Food Sciences and other post-harvest technologies: A group of sciences and technologies underlie the processing, storage, distribution, and marketing of agricultural commodities and by-products. Modern post-harvest technology help provides inexpensive and various food supplies for consumers, meets the demands of a variety of industrial users, and even creates replacements for fossil fuels. Research having particular significance to post-harvest technology includes genetic engineering techniques that increase the efficiency of various chemical and biological processes and fermentation for converting biomass to feedstock and for use in producing chemicals (including alcohol) that can replace petroleum-based products.

Agricultural engineering: Agricultural engineering includes appropriate areas of mechanical, electrical, environmental, and civil engineering, construction technology, hydraulics, and soil mechanics. Agricultural production presents many engineering problems and opportunities. Agricultural operations, such as soil conservation and preparation, crop cultivation and harvesting, animal production, and commodities transportation, processing, packaging, and storage, are precision operations involving large tonnages, heavy power and critical factors of time and place. Facilities designed to aid farm operations help farm workers to minimize the time and energy requirements of routine jobs. Four primary branches have developed within agricultural engineering, based on the problems encountered: farm power and machinery engineering, farm structures engineering, soil and water control engineering, and electric power and processing engineering.

Agricultural economics: The field of agricultural economics includes agricultural finance, policy, marketing; farm and agribusiness management, rural sociology, and agricultural law.

The agricultural sciences are poised to enter a new era, armed with ever more sophisticated research technologies, such as monoclonal antibodies and gene splicing, in their continuing drive to better harness nature for the ultimate benefit of human beings everywhere. Although broad and deep scientific investigations have been made in the biological, physical, and social realms related to agriculture, the need persists for additional research to close remaining gaps in knowledge, especially in molecular biology and the environmental, social, and economic effects of its fruits. From results of experiments already conducted, it is clear that molecular biology will influence plant genetics and crop production. Plant genetic engineers are working to improve specific economically important plant varieties by increasing their photosynthetic efficiency, improving their nutritional quality, and transferring to them such favourable properties as the ability to fix atmospheric nitrogen, as do legumes, and to better resist diseases and tolerate herbicides and natural environmental stress.

Animal scientists also are using new research methods in biotechnology, including the micromanipulation of embryos to produce multiple clones. Monoclonal antibodies are used in studies of specific factors in immune mechanisms, and recombinant DNA technology is used in the genetic engineering of microbes so that they can synthesize specific antigenic proteins useful in vaccine production. The ultimate goal of this research is to improve dramatically the health and productivity of agricultural animals.

NATURAL RESOURCES AS BASES FOR AGRICULTURAL PRODUCTION

Agriculture is an economic activity mainly dependent on natural factors that are beyond the control of a farmer, though the impact of certain factors can be modified to a certain extent. These natural factors resources determine the land use patterns, and also serve as the bases of agricultural productivity. How these resources affect the productivity of agricultural systems, has been discussed in this section.

Land as the basis for agricultural production: Soil is a medium for plant growth. Soil Plant Relations is a subject of vital importance to the practical soil scientists. Soil affects the productivity of agricultural systems in a number of ways. **Soil fertility** refers to the ability of a soil to supply the nutrients essential for plant growth. Fertility is one of the important factors that determine the magnitude of crop yields. Soils are known to supply at least 13 essential nutrient elements to the plants.

Agricultural production is also impaired under saline/sodic and waterlogged conditions. Yield reduction upto 70% have been recorded in such problems soils. The mechanisms that how the saline/sodic and waterlogged conditions affect the productivity have been discussed in the following chapter. Soil erosion is another important factor adversely affecting the productivity of our cultivated soils. Water and winds are gradually taking away the fertile upper parts of the cultivated soils. The process of erosion is more active on sloping and naked lands. About 1.4 million ha are affected by erosion in the Punjab alone, which accounts for 11.7% of the total affected area. Erosion is a threat to our valuable resources, and protection of our soils needs immediate attention.

Lands are classified into different capability classes on the basis of their suitability for cropping, grazing or forestry. Land capability class is determined by the degree of a limitation they impose on agriculture. Eight classes have been established. Soils having no limitations for general arable use are placed under Class I (very good agricultural land), those with minor limitations under class II (good agricultural land), those with a moderate degree of limitations under Class III (moderate agricultural lands), and those having severe limitations are put under Class IV (poor or marginal agricultural land). Soil under land Capability classes V to VIII are rated for forestry or range land. Soils with minor or no limitations for forestry or range development are placed under Class V (good forest or rangeland), those having a moderate degree of limitation are put under class VI (moderate forest range land), those having severe limitation are grouped as Class VII (poor forest or rangeland); and soils which have no potential for any type of agriculture, including forestry and range, are represented by class VIII (agriculturally unproductive or non-agricultural land). The detailed characteristics of each of the capability classification alongwith their extent is Pakistan has been shown in Table 1.1.

