

Chapter Two

Cold & Dry Environment of the HKH Region

Geo-physiognomic Features

The HKH is the world's highest mountain region. It extends over 3,500km, from Afghanistan in the west to Myanmar in the east, and ranges from the Tibetan Plateau in the north to the Ganges Basin in the south. Geographically, it covers all or parts of the eight countries falling in the Hindu Kush-Himalayan belt, which are Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan, where more than 120 million people live (see Map 1). The area and population of this region are given in Table 1. The HKH mountain region has a wide range of altitudes extending from the foothills to the alpine region and into a very high altitude region of perpetual snow and ice. It has been classified into 14 major topographical subdivisions: Balochistan, Sulaiman, Hindu Kush, Indus Himalayas, Karakoram, Kashmir Himalayas, Central Himalayas, Tibet, Assam Himalayas, Hengduan, Arakom Yoma, Shan Plateau, Gongga Shan and Yulongxue Shan (Chalise et al. 1994). The climate of these topographical subdivisions varies from tropical, subtropical, and temperate to alpine and cold tundra conditions. The precipitation extremes range from the driest west of the Himalayas, the Tibetan Plateau, and the rain shadow areas to the wettest in the eastern Himalayas, Assam, Myanmar, and parts of the Hengduan Mountains. The drastic varia-

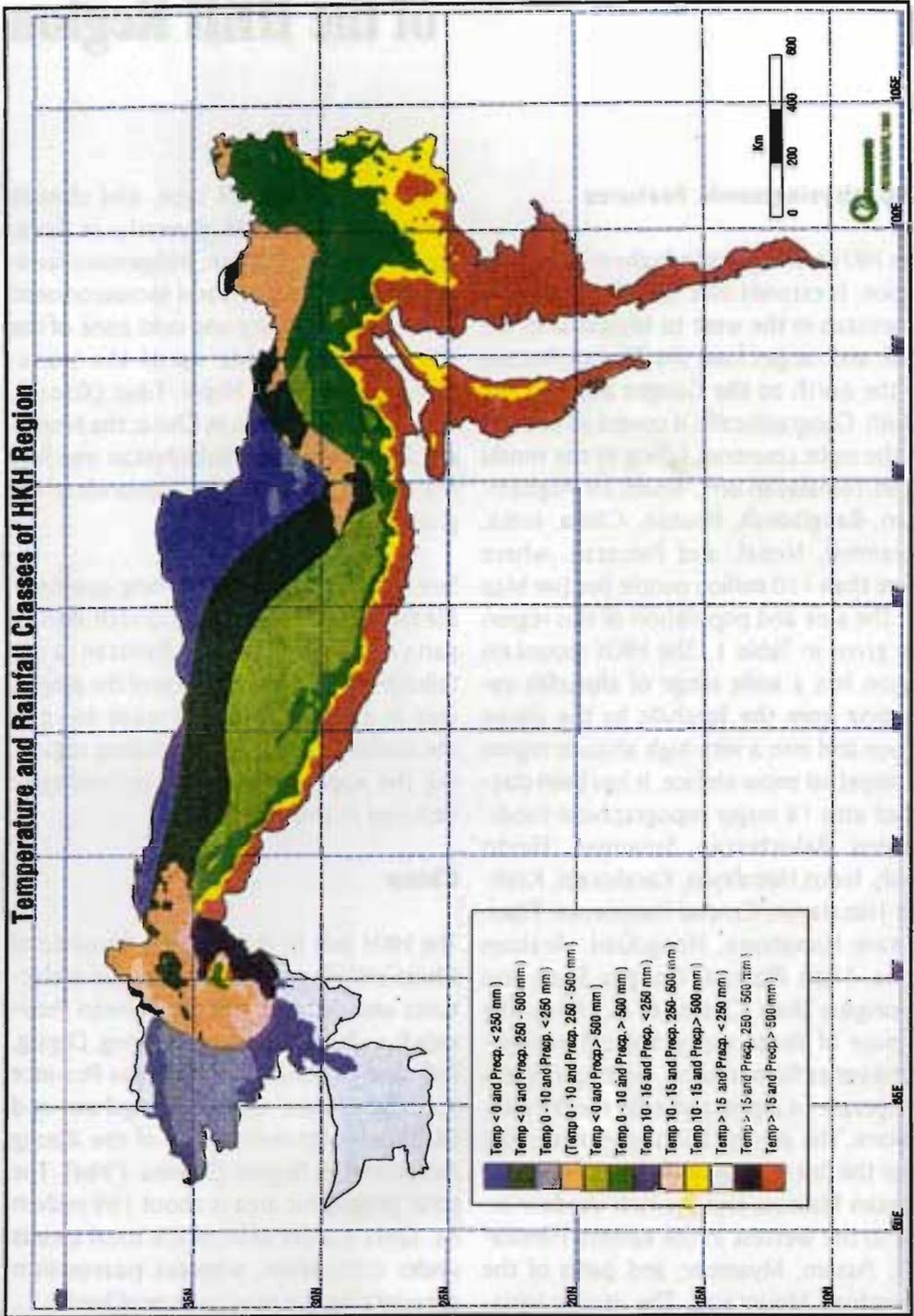
tions in altitude, soil type, and climate determine the great diversity in flora, fauna, land-use pattern, indigenous farming systems, cultures, and socioeconomic dimensions. The dry and cold zone of the HKH region is made up of the trans-Himalayan areas of Nepal, Tibet (*Xizang*), and Western Sichuan in China; the Northern Areas, Northern Balochistan and Rod Kohi in Pakistan; and the highlands of Afghanistan.

Since the work of documenting appropriate farm technologies was undertaken in parts of China, India, and Pakistan, a detailed biophysical description of the project area in each country was made to give the reader a better understanding regarding the applicability of all technologies included in this manuscript.

China

The HKH belt in the People's Republic of China includes all of Tibet, various prefectures and districts of both Yunnan Province (i.e., Baoshan, Lijian, Nuijiang, Diging, Dali, and Chuxiong) and Sichuan Province (i.e., Yann, Aba, Ganzi, Liangshan, and Dukou). It also includes all of the *Xizang* Autonomous Region (Sharma 1994). The total geographic area is about 169 million ha. Only 1.2 per cent of the total area is under cultivation, whereas pastoralism accounts for the principal use of land (i.e.,

Temperature and Rainfall Classes of HKH Region



Map 1: Temperature and Rainfall Classes of HKH Region

Table 1: Area and Population of the Hindu Kush-Himalayas

Country	Inclusions	Area (sq. km.)	Approximate Population '91 (in millions)	Density of Population (per sq. km.)
Afghanistan	25 of the 30 provinces	390,475	13.8	35
Bangladesh	Chittagong Hill Tracts	13,181	1.0	78
Bhutan	Entire territory	46,500	1.2	26
China	All of Tibet and parts of Yunnan and Sichuan Provinces	1,647,725	19.6	12
India	All of 8 and part of 3 northern states	482,920	35.0	73
Myanmar	States of Kachin, Chin, and Shan	280,862	5.6	20
Nepal	Entire territory	147,181	18.5	126
Pakistan	NWFP, FATA, Northern Areas and 12 of the 16 districts of Balochistan	404,195	22.7	56
TOTAL		3,413,039	117.4	34

53.4% as pasture areas). About 69.7 million head of different classes of livestock provide the socioeconomic activity in this part of the HKH region (Chalise et al. 1994).

In both Yunnan and Sichuan Provinces, the Hengduan mountains dominate the HKH belt (see Table 2). Tables 3 and 4 respectively contain information on the distri-

Table 2: Distribution of Major Mountain Systems in China

Name	Location	Orientation	Length (km)	Average Height (m)	Main mountain	Elevation (m)
Himalaya Mtns.	South Asia/ Tibet border	NW-SE	2450	6000	Mt. Qomolangma	8848.13
Gandise Mtns.	Southwest Tibet	NW-SE	600	5000-6000	Mt. Kangrengboqing	6711
Karakorum Mtns.	Xinjing and Tibet	NW-SE	400	6000	Mt. Qogir	8611
Tanggula Mtns.	Qinghai and Tibet	NW-SE	700	6000	Mt. Geladandong	6621
Hengduan Mtns.	Western Sichuan and Yunnan, and eastern Tibet	NS	1000	2000-6000	Mt. Gongga	7590
Kunlun Mtns	Among Xinjing, Tibet and Qinghai	WE	2500	5000-7000	Mt. Muzitage	7723
Bayanhar Mtns.	Qinghai	NW-SE		5000-6000	Mt. Bayanhar	5267
Tianshan Mtns.	Central Xinjing	WE	2500	3000-5000	Mt. Tuomuler	7435
Altay Mtns.	Northern Xinjing	NW-SE	2000	1000-3500	Mt. Youyi	4374
Qinling Mtns.	Between Gangsu and Qinghai	NW-SE	1000	4000	Mt. Shuleman	6346
Yinshan Mtns.	Central Inner Mongolia	WE	1200	2000	Mt. Huerbashenge	2364
Helan Mtns.	Ningxia -Inner Mongolia border	NS	330	2000-2500		-
Greater Hinggan Mtns.	Heilongjiang and Inner Mongolia	NE-WS	1200	1000-1400	Mt. Huangangliang	2029
Lesser Hinggan Mtns.	Northern Heilongjiang	WE	-	600-1000	-	-
Changbai Mtns.	Heilongjiang, Jilin and Liaoning	NE-WS	-	500-1000	Mt. Baitou	2749
Taihang Mtns.	Shai, Henan, Hebei	NE-WS	400	1500-2000	Mt. Xiaowutashan	2882
Qinling Mtns.	Qinghai, Gansu, Shaanxi and Henan	WE	1000	2000-3000	Mt. Taibaishan	3767
Wuyi Mtns.	Between Jianxi and Fujian	NE-WS		1000-1500	Mt. Huanggang	2158
Nanling Mtns.	Hunan, Jiangxi, Guangdong and Guangxi	WE	1000	1000	Mt. Maoershan	2141
Taiwan Mtns.	Taiwan	NS	-	-	Mt. Yushan	3997

