19/10/2019.

## Evolution of man and Agriculture / HISTORY OF AGRICULTURE.

There are different stages in development of agriculture, which is oriented with human civilization. They are Hunting → Pastoral → Crop culture → Trade (stages of human civilization).

**1. Hunting** – It was the primary source of food in old days. It is the important occupation and it existed for a very long period.

**2. Pastoral** – Human obtained his food through domestication animals, e.g. dogs, horse, cow, buffalo, etc. They lived in the periphery of the forest and they had to feed his domesticated animals. For feeding his animals, he would have migrated from one place to another in search of food. It was not comfortable and they might have enjoyed the benefit of staying in one place near the river bed.

**3. Crop culture** - By living near the river bed, he had enough water for his animals and domesticated crops and started cultivation. Thus he has started to settle in a place.

**4. Trade** – When he started producing more than his requirement the excess was exchanged, this is the basis for trade. When agriculture has flourished, trade developed. This lead to infrastructure development like road, routes, etc.

Agriculture became civilized from crop culture stage. Some important events for different periods that lead to development of scientific agriculture.

B.C. = Before christ (English phrase)
A.D = Anno domini (Latin phrase) (the year Jesus was born)
Latin = Language of Rome

| Period | Events |
|---|---|
| Earlier than 10000 BC | Hunting & gathering |
| 7500 BC | Cultivation of crops- Wheat & Barley |
| 3400 BC | Wheel was invented |
| 3000 BC | Bronze used for making tools (Copper) |
| 2900 BC | Plough was invented, irrigated farming started |
| 2300 BC | Cultivation of chickpea, cotton, mustard |
| 2200 BC | Cultivation of rice |
| 1500 BC | Cultivation of sugarcane |
| 1400 BC | Use of iron |
| 1000 BC | Use of iron plough |
| 1500 AD | Cultivation of orange, brinjal, pomegranate (Cassave Plant) |
| 1600 AD | Introduction of several crops to India i.e. potato, ~~tapioca~~, tomato, chillies, pineapple, groundnut, tobacco, rubber, American cotton |

## DEVELOPMENT OF SCIENTIFIC AGRICULTURE IN WORLD

Experimentation technique was started (1561 to 1624) by Francis Bacon. He conducted an experiment and found that water is the principle requirement for plant. If the same crop is cultivated for many times fertility is lost.

Jan Baptiste Van Helmont (1572-1644) was actually responsible for conducting a pot experiment. The experiment is called as 'willow tree experiment'. He took a willow tree of weight 5 pounds. He planted in a pot and the pot contained 200 pounds of soil and continuously monitored for five years by only watering the plant. By the end of 5th year, the willow tree was weighing 16 pounds. The weight of soil is 198 pounds. He concluded that water is the sole requirement for plants. The conclusion was erroneous.

In the 18th century, Arthur Young (1741-1820) published 'Annals of Agriculture'.

| | |
|---|---|
| Jethrotull (1674-1741 A.D) | Fine soil particle as plant nutrient |
| Priestly (1730-1799 A.D) | Discovered the oxygen |
| Francis Home (1775 A.D) | Water, air, salts, fire and oil form the plant nutrients |
| Thomas Jefferson (1793 AD) | Developed mould board plough |
| Theodore de-Saussure | Found that plants absorb $CO_2$ from air & release $O_2$; soil supply $N_2$ |
| Justus van Liebig (1804- 1873) | German chemist developed "law of minimum " |

**Advances in Agriculture in 19th Century**

Following Liebig, an agricultural experiment station was started in Rothamsted in England on 1843 (Old Permanent Manurial Experiment – OPME), it dealt with nutrients. Subsequently many developments took place. In U.S. land grant colleges was started in 19th century. Its objective was to meet the expenditure of the college from the land around the colleges. USDA (United States Department of Agriculture) is responsible for the introduction of herbicides 2,4-D and tractor combine for harvesting and threshing. Under Land Grant College, agriculture oriented teaching, research, extension are expanded. Many international research institutes were started for a specific crop.

- 1857–Michigan State University was established to provide agricultural education at college level.
- Gregor Mendal (1866) discovered the laws of hereditary.
- Charles Darwin (1876) published the results of experiments on cross and self fertilization in plants.
- Thomas Malthus (1898) proposed Malthusian Theory – states that humans would run-out of food for everyone inspite of rapid advance in agriculture due to limited land and yield potential of crops (i.e food may not be sufficient in future for the growing population at this current rate of growth in agriculture)
- Blackman (1905) theory of "optima and limiting factors" states that when a process is conditioned as to it's rapidity by a number of separate factors , the rate of the process is limited by the pace of the slowest factor"
- Mitscherlich (1909) proposed the theory of law of diminishing returns that increase in growth with each successive addition of the limiting element is progressively smaller and the response is curvilinear.
- Wilcox (1929) proposed "inverse yield nitrogen law". It states that the growth or the yielding ability of any crop plant is inversely proportional to the mean nitrogen content in the dry matter.

# AGRICULTURE

Agriculture is derived from two Latin words
Ager + Colere
Ager mean field/soil
Colere means cultivation
Therefore agriculture means the cultivation of the field.

- It is a scientific and technology oriented approach towards raising crops and rearing animals commercially through exploiting natural resources such as soil and climate with the coordination of Socio-economic infrastructure to meet the basic necessities of life such as food, feed, fiber and utilities.

Basic principles of Agriculture (Agronomy)/crop production

1- Good quality seed of recommended variety.
2- Soil management
3- Water management
4- plant protection measures.
5- Management of crop nutrition.
6- Manipulation of crop growth and development
(Growth regulators e.g hormones, seed treatment, use of cane ripener e.g polaris)

Agriculture can also be defined as an art, science and industry/business which makes the use of soil for production of crops, rearing of animals and birds which are directly or indirectly useful for maintaining human life.

As a art:- Performing different farm operations in a skillful manner e.g ploughing, layout, making beds & ridges.

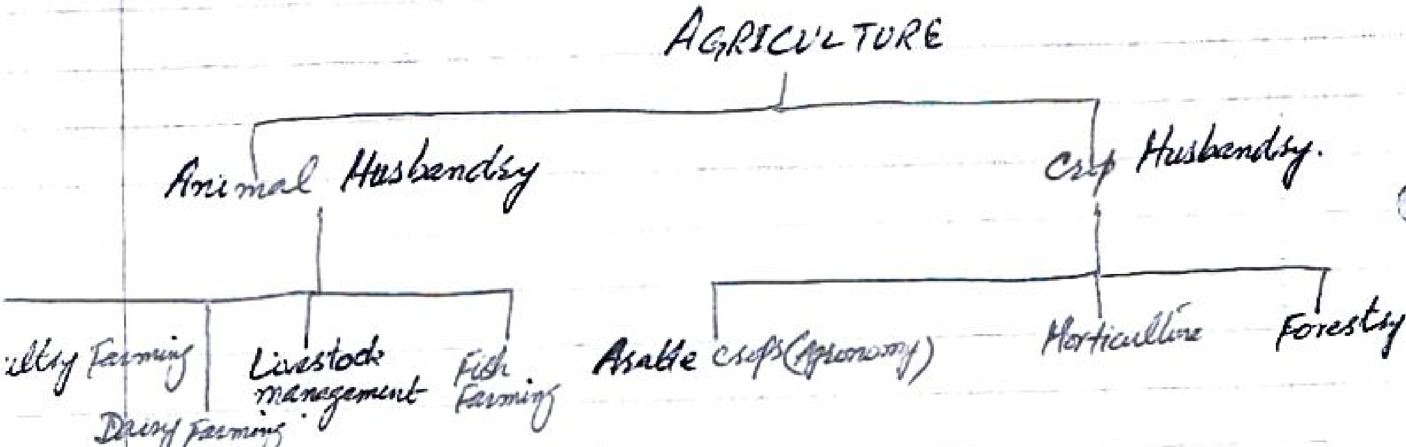
As a Science:- It utilizes all technologies developed on scientific principles such as crop breeding, crop physiology, crop protection etc. For example hybrid varieties, Transgenic crops, water management, use of bio-control agents to pests and diseases.

As a business:- As a business it aims at maximizing net return through ~~xxx~~ management of labour, capital & water. Now a days agriculture is commercialized & run as a business through mechanization.

1

## DIVISIONS OF AGRICULTURE

The Farmers raise different crops and keep different types of animals, so the two major divisions of Agriculture are:




Plant / Crop Husbandry:- deals with various aspects of crop plants from seeding to harvesting, threshing, storage and marketing of products. It includes 3 main sub-divisions

i) Arable Farming (Agronomy) ii) Horticulture (iii) Forestry.

Agronomy:- It is the mother discipline of agriculture. The word agronomy is composed of two Greek words i.e "Agros" meaning field and "nomos" meaning management. It can be defined as "The branch of agriculture which deals with the principles and practices of crop production and soil management on scientific basis."

It may be defined as the scientific and technology oriented approach towards raising field crops commercially through exploiting natural resources such as soil and climate with the co-ordination of socio-economic infra structure to meet the basic necessities of life such as food, feed and fiber."

Agronomy is a broad discipline and it covers following areas directly or indirectly.

a) Crop production:- It deals with sowing, casing, harvesting and threshing of all crops including cereals, legumes, oil seeds, fiber and sugar crops.

b) Crop Breeding:- Deals with crop improvement through selection and hybridization of superior phenotypes/genotypes.

c) Crop physiology:- Study of various plant processes such as photosynthesis, respiration and transpiration.

d) Crop protection:- It deals with the control of plant pests such as weeds, insects, diseases and rodents etc. It includes Entomology:- The study & control of insects. Pathology:- It deals with the study of disease producing organisms such as Fungi, bacteria, viruses and nematodes. Weed Science:- Study and control of undesired plants is called weed Science.

e) Soil Science:- It concerns with the physical and chemical properties of the soil in relation to crop growth. It also covers crop nutrition, soil and water management.

F) Farm Management:- It covers the overall organization and control of the farm and its resources in such a manner to get maximum production and net profit. It also includes farm accounts & records.

g) Farm Mechanics:- It is related to use and maintenance of farm equipment

h) Farm Economics:- It assesses the cost-benefit relationship of farm operations and production. It also covers the marketing of the farm commodities.

i) Biometry / Biostatistics:- It refers to the statistical evaluation of various aspects of crops, like varietal and fertilizer trials etc. It is also some time referred as Field plot technique.

NOTE:- In Most organizations agronomy is restricted to Crop production.

HORTICULTURE:-

Horticulture deals with the fruit, vegetable and ornamental plants. It covers the following subjects:

a) Pomology:-

It concerns with fruit production, laying and maintenance of fruit orchards.

b) Olericulture:-

It deals with the production of different typ of vegetables e.g Brinjal, Coriander, Chillies, onion, garlic and turmeric etc.

c) Floriculture:-

It deals with the growing and maintenance of flowers plants for their aesthetic value.

# ANIMAL HUSBANDRY:-

It refers to the rearing, breeding and maintenance of animals to provide food for human consumption.

Animal husbandry has the following sub-~~branches~~ division

i) Livestock Management:-

It is the sub-branch of animal husbandry which deals with cattle, horses, sheeps and goat rearing and breeding for milk, meat and ~~draft~~ draught purposes.

ii) Dairy Farming:-

Dairy farming deals particularly with the maintenance of cows and buffalo for milk production.

iii) Poultry Farming:-

It deals with the rearing of birds such as cocks, hens, ducks, and turkey etc. for egg and meat purposes

iv) Fish Culture:-

It is related to fish production for human consumption.

v) Apiculture:-

It refers to the rearing and maintenance of honey-bees for the production of honey.

Lac Culture:- It deals wi[illegible] [illegible] of lac insect for the production of lac. Lac is used for dye; It is used in medicine. It is also used as sealing wax.

Ecology:- It is the study of relations of organisms to their environment

Meteorology:- It is the science of atmosphere.

Book:- Cropping technology 2002 by Iqtidar Ahmad Khalil & Amanullah Jan, National Book Foundation, Islamabad.

## IMPORTANCE OF AGRICULTURE

NOTES

Agriculture has a great significance in over populated world. It would be impossible to feed human population without giving due importance to agriculture. The importance of agriculture is briefly discussed below.

1. Provision of Basic Necessities of Life:-
The three basic necessities of mankind are food, cloth and shelter. Agriculture is the only field which provides us all these three necessities in the following way.

A FOOD:-
We know that all the food stuffs which we eat to keep our selves alive are the production of agriculture such as milk, meat, roots, tubers, shoots, flowers and fruits.

B- <u>CLOTH</u>:-

Clothes of all major kinds are made of agricultural products such as cotton, jute, wool and natural silk.

C. <u>SHELTER</u>:-

Tree trunks, wood and leaves have been sheltering mankind from ages. Even now wood is the basic material used in our houses e.g ~~wo~~ windows, doors, roofs etc.

2- Provision of Raw Material for Local Industries.

Agriculture provides raw material to local industries such as textile, sugar, paper, oil/Ghee, wool, jute mills, cigarette, leather, ~~flour~~ flour mills, dairy, poultry, rice and fruit industry.

3- <u>Employment</u>:-

Agriculture provides employment to a large number of people. It has been estimated that ~~it provides~~ 38.5% employment to national labour force is provided by agriculture

4. <u>Source of Foreign Exchange Earnings</u>:-

The major agricultural products which earn foreign exchange are rice, raw wool, Yarn (Spun thread (سوت) hides or skins.

The important by-products which earn foreign exchange are foot wear (جوتے), leather goods, garments and carpets, sports goods consumes most of the raw material obtained from agriculture

5- <u>State Income</u>:- Major income of our Govt. comes from

6. Cleaning of Environment:-

Agriculture plays an important role in cleaning of atmosphere as plants absorb $CO_2$ and release oxygen for our breathing. A tree having 1 ton weight uses about 1.5 tons of $CO_2$ and releases more than 1 ton oxygen. It has been observed that 10-50% expenses to keep houses cool can be saved by planting these trees. Plants take up water from the soil and release it into the air through transpiration. This regulates the atmospheric temp and pressure.