TABLE - 1.1: Land Capability Classification of Pakistan

Land Capability Class	*Area (million ha.)*	*Soil Type/ Characteristics*
I. Very good Agricultural Land.	5.34	Loam and silt loam; irrigated soils. It is well suited for a wide range of crops. Soils in this class have no limitations for crop production. They are nearly level, deep, and well drained. They show the highest response to good management including the application of fertilizers. They are used for general cropping, vegetables, and orchards.
II. Good Agricultural Land.	6.89	75% clay loam to clay; 25% sandy; Saline. Soils in this class have minor limitations for crop production: either the range of suitable crops is somewhat narrow, or the management cost is somewhat high. Generally, the net return from this soil is about 25% less than that from class I land.
III. Moderate Agricultural Land.	4.92	One million ha. irrigated; salinity with minor problem of sodicity About 2 million ha. under dry farming; rest uncultivated. Soil in this class have moderate limitations for crop production. They have a limited range of suitable crops. The net return from this land is generally about 50% of that of Class I land.
IV. Poor Marginal Agricultural Land.	3.57	Soils in this class have severe limitations on account of shallow soil depth or strong salinity and sodicity combined with slow permeability, etc. The net return from this land is generally negligible.
V. Good Forest or Range land.	0.17	The soils are nearly level, deep but stony, and in some places, some what imperfectly drained.
VI. Moderate Forest or Range land.	1.18	Half with unfavorable relief and the other half too sandy/ gravely/ stony soil.
VII. Poor Forest or Range land.	18.02	Half mountainous and sandy deserts and other half, problem of erosion.
VIII. Non-Agricultural land.	29.83	Sand dunes, strong saline/sodic soils, severe erosion. This land has no potential for cultivation, forestry, or grazing because of very severe limitations imposed by soil erosion, excessive wetness, shifting sand or skeletal soils, severe salinity/sodicity plus lack of porosity, unstable soil, very arid climate, or ice/glacier cover.

The land capability classification also ranks soils according to their capacity to respond to improved management. Soils placed in Class I are generally very responsive to high inputs of water, improved seed, fertilizers, labour, etc, and also to improved management techniques, while the lower classes have correspondingly decreasing response to inputs and management. Consequently, each Land capability class/ subclass has a specific set of requirements for land use along with management practices, which would ensure optimal utilization as well as conservation of this resource.

Land resources and utilization patterns in Pakistan. Pakistan covers an area of 79.61 million ha of mainly arid or semiarid land, of which about 39% or 31.0 million ha is suitable for agricultural and forestry activities. The agriculturally important tract comprises the Indus plain including Potwar upland, Peshawar valley and adjoining areas. The area under cultivation is 22.27 mha, of which about 18.0 mha is irrigated. The canal commanded lands spread over approximately 13.8 mha. About 17% of the canal commended area is not under cultivation. About 3.68 mha are under barani farming. About 3.80 mha are exploitable forests, and 8.0 million ha are rangelands. A significant part is desert and mountainous. Forest covers about 4.77 per cent of the land area, while about 28.00 per cent is used for crop production. Table 1.2 shows the province wise statistics on the land utilization in Pakistan. Table 1.3 shows the area under different crops in Pakistan. In the Table 1.4 land utilization pattern over past few years has been shown.

About 6.60 million ha of the cultivated area (22.27 million ha) is fallow primarily because of inadequate supply of water. However, 6.45 million ha are sown more than once. Of the total cropped area, more than 70 per cent is utilized for production of food and cash crops.