Source: Data collection of Agricultural National Resources, State Agricultural Regionalisation Committees, China

Table 3: Distribution of Major Plateaux in China

Name	Area (10 ⁴ km ²)	Elevation (m)	Location	Distribution	Characteristics
Tibetan Plateau	249.6	3000-5000	Surrounded by Qilianshan, Alkin Hengduanshan and Himalaya Mountains	Qinghai Tibet, West Sichuan, Southwest Gansu	Highest in topography, plenty of snowy mountains with icebergs
Inner Mongolian Plateau	100	1000-1500	West to Greater Hingan Mountains, north to Qilianshan Mountains, the Great Wall and east to Tianshan Mountains	Inner Mongolia, North Hebei, North Ningxia and Gansu	Wind erosion, undulating landform
Loess Plateau	40	800-2000	West to Taihang Mountains, west to Wuqisoling. North to Qinling, south to the Great Wall	Shannxi, Gansu, Ningxia, Shanxi, Inner Mongolia, QingHai, Henan	Porous soil, severe soil erosion and water loss, complicated landform
Yungui Plateau	55	1000-2000	South to Sichuan Basin, east to Hengduan Mountains, west to Xuefengshan Mountains	Guizhou, East Yunnan, Northwest Guangxi. Boundaries of Sichuan, Hunan, and Hubei	Rugged landform, widely distributed landform

Source: Data collection of Agricultural National Resources, State Agricultural Regionalisation Committees, China

Table 4: Distribution of the Main Hills in China

Name	Distribution	Location
Liaodong Hills Liaoxi Hills	Southeast Liaoning Western Liaoning	Surrounded by sea except on one side that is adjacent to Changbaishan Mountain General term for the low hills south of the Laoha River in Liaoning Province, its main hills are Shongjiing, Nuluerhu, and Yiwulu
Shandong Hills Huaiyin Hills	Central & eastern Shangdong Henan, Hubei and Anhui	Two parts: to the west are the Vault Hills in Central Shandong, to the east are the Jiaodong Hills (also called the Laoshan Hills) Henan-Hubei border, the watershed of the Yangzi River and the Huaihe River in Central Anhui. It extends from Tongbeishan Mountain eastward to Hongze Lake, including Dabieshan Huoshan Mountains etc.
Minzhe Hills	Fujian, Zhejiang and Northeast Guangdong	General term for the low hills in Fujian, Zhejiang, northern and eastern Guangdong, including Tianmu, Wuyi, Xianxia, Kuocang, Yandang and Daiyun Mountains
Jiangnan Hills	Hunan, Jiangxii, southern Anhui and southern Jiangsu	General term for the hills south of Yangzi River, north of the Nanling Mountains, west of Wuyishan and Tianmushan Mountains, east to the Guizhou Plateau. The area can be divided thus: (1) West Hunan Hills, including Wuyishan and Xuefengshan Mountains etc. (2) Central Hunan Hills, including Henshan Mountain (3) West Jiangxi Hills, including Munishan and Luoxisoshan Mountains (4) East Jiangxi Hills, including Huaiyushan and Yushan Mountains (5) South Anhui Hills, including Huangshan and Jiuhuashan Mountains (6) Ningzhen Hills, including Ningzhen and Maoshan Mountains
Guangdong, Guangxi Hills	Guangdong and Guangxi	General term for the low hills in Guangdong and Guangxi, including Dayaoshan, Shiwaodashan, Gouloushan, Yunkaidashan, Luofushan and Linhuashan Mountains etc.

Source: Data collection of Agricultural National Resources, State Agricultural Regionalisation Committees, China

bution of major plateaux and the distribution of major hills in China.

Geo-ecological Conditions of the Hengduan Mountains

Zheng et al. (1993) have described the geo-ecological conditions of the Hengduan Mountains that fall in the HKH zone in China. The area was divided into three zones. On the northern side of the Himalayas is the agro-pastoral zone. On the southern side of the Himalayas and the southern section of the Hengduan Mountains is the agro-forest zone. The middle and northern sections of the Hengduan Mountains constitute the agro-forest-pasture zone.

The Hengduan Mountains comprise a series of high mountain ridges sandwiched between deep river gorges. The topography is interlaced and separated by mountains, plateaux, valleys, and basins in distinct relief.

The climate of the Himalayas and the Hengduan Mountains is characterised by a monsoon pattern with alternate wet and dry seasons. Winter lasts from November to April and precipitation rarely occurs. Summer extends from May and features heavy monsoon rainfall in most areas of the Hengduan Mountains. The annual precipitation varies between 500mm and 900mm. The mean temperature of the southern aspect of the Hengduan Mountains during the coldest months would be less than 18°C.

Zheng et al. (1993) also divided this area into four physio-geographical zones based on thermal-moisture regions and three-dimensional differentiations.

i) The tropical and subtropical montane monsoon region with a humid climate

This region extends over northwest Yunnan and western Sichuan, where elevation is below 2,500m above sea level (masl). The mean temperature of the warmest months varies from 18 to 25°C, and average temperatures during the coldest month fall between 2 and 16°C. The mean annual precipitation varies from 800 to 3,000mm. Popular fruit trees and cash crops are bananas, oranges, grapes, tea, and sugarcane at lower altitudes; while the temperate fruit trees and vegetables such as apples, pears, peaches, tomatoes, and pepper grow at higher elevations.

ii) The temperate plateau region with humid and sub-humid climates

This consists mainly of a series of high mountain ridges and comprises the central and northern parts of the Hengduan Mountains. The warmest mean temperature varies from 12 to 18°C at altitudes of from 2,500 to 4,000m. Annual rainfall totals from 400 to 1,000mm. This zone is rich in forest resources, medicinal plants, and mushroom production. Temperate fruit trees such as apples, pears, peaches, and walnuts grow well.

iii) The plateau temperate semi-arid climate zone

This is in south Xinang at altitudes of from 3,500 to 4,500m, where mean temperatures during the warm season fluctuate between 10 and 16°C, and average temperatures in the cool season remain within the 0 to 10°C range. Annual precipitation decreases from 500 in the east to 200mm in the west. Temperate fruit trees grow at

altitudes of less than 4,000m and the climate is suitable for potato production and for other vegetables.

iv) *The plateau temperate arid climate zone*

This covers the Nagri region and is composed of the upper reaches of the Indus River, and the broad valley of Banglong Lake where altitudes range from 3,800 to 4,500m. It is warm in summer and mean temperatures are between 10 and 14°C. Winters are severe, however, with a -10 to -14°C mean temperature range in the coldest month. Annual precipitation is less than 50mm. A large portion of the region is used for grazing small ruminants.

Basic Eco-environmental Characteristics of the Tibetan Plateau

Tibet, in the southwest of China, is composed of extremely high mountains and great plateaux. Its average elevation is between 4,000 and 5,000m. The Himalayas, Qandine, Karakoram, and Tanggula are famous mountain systems in the Tibetan region.

The Tibetan Autonomous Region (TAR) constitutes the main part of the Qinghai-Tibetan Plateau. The total area of TAR is 1.2 million sq. km. with an average elevation of 4,000m (Qinye 1997). The Himalayan Mountains from the southern side have a big influence on the climate of TAR. There are a series of high mountains and highlands characterised by wide valleys and basins. The higher altitude causes relatively low temperatures and cold weather. The mean annual temperature is below 0°C in the middle of the plateau and is below 10°C in July in most parts (Qinye 1997).

Qinye (1997) discussed the climate and land-use patterns of TAR. There may be

several different climatic zones, ranging from tropical low mountain areas to cold temperate highlands. The Himalayas serve as a barrier between north and south. In the warm season, flora and fauna are mostly distributed on the southern aspect. The southeast of TAR shows vertical zonation of forests, however, alpine meadows, steppe, and desert cover the central plateau. The horizontal changes may be seen from southwest to northwest in a sequence of forest-meadow-steppe-desert. The population density is very low at 4/km².

Livestock grazing is the major land use of the Tibetan plateau. There are more than 64 million ha of natural pastures of different kinds. The forage productivity of the pastureland is relatively low at 1,300kg/ha on a fresh weight basis. Forests make up 10 per cent of the total area. Only 0.22 million ha are cultivated (i.e., only 0.3% of the total area). Qinye (1997) divided the plateau into six land-use classes.

- High mountain valley agriculture and livestock region in eastern Tibet
- High mountain deep valley forestry, agriculture, and livestock region of the southern Tibet border area
- High mountain wide valley agriculture and livestock in central Tibet
- Plateau lake basin husbandry and agriculture region in southern Tibet
- Plateau lake basin livestock region in northern Tibet
- Initialised region in the northern Tibetan plateau.

Barley and wheat occupy more than 90 per cent of the cultivated land and aver-

age yield is seldom higher than 2,800kg/ha.

India

The project area of cold deserts in India covered about 15,000 sq. km. and extended over the Leh and Kargil districts of Jammu and Kashmir (J&K), districts of Lahaul and Spiti, and parts of Chamba and Kinnaur in Himachal Pradesh. These deserts are characterised by sub-zero winter temperatures (i.e., -20 to -40°C), a maximum day temperature of 40°C in summer and large diurnal variability in the ambient temperature. The annual precipitation is generally less than 30cm and is mostly received in the form of snow. Soils are shallow with little water holding capacity. High velocity winds blow for 12 to 18 hours per day. These distinct environmental characteristics have been supporting the succession of shrubby vegetation and C₃ plants over several stages. The deserts are ecologically varied and biologically diverse. Their biophysical conditions will be described separately.

