without, a dry evergreen shrub layer and little or no under wood. This type consists of Chir pine (*Pinus roxburghii*) forests found between 900 and 1,700 m elevation in the Western Himalayas within the range of the south-west summer monsoon. The characteristics genera of these areas are *Pinus*, *Xylosoma*, *Machilus*, *Celtis*, *Quercus*, *Pyrus*, *Ficus*, *Punica*, *Zizyphus*, *Pisticia*, *Olea*, *Zanthoxylum*, *Berberis*, *Cotoneaster*, *Indigofera*, *Carrisa*, *Rubus*, *Dodonaea*, *Justicia*, *Mallotus*, *Daphne*, *Vitex*, *Clematis* and *Tylophora*, etc.

1.1.6.3 Montane Temperate Forests

These forests occupy altitudinal range from 1,360 to 3,000 m. These forests are best classified by the rainfall during the season of vegetative growth. The wettest sites are predominantly occupied by the broad-leaved evergreen species. These forests are further divided into two groups (Hussain and Ilahi 1991).

Himalayan Moist Temperate Forests

The evergreen forests of conifers, locally with some admixture of oak and deciduous broad-leaved trees, fall in this category. These forests extend all along the

outer Himalayan ranges. Their undergrowth is rarely dense and consists of both evergreen and deciduous species. These forests occur between 1,500 and 3,000 m elevation in the Western Himalayas except where the rainfall falls below about 1,000 mm in the inner ranges, especially in the extreme north-west. These forests are divided into a lower and an upper zone. In the lower zone, *Cedrus deodara*, *Pinus wallichiana*, *Picea smithiana*, and *Abies pindrow* are the main conifer species in order of increasing altitude, with *Quercus incana* at lower altitudes and *Q. dilatata* above 2,130 m. In the upper zone *Abies pindrow*, *Populus*, *Salix*, and *Q. semecarpifolia* are the dominant tree species. There may be pockets of deciduous broad-leaved trees, mainly edaphically conditioned, in both the zones.

Himalayan Dry Temperate Forests

These are open evergreen forests with open scrub undergrowth. Both coniferous and broad-leaved species are present. This type occurs on the inner ranges and is mainly represented in the north-west. The representative genera of these forests are *Pinus*, *Quercus*, *Juniperus*, *Picea*, *Cedrus*, *Salix*, *Pistacia*, *Olea*, *Betula*, *Abies*, *Rosa*, *Ribes*, *Sorbus*, *Juniperus*, *Ephedra*, *Caranga*, *Salvia*, *Lonicera*, *Cotoneaster*, *Daphne*, *Berberis*, *Sorbaria*, *Artemesia*, *Astragalus*, *Thymus*, *Ferula*, *Allium*, *Tulipa*, *Nepeta* and *Ranunculus*, etc.

1.1.6.4 Sub-Alpine Forests

These forests occupy altitudinal range between 3,333 and 3,788 m and found throughout the Himalayas. In these forests trees are mainly deciduous, small sized and less in number. Evergreen conifers and mainly evergreen broad-leaved trees occur in relatively low open canopy, usually with a deciduous shrubby undergrowth of *Viburnum* and *Salix*, etc. *Abies*, *Betula*, *Pinus*, *Viburnum*, *Juniperus*, *Sorbus*, *Salix*, *Populus*, *Lonicera*, *Cononeaster*, *Rhododendron*, *Berberis*, *Bergennia*, *Euphorbia*, *Gentiana*, *Potentilla*, *Polygonum*, *Rumex*, *Ranunculus*, *Caltha*, *Anemone*, etc. are the characteristics genera of these forests.

1.1.6.5 Alpine Scrubs and Pastures

These forests consist of pasture and scrubby species and lie between 3,790 and 3,939 m altitude. The height of vegetation is generally less than a meter to 2 m. The herbaceous plants form mat-like structure. Growing season is very short due to predominant snow fall and strong winds. The characteristic genera are *Betula*, *Salix*, *Abies*, *Lonicera*, *Berberis*, *Cotoneaster*, *Juniperus*, *Rhododendron*, *Ephedra*, *Rumex*, *Rosa*, *Polygonum*, *Anemone*, *Senecio*, *Iris*, *Chrysanthemum*, *Gentiana*, *Arabis* and *Ranunculus*, etc.

1.1.6.6 Cold Deserts

They lie above the alpine zone at 4,550 m above sea level. Mostly they have no vegetation due to permanent snow cover. However, some herbaceous flora appears on the edges of these habitats after melting of the snow. The representative genera of such habitats are *Primula*, *Sibbalida*, *Sedum*, *Cerastium*, *Oxyria*, *Potentilla*, *Draba*, *Thlaspi*, *Arenaria*, *Luzula*, and *Waldheimia*.