TABLE 1.4: Land Utilization

Fiscal Year	Total Area	Reported Area	Forest Area	Not Available for Cultivation	CULTIVATED AREA: Culturable Waste	Current Fallow	Net Area Sown	Total Area Cultivated (7 + 8)	Area Sown More than once	Total Cropped Area (8+10)
1	2	3	4	5	6	7	8	9	10	11
1990-91	79.61	57.61	3.46	24.34	8.85	4.85	16.11	20.96	5.71	21.82
1991-92	79.61	57.87	3.47	24.48	8.86	4.87	16.19	21.06	5.53	21.72
1992=93	79.61	58.06	3.48	24.35	8.83	4.95	16.45	21.40	5.99	22.44
1993-94	79.61	58.13	3.45	24.43	8.74	5.29	16.22	21.51	5.65	21.87
1994-95	79.61	58.50	3.60	24.44	8.91	5.42	16.13	21.55	6.01	22.14
1995-96	79.61	58.51	3.61	24.35	8.87	5.18	16.49	21.68	6.10	22.59
1996-97	79.61	59.23	3.58	24.61	9.06	5.48	16.50	21.998	6.23	22.73
1997-98	79.61	59.32	3.60	24.61	9.15	5.48	16.48	21.96	6.56	23.04
1998-99	79.61	59.27	3.60	24.52	9.23	5.35	16.58	21.93	6.49	23.07
1999-00	79.61	59.28	3.78	24.45	9.09	5.67	16.29	21.96	6.45	22.74
2000-01	79.61	59.44	3.77	24.37	9.17	6.73	15.40	22.13	6.64	22.04
2001-02	79.61	59.33	3.80	24.31	8.95	6.60	15.67	22.27	6.45	22.12
2002-03	79.61	59.47	4.04	24.32	9.00	6.53	15.58	22.11	6.27	21.85
2003-04	79.61	59.44	4.04	24.20	9.08	6.05	16.07	22.12	6.87	22.94
2004-05P	79.61	59.44	4.04	24.20	9.08	6.05	16.07	22.12	6.87	22.94

Notes: TOTAL AREA REPORTED is the total physical area of the villages/deh. Tehsils or districts etc.

FOREST AREA is the area of any land administered as forest under any legal enactment dealing with forests. Any cultivated area which may exist within such forest is shown under heading cultivated area.

AREA NOT AVAILABLE FOR CULTIVATION is that cultivated area of the farm which is under farm home steads, farm roads and other connected purposes and not available for cultivation.

CULTURABLE WASTE is that cultivated farm area which is fit for cultivation but was not cropped during the year under reference nor in the year before that.

CURRENT FALLOW (ploughed but uncropped) is that area which is vacant during the year under reference but was sown at least once during the previous year.

CULTIVATED AREA is that are which was sown at least during the year under reference or during the previous year.

Cultivated Area = Net Area sown + Current Fallow.

NET AREA SOWN is that are which is sown at least once during (Kharif & Rabi) the year under reference.

AREA SOWN MORE THAN ONCE is the difference between the total cropped area and the net area sown.

TOTAL CROPPED AREA means the aggregate area of crops raised in a farm during the year under reference including the area under fruit trees.

TABLE 1.2 : Province Wise Land Utilization Pattern in Pakistan (2001-02)

Province	*Geographical area*	*Forest Area.*	*Cultivable Waste.*	*Cultivated Area.*	*Current Fallow*	*Net Area. Sown*	*Sown more than once.*	*Total Cropped Area.*
	1	2	3	4	5	6	7	6+7
Punjab	20.63	0.51	1.63	12.43	1.40	11.03	5.07	16.10
Sindh	14.09	0.84	1.27	5.86	3.43	2.43	0.73	3.16
NWFP	10.17	1.32	1.22	1.89	0.51	1.38	0.63	2.01
Balochistan	34.72	1.13	4.83	2.09	0.26	0.83	0.02	0.85
Pakistan	79.61	3.80	8.95	2.27	6.60	15.67	6.45	22.12

17.12 - Irrigated
05.00 - Rainfed

TABLE. 1.3 : Crop Area in Pakistan (2001-02)

Crops	*Area in 000 ha*	*Percent of total area*
Food crops	11999	54
Cash crops	4339	20
Pulses	1380	6
Oilseeds	579	3
Vegetables	329	1
Condiments	169	1
Fruits	664	3
Others	2662	12
Total	22120	100

Water as basis for agricultural production: Water resources are critical to sustainability of human life agro-ecosystems. Contrary to popular impression, water is a finite resource. There is a fixed amount on the planet ---- nearly 1400 million km^3, which can be neither increased nor decreased. Most of it (97.5 percent) is salt water, and is of little direct use to agriculture. A further 1.76 percent is locked away in permafrost, ice caps and glaciers. Nearly all of the remainder is stored underground, leaving only 136,000 km^3 (less than 0.4 percent of the world's fresh water) in rivers, lakes, reservoirs, the soil, swamps, the atmosphere and in living organisms.