Cold Desert of Jammu and Kashmir (J&K)

The cold deserts of J&K are restricted to the Ladakh area and are located between latitude 32 to 36° North and longitude 76 to 79° East. This zone lies in the high altitude range of the northwestern Himalayas. It covers Leh and Kargil districts in the east and borders with Gilgit and adjacent areas in the northwest. It has an area of about 0.067 million sq. km. The topography is rugged with rocky terrain and rough mountainous peaks reaching 4,000 to 5,500 masl. There are also sandy deserts, valleys, and a few fresh water bodies. This region comprises one-third of the total area of J&K. The valleys are relatively

long, wide, and open. Six rivers (the Indus, Syele, Zanskar, Nubra, Laru, and Drass) traverse the area.

The climate of Ladakh is temperate, arctic, and extremely dry and cold. Temperatures fall below -30°C. Drass, a small valley in the Ladakh area, is considered the second coldest place in the world. The region is mostly snow clamped and cut off from all other parts of the country for seven months of the year – from November to May. One of the most important characteristics of the area is an optimum thermal regime with stable weather – to which increased crop production can be attributed.

The flora and fauna of Ladakh are unique. Natural vegetation is mostly herbaceous and common plant species include *Juniperous wallichiana*, *J. communis*, *Caragana* spp, *Artemisia* spp, and *Betula utilis*. In addition, artificial forests, mostly made up of poplar, willow, and seabuckthorn, are found along the riverbanks, rivulets, and *nullah*(s). The main wildlife species include the snow leopard, ibex, blue sheep, wild ass, marmot, Tibetan wolf, and gazelle. There are nine varieties of birds, including the snow cock, partridge, and magpie. Large numbers of migrating birds also dwell on the lakes and rivers.

Social Environment

Although influenced by other parts of India and Tibet, the people of Ladakh have succeeded in developing their own distinct culture. They are simple and they follow the old cultural values. Their own script dates back to the seventh century A.D. Local people are fond of song and dance. Drama forms an important part of *Ladakhi*

culture. Losar (i.e., the New Year celebration in the Buddhist calendar) is one of the most important events of the year. *Ladakhi* is the main dialect in the Leh Valley, however, in Kargil both Urdu and *Ladakhi* are spoken. Buddhist priests, called *Lama(s)*, are the authority on traditional medicine, which is based on indigenous herbs and shrubs, and the medicinal literature is written in *Ladakhi*. This indigenous medicinal practice is called *emchi*. People in rural areas are engaged in the collection of minor forest products of medicinal value. Some of the important products are *Physochloina praoalta* (Langtang), *Ephedra* spp (*sapat*), and *Podophyllum* spp (*modi*).

The economy is mainly agro-pastoral. However, indigenous cottage industry is fairly well developed. Wood carving and woollen and *pashmina* shawls are popular with tourists. Tourism has great potential because of the unique terrain and rich cultural heritage. Leh is linked by air with Chandigarh, Delhi, and Jammu and has road links with Manali and Srinagar.

Farming Practices

The total cropland area in Ladakh is 1,060,000 ha, with a cropping intensity of 106 per cent. The net irrigated area is 97 per cent. The sole means of irrigation is by canal. Wells and tanks are yet to be used in the irrigation system of the region. Though the area has rich water resources, these are inaccessible. Groundwater is mostly saline and as such its use for irrigation purposes is negligible. The highest concentration of operational holdings is in the category of marginal farms (< 1.0 ha) which account for more than 55 per cent of the total operational holdings. Small farms (i.e., 1-2 ha)

and medium farms (i.e., 2-5ha.) constitute only 20 per cent of the total holdings. The average holding size is 1.54ha.

The region has essentially only a single cropping season, in the summer, this is called *kharif*, and extends from March/April to October. The cropping season varies at different altitudes, which may be up to two months in zones above 4,000 masl, three months in areas between 3,000-4,000 masl, and five months in locations below 3,000 masl elevation. This weather regime is optimum for growing a number of crops. Millet is grown on 50 per cent of the total cropped area. Wheat is the next most important cereal with 22 per cent of the total cropped area. Other crops grown in order of priority are fodder crops, barley, and pulses. Among the fodder crops, *alfalfa* is most popular due to its better adaptability to moisture stress conditions. The area under maize and rice is negligible.

Fruits and vegetables are the only commercial crops. Due to higher returns, farmers have recently introduced a fast-developing horticulture industry. Every year additional land is used for this activity. Apples, raisin grapes, and apricots are the main fruit crops in this zone, it is also known for its production of *pashmina* goats, yaks, donkeys, and double-humped camels.

The agroclimatic conditions within this zone vary greatly depending upon the altitude, soil, and climate. Hence, the cropping patterns and seasons also differ. During the winter months, different belts remain cut off because the high passes are blocked by snow. Specific farming situations have been identified as per the altitude.

- Upper Belt (3,500-5,000 masl)

This belt includes the sub-snow lines and highland meadows. Changthang, Khardung, and Diggar in Leh district, as well as Zanskar and Drass in the district of Kargil are inside this belt. Early maturing varieties of barley can be grown under irrigated conditions here. Rearing of goats, sheep, and yak is an equally important activity. Pastoral farming takes place in Changthang sub-division. Here, nomadic people rear the special breed of Pashmina goats and Changthangi sheep. In this belt, crop maturity is delayed and sometimes the crop is damaged by frost or hailstorms. The highland pastures and chunks of wasteland are also used for grazing. There are no systematic grazing patterns, and this has resulted in deterioration of the pastures.

This belt, being the highest inhabited part of the region, experiences low temperatures and a short summer. For the most part, no perennial forage crop is raised and the local pea variety is cultivated and hay preserved to feed animals in the winter.

- Central Belt (3,000-3,500masl)

This belt includes Leh and its surroundings, Nubra Valley and a small part of Kargil district. The majority of the land is under cultivation. It is a mono-cropped belt in which barley and wheat are the main cereal crops. Mustard, peas, and lathyrus are also cultivated on a small scale.

Among the fruit crops, apples and apricots are cultivated in limited amounts. This is the belt where most vegetables are being cultivated on an extensive scale. This is probably due to the benefit of being centrally located and near to marketing

terminals. The area has great potential for vegetable seed production. *Alfalfa* (Lucerne) is the major fodder crop. This crop is preserved as hay to stall-feed animals during the prolonged winter. Wheat and barley residues also have a lot of fodder value. Crop rotation is not common. Animal rearing is a subsidiary activity.

- Lower Belt (3,000 masl)

This zone is made up of the double-cropped area of Saspol to Dhahanu and Turtuk in Leh district; and Batalik, Gargarthang, and most parts of Kargil district. This area is considered to be a fruit growing belt. It is famous for the production of sun-dried apricots. Apricots and apples are the main fruit crops, along with walnuts, peaches, and plums. In some of the lowermost pockets, grapes are also cultivated. Common crop rotation patterns are barley-millet or turnip-wheat-fallow. Animal production is an essential secondary profession of the farming community.

Although small landholdings are a distinct overall feature of Ladakh, the size of the holdings are the smallest in this belt. This zone has a climatic condition that is suitable for extensive cultivation of vegetables. Conventional methods for preserving fruits are unhygienic and have little market value. Farmers need education and training which can enable them to adopt modern post-harvest technology.

Cold Deserts of Himachal Pradesh

The 'Cold Deserts' in H.P. are restricted to the districts of Lahaul and Spiti, parts of Kinnaur (on the Sumdo side), and Pir Panjal in Chamba. These areas have very difficult terrain with ice fields, perpetual snow-covered peaks, and a hostile climate. The

Great Himalayan range with a mean elevation of 5,500 masl extends from the Kunzam range to the Baralacha and Pin-Parvati ranges, separating the Chamba-Beas basin from the Sutlej-Spiti basin around Pooh. The Great Himalayan range is pierced by the Sutlej at Kalpa. The Zaskar range, beyond the Great Himalayan range, extends from Kinnaur, bordering China, and separates Spiti from Kinnaur and Tibet. The Zaskar range is pierced by the Sutlej at Shipki-la. The cold deserts in HP cover 35 per cent of its total geographical area.

The districts of Lahaul and Spiti are situated in the west of the greater Himalayan range between latitudes 30° 21' and 30° 50' 57" North, and longitudes 75° 46' 29" and 78° 41' 34" East. Lahaul and Spiti districts are composed of two different valleys, e.g., Lahaul and Spiti. The Lahaul Valley is narrow, steep, and studded with green patches of poplar, willow, and conifer. The Spiti Valley is rugged, with broad sand dunes, high peaks, and an average height of 6,600 masl.

The Pir Panjal ranges possess perpetual snow cover with steep, rocky, and gorgeous slopes. The Lahaul Valley is home to two very fast flowing rivers, the Chandra and the Bhaga, which converge at Tindi to form the Chandra Bhaga (Chenab). The Chandra Bhaga then flows down to Jammu and Kashmir through the Pir Panjal ranges. In the Spiti Valley, the Spiti is the main river, flowing through the entire length of the valley, and swallows numerous rivulets and rivers (the Pin, Lingti, Gumto and Parechu) on its way. It then converges with the Sutlej flowing through Kinnaur. The cold desert area in Kinnaur district falls adjacent to the eastern part of Spiti (Sumdo). The Sumdo area

in Kinnaur comprises a broad, sandy valley surrounded by high mountain peaks.

The geology is made up of gneiss and schistose rocks, slates, quartzite, phyllite, sandstone, (batal) slate, dolomite, shale, limestone (takche) and fossiliferous limestone. Calcareous shale with rich fossils are found in Lipak, Hunsa and Spiti. Fossils such as *Ammonites*, *Tenaculites*, and *Orthis* (Paleozoic and Mesozoic) are found in complete sequence from the Pre-Cambrian Quarternary.

In a broad sense, the climate can be categorised into spring, autumn, summer, and winter seasons. Natural springs and rivers become frozen in winter. The Lahaul Valley and Pir Panjal ranges experience heavy snowfall throughout the winter, while Spiti has very little precipitation during the winter. This lowers the mercury level to -40°C, although a temperature of -20°C is normally observed. Summers are associated with strong winds (40 to 60km⁻¹) causing dust storms. Relatively high diurnal temperature variations are observed in the summer season.