Plants act as vegetative sound barriers and help in controlling noise pollution. Planting hedges ~~or Shrubs~~ or Shrubs along the boundry wall of house can minimize noise pollution by absorbing sound.

Soils of Pakistan are generally Sandy & Sandy loam.
Organic matter contents in the soils of Pakistan is 0.45 to 0.58%
Nitrogen content in our soil are 0.04 to 0.06%
phosphorus " " " " are less than 1 ppm (10 mg/kg)
* Nitrogen is deficient in 100% soils.
P " " in 80% soils.
K " " " 20% soils.

Yield Gap :- ~~It is difference between potential yield and~~
:- It is the difference between yield potential of a crop and the national aver

| | |
|---|---|
| Cereals | 81% |
| Pulses | 76% |
| Oilseeds | 70% |

crops such as tobacco.

<u>Kharif Crops</u> :- These are the crops which have major growing period in Summer and their harvesting may commence from late summer to autumn but in some crops may continue even in winter such as cotton.

<u>Zaid Kharif Crops</u> :- The crop which is planted in August-Sept ~~harvested a little after~~ and harvested in December-January e.g Toria ~~the termination of normal Kharif season~~ is called Zaid Kharif crop such as Toria (Brassica campestris).

<u>Major Rabi Cereals</u>

Wheat
Barley

<u>Major Kharif cereals</u>

Rice
Maize
Sorghum
Millets

<u>Rabi pulses</u>

Gram
Lentil

<u>Kharif pulses</u>

Mash
Mung
Moth
Arhar
Lobia

<u>Rabi Fibre</u>

—
—
—

<u>Kharif Fibre</u>

Cotton
Jute
San-hemp

<u>Rabi oilseeds</u>

Rapeseed/Mustard
Linseed
Sunflower, Safflower

Rapeseed:- Toria, Gobi Sarson brown Sarson.
Mustard:- Raya, Taramira.

<u>Kharif oilseed</u>

Groundnut, Sesamum
Soybean, Castor

# Salient Features of Pakistan's Agriculture

Agriculture Sector share in total GDP is 19.8%

It provides employment to 42.3% total labour force.

Pakistan's Agriculture Sector consists of sub components

i) Crops sub sector
ii) Livestock
iii) Forestry
iii) Fishing

Crop sub sector is further divided into major crops & minor crops.

Maj Crop sector accounts for 23.55% of Agriculture GDP. Minor crops contributed 11.36% in Agriculture GDP.

$$\begin{array}{r} 23.55\% \\ 11.36 \\ \hline 34.91 \end{array}$$

The livestock sector having contribution of 58.55% in the Agri GDP. The fishing sector having contribution of 2.17% while forestry sector having contribution of 2.06

Agriculture 19.8%

- Crop Sector
  - Major crops
    + 23.55%
    2.32 cotton ginning
    [illegible]
  - Minor crops
    11.36%
- Livestock
  58.55%
- Forestry
  2.06%
- Fishery
  2.17%

GDP:- is a monetary measure of the market value of all the final goods & services produced annually in a country.

GNP:- GDP + the income from foreign investment remittance.

weather conditions: There is a strong relationship b/w agri and climate — temperature, precipitation, floods and other aspects of weather. Pakistan is basically an arid to semi-arid country and agricultural performance is closely linked with supply of irrigation Hr.

→* The negative growth of crop sub-sector is due to decline in cotton production, rice production and maize production during 2015-16. Only wheat & Sugarcane production showed a positive growth of 1.5% and 4.22%, respectively.

→ There are two principal crop seasons in Pakistan

i) Kharif Season (Summer season). It starts from April to June and ends with Oct — December
Major crops of this season are Rice, cotton, maize, Sugarcane, bajra, moong, Mash and Sorghum.

ii) Rabi Season (Winter Season) It begins with Oct-Dec and end with April to May. Major crops of this season are wheat, tobacco, gram, lentil, rapeseed, mustard and Barley.

→ During 2015-16 the availability of water during Kharif Season stood at 65.5 Million Acre feet (MAF) showing a decrease of 5.5% over Kharif 2014.
During Rabi Season 2015-16 the availability of water remained at 32 MAF which is 0.6% less than Rabi Season 2014-15.

## Main problems of Land Resources

→ About 4.9 Mha or 6.3 Mha of our cultivated irrigated land is flawless About 4.9 million ha or nearly one third has clayey soils, need special tillage implements.
→ About 10% or 0.6 mha of land has very sandy soils.
→ About 10% or 0.6 mha in Indus plain
→ Of total salt affected soils of about 6.3 mha in Indus plain only one half has practical significance and its main problem is sodicity covering about 1.7 mha. It has been reported that over 50% water pumped annually by tubewells causes sodicity in soils. Besides this about 1.3 mha of cultivated and 0.9 mha of uncultivated saline land & have drainage problem
In about 2.1 mha the water table is within 1.5 m depth in October and this increases to 5.2 million ha in April, which increases to 5.2 million ha in year to year.
water logged area varies from year to year.
→ About 70% of cultivated barani land has good soils but has a compact soil layer of 5–8 cm thick that has formed below 7 to 10cm the plough layer 8.7–10cm

→ ~~Now~~ Soil Erosion is a problem in about 1.0 million hectares especially on mountaineous lands. It is the result of cultivation without conservation measures and excessive cutting & grazing. However 2 million ha ~~especially on mountains~~ of riverain land, of which 0.3 mha are cultivated with moisture left by summer floods. This land offers possibility of irrigation development with tubewells.

→ Narrow strips of cultivated land bordering the sandy deserts is affected and threatened by wind erosion.

Source:- Govt. of Pakistan. 2016-17. Economic Survey of Pakistan 2016-17. Ministry of Food, Agriculture and Livestock, Federal Bureau of Statistics. PP 23 - 41.

## CROP SEASONS

In Pakistan there are two major crop season

1) Rabi (Winter Season):- The season which starts from Sept-Oct and ends with March April.
2) Kharif (Summer Season):- The season which starts with March-April and ends with Sept-Oct

On the basis of these seasons, the crops are classified in to Rabi and Kharif crops. However, a few crops are further sub-divided in to Zaid-rabi and Zaid-kharif crops.

Rabi Crops:- These are the crops which have their major growing period in winter and their harvesting may commence in spring but in some crops may continue even in summer as in wheat.

Zaid Rabi Crops:- Those crops that are ~~harvested a little after the termination of normal Rabi season are called Zaid rabi~~ planted in February and harvested in May-June e.g tobacco.

Pakistan lies approximately between latitudes 24 and 37°N, and longitudes 61 and 76°E. To its northeast are situated the world's biggest mountain ranges: the Hindukush, Karakorams, and Himalayas. For the most part, its western border with Afghanistan and Iran too is uneven, mountainous country that steadily loses height southward. The northern part of this border is crossed by a number of passes. All these physical features have a great effect not only on the temperature and rainfall pattern of Pakistan, but also on the general circulation of the atmosphere over southern Asia.

The climate of Pakistan falls into the following five climatic types.

1. Tropical semiarid climate with mild winter. This includes Karachi, Hyderabad, and southern Khairpur Divisions. The mean annual temperature is above 18°C.

2. Subtropical semiarid climate with average annual temperature about 18°C and a distinct, short winter. This includes southern Kalat and the whole of the Indus plain from Lahore, Rawalpindi, and D.I. Khan Divisions to the northern half of Khairpur Division.

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[1]Dr. Shamshad Hussain Shah is Professor, Department of Agronomy, University of Agriculture, Faisalabad.

WEATHER: It refers to atmospheric conditions (rainfall, temperature humidity etc) of any place over a short period of time e.g Weather is smoggy in Sargodha today.

Climate: It is the sum total of day to day weather conditions of any place over a long period of time. It is the generalization of atmospheric conditions of any place. e.g The climate of Sargodha is semi-arid. It is generally the average 30 years atmospheric conditions of any place.

Moisture:- It is present in small quantities in desert air and in abundance in humid areas. It ...
Impurities in the atmosphere:- Bacteria, dust, smoke, $SO_2$, NO, $N_2O$ (nitrous oxide) (nitrogen monoxide)



3. Semiarid climate with rather dry summer. This includes the hilly regions of southern NWFP (KP), the southern part of Azad Kashmir, Zhob and Quetta Divisions, and the northern half of Kalat Division.

4. Moist temperate climate with the average temperature of the coldest month below −10°C, warm summer with mean temperature of the warmest month between 10 and 22°C. It includes the central mountainous areas of NWFP (KP) and Kashmir, and northern hilly areas of Punjab.

5. Alpine climate with average temperature of the warmest month between 10 and 0°C. It includes Baltistan, Gilgit, northern Chitral, and the eastern and northern parts of Kashmir including Ladakh.

① Tropical Climate
Severe summer throughout the year without distinct winter.
① Sub-tropical
Long severe summer during most part of the year with short distinct but mild winter.
③ Temperate
Long severe winter during most part of the year with short distinct but mild winter. Summer
Alpine Climate
Severe winter throughout the year without distinct summer.

## 10.2 Soil zones of Pakistan

Geographically, Pakistan has a highly diversified landscape and environment. Lofty, snow-covered mountains, vast sandy deserts, and extensive river and piedmont plains combine to give rise to wide variations in soil-forming factors. This is clearly reflected in the variety of soil characteristics found in Pakistan. The different kinds of soil found in Pakistan fall into the following nine broad ecological zones (See Fig. 10.1, foldout page).

1. Northern mountainous region
2. Western mountainous region
3. Pothwar upland
4. Sandy deserts
5. Piedmont plains
6. Old river terraces
7. Sub-recent river plains
8. Recent river plains
9. Indus delta

### 10.2.1 Northern mountainous region

This region includes the mountainous country of the Himalayas, the Karakorams, and the Hindukush. Several types of climate are found within this region. A wide variety of sedimentary, igneous, and metamorphic rocks are exposed in this area. The soils characteristically have a high content of organic matter and abundant moisture at lower depths. Absence of soil salinity or sodicity is a universal characteristic of this region. The soil reaction varies from moderately alkaline to medium acid (pH 8.0–5.6). The soil materials are of alluvial origin and quite deep. Natural vegetation over the area is coniferous trees.

Alpine Climate (Highland Climate):- It is one of the coldest climate in the world. It is so cold because of its high altitudes. Alpine climate is cold and dry throughout the year.

as narrow belts along the
bject to periodic flooding.
pecially those overlooking
sodicity. The processes of
on are concurrently active

ver extending from a little
he area consists of estuary
r with the sea. The surface
ie salinity found here is of
: coastal area consists of
v tidal ridges. The saliniza-
The dominant soils of the
uctural development. The
i very rapid resalinization

... They have been grouped into eight land capability classes. Class I land is the best for all purposes, and Classes II through VIII have a progressively increasing number of limitations for agricultural use. Soils in the highest class (I) have no limitations for agricultural use, and relatively little effort is required to produce high yields of a wide range of crops. Soils in Class I give a very high response to good management, including inputs of water, improved crop varieties, and fertilizers. The suitability of soils for farm crop production gradually diminishes, until by Class IV, the soils are marginally suitable for this purpose. The lower classes give successively lower responses to various inputs. Class V through VII lands are not fit for regular farming; these are, however, decreasingly suitable for forestry and range management. Class VIII land is of no agricultural use whatsoever.

The extent of different kinds of land in the cultivable commanded area is given in Table 10.1.

Cultivable waste: It is uncultivated farm area [illegible] cultivation

[illegible] Area

more than once

= 15.35 + 7.33 = 22.67

Cultivated Area : Net area [illegible]

A land capability class is determined by the degree of limitation.

**Table 10.1** Area under different land classification categories in culturable commanded area (CCA) (thousands of hectares)

| | NWFP | Punjab | Sindh* | Pakistan | Percent of CCA |
|---|---|---|---|---|---|
| **a. Cultivated land** | | | | | |
| NON-SALINE | | | | | |
| Class I | | | | | |
| Flawless | 79.2 | 2999.0 | 1077.3 | 4155.6 | 30.6 |
| Class II | | | | | |
| Clayey | 102.7 | 1607.7 | 2356.6 | 4067.1 | |
| Sandy | 22.0 | 574.9 | 39.1 | 636.0 | |
| Waterlogged | 34.0 | 215.4 | 7.6 | 257.2 | |
| Uneven | 31.4 | 27.0 | – | 58.4 | |
| Subtotal | 190.1 | 2425.2 | 2403.3 | 5018.7 | 37.0 |
| Class III | | | | | |
| Sandy | 4.1 | 169.6 | 131.2 | 305.1 | |
| Waterlogged | 10.6 | 34.0 | 174.3 | 219.1 | |
| Subtotal | 14.7 | 203.7 | 305.6 | 524.2 | 3.9 |
| Class IV | | | | | |
| Sandy | – | 295.7 | 29.3 | 325.1 | |
| Waterlogged | – | 7.4 | 1.8 | 9.1 | |
| Subtotal | – | 303.1 | 31.1 | 334.2 | 2.5 |
| **Total non-saline** | 284.1 | 5931.0 | 3817.4 | 10,032.6 | 74.0 |
| SALINE | | | | | |
| Class II | | | | | |
| Slightly saline | 2.4 | 464.6 | 334.2 | 801.2 | 5.9 |
| Class III | | | | | |
| Saline–sodic and saline, gypsiferous | 1.6 | 126.0 | 124.2 | 251.8 | 1.8 |
| Class IV | | | | | |
| Saline–sodic | – | 42.4 | 102.1 | 151.8 | 1.1 |
| **Total saline cultivated** | 4.0 | 633.0 | 560.6 | 1197.6 | 8.8 |
| **Total cultivated** | 288.1 | 6564.1 | 4378.0 | 11,230.2 | 82.8 |
| **b. Uncultivated land** | | | | | |
| NON-SALINE | | | | | |
| Class VII | | | | | |
| Severely eroded | 9.4 | – | – | 9.4 | |
| Sandy | 12.8 | 298.8 | 0.12 | 311.8 | |
| Marsh | – | 1.1 | 1.1 | – | |
| Subtotal | 22.2 | 299.9 | 1.2 | 321.2 | 2.4 |

| | NWFP | Punjab | Sindh* | Pakistan | Percent of CCA |
|---|---|---|---|---|---|
| Class VIII Shifting sand dunes | - | 43.1 | - | 43.1 | 0.3 |
| Total non-saline | 22.2 | 343.0 | 1.2 | 364.4 | 2.7 |
| | | SALINE | | | |
| Class VII With sparse vegetation | 9.6 | 911.7 | 858.5 | 1779.8 | 13.1 |
| Class VIII Almost bare | - | 69.0 | 112.2 | 181.2 | 1.4 |
| Total saline, uncultivated | 9.6 | 980.7 | 970.7 | 1961.1 | 14.5 |
| Total uncultivated | 31.8 | 1323.8 | 971.8 | 2326.5 | 17.2 |
| Grand total or CCA | 320.1 | 7887.8 | 5349.8 | 13,556.8 | 100 |

* Including commanded area of Pat Feeder canal in Balochistan.
Source: Bhatti et al. (1988).