1.2 Himalayas in Pakistan

Himalaya is derived from two Sanskrit words hima, “Snow,” and alaya, “House” factually means “House of Snow.” This word was coined by the ancient pilgrims of India who travelled in these mountains. The attractiveness of the Himalayas has lured visitors to this region since ancient times. Being the world’s highest mountain chain, it constitutes the greatest fascination to climbers and trekkers all over the world. The Himalayan mountain system is the planet’s highest and home to the world’s highest peaks: the Eight-thousanders, including Mount Everest (Nepal/Tibet) and K2 (Pakistan’s Northern Areas). The Himalayas represent the tremendous power, beauty, and magnificence of Nature. Himalaya is the land that houses the world’s largest non-polar ice masses.

The Himalayan system stretches across six countries: Bhutan, China, India, Nepal, Pakistan, and Afghanistan. Its widespread glacial networks feed Asia’s major rivers including the Ganges, Indus, and Brahmaputra. More than a billion people rely on these glacier-fed water sources for drinking water and agriculture. The Himalayan range runs west to east, from the Indus river valley to the Brahmaputra river valley, thereby forming an arc 2,400 km long, which varies in width from 400 km in the western Kashmir-Xinjiang region to 150 km in the eastern Tibet-Arunachal Pradesh region.

1.2.1 Himalaya Range

The greater Himalaya range runs west to east, from the Indus river valley in northern Pakistan to the Brahmaputra river valley in northern India and Tibet, forming an arc 2,400 km long which varies in width from 400 km in Northern Pakistan to 150 km in the eastern Tibet. The Western Himalayas are situated in Kashmir valley and Northern Pakistan, to the south and east of Indus River, and is dominated by Nanga Parbat massif with highest peak rising 8,125 m above the sea level, Pakistan’s second and world’s ninth highest peak. Nanga Parbat peak is also famous for its unique Rupal Face which rises 4,600 m straight above its base and the mountain is considered as one of the most difficult and dangerous to climb,

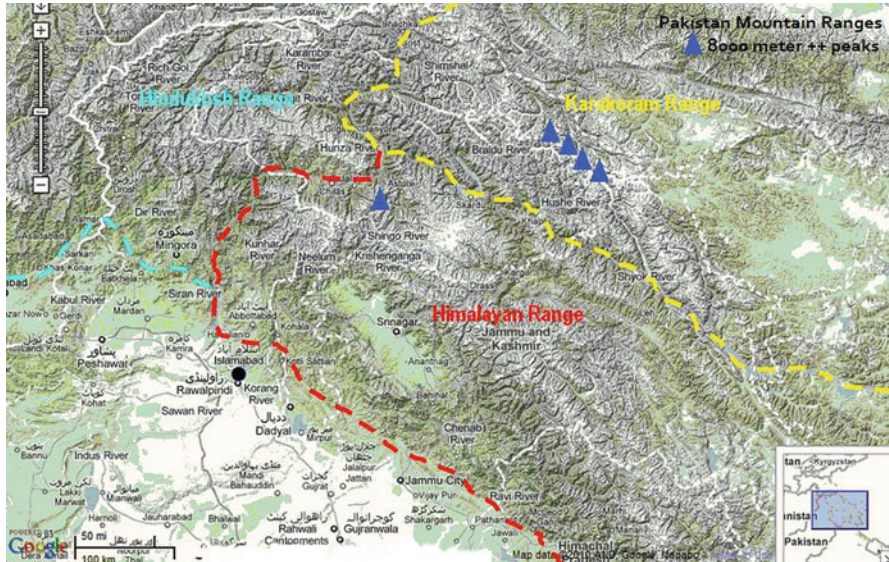


Fig. 1.2 Himalayas in Pakistan (Source: [http:// cn.bing.com/physical map of Pakistan](http://cn.bing.com/physical map of Pakistan))

nicknamed as Killer Mountain. The Himalaya range occupies in Pakistan the regions of Kashmir, Kaghan, Kohistan, Deosai, and Chilas. The Western Himalaya is also dominated by Deosai plains situated at the average height of about 4,114 m and covering an area more than 3,000 km². The place can be accessed from Skardu and is very well-known for its rich flora and fauna including summer flowers and endangered wild life species like brown bears. The Himalayan system in Pakistan is classified into three parallel and longitudinal zones (Fig. 1.2).

1.2.1.1 The Sub-Outer or Siwalik Himalayas

This zone extending over the southern part of Hazara-Murree hills, Rawalpindi hills, and Pabbi hills. Width of this zone varies from 8 to 48 km, with an average elevation of 909–1,212 m (Fig. 1.3).

1.2.1.2 The Lesser or Middle Himalayas

This zone occurs in the northern Hazara and Murree hills including main range, Dunga gali (4,546 m) in the north. Lesser or middle Himalayas are closely related to the greater Himalayas but of lower height. The average width of this zone is 80.5 km (Fig. 1.4).