The natural vegetation cover of the entire area is fairly sparse. However, the Lahaul Valley and Pir Panjal areas still possess some forests on alluvial deposits. In the Spiti and Sumdo area, the number of old trees can be counted on the fingers. The overall vegetation consists of a few tree species, namely, junipers, *Betula utilis*, poplars, and willows. Common shrub species are *Hippophae*, *Myricaria*, *Ephedra*, *Artemisia*, *Rosa*, *Astragalus*, *Caragana*, and *Salix*. Herbaceous elements commonly found are *Thymas*, *Medicago*, *Trifolium*, *Anemone*, *Potentilla*, *Epilobium*, *Verbena*, *Allium*, *Aconite*, *Delphenium*, *Aquilegia*, *Primula*, *Geranium*, *Polygonum*, and *Can-*

nabis. The distribution of these species depends upon the altitude, direction, and availability of soil moisture. The fauna are unique with palaeoartic affinities and Tibetan birds and animals such as the ibex, bharal, brown bear, Tibetan wolf, nayan, marmot, snow leopard, lynx, weasel, vole, snow cock, snow partridge, *chukor*, chough, and raven. Two sanctuaries, namely, Pin Valley National Park in Spiti and the Sechu Tuan Nala in Chamba, have been established in the cold deserts.

Social Overview

The inhabitants of Lahaul, Spiti, and the Sumdo area of Kinnaur are overwhelmingly Buddhist. The 11th Century BC monasteries at Gumrang, Sissoo, Udaipur, Tabo, and Kee are still in good repair. However, in the Pir Panjal area, Hinduism is practised. In Lahaul Valley, the people have their own dialect, whereas in the Spiti and Sumdo area, the language is closer to the Tibetan dialect. The entire population can be categorised as *Swangla(s)* and *Lahaul(s)* in Lahaul, *Bodh(s)* in Spiti and Kinnaur, and Hindus in the Pir Panjal area.

Agriculture and animal husbandry are the main occupations. The area is well known for its disease-free seed potato with the highest yield in the world. *Lahaula(s)* are comparatively open and highly educated. The rise in literacy has abolished the polyandry system from Lahaul, whereas it still prevails in Spiti to some extent. In the Pir Panjal area, livelihoods mainly depend on the agropastoral system.

The traditional medicine system, mostly of Tibetan origin and based on local flora, can be effective in curing both common as well as chronic diseases and disorders. The weaving of indigenous fibre and wool fibre is quite a common practice, especially

in winter. Handmade shoes of fibre from *Cannabis* and local leather are comfortable and warm. Woollen garments are made from local wool/hair (sheep, goat, yak). During the summer, the inhabitants collect precious stones and minor forest products of medicinal value in order to earn extra income.

Due to poor communication facilities, tourism prospects are restricted. However, the Lahaul Valley and Pir Panjal ranges offer some very good trekking routes and sites. The Spiti Valley has been opened to foreigners.

General Farm Practices

Farming practices in the cold deserts of HP are discussed separately to facilitate better understanding of local agro-ecosystems.

- Lahaul Valley

The age-old cropping pattern meets the agroclimatic and socioeconomic needs for sustainability of the village ecosystem. Only one ploughing (i.e., pre-sowing) season is the general practice. The fields are ploughed in September before the onset of snowfall in November-December. As soon as the snow melts, the upper surface is stirred up with a rake or hoe for sowing seed. Whenever snow is heavy, there is plenty of moisture for seeds to grow, otherwise fields are irrigated by water channels. Sowing is completed in May or at the latest by early June. Sowing would necessarily be followed by irrigation after every fortnight and sometimes earlier, depending upon the availability of irrigation water. Barley, wheat, buckwheat, peas, and mustard are the most important crops. Barley is the most important staple food crop of the people. Buckwheat

is sown in succession to barley and is grown only on lower ranges. Peas and seed potatoes are grown all over the valley and have changed the tribal economy into a market economy. This process of economic transformation was introduced with the use of *kuth*, which is exported not only to other districts of the state and to other states in India but also outside the country. In May, *kuth* seed is broadcast along with barley. Thereafter, the young *kuth* plants, three months old, are properly spaced and manured. *Cheena* and tobacco are among the additional crops grown in this area. Mustard is grown on a smaller scale at lower elevations for its oil. *Bhang* and a few other vegetables are grown near homesteads. Popular vegetables are radishes, turnip, carrots, French beans, beetroots, cabbages, cauliflowers, and tomatoes. Soybeans are also grown. Crab apples, small in size and poor in taste, are common. Small pears grown here are juicy and delicious. Apricots grow mostly in the wild. They are small and possess a long shelf life. Oil is extracted from the kernels and used for cooking.

A few wild fruit plants include *nangke*, a thornless shrub of 1.2 to 1.5m which bears a red berry-type fruit. Another thornless shrub found here is called *rashtu*. This is almost of the same size as *nangke* and bears a round, black berry. There is yet another thorny shrub, which bears sour, red berries. *Lizo* and *rizo* varieties of wild cherry are also found. Alpine strawberries, small but tasty, and gooseberry bushes having fruits a little larger than grapes, are also found.

Various ceremonies are observed concerning cultivation. Ploughing operations start on an auspicious date fixed by a *Lama* skilled in astrology. When the seed has been sown, the fields are likewise blessed; the

Lama(s) are led to the fields in a procession to the accompaniment of the local orchestra. Prayers are held and the proceedings terminate with a small feast. To ensure that every seed that has germinated will produce corn ears, yet another ceremony is held in which the fields of sprouting corn are dotted with small sticks of juniper.

- Spiti Valley

Traditional farming is still a common practice throughout the entire Spiti Valley. The main crops are naked barley, common barley, wheat, and potatoes. With the dissemination of new technology by various extension agencies, cash crops such as off-season peas and hops are becoming popular and remunerative. However, lack of transportation facilities is still a main constraint to their cultivation. Sowing operations remain traditional. The area under cultivation is dependent upon assured irrigation. Indigenous ploughing is a common feature, although with the aid of subsidies, threshing operations are carried out mechanically. Farming conditions in the valley are entirely different from other parts of the state. Farmers have to struggle to make a living out of their small holdings on which nothing can be grown without irrigation. The area has witnessed a gradual shift in cropping patterns during the past two decades, from the growing of field crops to the cultivation of high-value cash-crops. At present, more than 50 per cent of the cultivated land is under cash crops such as off-season peas and seed potatoes.

Continuous flooding of individual fields is a common feature in the valley. The water supply and maintenance of the *kuhl* is managed by the community, and water availability is scheduled on a rotational basis depending on the size of the land-

holding. Generally, every farmer gets his turn once a week. The source of irrigation water is generally local *nullah*(s). Maintenance of the irrigation *kuhl* is carried out by the irrigation department. Due to the short growing season and cool climate of the region, monocropping is prevalent throughout the valley. The cereal crops, potatoes and peas are sown in April and are harvested in September-October. The yield is low as technology packages in terms of quality seed and fertilizer application are rarely used.

- Bharmaur Valley

The Bharmaur area is mountainous. The fields are usually of small size and are arranged in terraces, the lower border of each being formed by a rough wall providing terraces upon terraces to make the field more level for ploughing. The people of Bharmaur are agrarian. The net area sown is 2.01 per cent of the total geographical area. The practice of double cropping is limited. There are two crop seasons, namely, *kharif* and *rabi*. The *kharif* sowing season is between the months of April and June and the harvesting is completed by late August to early October. The *rabi* crop is sown during the months of October and November and is reaped in May and June. Because of variations in altitude and temperature, harvesting operations have a wide time gap. These variations have determined different patterns such as monocropping, double cropping, and sometimes biannual cropping.

Food grains occupy 19.1 per cent of the gross cropped area. The principal cereals grown in the valleys are wheat, barley, and maize. Besides these, important locally grown cereals are *phullan*, *seul*, *korda*, *bhaves*, *kanni*, and *chanat*. Wheat, barley, mustard, linseed (grown on a small scale),

and lentils are the main *rabi* crops. Vegetable crops, such as cabbages, cauliflowers, peas, onions, turnips, carrots, and radish are also grown in limited amounts. Maize, rice, *mash*, *moong*, *seul*, *phullan* and *bhare* varieties of lentils are the main *kharif* crops. Cash crops such as potatoes, tobacco, and chillies, and vegetables, such as beans, pumpkin, *brinjal*, lady fingers, etc., are cultivated to a small extent. During *kharif*, maize and rice are the predominant crops, while wheat and barley are important cereals of the *rabi* season.

A rudimentary form of green manuring is practised in paddy cultivation by using the leaves of wild bushes such as *basuti* and *kaimal* in fields before sowing. The practice of growing paddy mixed with *dhaincha* is also adopted, in fields where the paddy crop is broadcast. For this purpose, about 10 to 15kg of *dhaincha* seeds are mixed with every ton of paddy seed. During inter-culture, about a month after sowing, the *dhaincha* plants are uprooted and trampled into the soil in order to serve as green manure. The practice results in an increase in the yield of paddy by one to one and half tons per acre.

Men, women, and children work together in the fields all over the valley. Agricultural operations carried out by men are tilling, sowing, and harvesting. Women play an important role in weeding, harvesting and threshing operations. Children also render considerable assistance in threshing and storage.

The edible nut of *Pinus gerardiana*, locally called *chilgoza* and the hazelnut (called *thangi*) growing under wild conditions are the specialities of the Pangri sub-*tehsil*. Walnut grows wild and is cultivated in fields and in grazing areas throughout the Pangri and Bharmaur sub-*tehsil*(s) and in

many parts of the Churah, Chamba and Bhattiyat *tehsil*(s). Certain parts of the Chamba, and Churah *tehsil*(s) abound with mango trees. These lower regions are climatically suitable for all kinds of subtropical fruit. Gooseberry, strawberry, blackberry, redberry, rhubarb, bramble, and raspberry, all growing in the wild, are found in various parts and at different altitudes. The wild apricot is also harvested and dried. Oil is extracted from the kernels of some fruits, such as walnuts and apricots, and is used for burning in lamps, as well as being eaten as food.