The cultivated land is by and large suitable for growing crops, as detailed below.

**Class I. Very good agricultural land.** This land occupies an area of 4.2 million ha. It is well suited for a wide range of crops. Soils in this class have no limitations for crop production. They are medium-textured and easy to work. 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.

**Class II. Good agricultural land.** Class II land occupies 5.0 million ha in the cultivated part of the cultivable commanded area. 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.

**Class III. Moderate agricultural land.** This land covers an area of 0.76 million ha of the cultivated part of the culturable commanded area. Soils 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. *Porous saline-sodic soils & respond well to reclamation.*

**Class IV. Poor agricultural land.** This land occupies an area of about 0.48 million ha in the cultivated part of the cultivable commanded area. Soils in this class have severe limitations on account of shallow soil depth or

*Class IV Saline sodic soils having very low porosity*
*Sandy & very shallow soils with very low water holding capacity.*
*Severely waterlogged soil.*

*Problems c-- Slow permeability*
*limitation to root growth*
*temporary water logging.*
*Special implements are needed*
** Moderately water logged*
*sloping soils (erosion)*

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...categories in culturable
...hectares)

| ...h* | Pakistan | Percent of CCA |
|---|---|---|
| | 4155.6 | 30.6 |
| | 4067.1 | |
| | 636.0 | |
| | 257.2 | |
| | 58.4 | |
| | 5018.7 | 37.0 |
| | 305.1 | |
| | 219.1 | |
| | 524.2 | 3.9 |
| | 325.1 | |
| | 9.1 | |
| | 334.2 | 2.5 |
| | ,032.6 | 74.0 |
| | 501.2 | 5.9 |
| | 51.8 | 1.8 |
| | 1.8 | 1.1 |
| | .6 | 8.8 |
| | .2 | 82.8 |
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→ Class V :- These soils are nearly level, deep but stony and in some places imperfectly drained. These are good forest or grazing lands (0.17 mha)
→ Class VI :- These are moderate forest or range land (1.27 mha). Stony, wet lands with lack of aeration. Very sandy, gravelly. Management is needed for planting grasses, shrubs or trees. Moisture shortage due to inadequate rainfall.
→ Class VII :- Poor forest or range land (15.4 mha). Erosion hazard, severely waterlogged
Marshlands and open water areas

Class VIII :- (23.3 mha) .. This land has no potential for cultivation, forestry and grazing because of severe limitations imposed by erosion, excessive wetness, shifting sand, severe salinity, very arid climate, glacier cover.





strong salinity and sodicity combined with slow permeability, etc. The net return from this land is generally negligible.

Soils in Classes I to IV are cultivated for farm crops, while some of the lands in Classes V to VII are suitable for perennial woody vegetation and grasses, etc.

### 10.3.1 Uncultivated areas of CCA Culturable commanded area

About 17% of the CCA is presently not under cultivation. Class V, VI, and VII land has severe limitations or hazards for cultivation, most being level but strongly affected by salts. A large proportion of the saline land can be considered culturable because its reclamation is economically feasible provided sufficient water is available after the water needs of good land have been met. The rest of the saline land is so bad that its reclamation, though technically useful, would not be economical. Some parts of the uncultivated land are either too sandy or too rough and broken to be cultivable.

About 60% of the uncultivated land has moderate potential for irrigated agriculture (Class III land); about 30% is not culturable, but supports a cover of vegetation providing some grazing (Class VII land), and the remaining 10% is fit neither for cultivation nor for grazing (Class VIII land).

### 10.3.2 Irrigated area

Canal-irrigated area constitutes the major part of agricultural land in our country. The canal-commanded lands spread over approximately 13.8 million ha of a variety of land in the Indus plains. Of this, nearly 2.4 million ha, although within the command of canals, is virgin, but the bulk of the land, measuring about 11.3 million ha, is actually under cultivation.

### 10.3.3 Barani areas

About 3.68 million ha are under barani farming, which includes rainfed cultivation, riverine *sailaba* areas (kacha area), and torrent-watered *sailaba* cultivation in Balochistan and the outwash plains of the Suleiman and Kirthar ranges.

The main barani areas of the Punjab, Sindh, NWFP, and part of Balochistan have been covered by soil survey, and the soils have been evaluated in terms of their agricultural potential. Class I and II lands do not exist under barani cultivation because of the limitations imposed by climate, especially inadequate rainfall. The best barani land falls in Class III—moderately productive agricultural land. About half of the barani area consists of Class III lands. They occur in areas with annual rainfall of more than 50 cm. A major part of Class III barani lands have no soil limitation, whereas slope, limited soil depth, and erosion are the important soil problems in the re-

50×10=500 mm

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maining part of this class. Class IV lands are either located in low-rainfall areas where moisture availability is inadequate and uncertain, or have severe problems of slope, limited soil depth, and erosion. Possibilities for increasing agricultural production on this land are limited. Low-rainfall areas and the torrent-watered *sailaba* areas fall into this class.

### 10.3.4 Uncultivated areas not in CCA

The uncultivated areas (Class V through VII) are used for grazing or forestry. The natural forest areas are confined to the northeastern parts of the country, where adequate precipitation and the effect of high altitude permit growing of natural forests. The soils under these forests are generally deep and quite stable in spite of their position on steep slopes. But due to strong biotic pressures, not only are the areas under natural forests dwindling, but the denuded soils are also being subjected to erosion.

Large areas of the uncultivated land in the country are used for grazing. The grazing potential varies with the availability of moisture, and is influenced by rainfall, temperature, and the depth of the soil. Soils in these areas show a great range of physical and chemical characteristics.

## 10.4 Sustainability of land resources

It is commonly believed that most of our prime agricultural land, though inherently problem-free and fertile, is in impending danger of deterioration due to salinization and waterlogging.

**Hazard of salinization.** Studies of soils all over the Indus plains have revealed that most of the soil salinity there is very old, produced in the process of soil formation much before the introduction of the modern canal system. The extent of (secondary) salinity produced as a result of irrigation is limited and includes no more than a small proportion of the affected land.

There is, however, another process of soil deterioration that should be of great concern to the nation. It is the sodication of first-rate agricultural land caused by irrigation with low-quality tubewell water. This type of salinity was introduced with the accelerated use of ground water. The symptoms of the sodicity of soils are widespread, as observed from hardening of the soil surface, decrease in rate of infiltration, and inadequate seed germination — especially of alkali-sensitive crops. This mode of soil degradation is treacherous, beginning insidiously at a slow rate.

**Hazard of submergence.** The apprehension of submergence of large parts of the irrigated plains is not based on fact. The irrigated Indus plains, although apparently level, are far from being flat. There are small but important local variations in relief inherited from depositional patterns of

... in the soil but crop yields are low
this may be due to compaction, poor drainage, low aeration, greater pathogen infection, more insect damage.



the river alluvia. The rise in water table due to seepage from the canal system does not affect all the land uniformly. In depressional areas representing filled-in channels and basins the water table comes close to the surface, and in some cases small local areas are submerged and turn into marshes. In most areas, the water table remains deep enough not to affect crop production and cropping patterns.

The general layout of land and the net input of water in the Indus plains are such that not more than about one percent of canal-commanded area can ever be submerged, and the prediction that unless a massive drainage system is provided certain regions will turn into lakes has no basis.

**Hazards of soil erosion.** 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.

Protective measures on a large and costly scale are necessary, but much can be done in simple ways at the level of the individual farm. Proper crop management, contour farming, and strip cropping are economical and effective ways to reduce soil erosion. One of the secrets of good crop management is to keep the ground covered for the major part of the year.

## 10.5 Managing soil resources

Land differs considerably from place to place in its response to agricultural use. The new lands which can now be developed for agriculture are mainly those which have no or only a low potential for that purpose, so that very low or negative returns are expected from most of them. The proportion of potentially productive land is rather small. The following points should be considered for the management of soil resources in the country.

**1. Soil fertility.** The nutritional status of soil varies with the difference in the parent material and is likely to affect the availability of some micronutrients. Slight differences in clay mineralogy can also be expected, depending upon the differences in the parent materials (Indus river alluvium, Suleiman piedmont alluvium, loess or eolian silt, and eolian sand). Indus alluvium is low in zinc and copper, but relatively high in iron and manganese because of biotite mica. Therefore zinc and copper nutrient deficiencies are the first to appear in plants in the Indus plain.

**2. Soil tillage.** Tillage operations are affected mainly by soil texture and type of clay. Seedbed preparation is affected mainly by soil texture, as the clay type is almost uniform in the Indus plain, except in some clayey soils in

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the rice tracts of the Punjab. At present, seedbed preparation is done by tilling the soil to a depth of about 8 cm, whether by bullock-drawn local cultivator (*munnah*) or by tractor-operated tine cultivator. This practice is suitable for loamy and sandy loam soils. For clayey soils, however, we need special tillage implements like the disc harrow, clod breaker, etc. The present cultivator is completely inadequate for clayey soils, no matter how many times it is worked. It is through field experiments that suitable tillage operations can be evolved for proper seedbed preparation in clayey soils.

Our tillage operations work the surface soil layer to a depth of about 8 cm, below which is formed a dense layer about 5–7 cm thick. This layer is called **plough pan**; it hinders the movement of water and air as well as the growth of plant roots. The problem is severe in clayey soils and loamy soils of irrigated areas, and in loamy soils of rainfed land. The plough pan can be shattered by working a chisel plough to about 15 cm depth when the soil is nearly dry. Performing the operation at *wattar* condition (soil moisture level suitable for cultivation) is totally ineffective. If ploughing is done to greater depth, it will be harmful because the soil pores in the layer below the plough pan will be destroyed. In clayey soils, tillage operations should be performed when the soil layer at a depth of 7–15 cm is in a moist condition suitable for tillage operations. Field experiments are needed to evolve suitable tillage operations to control the plough pan problem.

**3. Cultural practices.** In clayey soils, the effect of inadequate seedbed preparation can be overcome by adopting a better method of sowing crops. Sowing on ridges may prove to be useful on clayey soils. For loamy soils, however, this method of sowing may not be any better than sowing on the flat.

Improper seedbed preparation in clayey soils adversely affects the germination of crop seeds, but the problem can be overcome by using a higher seed rate. Through field experiments, suitable seed rates for various crops can be found on different soils — sandy, loamy, and clayey.

**4. Irrigation water management.** This involves the adoption of suitable methods of irrigation, and managing water application depending on the water infiltration rate of the soil and the thickness of the root zone. For example, sprinkler and drip irrigation methods are suitable in all sandy soils. For loamy and clayey soils, basin or border irrigation is appropriate. The size of the basin will depend upon the water infiltration rate and the discharge of the irrigation ditch. The amount of water to be applied depends upon the thickness of the effective root zone. Through field experiments, irrigation schedules can be evolved for various crops on different soils. At present, half an acre (2000 $m^2$) is the common size of the basin. It results in the loss of water through percolation in sandy loam soils, but causes underwatering of crops in clayey soils.

**5. Special management practices.** Some special management practices are required for fields having saline-sodic patches. The water intake is much slower in saline patches than in the non-saline parts of the fields. So when irrigation water is applied the saline patches are unable to absorb their due share of water because it goes to the non-saline part of the field, which has a higher rate of water infiltration. It is postulated that if a *bund* dike is built around each saline patch and water is let into it through an opening in the dike and then the opening is closed immediately after water application, it will help to reclaim the saline patch. If the normal crop, for example cotton, does not grow in the saline patches, a salt-tolerant crop like *Sesbania* (*dhaincha*) should be sown. This way it may be possible to reclaim saline patches using the present irrigation water supplies, without waiting for additional water.

## QUESTIONS

1. In what respect does the northern mountainous region differ from the western mountainous region?
2. What are the general features of the Indus delta?
3. Explain how the soils of Pakistan have been grouped according to their land capabilities.
4. Summarize the characteristic features of the land placed in land capability Class III.
5. Name the different soil hazards and the extent to which they affect Pakistan's soils.
6. How can alkali and saline soils be reclaimed?
7. What is soil erosion and how can it be checked?
8. (a) What is soil management? (b) Explain the agro-techniques involved in it.
9. What special management practices are needed to manage problem soils?

## REFERENCES

Bhatti, H. M.; Mian, M. A.; Qureshi, R. H.; Malik, K. A.; Ibrahim, M; Rasheed, M. eds. Managing soil resources: Proceedings of First

National Congress of Sc
Science Society of Paki

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Water:- It is a chemical compound of hydrogen and oxygen. It is a substance which may be called as a fluid of life as no plant or animal life is possible without water. It possesses unique physical and chemical properties which enables it to play a dominant role in various plant growth processes.



## 4.4 Sources of irrigation water

There are three sources of irrigation water in Pakistan: precipitation, surface water, and ground water.

**Precipitation.** The source of all water supplies is atmospheric precipitation: rainfall, dew, mist/fog, hail, and snow. Amongst these, however, rainfall is the most important because it contributes substantially to crop water requirements.