While the world's water is finite, it is continuously recycled as a result of evaporation by the sun. Every year, solar energy converts 500,000 km^3 of water from land and sea into water vapor free of contaminants. This water vapor eventually returns to the surface as rain and snow, but it is not deposited on the land and sea in same proportion as it is evaporated from them. More water (some 40,000 km^3 more) falls on the land than is evaporated from it. It is this water that powers hydro-electric stations, fills lakes and rivers, tops up underground aquifers and helps wash away the water pollution generated by the human population. This is the fraction of the water cycle on which the human population and agriculture must depend.

Water in the physiology of plants: Given certain light and temperature conditions, water is the next most important limiting environmental factor in selecting a planting site and plant materials. Historically, agriculture started along the banks of rivers and lakes, and only later, when man developed a variety of irrigation systems, expanded into arid and semiarid areas. An adequate water supply must be ensured for any agricultural enterprise.

1. It is a necessary constituent of all living plant cells.
2. It serves as solvent for nutrients from soils and CO_2 from air.
3. It acts as a raw material in the process of photosynthesis.
4. It is a medium of translocation from site of uptake for raw materials and site of production of plant compounds to their sites of utilization.
5. It is a reagent/substrate for a variety of chemical reactions, and acts as a pH buffer.
6. It maintains the turgidity of plant cells which is required for growth and development, and for vital functions like stomatal opening.
7. Because of its high specific heat, transpiration of water dissipates large quantities of the heat and suppresses leaf temperature.

The health of the plants depends, ***inter alia***, on the availability of water which enters through the root hairs and most of it is evaporated from the leaf and stem surface. If water supply to the roots is reduced, transpiration exceeds uptake of water and the plant first loses its turgidity and later dies, if the condition persists for long. The transpiration ratio has been worked out in the United States of America and the following figures are available in terms of units of water transpired for each unit of dry matter produced: millets (310), potato (636), cotton (646), corn (368), cucumbers (713), alfalfa (831), regweed (948), oats (557) , pumpkin (834), and red clover (453).

The transpiration ratio varies in different crops as shown above. This ratio is some times called the **water requirements of the crop**. This term, however, tells half the story because water is not only lost from the plant but also from the soil. A better measure, therefore, is the **consumptive use** of water, which includes the total water transpired by the plant as well as the quantity of water evaporated from the soil. A very good summary of the water requirement of crops was published by the Directorate of Soil Reclamation in 1970. Based on all these studies, the consumptive use of water by different crops are: Rice, 39.18, wheat, 20.54, cotton 28.19, sugarcane, 49.94, maize, 16.26, and barseem, 32.86, acre inches.

Water in agricultural systems: There has been circumstantial evidence that increased water availability to led to expansion in cultivated area and enhanced the agricultural productivity in a number of countries. The impact of increased water availability on Pakistan's agriculture can be judged from the fact that total irrigated area in Pakistan has increased from 10.52 mha in 1961 to 18.0 mha in 1998 due to the massive development in water resources following the signing of Indus Basin Treaty in 1960. These included the construction of Terbela and Mangla dams, five barrages, one gated siphon and eight link canals.

Recent reports by different international research organizations have warned of the dangers of a diminishing water supply for drinking, industrial and agricultural purposes. They have emphasized the urgent need for conservation and efficient use of water supply in the face of what is expected to be a permanent global water shortage. The world's existing sources of water for drinking, agriculture and industry have fast been approaching their limits. It has also been found that the traditional ways of expanding available water resources, as by building dams, reservoirs and canals, can no longer provide a satisfactory solution for irrigated agriculture. Constant depletion and over-use of water supplies, the high capital cost of large irrigation projects and rising pumping costs, call for a change in strategies to ensure that water is effectively valued, used and managed.

Presently, the Pakistan's irrigation system faces certain constraints which are identified in the following paragraphs. These need to be attended in order to sustain our agricultural system.

1. Waterlogging and salinity: The Indus Basin has a flat topography, poor natural drainage and a semi-arid climate with high evaporation. In such an environment, irrigation without adequate drainage has inevitably resulted in the twin problem of waterlogging and salinity. Increases in diversion of river flows and seepage from canals, water courses and irrigated areas have led to a gradual rise in groundwater levels. Within last 100 years the water table has risen from 40 to 3 meter on about 42 percent area of the Indus Basin. The situation is worst in Sindh province where water table is within 3 meter on 57% of irrigated area. The high water table creates problems of oxygen deficiency, salt build-up in the soil profile and poor workability with soil. According to WAPDA (1981), about 26 and 39 percent area of the Indus Basin is affected by surface and profile salinity, respectively.