According to a 1982 livestock census, the sheep and goat population constitutes the most significant category of animals, numbering 1,38,365 and forming 87.4 per cent of the total livestock population. Pastoralism is one of the main activities of the area. The steep gorges provide grazing facilities throughout the summer months. A migratory tribe called the *Gaddi* is unique to the area. *Gaddi*(s) own large flocks of sheep and goats and continuously migrate from alpine pasture to foothills and vice versa.

Household cottage industries, such as weaving and spinning, contribute to the economy of the area. Cloth is spun on indigenous home looms called *khadi*(s) in order to fulfill domestic needs. Among the main items made in cottage spinning are *pattus*, *pattis*, and *chadars*. These goods are sold at fairs and when the population migrates to the plains.

- Pangli Valley

The Pangli Valley is surrounded by high mountain ranges. The area is situated in the alpine pastoral zone, which remains under snow for about five to six months annually. Maize, wheat, barley, and po-

tatoes are the staple foods. Wheat is mixed with certain edible grasses and roots before it is consumed. Lentils, such as *mash*, *masur*, and *moong*, are more commonly used. Generally, farmers are sedentary rather than migratory, except in the case of the inhabitants of the higher altitude Sural, Hudan and Saichu *nullah*(s), sub-villages from which the populations migrate to the adjoining areas of Chamba and Churah *tehsil* during the winter months. Agriculture is a way of life rather than a commercial proposition for the people here. The net area sown in the Pangli *tehsil* is one per cent of the total geographic area. The practice of double cropping is very limited. Food crops occupy 99.8 per cent of the total cropped area. The principal cereals grown in the valley are wheat, barley (including a special variety of barley which is used for wine preparation) and maize. The average holding size in this valley is very small, and this can be attributed mainly to the hilly terrain and partly to sub-divisions, a result of the prevailing laws of inheritance.

The people of Pangli Valley are not seasonal migrants in the pastoral sphere of their economy, as is the case in Bharmaur. Migratory herdsmen from outside the Pangli *tehsil* derive much advantage from the summer pastures in this area. The main breed of cattle is the *Choor* (male) and *Choori* (female), which is a crossbreed of the yak and hill cow. The crossbred animals are superior to ordinary local breeds of cattle, both in draught power and milk yield. Sheep and goats are also reared for meat and fibre. The contribution of the bovine population to the economy of the area in terms of milk and milk products, animal manure and animal power used on farms, and for transport cannot be over estimated.

The residents of this tribal area undertake weaving and spinning on indigenous *khadi(s)* as a subsidiary occupation in order to cater to their domestic needs. Among the main items manufactured are *pattoos*, *patties*, *chadars*, and *thobis* (matting). These are generally made for household consumption and most of the raw materials used are available locally. Blacksmiths, carpenters, and tailors are the only village artisans, although in certain places, oilmen, tinsmiths, brasssmiths, and goldsmiths are found. Each artisan caters to the needs of a group of villages. In most cases, the customary payment is made in kind, depending upon the size of a family and the number of implements supplied, or the nature of services rendered.

- Kinnaur

Generally, very little land out of the total geographical area is suitable and available for cultivation of crops in the hills. However, as there is limited scope for other economic activities, such as industry, commerce and trade etc, agriculture is the mainstay of the people.

Farmers take advantage of the *kharif* as a full cropping season. Millet and other grains, including *ogla*, *faphra cheena*, *cholai*, *kangni*, and *bathu* (chenopodium), are the main crops of this season. In winter, the entire area remains under snow. Only wheat, barley, and peas are grown in the *rabi* season, the remaining *rabi* crops in the whole of Kinnaur are grown in the *kharif*. However, in upper Kinnaur, there is only one cropping season and all *rabi* crops are sown in summer. Only one crop is grown in a year and people have to depend upon imported wheat. Wheat and barley are grown in the summer season in fields on high hills owned by farmers. These fields are locally called *kanda*.

Fruit growing occupies an important place in local farming. The dry and cold climatic conditions are ideally suited for the cultivation of fruit such as apples, almonds, apricots, grapes, prunes, and nuts. A limited area is also under *chilgoza* forest. A shift in the cropping patterns, from traditional agriculture to the raising of horticultural and cash crops is taking place.

Vegetables grown include cabbages, peas, turnips, tomatoes, cauliflowers, lady fingers, brinjals, and spinach. Other non-food crops include condiments and spices, such as *zeera* (cummin), and saffron; and drugs and narcotics such as hops, *kuth* (*Saussurea lappa*), chicory, *karoo* (horse chestnut), and *patish*. The climate is most suited for the production of temperate vegetable crops such as tomatoes, cabbages, carrots, turnip, and beans. Vegetables, such as tomatoes, turnips, and so on, are dried in the sun and used during the winter months when no other vegetable is available. Fruits, such as grapes, apricot/*chuli*, prunes, apple rings, and pear rings, are dried and consumed during the winter months. The quality of these dried fruits and vegetables is poor due to traditional preservation techniques.

Pakistan

The HKH belt in Pakistan may be divided into two parts, namely, the western mountains and the northern mountains. The documentation of technologies was undertaken in the western mountains, in the northern uplands of Balochistan Province and in the mountains of Sulaiman Rod Kohi. Hence, only the salient features of these two zones of the western mountains are described in this chapter.

Uplands of Balochistan

Balochistan Province may be divided into the northern uplands and the southern

zone. It lies as far south as latitude 25° to 30°N of the Arabian Sea and towards the north it borders Afghanistan at a latitude of 32° 00'N. In the west, it shares the border with Iran and its eastern border coincides with three other provinces (i.e., Rod Kohi region). The area of the northern uplands is approximately 132,000 sq. km. The weather data for the highlands of Balochistan are given in Table 5.

Agriculture is the predominant activity in Balochistan, contributing to over 50 per cent of the province's gross domestic product. About 67 per cent of the labour force of the province are engaged in agriculture.

Balochistan comprises some 40 per cent of Pakistan's area, but due to its arid climate and poor water resources, it has the smallest irrigated area of all four provinces. Whilst grain production is possible on rainfed and flood (*sailaba*) irrigated land, yields are not only low but are also uncertain. High-value agricultural production is only possible on perennially irrigated land and water sources for such irrigation are very limited, comprising occasional per-

ennial streams, *karez*, and groundwater development through tubewells and dug wells. The irrigation water from each of these sources is extremely limited and hence needs to be used as efficiently as possible. This is even more important where groundwater resources are concerned as it is rapidly decreasing.

Balochistan, although having a smaller area of irrigated agriculture than other provinces, produces some high-value crops. This is due to the topography and climate. High elevation valleys (over 1,500m) in northern Balochistan are one of the few areas in the region capable of producing deciduous fruits such as apples, pears, plums, peaches, and grapes, all of which command a high price. Medium elevation valleys to the south and west of the above (1,000 to 1,500m) are capable of producing vegetables in different seasons to those in much of the rest of the country and therefore command a premium price. It is only the lower elevation areas in the plains to the south and east of the province which directly compete with the main, irrigated areas in the Pun-

Table 5: Weather Data of Upland Balochistan (1994)

Months	Quetta		Zhob		Barkhan	
	Temp* (°C)	Precipitation (mm)	Temp* (°C)	Precipitation (mm)	Temp* (°C)	Precipitation (mm)
January	11.4	48.4	N.A.	16.0	17.3	2.3
February	12.1	35.2	12.5	35.0	17.2	56.8
March	20.3	26.6	22.9	59.0	25.7	9.4
April	24.2	4.6	15.1	52.0	27.5	30.9
May	31.4	29.0	33.0	0.8	35.8	7.0
June	36.3	Trace	37.5	54.0	38.5	17.8
July	35.9	64.0	34.6	95.0	33.3	229.1
August	35.8	22.0	35.0	3.3	33.0	96.7
September	28.3	62.0	30.8	58.0	31.1	135.5
October	24.1	Trace	26.9	0.0	28.8	2.3
November	21.8	0.0	24.0	3.0	25.0	2.1
December	13.5	13.0	16.2	16.0	18.3	11.7
Annual	24.7	304.0	-	392.1	27.6	601.6

Source: GOB 1996

* Mean monthly maximum or mean daily maximum

jab and Sindh, since both grow similar types of tropical and subtropical fruit, vegetable, and grain crops. Even in the lower elevation areas, however, some crops such as coconuts, dates, and pineapples are grown which are capable of providing a higher than average return.

In the northern uplands, pastoralism with its associated raiding and caravan trading remained the mainstay of the economy until recently. An irrigated fruit and vegetable culture is now taking over as the main source of income. Nomadic pastoralism is widespread. Land utilisation statis-

tics of cultivable areas under *rabi* crops, and areas under *kharif* crops in eight districts in the highlands of Balochistan are indicated in Tables 6, 7, and 8 respectively.

Table 6: District-wise Cultivable Area in the Northern Uplands of Balochistan

District	Cultivable area (ha.)
Quetta	29,400
Pishin	115,900
Zhob	44,900
Loralai	133,700
Kohlu	30,100

(FAO 1983)

Table 7: Land Utilisation Statistics of Upland Balochistan (Area in hectares)

District	Geographical area	Reported area	Current fallow	Net sown	Sown more than once	Cultivable waste	Forest	Not available for cultivation
Quetta	265,287	139,825	26,997	12,712	100	39,175	39,088	21,853
Pishin	1,111,159	265,470	47,287	51,707	150	11,261	73,065	82,150
Loralai	1,907,140	377,750	106,275	42,971	150	75,598	64,589	88,317
Musa Khail	*	*	8,477	5,957	-	*	*	*
Barkhan	*	*	18,861	16,859	-	*	*	*
Zhob	1,651,787	60,930	9,776	13,904	50	13,387	13,010	10,853
Killa Saifullah	1,061,098	69,728	13,228	20,814	200	8,148	20,302	7,236
Ziarat	95,362	65,976	8,674	3,391	30	76	51,335	2,500
Kohlu	761,025	50,000	17,080	8,971	20	1,512	-	22,437
Dera Bugti	1,015,952	61,014	11,413	7,766	-	1,835	-	40,000

Source: GOB 1996

* Rabi crops include wheat, barley, oilseeds, cummin, pulses, vegetables, fodder.