Fig. 1.3 Panoramic view of a village in Lesser Himalayas, Pakistan

1.2.1.3 The Central or Great Himalayas

This zone comprises an average height of 6,061 m. Some of the height peaks of the central or great Himalayas are like Mount Everest (8,529 m) and Dhaulagiri (8,119 m) in Nepal and Nanga Parbat (8,066 m) in Pakistan.

1.2.2 Climate

Due to variation in the topography, altitudes aspects, and vegetation cover, the climate of Himalaya ranges shows tremendous variation. Even within the range, inner and outer parts contrastingly differ in the amount of rainfall, snowfall, and temperature conditions. The altitude varies from less than 500 m to over 5,000 m in the alpine regions which make with a shift in the climate also. The amount and time of rainfall, snowfall, and temperature are the major climatic factors.



Fig. 1.4 A view of Siri Paiya (Shogran)

1.2.2.1 Rainfall and Snowfall

It has been usually observed that the amount of rainfall reaches to its maximum up to 3,000 m within the moist part of the Lesser Himalayas. The climate of Lesser Himalayas falls into two major types

- (a) Subtropical Continental Lowland including the plain and foot-hills zone.
- (b) Subtropical Continental Highland including outer and middle Himalayas, Siwalik hills, Murree hills, and entire Hazara hills.

The climate of Haripur, Tarbela, Khanpur, Tanawal, Kahuta, Rawalpindi, and Islamabad appears to be likely dried subtropical. The average rainfall varies from 70 to 90 mm. There is a short monsoon period of 3 months during July, August, and September, which has monthly average of 100–200 mm. Snow is usually very rare phenomenon. In the lower Siwalik range covered by *Acacia-Olea* semi-evergreen forests, the climate is slightly mild. The upper Siwalik zone is the home of Chir pine; a true subtropical climate prevails. The climate data for Abbottabad, Mansehra, Goragali, Balakot, Bisham, Shinkiari, and Dadar shows that the average annual rainfall lies in between 100 and 130 mm. October and December appear to be the primary dry periods, which is followed by the secondary dry spell in May-June. A large part of the winter precipitation from the western disturbance is received in the form of snow.

The northern parts of Batagram, Balakot, Allai-Madakhel, Galiyat range, Dungagali range, entire Kaghan and Siran valleys, and middle parts of the Lesser Himalayas are characterized by cool temperate climate. The mean annual rainfall varies in between 100 and 130 mm. The precipitation from this source is mainly in the form of snow. Beyond Batakundi the monsoon rains are rare. The northern parts receive little rain but heavy snowfall in the winter. At the peaks monsoon fades and winter precipitation in the form of snow is more prominent as seen in Malika Parbat, Musa-ka-Musalla, and other peaks within the area.

1.2.2.2 Temperature

As a general rule the temperature decreases at a normal lapse rate of $0.5^{\circ}\text{C}/100\text{ m}$ during an altitude rise. In the western Himalayas there is a decline of 3°C per every 303 m and 4°C in the eastern Himalayas. The mean annual temperature of Tarbela, Khanpur, Tanawal, Kahuta, Oghi, Balakot, Kakul, Rawalpindi, and Islamabad is around 21°C with summer temperature rising over 41°C . June and July are hot months while December and January are coldest. There is a definite cool winter with frost and occasional snowfall. The climatic data for Abbottabad, Mansehra, Ghoragali, Balakot, Bisham, Shinjiari, and Dadar indicate that the mean annual temperature fluctuates in between 15 to 18°C . December and January are the coldest month and mean maximum temperature may be around 10°C . Frost and snowfall is common phenomenon. The mean annual temperature of the northern parts of Batagram, Balakot, Naran, Allai-Madakhel, Galiyat range, Dungagali range, entire Kaghan and Siran valleys, and middle parts of the Lesser Himalayas ranges from 4 to 10°C . In the wet temperate forests the winter accumulation of snow may be up to 7 m or more (Hussain and Ilahi 1991).

1.2.3 Hydrology

The important rivers of Himalayas in Pakistan are Siran, Dor, Haro, Kunhar, Jehlum, Soan, and Kurang. The mighty Indus strikes it on the west for 48 km and Jehlum River on the east for about 40 km. The Siran River arises in the north of the Bhogarmang valley then turns northwesterly in Heripur areas to join Indus at Tarbella. The total course of the Siran River is about 129 km. This river irrigates parts of Mansehra, Abbottabad, and Haripur. The river Dor originates at the northern end of Dungagali and flows through the Haripur plains and ultimately joins Siran near the north eastern end of the Gandgar range. The total length of Dor is 65 km and it irrigates parts of Abbottabad and Haripur. Haro rises at the southern end of Dungagali range where it has two branches. The eastern branch is called