2. Shortage of irrigation water: Pakistan has significant water resources but these are inadequate for crop production on the available land. A researcher has indicated that the water requirements for net crop use comes to 8.513 mhm whereas the availability of irrigation water for crop consumptive use is 6.1 mhm. The river flows are highly seasonal. Roughly, 85 percent of annual flows are in the kharif season (summer) and only 15 percent in the rabi (winter) but Pakistan does not have enough reservoir capacity in its irrigation systems to store seasonal waters. Due to inadequate water availability in winter and at the beginning and end of the summer, cropping intensity is exceptionally low.

3. Inequitable distribution: It is another serious problem of the irrigation system. The optimistic assumption in the original design about delivery efficiency means that in reality water does not reach the users at the tail-end of the system or at least not at the rate intended in the design. Illegal pumping from canals adds to the inequity in distribution. Moreover, the Indus Basin irrigation is based on gravity flow. It has low use efficiency. Besides, the system is supply based and so cannot accommodate changing water demands during the crop season.

4. Over-exploitation of fresh groundwater: Groundwater use has been a major factor in raising agricultural production over the past 20 years. Groundwater tuvbewells not only supply additional water but also provide flexibility to match surface water supplies with crop water requirements. Due to explosive development of groundwater by the private sector (roughly 6 percent annual growth) there is danger of excessive lowering of water table and intrusion of saline water into fresh water aquifers. Furthermore, in many canal commanded areas (CCA) where canal water is not sufficient because of inequitable distribution, the farmers depend on tubewells and

tend to over exploit groundwater. Excessive pumpage in the absence of adequate leaching and ineffective conjunctive use of surface and groundwater have caused salinity in the root zone.

5. Low Delivery Efficiency: The average delivery efficiency of the Indus Basin irrigation system is 35 to 40 percent from the canal head to the root zone. The Colorado State University Water Management Research Team in Pakistan through two independent surveys across the irrigated commands of the Punjab and Sindh provinces indicated that the watercourse command areas have a mean conveyance efficiency of approximately 60 percent and a farm application efficiency of approximately 75 percent. These two efficiencies provide a net sub system mean efficiency of about 45 percent.

Environment as a basis for agricultural production: All plants have certain environmental requirements and these must be met if they are to survive. The main environmental features are climatic, physiographic, edaphic, and biotic. The climatic features that affect agricultural productivity are solar energy, temperature, precipitation, humidity and wind. Agricultural production is affected by both the macro and micro-climate. The physiographic requirements of plants mainly depend upon special geographical features like elevation, wind velocity and direction, etc. The edaphic features pertain to terrain, relief, and soil while the biotic features include competition between plant and plant or plant and insect or animal. But for agriculture, climate and moisture alone add up to a tremendous clout. All crops have climatic and soil moisture limits for economic production. For example, the optimum temperature for wheat growth is 25°C. Maximum photosynthesis takes place at 37°C and stops at 45°C .

When a plant is introduced to a new place, its success in the new habitat depends upon agro climatic analogy which means that the old and the new habitats should have similar weather characteristics, particularly during the growing period, to offer a fair chance for the success of the plant concerned. Examples of successful introduction of plants are legion. Coffee, native to the highlands of East Africa, is now mainly grown in Latin America. Brazil controls the coffee market of the world. Rubber, native to Brazil, is now more successfully grown in South East Asia. Mediterranean trees like citrus, olives and grapes are now grown extensively in other countries.

Plant acclimatization can be regarded as accelerated evolution. A classical example is the introduction of upland Cotton in Pakistan. The seeds of upland cotton were imported in India during 1818-1840. The crop made some headway in Bombay but utterly failed in Pakistan and northern India. The seeds having been introduced did not die out entirely but stray plants managed to survive year after year for about three quarter of century. During this period, the plant habit was changed and hairs developed on stem and leaves. These stray plant when properly husbanded, gave rise to the first commercial variety of upland cotton in 1914 in the Punjab.

The climatic analogies were used to suggest the introduction of Egyptian cotton into Sindh. The Indian cotton Committee in their report to the Government of India, in 1919, made a general remark that the lower Indus valley was climatically similar to the Nile valley and it was suggested that Egyptian cotton should be tried whenever irrigation became available. Based on these suggestions, Egyptian cotton was introduced in Sindh after the opening of the Sukkur Barrage canals in 1932 . All these efforts failed. The reason was that the Egyptian cotton was grown in the wrong place. A special climatic requirement of Egyptian cotton is that flowering is initiated only when the minimum temperature in the region is 10°C, but without frost during the boll maturation period. Such conditions exist only between Thatta and Kotri where Egyptian cotton has now been found to grow successfully.