Table 8: Scale of Cultivation in Upland of Balochistan Area (ha)

District	Rabi crops*			Kharif crops**			Fruits***
	Irrigated	Un-irrigated	Total	Irrigated	Un-irrigated	Total	
Quetta	3,806	554	4,360	8,332	20	8,352	5,696
Pishin	15,535	10,420	25,955	25,195	557	25,752	15,924
Zhob	1,335	1,595	2,930	10,639	335	10,974	9,715
Loralai	11,300	10,400	21,700	19,131	2,140	21,271	14,073
Musa Khail	720	1,100	1,820	2,685	1,452	4,137	161
Barkhan	4,920	6,700	11,620	2,272	2,967	5,239	1,523
Killa Saifullah	6,265	2,220	8,485	11,659	670	12,329	5,284
Ziarat	-	-	-	3,391	-	3,391	3,369
Kohlu	1,635	4,506	6,141	1,873	957	2,830	810
Dera Bugti	2,235	4,352	6,587	178	1,001	1,179	14

* Rabi crops include wheat, barley, oilseeds, cummin, pulses, vegetables, fodder.

** Kharif crops include sorghum, millet, maize, oilseeds, lentils, onion, potato, other vegetables, tobacco, fodder, sugarcane, cotton etc.

*** All fruits are also included in Kharif crops. The main fruit crops are apple, almond, apricot, grape, peach, plum, pomegranate, cherry and pistachio.

Sociocultural Indicators

Balochistan province had an excessively high annual population growth rate of seven per cent between 1972 and 1981. The enumerated and projected population for Balochistan is indicated in Table 9.

The literacy rates of 12.5 per cent for men and three per cent for women are far below the low national average of 31 per cent and 13 per cent, respectively. The majority of the population is Muslim (95.5%). Almost two per cent are Christians and 1.6 per cent Hindus.

The average rural population density of 12 inhabitants per sq. km. (1981) makes Balochistan by far the most thinly populated province of Pakistan (see Table 10). Among the socio-linguistic groups, the *Balochi* predominate in the Marri-Bugti and Kohlu areas. The *Sardary* (i.e., tribal) system is particularly strong in this region.

In other districts (Zhub, Loralai, Ziarat, Pishin, and Quetta), *Pathan(s)* are the largest socio-linguistic group. The *Pathan(s)* contrast sharply with the *Baloch*. The *Malik(s)* are the chief tribal representatives, while the strongest moral and social power is centred in the religious leadership of the *Mullah(s)* (Saints).

Biophysical Environment

Components of the biophysical environment of each district will be described separately.

• Quetta district

Quetta district lies along longitude 66°-53' to 67°-05' E and latitude 29°-55' to 30°-05' N. Quetta Valley is surrounded by the Murdar, Daghari, and Dhik moun-

Table 9: Human Population in Balochistan

Year	Population (million)
1951	1.2
1961	1.4
1972	2.4
1981	4.3
1990	7.1
2000	10.7
2010	14.6

Table 10: Human Population Density in Upland Balochistan ('000)

District	1951	1961	1972	1981
Quetta	109 (41)*	142 (54)*	253 (95)*	380 (143)*
Pishin	104 (9)	125 (11)	249 (22)	374 (34)
Loralai	97 (5)	111 (6)	187 (10)	391 (21)
Zhub	65 (2)	88 (3)	172 (6)	360 (13)
Kohlu	66 (4)	61 (3)	108 (6)	178 (10)

Source: GOB 1996

* Persons per square kilometre

Table 11: Altitude of District Head Quarters in Upland Balochistan

District headquarters	Metres above sea level
Quetta	1,676
Pishin	1,572
Loralai	1,433
Barkhan	1,067
Killa Saifullah	1,550
Ziarat	2,454
Kohlu	1,219
Dera Bugti	450

GOB 1996

tain series on the east with Chiltan and Kumbela mountain ranges on the west. The elevation of these ranges is from about 2,100 to 3,300 masl.

This district is classified as 'subtropical continental highland' characterised by cold snowy winters, cool summers, and frequent fog. It has a dry climate with a

mean annual rainfall of about 200mm, occurring mostly in winter. North and northwest winds, known as 'gorich', blow from October to February. Precipitation includes rainfall as well as snowfall. There are usually one to two episodes of snowfall in a year which take place between November and March. Precipitation in the area varies greatly from year to year.

Quetta district consists of a series of flat inter-montane basins surrounded by the Toba-Kakar Mountains. These basins have extensive alluvial and colluvial fans with broad aprons fanning out from the base of the mountains. Physiographically, there is shallow, stony, and steep land, gravelly fans and aprons; piedmont plains; piedmont basins; and loess plains.

The total population stands at 676,941 persons (GOB 1997a). Population density in Quetta district is 144 persons per kilometre, compared to Pakistan's average density of 106 persons per km². The urban population in the district is 75 per cent. The average household size is 7.7 persons.

Most of the area has a great potential for irrigated agriculture, nearly 64 per cent of the area is free from physical and chemical limitations and requires only slight to moderate ameliorative measures. The remaining 36 per cent of the area suffers from excessive slopes and may be used for grazing or forest purposes.

Agriculture that is rainfed, or irrigated using traditional practices such as *karez* and springs, is usual in this area. With the supply of electricity and mechanisation, use of tubewells has become a recent practice. The main crops cultivated here are vegetables, fruit (apples, grapes, and apricots) wheat, melons, etc. The ac-

tual annual cropped area is generally about 30-50 per cent of the cultivated area.

The existing agricultural land is classified into three different land tenure systems namely 'owner occupier', 'occupancy' (tenant), and 'tenant' at will. Crops are cultivated under rainfed conditions by flooding the fields. This practice is common for wheat production, however irrigation for fruit and vegetables is carried out using well water.

Use of inputs is minimal. Less than 25 per cent of wheat producers use limited amounts of fertilizer and almost no pesticides. For cash crops, such as potatoes, onions, other vegetables, and apples, almost all producers apply fertilizers and pesticides.

Draught animals, mostly camels, or tractors are used for land preparation. Household labour is generally used for farm activity, however, one-fourth of wheat growers hire labourers for harvesting and threshing.

- Farmers grow the following crops. The major summer crops (*kharif*) are sorghum (fodder and grain), maize (fodder and grain), and vegetables such as onions and potatoes, as well as melons.
- The winter crops (*rabi*) are wheat, cummin, vegetables, and *alfalfa* as fodder.

Most of the existing irrigation facilities, except *karez*, are constructed and owned by individual farmers. Most of the *karez* systems have now been abandoned because the water table has gone down, or they are in a state of collapse because of the intrusion of flood water. Most irriga-

tion facilities include open/tubewells, pumps, farm ponds, irrigation channels, and pipelines. Tubewells are used increasingly for irrigation or rural water supplies. Various provincial government agencies facilitate tubewell installations on farmers' requests wherever it is technically feasible. Normally, the turbine or submersible pumps for tubewells, and centrifugal pumps for open wells, are operated by electricity or diesel. Usually a 5cm to 12.5cm dia pump is installed and its discharge is 2 litres to 15 litres/second, enough to irrigate 2 ha to 12 ha of vegetables or fruit trees. Pumped water is usually stored in a farm pond through a pipe leading from the well.

Delay action dams (DADs) have been constructed to recharge the groundwater table and to minimise the flood peak discharge.

- Pishin district

Pishin district was created in 1972. It is bounded in the east by Qilla Saifullah and Ziarat and in the south by Quetta district. The total population is 311,227. The reported area of the district is 210,500 ha, out of which 90,700 ha are cultivated and 119,800 ha are available for grazing livestock (Iqbal et al. 1981).

The general physiographic characteristics of the district are mountainous. Its northern half is covered by *toba* plateau. The hill ranges are uniform in character and consist of long central ridges where frequent spurs descend. These spurs may vary in elevation from between 1,500 and 3,300m (GOB 1997b).

Pishin district is extremely cold during the winter, while summer is pleasant. Rainfall is between 200-250mm annually. In sum-

mer very little rain occurs. Rainfall and snow usually occur from January to March. Sometimes winter rains continue throughout April.

Crop and livestock production are the two main agricultural operations. Crop cultivation is generally rainfed; however, in some parts irrigated agriculture prevails with the help of the *karez* system. Irrigation is also supplemented by tubewells for growing a wide range of fruits (mainly apples, apricots, and grapes) and varieties of chewing tobacco. The chewing tobacco industry is developing rapidly in this district and tobacco production is emerging as a principal cash crop for local farmers. The main sources of irrigation are the *karez* system, open surface wells, tubewells, and delay action dams.

Pishin is well connected by road with other principal cities of Balochistan. Early varieties of apricot and grapes, better market access, and higher market prices early in the season makes orchard production a highly profitable proposition for the local growers. Since the district is near the biggest civic centre of the province (Quetta), vegetable production is also quite common.

Wheat is considered less profitable compared to fruit, vegetables, tobacco, etc under irrigation. It also competes with highly popular fruit and vegetable crops in the annual crop calendar, as it is harvested in late May or in early June. Wheat growing is further limited by the lack of water for irrigation during the months of October and November, due to low water levels in the *karez* and because of very little summer rain.

Land tenure is a legal relationship between the landlord and the cultivator for the dis-

tribution of farm produce and the sharing of farm costs. There are three main types of tenure system: owner, owner-cum-tenant, and tenant.

Most of the rural labour force are engaged in raising animals. Sheep and goat breeding is common. These small ruminants are not only more appropriate physiologically to withstand the harsh climatic stresses of the region, but they are also the only means of utilising the vegetation of depleted rangelands in far-flung areas. Cattle are used for draught, meat, and milk purposes. Due to the shortage of fodder and grazing lands, in some villages each family owns a few donkeys and camels that provide help in agricultural operations.