The cultivable canal-commanded area of the Indus plain and Peshawar Vale (irrigated by Kabul River) receives 25 maf (22.5 cm) rainfall annually (Ahmad and Chaudhry (1988:3.1). However, distribution and intensity of this rainfall is so erratic that successful crop husbandry is not possible with rainwater alone. Therefore, surface and ground water are needed to supplement the crop water requirements on a continuous basis to harvest the maximum potential of crops.

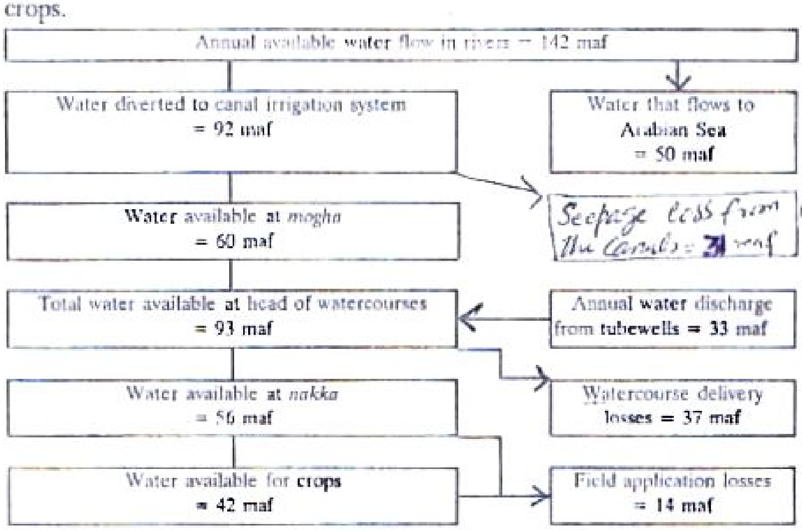


Figure 4.3 Flow chart of the Indus Basin Irrigation System (Cheema 1982:48).

**Surface water.** Surface water is mainly derived from the Indus River system, which is one of the great fresh water resources of the world. The annual available river flow in Pakistan is 142 maf, of which 92 maf (65%) is diverted into the canal irrigation system, and 50 maf (35%) flows into the Arabian Sea (Fig. 4.3). Of the 92 maf water diverted to the canal irrigation system, only 65% is available at *mogha* while the remaining is lost through seepage from canals.



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## 4.5 Soil water

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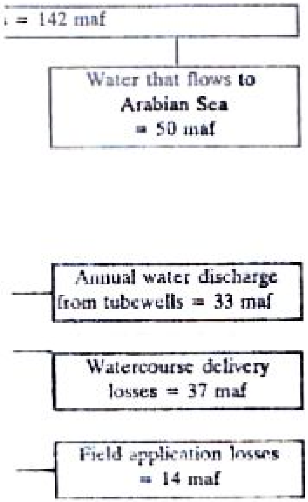


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## 4.5 Soil water

### 4.5.1 Classes and availability of soil water

Water present in the pore space of soil is of three types: hygroscopic, capillary, and gravitational.

**Hygroscopic water.** Hygroscopic water is water that is attached to soil particles by loose chemical bonds and does not move by the action of gravity or capillary forces. This water is not available for plant growth because plant roots are unable to extract this water from the soil.

**Capillary water.** Capillary water is soil water in excess of hygroscopic water which exists in the pore space of the soil by surface tension or molecular attraction against gravitational forces. It is available for plant growth and development. Soil pore space that capillary water occupies is called **capillary pore space.** This determines the amount of water that is retained in the soil after a rain or irrigation and is available to the plant. The proportion of capillary pore space and consequently the amount of capillary water varies with the type of soil, being minimal in coarse, sandy soils and greatest in clayey soils. However, the water-holding capacity of a soil can be improved by various soil management practices like addition of organic matter, clay, or both.

**Gravitational water.** Gravitational water is water in excess of hygroscopic and capillary water that percolates through the soil under the action of gravity if favourable conditions for water drainage are provided. This water passes down to the ground water table, and hence is not available for plant growth if the water table lies very far below the root zone.

### 4.5.2 Measuring the availability of soil water

The availability of soil water to plants can be measured by determining soil water potential, saturation capacity, field capacity, permanent wilting percentage, and available water content (Kramer 1983:68). However, **soil water potential** is the most reliable indicator of water availability to plants.

Adhesion:- is the tendency of dissimilar particles to cling to one another e.g between soil and water molecules.
Cohesion:- is the tendency of similar particles to cling to one another e.g between water molecules.

Surface tension:- It is a phenomenon in which the surface of a liquid acts like a thin elastic sheet. This term is typically used when the liquid surface is in contact with gas (such as water and air).
Causes:- Various intermolecular forces such as Van der Waals forces draw the liquid particles together. Along the surface, the particles are pulled towards the rest of the liquid.

**a. Water potential.** Water potential refers to the chemical potential of water. It depends on the mean free energy per molecule and the concentration of water molecules. Water always flows from a higher potential to a lower potential.

Soil water potential comprises four components: **osmotic potential** (also called solute potential) produced by various solutes in soil water; **matric potential** produced by capillary and surface forces (water adsorption to soil constituents); **gravitational potential** produced by gravitational forces operating on soil water; and **pressure potential** produced by actual hydrostatic pressure (Kramer 1983:69). However, the former two components are much more important in determining soil water potential than the latter two.

**b. Saturation capacity.** This term refers to the amount of water present in the soil when it is completely saturated with water. It is also called **total capacity or maximum moisture-holding capacity**. During and immediately following surface irrigation or heavy rainfall, the soil below the water surface is nearly saturated. The pore space of the soil is almost completely filled with water, and there is little air present in saturated soil. Since plants, with the exception of rice, need air as well as water, some of the water from the larger pores must leave in a reasonable length of time to prevent damage to the crop. If the soil is well-drained, part of the water will move downward by gravity and, to a limited extent, laterally by capillarity. The water moving downward by the force of gravity is called **gravitational water** or **free water.**

**c. Field capacity.** The amount of water retained by soil after drainage of saturated soil by gravitational force is called the **field capacity** of a soil. Field capacity is also called **field carrying capacity, normal moisture capacity,** and **capillary capacity** (Kramer (1983:70). At field capacity, each soil particle is completely surrounded with a relatively thick film of water. Soil water content at field capacity can be determined by using the formula:

$$\text{Field capacity} = \text{Saturation capacity} - \text{Gravitational water} \qquad (4.3)$$

Soil water reaches field capacity several days after soil saturation, the specific time varying with the soil type. Sandy and deep soils reach field capacity in a much shorter time than clayey and shallow soils. The presence of hardpan/plough pan or high water table prolongs the time required to reach field capacity.

**d. Permanent wilting percentage.** The soil water content at which plants can no longer extract sufficient water from the soil for their growth is called permanent wilting percentage. If sufficient water is not available to the plant to meet its requirements, the plant will wilt permanently and will not recover even when placed in a saturated atmosphere. By contrast, soil water content at which plants wilt during the hot windy part of the day (at noon and afternoon) but regain turgidity during the cooler part of the day (dawn and early morning hours) is called **temporary wilting percentage.**

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**c. Available water.** The water retained in a soil which represents the difference between field capacity and the permanent wilting percentage is the **available water**. The amount of available water depends on several factors like size, shape and depth of root system, soil texture, level of underground water table, and the presence of an impervious soil layer. The available water capacity of different soils varies widely (Fig. 4.4). The portion of the available water that is most easily extracted by a plant is called **readily available water**; it is about 75% of the available water.

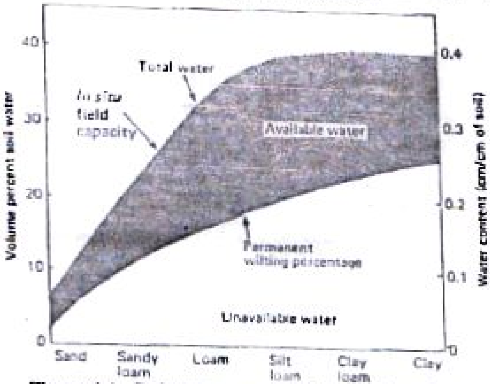


**Figure 4.4** Relative amounts of available and unavailable water in soils ranging from sand to clay. Reproduced with permission from Kramer (1983:69).

## 4.6 Quality of irrigation water

The water of rivers in Pakistan, like all rivers of the world, contains soluble salts, the content of which ranges between 200 and 250 ppm (Ahmad and Chaudhry 1988). This concentration increases as the water approaches the delta. Total soluble salt content varies for each river because of differences in catchment areas and sources of water supply, and with the season. Moreover, with the rapid, unplanned expansion of industry, risk of both surface and ground water pollution has greatly increased because little attention is being paid to the proper disposal of industrial chemicals. Many of these chemicals, heavy metals, etc. may be injurious for both plant and soil health. Determination of the quality of irrigation water is essential, therefore, in order to ensure good quality water to crops and obtain maximum yields as well as to avoid the risks of soil salinization and sodification.

Regardless of the source of irrigation water, some soluble salts are always dissolved in it. However, the nature and quantity of dissolved salts depend on the source of water and its course before use. Among the soluble constituents, calcium, magnesium, sodium, chloride, sulphate, bicarbonate, and boron are of immense importance in determining the quality of irrigation water and its suitability for irrigation purposes. Ions of selenium, molybdenum, and fluorine, if absorbed by plants in excessive amounts, may prove harmful to animals which eat them. Other factors including the structure and texture of soil, soil drainage, depth of the water table, presence of hardpan of lime or clay, type of crop grown, and climatic conditions are also important in determining the suitability of irrigation water for agriculture.

Factors that influence quality of irrigation water are: (i) total soluble salt concentration (TSS) as measured by electrical conductivity; (ii) relative proportion of cations as expressed by the sodium adsorption ratio (SAR); and (iii) bicarbonate and boron content. $CaCO_3$ content in the soil and $K^+$ and $NO_3^-$ ions in the water also indirectly affect the suitability of irrigation water. The criteria presented in Table 4.3 are internationally recognized for judging water quality (Afzal 1976).

**Table 4.3** Criteria for judging the quality of irrigation water

| Type of water | TSS (ppm) | SAR (ppm) | Residual sodium carbonate (ppm) | Use for irrigation |
|---|---|---|---|---|
| Very good | <1000 | <10 | Negligible | Suitable for all crops and all soils. |
| Good | 1000–2000 | <10 | <5 | Acceptable for permeable soils and hardy crops. |
| Poor | 1000–2000 | 10–15 | 5 (approx.) | When used on ordinary soils, will bring about deterioration of topsoil except in the case of sandy and gypsiferous soils. |
| Bad | >2000 | 10–15 | 5 (approx.) | Not suitable for use in agriculture. |

**Source:** Afzal (1976:60).

## 4.7 Irrigation scheduling

**Irrigation scheduling** refers to the number of irrigations for a crop and their timing. Assuming that water is available, the most important problem is to determine when and how much to apply. This depends on several factors including type of crop, its stage of development, extent of the root system, rate of evapotranspiration, and the water-holding capacity of the soil.

There are three common approaches to the problem of determining when to irrigate. They are based on measurement of soil moisture, estimates of water usage from climatic data, and measurement of plant water stress. However, the water-stress approach for scheduling of irrigation is probably most useful, as it is based on the plant's water status itself. Plants should be the best indicators of the need for irrigation because they integrate the soil and atmospheric factors controlling the plant water balance. In many



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## 4.8 Irrigation effic

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sumption is less than 20
works or discharged by

**Table 4.4** Water losses

| Source | |
|---|---|
| Canal head to outlet | |
| Watercourses delivery | |
| Field application | |

Source: Data derived from p
Directorate of Agricultural In

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AGRC-101

Dr. IHSAN AZIZ

Chapter-1

# IRRIGATION WATER RESOURCES

## 1.1 Irrigation

Irrigation is generally defined as 'the artificial application of water to soil through a manually, electrically or mechanically managed system, for the purpose of supplying moisture essential for plant growth. However, in the broader sense, it may be defined as the application of water to the soil for any number of the following purposes:

1. To supply the moisture essential for plant growth.
2. To transport nutrients from soil to the plant
3. To provide crop insurance against short duration droughts.
4. To cool the soil and the atmosphere, thereby making more favorable environment for plant growth.
5. To protect the crop from hazard of frost.
6. To washout or dilute salts in the root zone of salt affected soils.
7. To soften tillage pan and clods for facilitating fine seedbed preparation and planting operation.
8. To encourage plant root development.
9. To encourage biological activities in the root zone.

## 1.2 Importance of Irrigation

Under arid and semi-arid climatic conditions of Pakistan, where average annual rainfall ranges from 10 to 14 inches against a potential demand of about 70 inches of water for agriculture, irrigation is considered essential for crop production. Increasing pressure of population demands increased agricultural production for food security. This necessitates multiple cropping and better uses of fertilizers and crop varieties, which cannot be practiced successfully without providing requisite irrigation water.

## 1.3 Source of Irrigation Water

Primarily there are three sources of irrigation water in Pakistan, namely, surface water (canal water), groundwater (pumped water) and rainfall.

### 1.3.1 Surface Water

The major sources of surface water contributing to the Indus Basin Irrigation System, are the snowmelts and precipitation over the mountainous regions. Runoff water through streams and rivers is stored in reservoirs or is diverted directly through canal systems to the fields for irrigation. The Indus Basin Irrigation System primarily comprised 6 rivers namely, Indus, Jhelum, Chenab, Ravi, Sutlej and Bias . In Pakistan, however, the surface water resources as a result of Indus Water Treaty that was implemented in 1960 were limited to the waters of the Indus, Jhelum and Chenab rivers. Since, Pakistan has been deprived of eastern rivers namely, Ravi and Sutlej, water from western rivers has been diverted to eastern rivers through link canals to supply water to the areas previously irrigated by Ravi and Sutlej.