Environmental zones of Pakistan and their relation with crop production: Pakistan Agricultural Research Council (PARC) has delineated ten agro-ecological regions of Pakistan based on physiography, geology , climate, agricultural land use and water availability. A brief description of the agro-ecological zones is in the Table 1.5.

TABLE: 1.5: Main features of agro-ecological zones of Pakistan

Zone	*Physiography and climate*	*Soils and land use*
I. Indus Delta	Represent the Indus Delta. Climate arid tropical marine; mean daily max. summer temp. between 34-40°C, and winter temp. between 19-20°C mean monthly summer rainfall 75 mm; and winter less than 5 mm; relative humidity 67-68% in the morning and 30-35% in the afternoon.	Two types of soils; clayey and silty; clay soils found in shallow basins and silty soils in nearly level flat areas; strongly saline-alkali soils are barren and parts of clayey soils are under cultivation with rice, sugarcane, pulses, banana as main crops.
II. Southern irrigated plain.	Represents lower Indus plain formed by the meandering of Indus river. Climate arid sub-tropical continental with hot summer and mild winter; mean daily max. and min. temp. 40-45°C and 8.5°C in the northern areas, and 38-43°C and 8-12°C in the southern areas resp., mean monthly summer rainfall 18 mm in the north and 45-55 mm in the south; winter is practically dry.	Soil is silty and sandy loam, associated with the active flood plain, upper areas of the flood plain calcareous loamy and clayey. Crops grown: cotton, wheat, mustard, sugarcane, berseem on the left bank of the Indus and rice, wheat, gram and berseem on the right bank; sorghum is the main crop in southern Dadu.
III. Sandy desert.	A. sandy desert with xerophtic vegetation; central part occupied by salt lakes; southern part rainfall 300 mm.	Sandy soils and moving sand dunes, undulating sand ridges 20-25 m high and 1-3 m long; western part has strips of clayey soils; land use: grazing.
	B. Area covered with various forms of sand ridges and dunes and sand sheets with profuse short trees and vegetation: northern part rainfall 300-350 mm.	Sandy and loamy fine sandy soil stable ridges; moderately to strongly calcareous, locally saline-sodic, land use: grazing.
IV. Northern irrigated plain.	A. Areas between Sutlej and Jhelum river; different flood plains and bar uplands. Climate semi-arid to arid (east to south west) subtropical continental; mean daily max. (summer) and min. (winter)temp. 39.5° C and 6.2 resp., in the east and 41-42°C and 6°C resp., in the southwest; mean annual rainfall 300-500 mm in the east and 200-300 mm in the southwest.	Southern and central part calcareous silt loams and about 15% saline-sodic; northern part loam and clay loam, mostly non-calcareous, saline sodic in local areas. Canal irrigated agriculture; crops; wheat, rice, sugarcane, oilseeds and millets in the north and wheat, cotton, sugarcane, maize as well citrus and mangoes in the central and southern parts.
	B. Alluvial valleys of Peshawar and Mardan plains. Climate semi-arid subtropical continental: mean daily max.(summer) and min.(winter temp. 43-44°C and 5.0°C resp., mean monthly rainfall range 20-32 mm both in winter and summer.	Central valley silty clays and clay loams. Moderately calcareous with minor salinity sodicity, sloping sides of the valley non-calcareous to moderately calcareous loams. Main crops sugarcane, maize, tobacco wheat, berseem, sugarbeet, considerable areas under fruit orchards (pears and plums).
V. Barani (rainfall) lands	Covers the Salt Range, potwar plateau (generally open and undulating) and the Himalayan piedmont plains. Narrow belt along the foot of the mountains nearly humid, mean daily max.(summer)temp. 38.5°C and min. (winter) temp. 3-6°C; mean monthly rainfall 200 mm in summer and 36-50 mm in winter (Jan.-Feb.). Southwestern part semi-arid and hot.: mean daily max.(summer)temp. 38°C and min. (winter) temp. 4-7°C;	Eastern part dominantly non-calcareous to moderately calcareous silt loams; west southern part mainly calcareous loams. Rainfed agriculture is the main land use and wheat and millets the main crops. Part of the eastern areas irrigated and wheat, rice, maize, millets, oilseeds, pulses grown.