- Ziarat district

Ziarat district lies at latitude 30°-28' in the north, longitude 67°-37' in the east, and at an altitude of 1,700 to 3,000m.

The annual precipitation ranges between 200mm to 400mm. The wettest months are July and August, although significant amounts of precipitation also occur from December to March, much of this falling as snow. The climate is characterised by moderate winds, low humidity, cold winters, and cold summers. Hailstorms are a common crop hazard, otherwise the area has an ideal climate for the production of high quality fruit.

Soils are generally shallow and gravelly. The standard practice is to transport soil by digging silt from the nearest dams or delay action dams and from other muddy areas. The silt is transported in trucks or tractor trolleys and is spread 0.9 to 1.2m deep over the newly terraced fields prior to the planting of young fruit trees. These soils are non-saline and rich in the nutri-

ents required for the kinds of crops grown in the area.

Existing farm operations are geared towards orchard raising. The main fruit trees include apples, apricots, almonds, cherries, plums and peaches. The orchards are irrigated by *karez* and dug wells scattered throughout the district.

In addition, intercropping of tomatoes, potatoes, summer vegetables, onions, and *alfalfa* is common. The fodder production is inadequate for livestock. Winter feed shortages pose a severe constraint to livestock production. *Alfalfa*, maize, and leaves are the main source of fodder for livestock. Small flock owners buy dry leaves from the orchards to graze the animals on. Because of this, sheep are preferred over goats because sheep cause less damage to the tree shoots.

Establishing a young orchard is an arduous task because it requires heavy inputs and involves negative cash flow, at least for the first four to five years until trees reach the fruit stage. Hence, it is common practice to intercrop the young orchards with *alfalfa* for four to five years to improve soil fertility levels.

Apples are the most important fruit. However, there is a good premium for the early crop of cherries in the Quetta and Karachi markets. Sometimes, the premium price may be doubled due to good quality and taste. Young saplings are usually planted after two years in the nursery. Most planting is completed before the end of February and the middle of March. Local nurseries for apples and cherries meet the local demand. Tree spacing is generally adopted, as recommended by the Department of Agriculture. The most popular practice is to plant apple saplings eight to

nine metres apart, while the distance for apricot and cherry trees is about six to eight metres. Farmyard manure is mixed with soil when planting a sapling in the field. Fertilizers are never used at this stage because these are believed to burn the roots of a new plant.

All agricultural products (i.e., apples, apricots, cherries, plums, tomatoes, potatoes, and onions) are transported to various markets of the Punjab, namely, Multan, Faisalabad, Lahore, Rawalpindi, and occasionally to Quetta and Karachi.

Trucks are the means of transportation, with each truck carrying 450 to 500 crates of apples containing 15 to 18kg per crate. Tomatoes are packed in small crates with (approximately) a net weight of 15kg. Onions and potatoes are dispatched in gunny bags containing approximately 100kg and are transported to the Quetta market. Cherries are marketed in 5kg crates to Quetta, to the Pakistan International Airlines (PIA) freight terminal, then onward to Karachi airport and finally by truck to the main fruit markets in Karachi.

Juniper forest makes the beauty of Ziarat Valley and provides firewood. Ziarat possesses one of the most rare forest types in the world, the arid Juniper, *Juniperus excelsa*. The state Juniper forest of Ziarat stretches over an area of 50,000 ha. The tree is extremely slow growing, reaching a height of 1 to 1.5m and a diameter of 2.5cm in approximately 60 years. Many trees having a girth of 1.5m and over 20m tall are 2,000 years old.

Other vegetation in the Juniper forest is as follows.

Trees: *Fraxinus xanthoxyloides* and *Pistacia khinjak*

Shrub: *Artemisia maritima*, *Caragana ambigua*, *Prunus eburnea*, *Ephedra nubrodenis*, *Sophora alopecuroides* etc.

Grasses: *Pennisetum orientale*, *Stipa pennanta*, *Dicanthium annulatum*, *Chrysopogon montanus*, *Cymbopogon jawarencusa* etc.

- Loralai District

The district of Loralai consists of two *tehsil*(s) (Loralai and Dukki), and two sub-*tehsil*(s) (Mikhtar and Sanjavi). The physiographic delineation of Loralai district is given in Table 12.

Table 12: Physiographic Regions in Loralai District

Land form	Area (km ²)	% of total area
Mountain 2,000m	3,659	19
Upland 2,000m	2,965	16
Piedmont	10,979	58
Flood plain	1,468	7

Source: FAO 1983

The climate of Loralai is a typical semi-arid one. The average daily temperature falls below zero during winter and summer temperatures peak at 40°C for three to four months. It receives winter precipitation although a predominantly summer rainfall regime prevails as one approaches the Takht-i-Sulaiman mountains on the eastern border. The magnitude of annual precipitation is from 250 to 350mm, increasing to 450mm towards the eastern border.

Soils associated with the mountains are largely lithosols, since much of the parent material is high in calcium carbonate. The soils of extensive basins and floodplains are strongly influenced by localised cultivation and fallow practices. The soils are

generally low in both nitrogen and carbon and have a wide textural range.

Crop production in this area is a mix of rainfed, flood, and perennial irrigation systems, with most settlements benefitting from springs and *karez*. Fruit growing is an important way of earning money. Orchards, mainly apples at higher altitudes and almonds at lower elevations, are common in Loralai district. These orchards are being irrigated from the *karez*, springs, and tubewells. Vegetables, wheat, and fodder are grown as intercrops.

Although almonds dominate the area of established orchards, apples are the most important fruit in recent plantations. This shift in production is occurring throughout the district, despite the fact that the climate is generally better suited to almonds, apricots, and pomegranates. Peaches are grown as a minor crop, while there are small patches of cherries and plums.

Young saplings are usually transplanted into the field after two years in the nursery. Most planting is done in late December and January. Nurseries of all fruits are found in the area. The quality of stock in local nurseries and new nurseries is generally poorer than those coming from Ziarat and Quetta. Tree spacing is quite variable and standard layouts are rarely observed. The popular range of spacing for apples is between 6.25 and 9.5m, while the distance for stone fruits is 5.5 to 8 metres apart.

Young apple orchards dominate the area as farmers replace almond trees with apple trees. The current practice is to cut down the almond tree and leave it for two years until the roots have grubbed out, then it is replaced by an apple sapling.

Pruning trees is a very common practice in Loralai. The better-pruned trees show more inward growth and early on display upward growing limbs.

Tomatoes, chillies, cauliflowers, onions, and potatoes are the most common vegetables. Tomatoes and chillies are grown as bushy crops and are not usually supported by stacks. Most farmers get vegetable seeds from Loralai or Quetta. Progressive farmers grow their own seedlings in a nursery for transplanting. Cotton is also grown at high altitudes in Sanghari-Dukki. A small area is used for lentils such as *moong* and *mash*.

The majority of farmers still use a substantial amount of farmyard manure. They never use chemical fertilizer in stone fruit orchards as they believe that it causes excessive growth of the plant. However, a small number of farmers regularly use chemical fertilizers for vegetable production.

Farmers are very conscious of insect pests and other plant diseases. Almond scale is a problem that causes heavy losses and is seldom under control. There was an orchard in which approximately 200 almond trees were affected by almond scale and the farmer was unaware of the chemicals that could be used to control the pest.

In recent years, farmers have started spraying their orchards. In apple orchards, farmers are aware of the danger of the codling moth, green aphid, and hairy caterpillar and now have control over these insects.

While visiting different farms, it was observed that most farmers were using untreated seeds in their nurseries. Consequently, in one of the farms, the chilli crop was completely damaged and the farmer

was unaware of the disease. During an interview, it was found that the seeds for the nursery were untreated.

There is no tenancy system in the area. The ownership of land is common and the owner takes much interest in establishing orchards. Tractors are common throughout the district. Any farmer can easily hire a tractor on an hourly basis. Tractors and bulldozers are used for land preparation. Bullocks are still used by small farmers. The beds and ridges for vegetables are usually made manually.

- Zhub District

Zhub district is dominated by the Toba Kakar Mountains that run through the central and northern part of the region. A large portion of the district is mountainous. The most extensive floodplain is formed by the Zhub River.

Climatic fluctuations are caused by a gradual increase in precipitation from west to east (i.e., 200 to 400 mm annually). The eastern part of Zhub has two precipitation periods, one lasting from January until March and the other in July and August. The district experiences latitudinal temperature variations between valleys and slopes. There is a marked temperature gradient from north to south.

In general, soils are high in calcareous material and there is little turn over of organic matter. In mountainous regions, soils are largely composed of weathered parent material with no profile differentiation. The soils of piedmont slopes are strongly affected by periodic erosion and deposition. The floodplains have shown a high degree of disturbance, both from natural and human processes. These soils tend to be formed from alluvial deposits

and finely textured loess material. Soils in the *Pinus gerardiana* zone along the northern border of the district are very severely eroded.

Cultivation, mainly in the *kharif* season, is irrigated. Fruit production is the main source of income during *kharif*. Apples are predominant in the orchards, followed by almonds and apricots. Other important fruits are grapes, pomegranates, peaches, and plums. Maize and onions are the main crop cultivated. Maize is cultivated under rainfed conditions in about half of the area where it is grown. Some farmers grow tobacco and potatoes exclusively by irrigation. Wheat is the most important *rabi* crop and is grown under both irrigated and *barani* conditions. Barley is also grown along with wheat. Some vegetables and fodder (alfalfa) are grown in irrigated fields.

Blue pine (*Pinus wallichiana*) and *chilgoza* pine (*P. gerardiana*) are found along the northern border. The blue pine is found at the highest altitudes and has survived only on extremely steep, inaccessible slopes. The *chilgoza* pines are harvested extensively for timber, fuelwood, and resin. The edible nuts are collected each year. The largest area of Zhub, in the eastern and central parts, consists of scattered parkland made up of trees, with a lower stratum of herbs and shrubs. *Acacia modesta*, *Pistachia* spp, *Olea ferruginea*, etc occur most frequently in the upper vegetal stratum.