The irrigation water in the Pakistan's Indus Basin Irrigation System (IBIS) is conveyed through 56,073 km of canals and 1.6 million km of watercourses, farm channels and field ditches. The total number of watercourses in the four provinces has been estimated as 137,000. The canal system supplies water to a network of branch canals, distributaries, minors, watercourses and field channels as shown in Fig. 1. According to Bandaragoda and Rehman (1995), the total annual flow into the river system of the Indus Basin is estimated to be 139 maf (million acre feet), out of which 104 maf are diverted to the canal irrigation system to irrigate over 16 million hectares of land. About 77.4 percent of the total irrigated area falls in Punjab, 2.8 percent in NWFP, and 19.8 percent in Sindh and Balochistan. A significant portion of annual inflow is lost through seepage in the conveyance system (canals, distributaries, minors and watercourses) allowing only 43 maf at field inlets and 31 maf for crop use in the field as shown in the flow chart (Fig. 2).

About 84 percent of the total annual river flow occurs during kharif season and about 16 percent during Rabi season giving a Rabi: Kharif ratio of 1:5.2. The crop water requirements on the other hand occur at the ratio of 3:5 between Rabi and Kharif. Thus, there exists incompatibility between the water availability and requirements, which has partially been regulated through managed releases from dams and reservoirs. Presently, there are 3 major reservoirs in Pakistan namely, Tarbela, Mangla and Chashma having a total capacity of about 16 Maf. An estimated annual flow of 35 maf does not become part of the canal irrigation system as it escapes to the sea unused during floods. Out of this, 10 maf (million acre feet) are claimed to be required for harbor development and fish culture. The remaining 29 maf can be beneficially conserved and stored in proposed storage dams such as Kalabagh, Bhasha and Dhasu etc. The Development of storage reservoirs is the prime need of the country to overcome the deficits, particularly during winter season.

### 1.3.2 Ground Water

The groundwater has been in use since ancient times. Groundwater, which meets more than 40 to 50 percent of the irrigation water requirements, is obtained by pumping groundwater from the alluvial aquifers of the Indus Basin. Pakistan is very fortunate to possess a rich source of groundwater, particularly in the province of the Punjab. According to the Planning Division / NESPAK (1990), about 48.5 maf are being pumped for use on agricultural lands, for human consumption and industrial uses. More than 90 % of the extracted groundwater is used for irrigation purposes, and the remaining 10 percent is used for domestic, industrial and livestock needs.

In 2003, about 6290,000 private tubewells in addition to more than 2500 public tubewells including SCARP tubewells were reported to be pumping groundwater to supplement surface water supplies (Qureshi et al 2003). Historically, on the average, about 10,0000 tubewells have been added to the system annually. According to Bandaragoda and Rehman (1995), the public and private tubewells contributed about 44 maf to the field outlets, which allowed about 29 maf of ground water for crop use (Fig. 2).

The major sources of recharge to the groundwater reservoir of the Indus Basin include the canal irrigation network (canals, watercourses, farm channels and irrigation return flow) and rainfall. The return flow from field irrigation has been estimated about 24 percent of the total annual recharge to groundwater.

### 1.3.3 Rainfall

The third major source of water for agricultural purpose is rainfall, which is neither sufficient nor reliable. Practically, whole of the Pakistan lies in arid to semi arid zone. The annual rainfall over the Indus Basin ranges between 12.7 to 35.6 cm in the plains and above 51 cm in the northern areas. The Indus Basin can be categorized in rainfall zones as given in Table 1.

Table 1: Arial distribution of rainfall zones in Pakistan

| Rainfall zone | Percent of land | Averaged annual rainfall |
|---|---|---|
| Arid | 67 | Less than 10" |
| Semi-arid | 24 | 10-20" |
| Humid | 5.5 | 20-30" |
| Para humid, very wet | 3.5 | 30" |

Annually about 9 MAF of rainfall are estimated to reach the irrigation system for crop use (Bandaragoda and Rehman, 1995). Thus, a total of 69 maf water is available from all sources, which meet only 64% of the annual irrigation requirements.

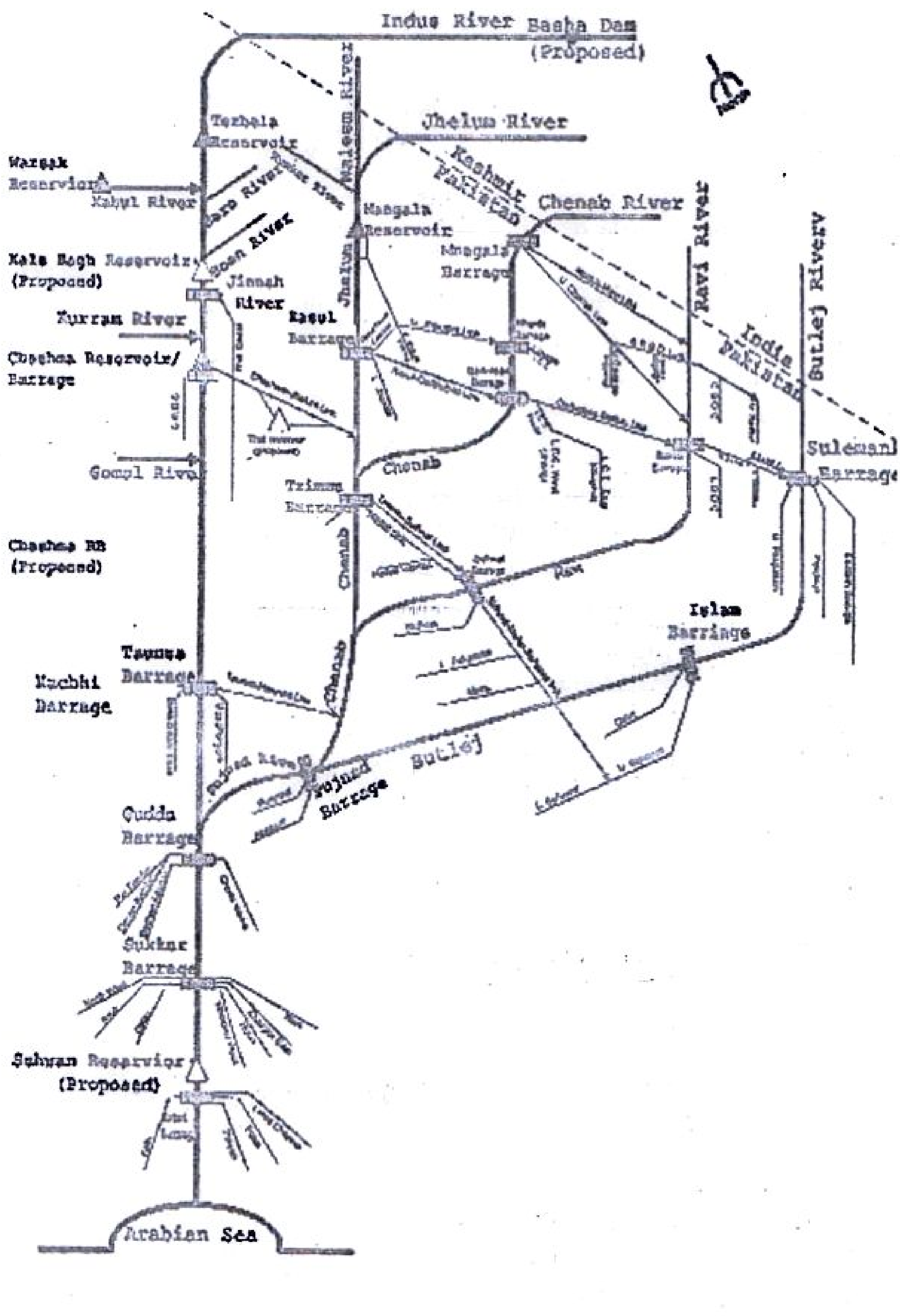



Fig. 1 Schematic Diagram of Indus Basin Irrigation System of Pakistan

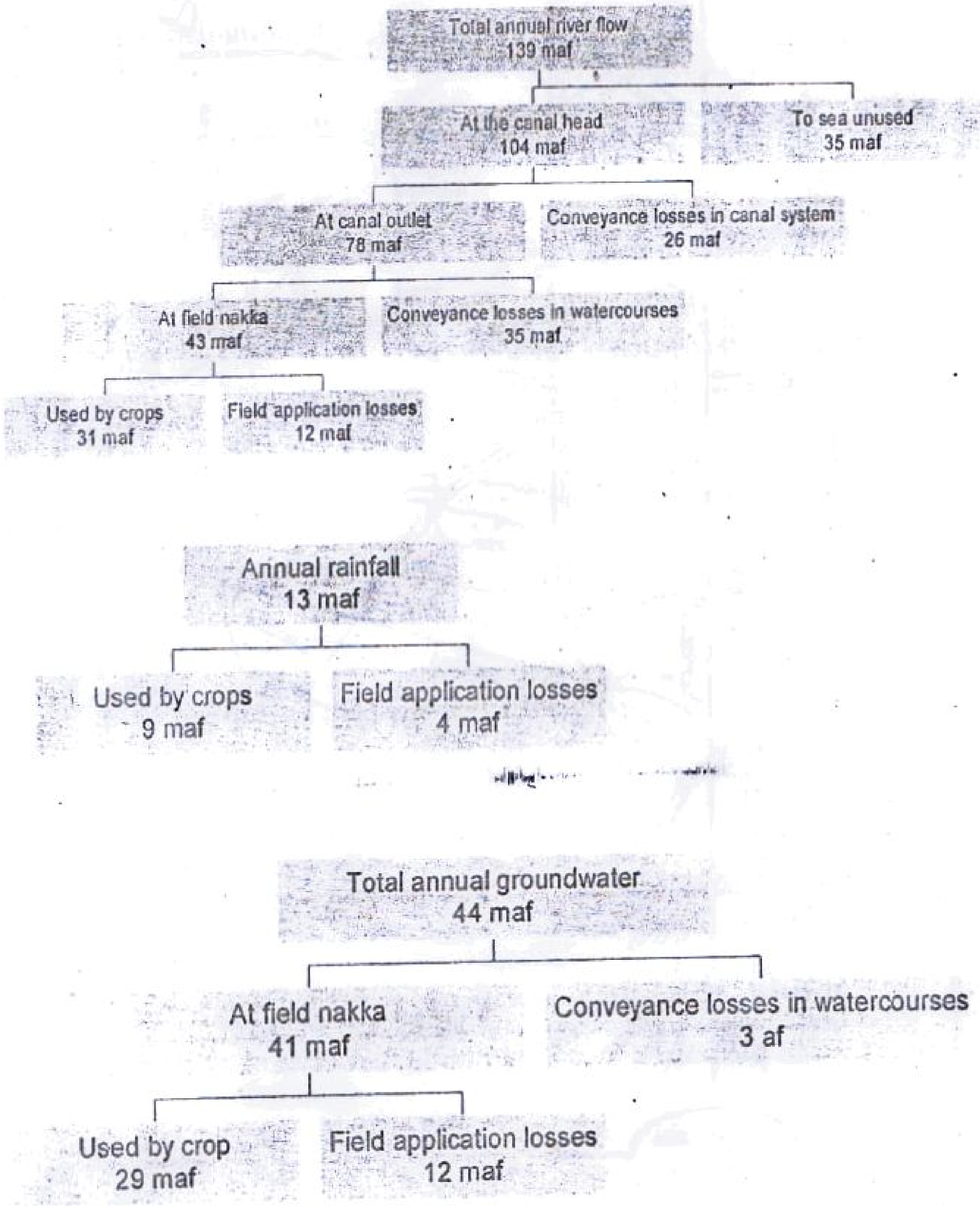



Fig . 2 Flow Chart of Indus Basin Irrigation System

a. Basin irrigation :- In basin irrigation, the entire soil surface is flooded. The bunds prevent water from flowing to the adjacent plots. Basins are flat areas of land surrounded by low bunds (ridges). This method is most common in Pakistan. In this method an acre can be divided into eight beds of one Kanal each for wheat or four beds of two Kanals each for cotton or paddy.

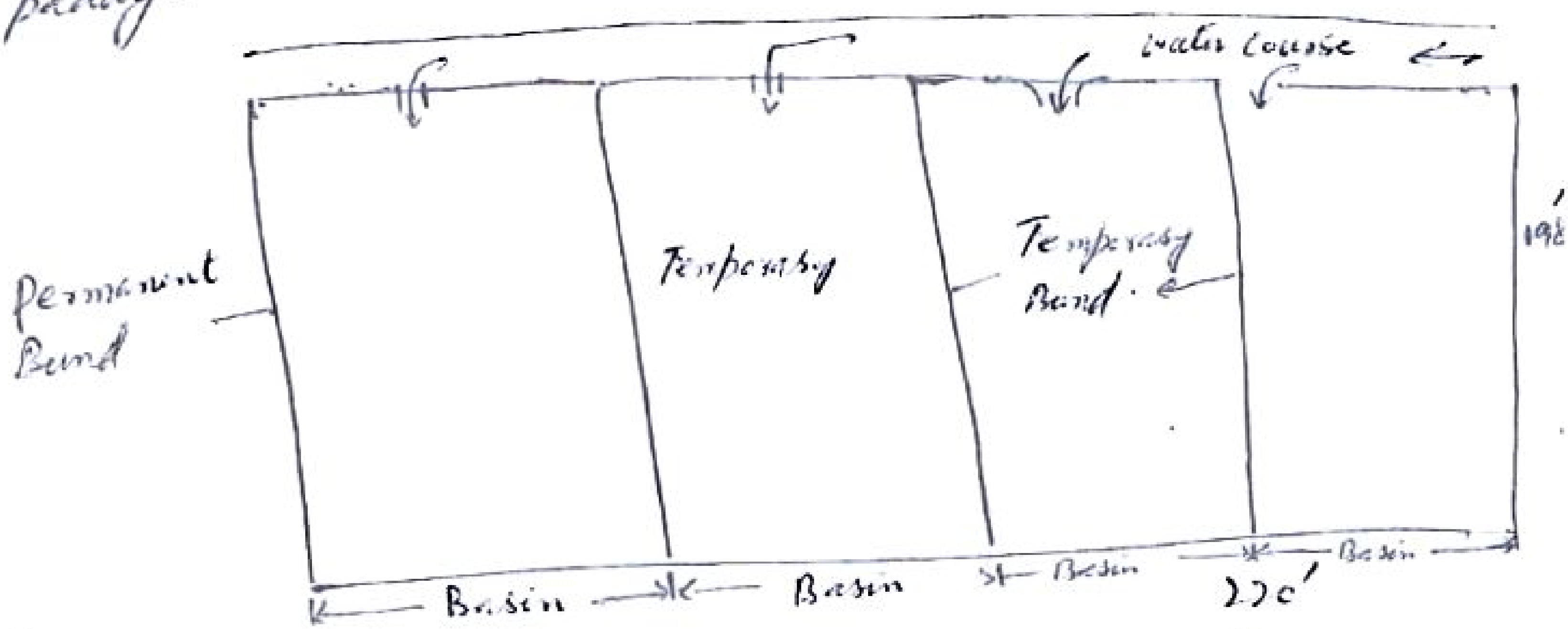



Fig: Method of water supply in basin irrigation by direct method

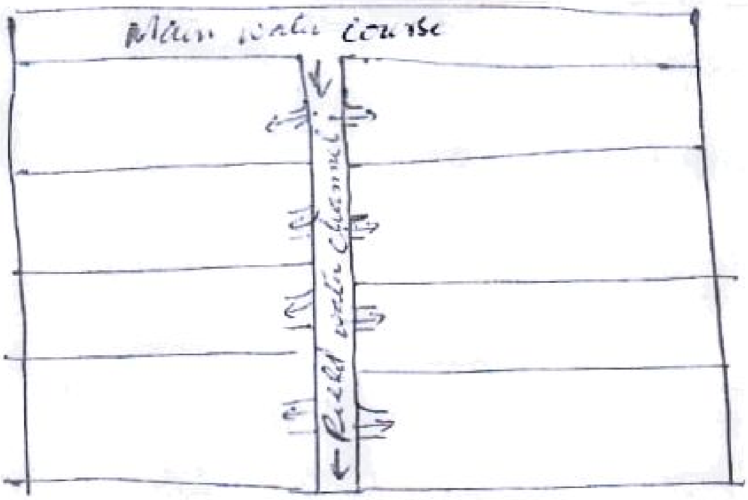



Fig: Method of water supply in basin irrigation
(One acre is divided into 8 basins as in wheat)

Special types of basins are formed for orchards. Usually a separate basin is formed for each tree, but in some cases one basin may be formed for several trees where soil slope is suitable. Water is supplied to these basins from a supply ditch. In some cases basins may be interconnected and cascade method of water supply to fruit trees is used.

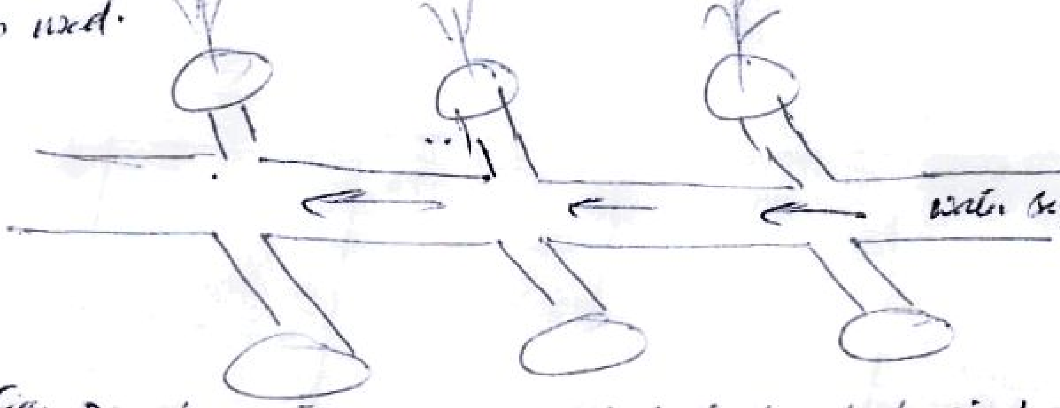



Fig:- Direct method of water supply to fruit orchards using basin irrigation system.

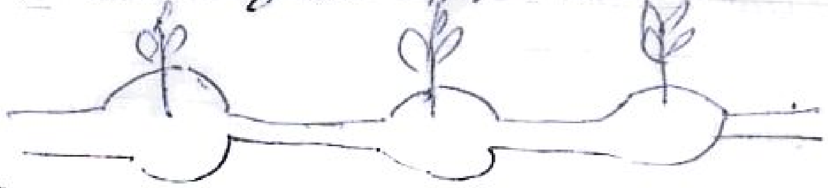


Fig:- Cascade ...

C) Border Irrigation

There are two types of border irrigation

i) Straight border irrigation

ii) Contour border irrigation

Straight border irrigation

In this system the borders are long strips of land which are separated from one another by earthen ridges.
The width of a border strip is usually ~~10 to 50 feet~~ 3 to 15 meters and length varies from 60—120 meter in sandy soil, 100 to 180 meters in medium loam soil and 150 to 300 meters in clay loam soil.

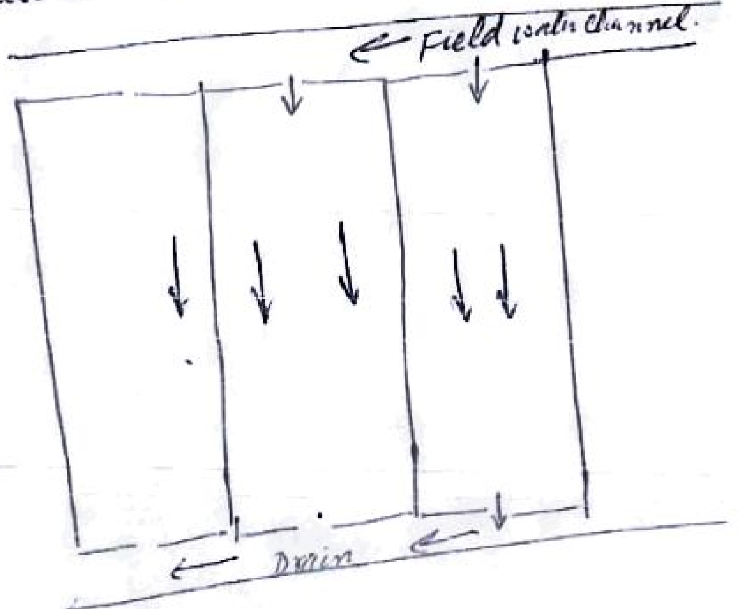



Fig Straight border irrigation

Straight border irrigation is suitable for large mechanized farms. Suitable for close growing crops such as alfalfa, wheat, barley or legumes etc.

Contour border irrigation. In this system ridges are made across the slope so that field is divided into a series of ~~slopes~~ strips on the contour. This method is practiced in hilly areas having unlevelled fields.

b) Furrow Irrigation: Furrows are small parallel channels or ditches which carry irrigation water to the crop. Crops are usually grown on the ridges between the furrows. The size and the shape of the furrows depends on the crop grown and space between the crop rows.

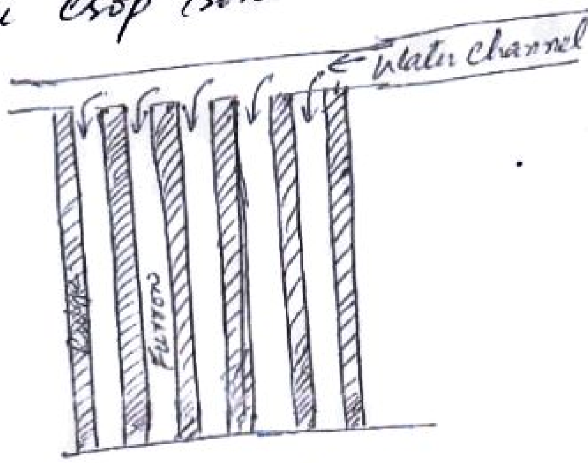



Fig:- Furrow irrigation

Crops that are damaged if water covers their stem should be irrigated by furrows. Examples of these crops are tomato, potato and various vegetables crops like maize, sunflower, sugarcane, cotton, soybean, tobacco and groundnut are also suitable for furrow irrigation.

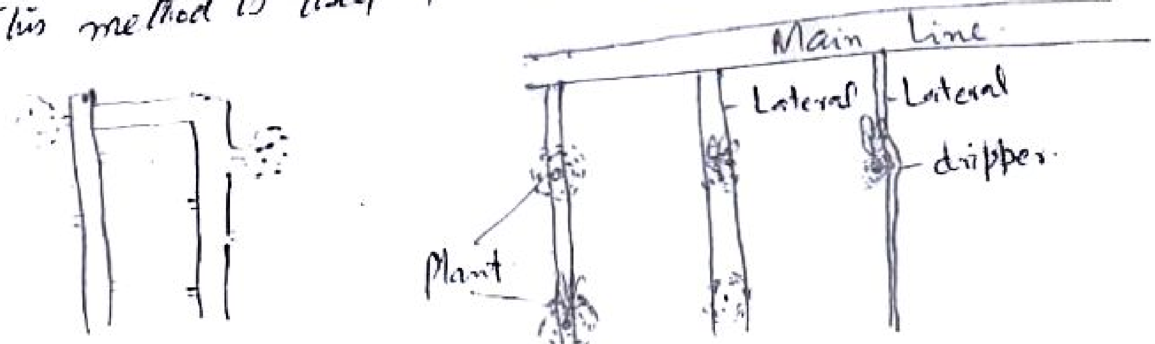
CORRUGATION IRRIGATION:- This is the modified form of furrow irrigation. In this irrigation method smaller and numerous furrows are created. This method can be used for broadcast crops like wheat, berseem, oat etc.

2- Subsurface irrigation

:- In sub-surface irrigation system water is applied to a series of field ditches deep down to the impervious layer. Water moves laterally and upward through capillaries and saturate the root zone. Sub-surface irrigation is suitable where subsoil at a depth of 2m is impervious. Ditches are 3-4 feet deep and suitably spaced "9 feet" apart.
Suitable for sandy loam surface soil.

3- Sprinkler Irrigation :- Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping.
Sprinkler are adaptable to most soils but they are best suited to sandy soils with high infiltration rate.
All row crops and trees can be irrigated by this method.

4- Drip irrigation :- Drip irrigation involves dripping water in to the soil at very low rates from a system of small diameter plastic pipes fitted with outlets called emitters or drippers. Water is applied close to the plants so that only part of the soil in which roots grow is wetted.
This method is used for row vegetables, trees and vine crops.



Dr. AHSAN AZIZ 5th Agro-509

## 2. AGRO-ECOLOGICAL ZONES OF PAKISTAN

Pakistan is a land of diverse ecologies. In the north there are high mountains interspersed with valleys. Southwards there is the Pothwar Plateau followed by fertile Indus Plain, which is 1287 km long and 322 km wide, with a 1.0 percent gradient from north to south. The western part mainly comprises Baluchistan Plateau, bordered by high to low mountains on the north-east. There are two sandy deserts in the Indus Basin; the Thal desert in the upper part and the Thar desert in the south-east. Marshy areas occur in the Rann of Kutch, along the southern most border of the country.

### 2.1. AGRO-ECOLOGICAL ZONES BASED ON PHYSIOGRAPHIC CHARACTERISTICS

PARC (1980) and Muhammad (1986) have delineated the country into ten agro-ecological zones/regions of Pakistan mainly on the basis of physiographic and on climate, soil type and agricultural land use.

The main agro-ecological zones of Pakistan are the following;

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

These agro-ecological zones of Pakistan are depicted in map no. 1.

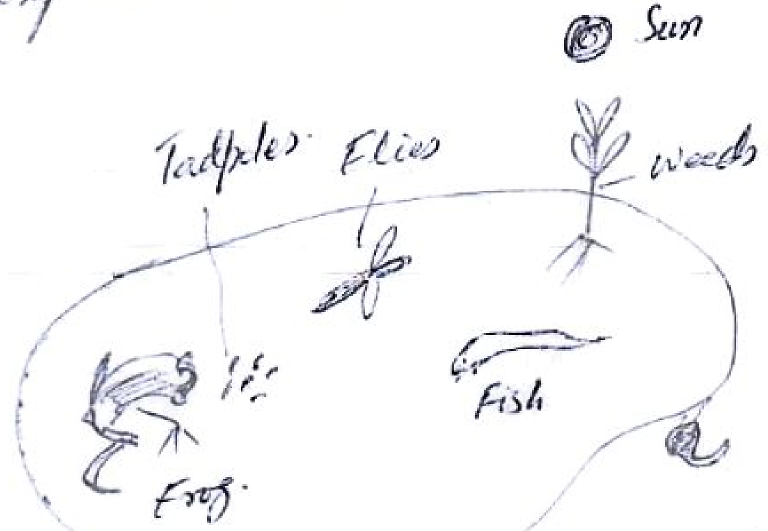
Delta: A nearly flat plain of alluvial deposit between diverging branches of a river.
Alluvial land enclosed between two or more mouths of a river.

✓ Ecosystem:- An ecosystem includes all the living things (Plants, animals, micro-organisms) in a given area, interacting with each other, and also with their non-living environments (weather, earth, Sun, Soil, climate."

Ecology:- It is the study of ecosystems.