- Kohlu District

Approximately 38 per cent of the district is made up of mountains and uplands, with only three per cent as floodplains.

The southern part (i.e., 60%) of the district is arid, and precipitation is below

200mm. However, towards the north there is a marked increase in precipitation due to the summer southeast monsoon.

Dryland farming during the *rabi* season is the general practice. Wheat is the main crop. Vegetables and fodder are grown under irrigated conditions. Fruit production is less in the Kohlu area. During *khariif*, millet and sorghum are grown as fodder crops. Farmers grow onions, potatoes, melons, garlic, and other vegetables wherever irrigation water is available. Tubewells, wells and *karez* are the main source of irrigation.

Rod Kohi Region

The Sulaiman Rod Kohi Region covers the Sulaiman Mountains and piedmont plains comprising D.G. Khan, the Rajanpur districts of Punjab, D.I. Khan, Tank of the NWFP, and parts of Barkhan, Dera Bugti, and Kohlu districts of Balochistan Province. The area is mostly level, with a gentle slope towards the east. The Sulaiman mountain

range extends from north to south along the western side of the piedmont plains. It lies between latitudes 29°-15' and 32° N and longitudes 67°-30' and 71° E.

The region extends over an area of 42,000 sq. km. It is one of the least developed areas in the country but is endowed with ample natural resources. If used and managed properly, it has tremendous potential for increasing food, fodder, fuel, and fibre production. Since land and water are the basic components of agricultural production, their proper use is a prerequisite for achieving sustainable production. The factors that directly influence land use are of a physical, biological, social, and economic nature. A clear perception, knowledge, and evaluation of all the dynamic forces affecting the agro-system is *sine qua non* for ensuring sustainable management of resources. Salient features of the region are given in Table 13.

The climate of this zone is greatly influenced by elevation. Five bioclimatic zones

Table 13: Salient Features of Sulaiman Rod Kohi Region

Extent	42,000 Km ² (D.G. Khan, Rajanpur, D.I. Khan, Tank and parts of Barkhan, Dera Bugti and Kohlu districts)
Altitude	250-2,500m
Population	4.0 million
Climate	Arid to semi-arid sub-tropical
Linguistic groups	Siraiki, Pushto
Soils	Deep, loamy through clayey, locally gypsic salinity
Tenure system	State, privately owned large and small holdings
Economic indicators	Livestock production, date-palm and subsistence cropping
Plant indicators	<i>Prosopis cineraria</i> , <i>Tamarix aphylla</i> , <i>Haloxylon</i> spp
Wildlife	Chinkara, bustards, sand grouse
Development issues	Flash floods Inadequacy of potable water Soil erosion Deforestation/loss of biodiversity
Development options	Management of Rod Kohi irrigation Soil and water conservation Promotion of fruits and vegetables Management of rangelands and livestock production Agroforestry and dryland farming Wildlife conservation and propagation of medicinal plants

Source: Muhammad 1996

can be distinguished, i.e., (i) mountains (1,000 to 2,500m), (ii) piedmont plains, (iii) desert ranges, (iv) irrigated plains, and (v) riverain areas.

The climate is arid and semi-arid subtropical. Because of low humidity, continental location, and dearth of vegetation, both diurnal and seasonal temperatures are extreme. Beginning in May and lasting until August, the area often experiences a mean maximum temperature of more than 39°C. Winters are cold, but temperatures rarely fall below 5°C.

Mean annual precipitation varies from 180mm in the south to about 305mm towards the north. As expected, most of the rain is likely to fall in the form of several brief, but conventional, summer showers, except for in northern parts where it is more evenly distributed throughout the year. Average monthly rainfall is never sufficient to meet the atmospheric demand or potential evapotranspiration. Periodic rainfall trends are given below.

December to March: Weather during this period is affected by frequent and rapidly moving western disturbances or frontal systems. The mean number of rainy days can be put at one or two in January and two or three per month from February through March. Thunderstorms are also frequent in the month of March.

April to June: This is a season of increasing temperatures, strong surface winds, dust storms, and thunderstorms. Western disturbances continue to move at high altitudes. The mean number of rainy days ranges from one to two per month from April throughout June.

July to September (Monsoon): Active western disturbance and the associated

monsoon control the weather during this period. The mean number of rainy days per month stands at three, from July until September.

October to November: During this period, the weather is good. Occasional light rain is caused by movement of a frontal system from the west.

Climatic characteristics of the region recorded at various locations are given in Table 14.

Soil Resources

Soils of the piedmont plains are alluvium, formed of material from the Sulaiman mountain rocks. The main rocks are sandstone, shale, and limestone. Soils are generally very deep, well-drained, homogenised to a depth of more than 90cm with a weak structure. These are predominantly silty loam and fine-silty loam, although locally, clayey and sandy soils also occur and are moderately to highly calcareous. The lime content of the soil ranges from 17 to 43 per cent and is uniformly distributed in the profile. However, in some older soils, lime has concentrated in the form of nodules. These nodules are few and are scattered throughout the profile. The high lime content makes soils hard when dry but soft and friable when moist. These have rapid to slow permeability as well as poor to high water-holding capacity. Soils are generally deficient in organic matter, nitrogen, and available phosphorus as well as micro-nutrients such as iron and manganese.

Locally saline-sodic soils are also found. These soils are characterised by hygroscopic and gypsic salinity and are self-reclaimable if ample quantity of sweet water is available. Most of the soils in the

Table 14: General Climatic Characteristics of the Sulaiman Rod Kohi Region

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
D.G. Khan													
PM	9	9	11	10	9	11	38	34	11	2	2	6	151
P50	2	2	3	3	2	3	21	17	3	0	0	1	135
P70	0	0	0	0	0	0	7	5	0	0	0	0	86
RPAR	0.30	0.30	0.30	0.30	0.30	0.30	0.70	0.60	0.30	0.10	0.10	0.10	2.90
TEMP	12	15	20	26	30	34	33	32	31	26	19	14	24
ETP	67	81	135	186	241	270	253	237	216	166	103	70	2,029
MAI	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02	0.00	0.00	0.00	0.00	0.04
D.I. Khan													
P95	0	0	0	0	0	0	8	1	0	0	0	0	114
P75	1	3	6	1	0	0	28	8	0	0	0	0	178
P50	5	10	18	7	2	2	53	24	4	0	0	1	234
P5	58	60	112	99	48	58	170	125	74	21	17	41	418
PM	14	17	32	23	10	12	66	38	16	4	3	8	246
TEMP	12	15	20	26	30	34	33	32	31	26	19	14	24
ETP	69	85	127	161	208	257	221	200	186	140	76	62	1,791
MAI	0.01	0.04	0.04	0.01	0.00	0.00	0.13	0.04	0.00	0.00	0.00	0.00	0.10

Source: Muhammad 1996

PM : Precipitation/month
 P95 : Precipitation at 95% probability
 P75 : Precipitation at 75% probability
 P50 : Precipitation at 50% probability
 P5 : Precipitation at 5% probability

RPAR : Relative photosynthetically active radiation
 TEMP : Temperature °C
 ETP : Evapotranspiration (mm)
 MAI : Mean aridity index

pedmont plains are dry and barren. Locally, where flood water impounds, a few scattered shrubs of *Capparis*, *Suaeda*, *Salsola*, and *Haloxylon* and moderate cover of *Panicum* and *Sporobolus* grasses are found.

Cropping Patterns

Crop production in the Rod Kohi area is unique and traditionally occurs at the subsistence level. The Rod Kohi area is a flood-plain that has a long planting season, starting from February and continuing until August for spring and summer crops and from October to December for winter crops. The main crops grown during the *rabi* season are wheat and barley, while millet sorghum, and *mung* beans make up the summer crops. Crop rotation is traditional. The main crop rotations tested in this area are given in Table 15.

Table 15: Crop Rotations in Rod Kohi Area

i)	Wheat	Sorghum	Fallow
ii)	Wheat	Fallow	Wheat
iii)	Gram	Melon	Gram
iv)	Barley	Millet/ Sorghum	Fallow
v)	Melon/ Sorghum	Fallow	Melon/ Sorghum
vi)	Barley	Fallow	Barley

Source: Muhammad 1996

Cropping Intensity

Cropping intensity in summer, as well as in winter, is very low. Overall, annual cropping intensity is not more than 80 per cent, i.e., 30 per cent in summer and 50 per cent in winter. Wheat accounts for 40 per cent of the cultivated area and is the main crop in winter. Sorghum/pearl millet, with a 25 per cent share of the cultivated area, has second position. Because of their food and feed value cereals are the

most important crop and occupy more than 60 per cent of the area. Musk melon and oilseeds are cash crops. Gram is planted in piedmont sandy areas.

Livestock Production Systems

Livestock production is the main land use in the Sulaiman Mountain and Rod Kohi areas. It is a traditional system based upon rangeland grazing in the hills and integrated with crop farming in the plains, depending on the availability of runoff water. The livestock component of this farming system is managed in such a way as to provide much of the subsistence needs of a farm family during a year. The area is used for grazing camels, sheep, goats, and cattle. These animals are owned by nomads as well as the local population.

There is a shortage of fodder, resulting in problems when breeding sheep. The breed-

ing season occurs in autumn when sheep are in poor health, causing oestrus failure, the loss of fertile ova, and high mortality of lambs. Mineral deficiency is common. Sheep in particular are susceptible to internal parasites and most of them suffer from worms and externally from mites. Common livestock diseases are foot and mouth, sheep pox, pleuro-pneumonia, enterotoxaemia, and black quarter.

Most farmers rear sheep for lambing, milk, and wool, and these provide an income to most families. Damani sheep involve a smaller capital outlay and only seasonal work. They can easily be milked by hand and the milk is converted into yoghurt and cheese. The lactating sheep have well-developed udders and long teats. Milk production of two to three litres per day has been recorded.