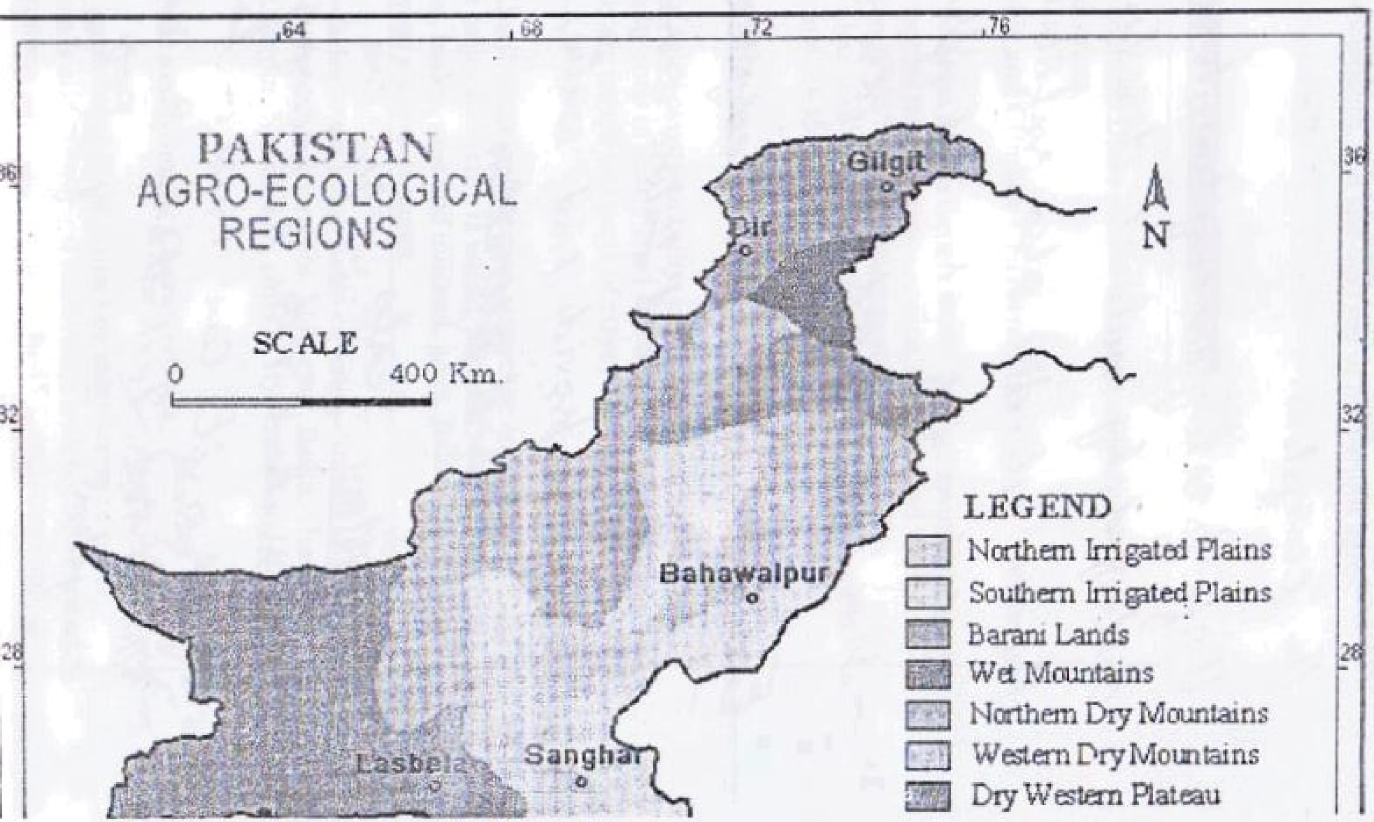
In an ecosystem, each organism has its own role to play.

Example:- Consider a puddle land. In it You may find all sorts of living things i-e micro-organisms, insects and plants. These depend on non-living things like water, Sunlight, turbulance in water, temperature, atmospheric pressure, nutrients in the water for life.




This very complex, wonderful interactions of living things and their environment has been the foundations of energy flow and recycle of carbon and nitrogen.

Any time a stranger living Thing or external factor such as Rise in temperature is introduced to an ecosystem, it can be disastrous to that system


PAKISTAN
AGRO-ECOLOGICAL
REGIONS
SCALE
0
400 Km.
64
68
72
76
36
32
28
Gilgit
Dir
Bahawalpur
Lasbela
Sanghar
N
LEGEND
Northern Irrigated Plains
Southern Irrigated Plains
Barani Lands
Wet Mountains
Northern Dry Mountains
Western Dry Mountains
Dry Western Plateau

usually biotic and abiotic factors of an ecosystem depends upon each other. This means the absence of one member or one abiotic factor can affect all parties of the ecosystem.

Unfortunately ecosystems have been disrupted and even destroyed by natural disaster such as fires, floods, storms. Human activities also contribute to the disturbance of many ecosystems e.g chemical spray kills the insects, cultivation of same crop again and again also distorb the ecosystem.

Ecosystem Services :- Ecosystem provide support to human life, its well-being and future economic & social development. Ecosystem provide food, water, timber, air purification, soil formation and pollination.

Ecosystem Scales :- It can exist in a small area such as underneath a rock, a decaying tree trunk or a pond in your village or it can exist in large scale such as an entire rain forest. Technically, the earth can be called a huge ecosystem.

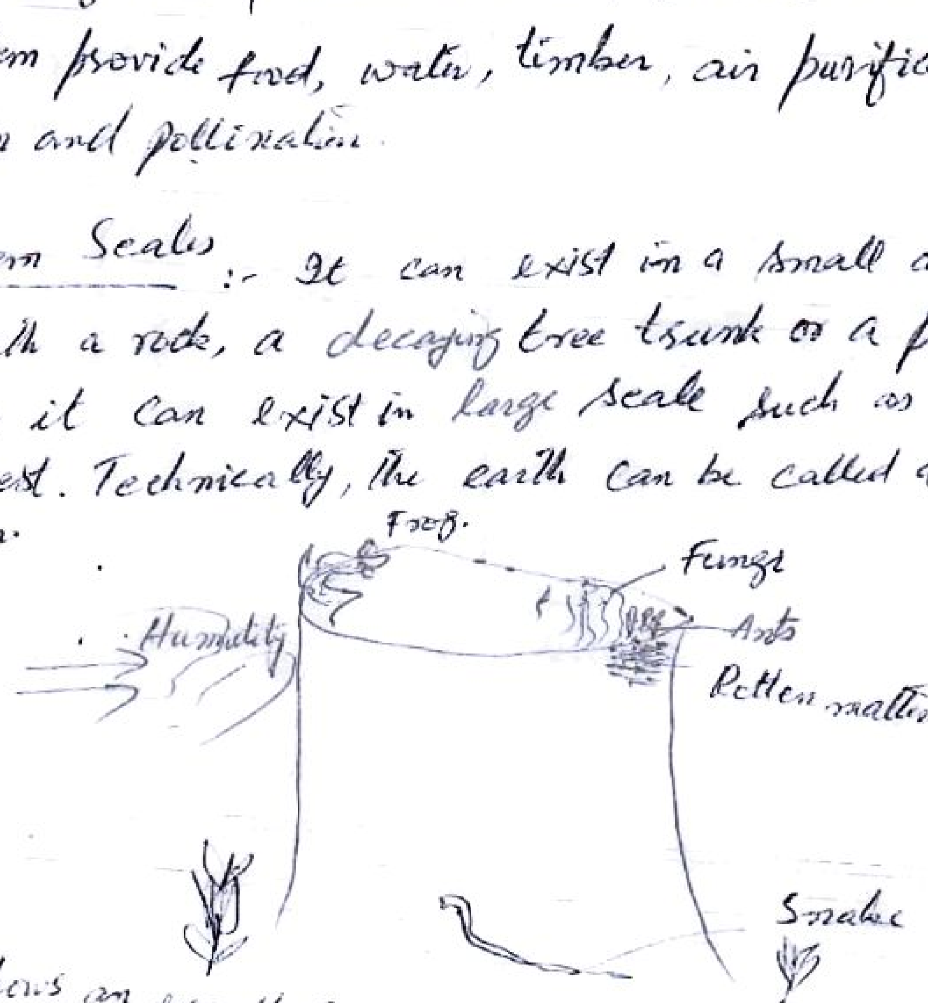



Fig: Shows an example of a small ...

The physiographic, climatic characteristics, soil and land use of the various agro-ecological zones are summarized in table 2.

**TABLE 2 AGRO-ECOLOGICAL ZONES OF PAKISTAN**

| | |
|---|---|
| **1- Indus Delta**<br>(125-250mm) | This zone comprised Thatta district and parts of Badin and Hyderabad districts.<br><br>**Physiographic and Climatic Characteristics**<br><br>Represents the Indus delta. Climate is arid tropical marine; mean daily max. summer temp. ranges between 30-40°C; and winter temp. between 19-20 °C; mean monthly summer rainfall is 75 mm and winter is less than 5 mm ; relative humidity 67-68 percent in the morning and 30-35 percent in afternoon.<br><br>**Soil and land use**<br><br>Two types of soils; clayey and silty; clay soils found in shallow basins and silty soils in nearly level flat areas; strongly saline-alkaline soils are barren and parts of clayey soils are under cultivation.<br><br>The main Kharif crops include rice, sugarcane and cotton, whereas the major Rabi crop is wheat, however, other crops like millet, maize, barley, rape and mustard, gram, fodder, pulses and vegetable crops are also common. |
| **2- Southern irrigated plain**<br>(< 125mm-250mm) | The zone includes lower Indus Basin covering districts of Dadu, Larkana, Jaccobabad, Sukhur, Sibi, Shikarpur, Badin, Tharparkar, Sanghar, Khairpur, Nawabshah, parts of Hyderabad and Rahim Yar Khan.<br><br>**Physiographic and Climatic Characteristics** Moving slowly in no particular direction<br><br>Represents lower Indus Plain formed by meandering of Indus river. Climate is arid subtropical continental with hot summer and mild winter; mean daily max. temp. is 40-45°C and min. temp. is 8.5°C in the northern areas, and 38-43°C and 8-12°C in the southern areas, respectively; mean monthly summer rainfall is 18mm in the north and 44-55 mm in the south; winter is practically dry. |

Physiography: Natural features of earth surface.
Lower Indus Plain = Sindh (South eastern part of Country)
Punjab is in its north, Baluchistan in west

Big > Small

Less than <

Humidity

Abiotic facts which provides moisture for the tree to decay. So, the tree-trunk depend on humidity to be able to decay.

↓

The decaying trunk provides fertile organic matter for tiny green plants to grow.

↓

Tiny green plants become food for bugs & insects

↓

Bugs & insects become food for the small animals like frog

↓

And frog becomes food for the snake

So, if one member is taken out the entire relationship will be affected e.g if fire burn out the trunk the insects will starve to death, frog will have no food and the snake will go somewhere else.

NATURAL RESOURCES

Things that exist freely in nature e.g water, air land, soils, rocks, forests (vegetation), animals (fish) fossil fuels and minerals they are called natural resources and are the basis of life on earth

Water:- Energy, drinking water

oil :- Energy fuel.

Forests :- wood, Food, medicine, pulp, rubber, Home of wild life.

Rocks:- Construction, Shelter.

Minerals:- Jewelry, Glass, ceramics

Soil:- Agriculture

Animals:- Food, wool, recreation

| | |
|---|---|
| Badin & Thatta | **Soils and land use**<br><br>Soil is silty and sandy loam associated with the active flood plain, upper areas of the flood plain is calcareous, loamy and clayey.<br><br>Crops grown: cotton, wheat, mustard, sugarcane, berseem on the left bank of Indus and rice, wheat, gram and berseem on the right bank; sorghum is the main crop in Southern Dadu. |
| 3- Sandy Desert<br>(125- 250 mm) | This zone comprises **Bahwalpur**, Tharparkar (partially), Khairpur, Nawab Shah, Sanghar, Rahim Yar Khan and Bahwalnagar districs. Parts of Muzaffargarh, Mianwali and Sargodha districts constitute this zone.<br><br>**Physiographic and Climatic Characteristics**<br><br>a. Sandy desert with xerophytic vegetation; central part occupied by salt lakes; southern part rainfall 300 mm.<br>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.<br><br>**Soils and land use**<br><br>a. 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.<br>The major Rabi crops are millet, wheat, rape and mustard and fodder whereas the major Kharif crops are cotton, fodder, sugarcane and remaining crops are millet, sorghum, rice, maize, pulses etc.<br><br>b. Sandy and loamy fine sandy soil, stable ridges; moderately to strongly calcareous.<br>The major crops in Kahrif are cotton, sugarcane and rice and in Rabi are wheat and gram. The other crops include rice, maize, sorghum and millet, pulses and vegetable. |
| | This zone comprises Multan, Vehari, Sahiwal, Lahore, Kasur, Faisalabad, Jhang, Shiekhupura, Gujranwala and parts of Bhawalnagar, Rahim Yar Khan, Muzaffargarh, Sargodha and Gujrat districts. Furthermore districts of Peshawar and Mardan are |

Jacobabad, Kashmore, Qambar, Larkana, Shahdadkot

Indus Plain :- Punjab province, drained by 5 rivers. It has sub-division Himalayan piedmont. the doabs and Sulaiman ... ot

**CROP ECOLOGY:** It is a subdiscipline of ecology which studies the distribution of plants, the effects of environmental factors upon the abundance of plants and the interactions among and between plants & other organisms.

" Crop ecology involves the study of interactions between crops and their abiotic & biotic environment."

**AGRO- Ecological Zone** :- "is a land resource mapping units defined in terms of climate, landform and soil, land cover (vegetation) and having a specific range of potentials and ~~constrains~~ constraints for land use."

"A unique combination of landform, soil and climatic characteristics."

**Ecological Zone** :- is a

| | |
|---|---|
| **4-Northern Irrigated plain**<br><br>(125 – 500 mm) | 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 °C respectively, mean monthly rainfall range 20-32 mm both in winter and summer<br><br>**Soils and land use**<br><br>Soil sandy loam-clay loam; southern and central part calcareous silt loams and about 15 percent saline-sodic; northern part loam and clay, calcareous, saline sodic in local areas.<br><br>Canal irrigated agriculture; crops: wheat, rice, sugarcane, oilseeds and millets in the north and wheat cotton, sugarcane, maize as well as citrus and mangoes in the central and southern parts. |
| **5. Barani (rainfall)**<br><br>(200 – 1000 mm) | The parts of D.I. Khan, Banu, Mianwali, Abbotabad, Rawalpindi, Gujrat, Gujranwala, Attock, Jhelum and Sialkot are included in this zone.<br><br>**Physiographic and Climatic Characteristics**<br><br>north of punjab.<br>Covers the salt range, Potowar Plateau (generally open and undulating) and the Himalayan Piedmont plains.<br><br>Narrow belt along the foot of mountains nearly humid, mean daily max. (summer) temp. 38.5 °C; mean monthly rainfall 200 mm in summer and 36-50 mm (Jan-Feb).in winter.<br><br>Southwestern part is semi-arid and hot; mean daily max. (summer) temp. 38 °C and min. (winter) temp. 4-7 °C; mean |

| | |
|---|---|
| | **Soils and land use**<br><br>Eastern part dominantly non-calcareous to moderately calcareous silt loams; west southern part mainly calcareous loams.<br><br>Rainfed agriculture is the main land use. The major Kharif crops are rice, sorghum, millet, maize, pulses, groundnut and sugarcane, whereas main Rabi crops are wheat, gram, rape seed and mustard and barley. |
| **6. Wet Mountains**<br><br>(> 1000 mm) | This zone includes Mansehra district and part of Rawalpindi and Hazara districts.<br><br>**Physiographic and Climatic Characteristics**<br><br>Covers high mountains (intervented by wide and narrow valley plains) and plateaus.<br><br>Eastern part is humid with mild summers and cold winters; mean daily max. (summer) temp. 35 °C and min. (winter) temp. 0-4 °C; mountain tops covered with snow in winter and spring; mean monthly rainfall 236 mm in summer and 116 mm in winter.<br><br>Western part is sub humid Mediterranean, with dry summer; rainfall confined to winter and spring.<br><br>**Soils and land use**<br><br>Soil is silt loam to silty clays, non-calcareous to slightly calcareous (pH 7.5-8.1); organic matter 1 percent in cultivated fields and 2-4 percent in forest areas.<br><br>Only 25 percent of the area under rainfed agriculture, the rest under the forest; main crops maize and wheat (rice grown in small areas irrigated from springs and streams); fruits (mainly apples) in areas at more than 1500 m altitude; olives grown in low hills; on 1500-5000 m altitude coniferous forests and scrub vegetation and about 5000 , permanent snow |
| | This zone comprises Chitral, Dir, Swat, Tribal areas of Peshawar and Kohat and some of the agencies. |

| | |
|---|---|
| 7. **Northern dry mountains**<br>(300-1000 mm) | **Physiographic and Climatic Characteristics**<br><br>Includes Gilgit, Baltistan, Chitral and Dir valleys irrigated by glacier-fed streams; climate is undifferentiated; tops of high mountains covered with snow, greater part of the year; mild summers and cold winters; mean monthly rainfall 25-75 mm in winter and 10-20 mm in summer.<br><br>**Soils and land use**<br><br>Soils in valleys is deep and clayey and on mountain slopes shallow; non-calcareous acid (pH 5.5-6.5) above 2100 m altitude and calcareous at lower altitude<br><br>Most of the area is used for grazing; a part under scrub forest. Wheat and maize grown rainfed in valleys and lower mountain slopes and rice irrigated in local areas; fruits grown in flank streams. |
| 8. **Western dry mountains**<br>(125-500 mm) | The districts of Kohat, Zohb, Loralai, Kallat, Sibhi, Quetta; part of Karachi, Banu and its tribal areas and agencies.<br><br>**Physiographic and Climatic Characteristics**<br><br>Composed of barren hills (1000-3000 m) with steep slopes. Climate is undifferentiated; greater part is semi-arid highlands with mild summers and cold winters. Southern areas mean daily max. (summer) temp. 30-39 °C and min. (winter) temp. -3-7.7 °C mean monthly rainfall 30-35 mm.<br><br>Extreme north western area sub humid, mean daily max. (summer) temp. 32 °C and min. (winter) temp 2 °C; mean monthly rainfall 95 mm in summer and 63-95 mm in winter.<br><br>**Soils and land use**<br><br>Soils in valleys are loamy, deep and strongly calcareous; mountains have shallow soil.<br><br>Major land use is grazing; part of the loamy soils grown to wheat with the flood water; very small portion is irrigated and fruits (apples, peaches, plums, apricots, grapes) wheat and maize are grown. |

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| (50-200 mm) | **Soils and land use**<br><br>Soils in plains are silt loams, deep and strongly calcareous, and hill slopes are shallow. The lower regions have xerophytic vegetation and grasses and higher altitudes have juniper forests and wild olives.<br><br>Land use is mainly grazing; melons and sorghum quite extensive; fruits, vegetables and wheat grown where spring or "Kareze" water is available. |
| **10. Sulaiman Piedmont**<br><br>(125-250 mm) | This zone comprises districts of D.I. Khan and D.G. Khan, Dhadar, Bagh tehsil of Kacchi District.<br><br>**Physiographic and Climatic Characteristics**<br><br>Comprises piedmont plains of Sulaiman Range and alluvial fans built by streams. Climate is arid and hot, subtropical continental; mean daily max. (summer) temp.40-43 °C and min. (winter) temp. 5.8-7.6 °C; mean monthly rainfall 13 mm in summer.<br><br>**Soils and land use**<br><br>Soils are loams in gently sloping areas but clayey further away; strongly calcareous, with narrow strips of salinity sodicity at the junction of piedmont plain and river flood plain.<br><br>Torrent-watered cultivation is the main land use, and wheat, millets and some gram and rice main crops. |

## 2.2. AGRO-ECOLOGICAL ZONES BASED ON ARIDITY

According to FAO (2001), Pakistan has been divided into five agro-ecological zones which have been given as under;

1 Desert
2 Arid
3 Semi-arid
4 Dry Sub-humid
5 Moist Sub-humid

The above mentioned agro-ecological zones and respective densities of human population and of total livestock units, large ruminants (cattle and buffalo), small ruminant units (sheep and goats) and poultry units per square kilometer are given in fig. 2 and fig. 3.

AGRO-CLIMATIC ZONE:- An agro-climatic zone is a land unit uniform in respect of climate and length of growing period (LGP) which is climatically suitable for a certain range of crops and cultivars (FAO, 1983)

AGRO-ECOLOGICAL ZONE: An ecological region is characterized by distinct ecological responses to macroclimate as expressed in vegetation, soils, fauna and aquatic system

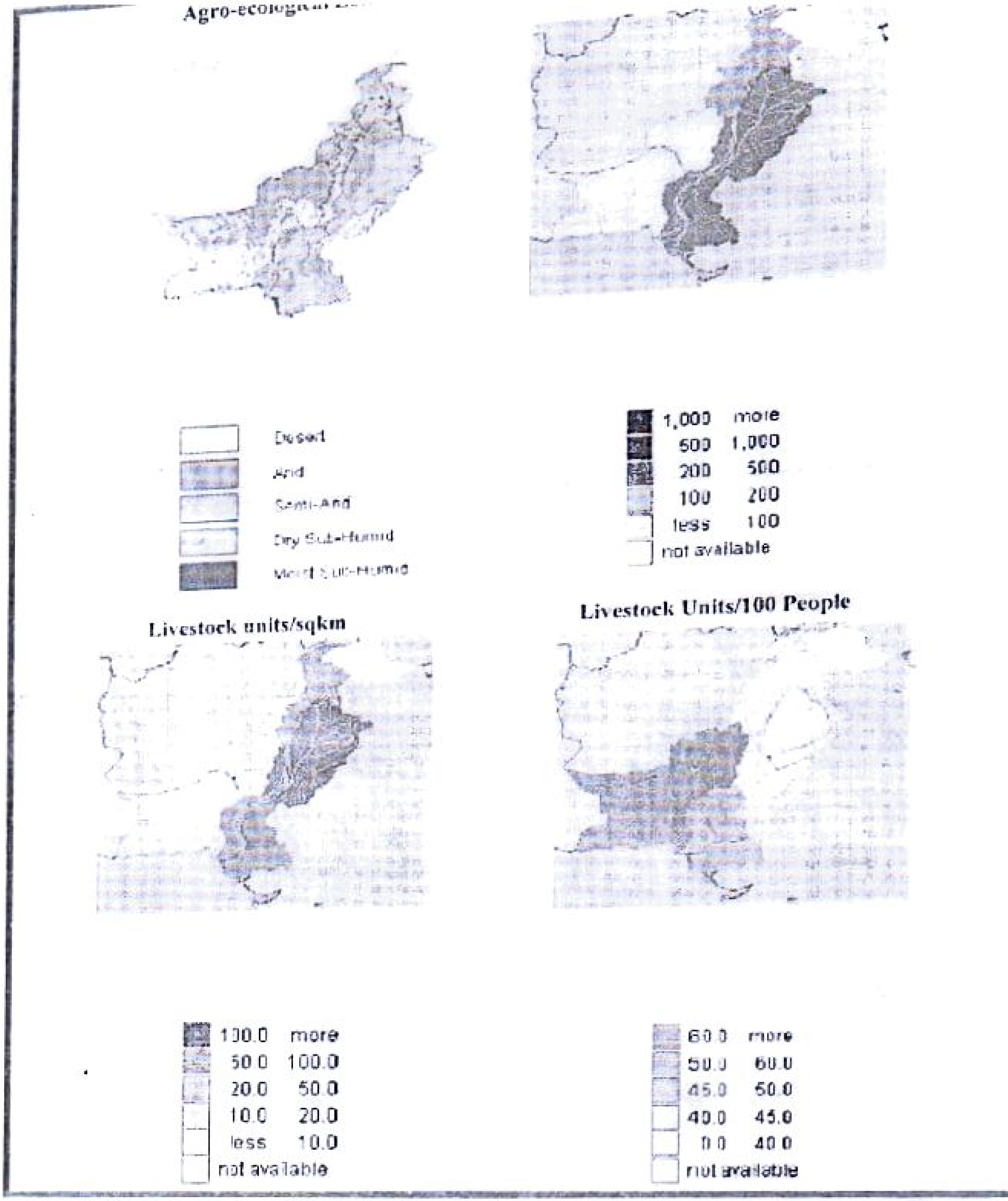


Fig. 1 Agro-ecological Zones of Pakistan, Human and Livestock Population Density

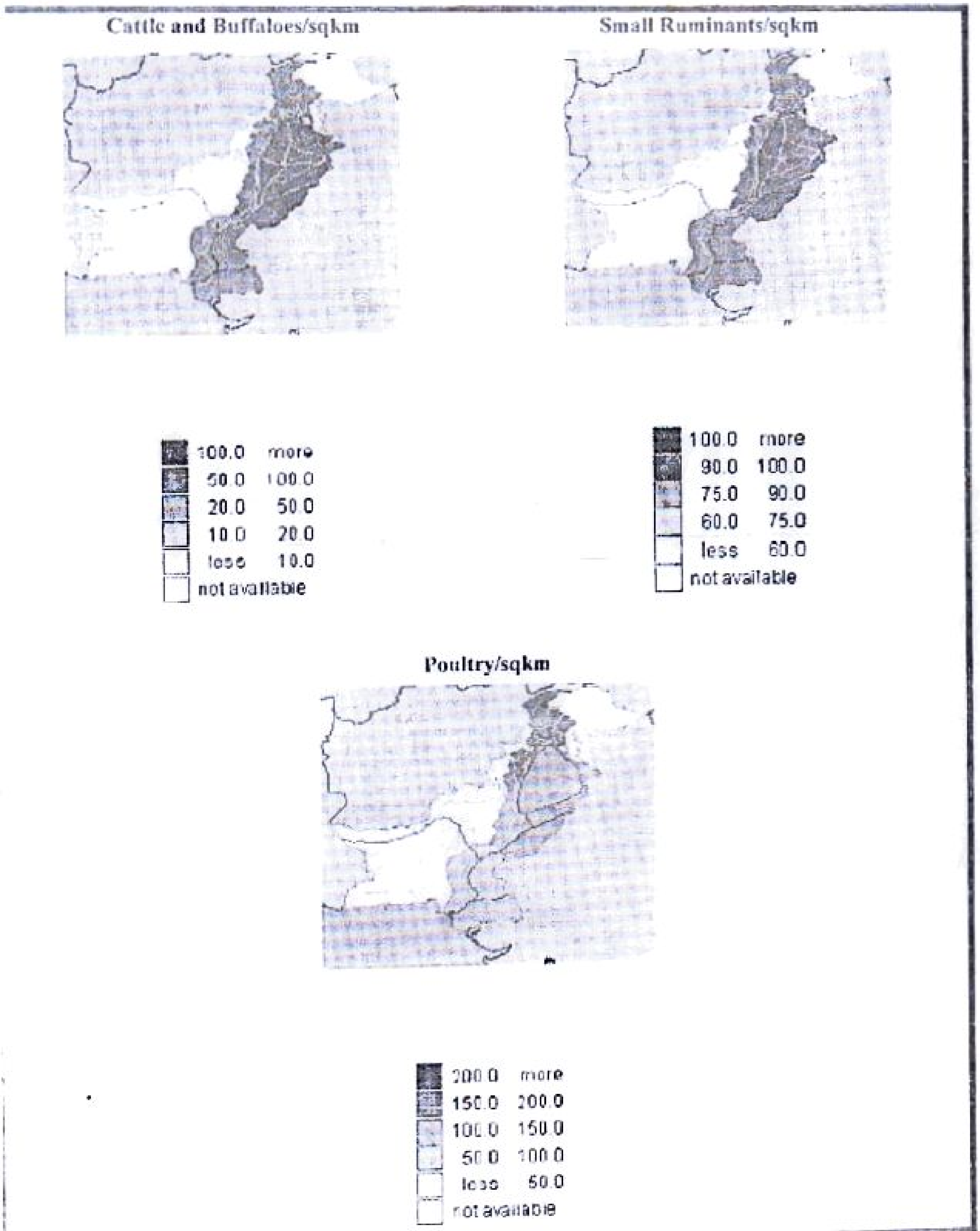


Fig. 2 Small and Large Ruminant Population Density

# FARMING SYSTEMS

The term farming System consists of two words i.e Farm and System

FARM:- A farm is a piece of land on which crops, livestock or both are raised

Farming is the business of operating a farm which includes all the operations which farmers perform to raise a crops or livestock.

SYSTEM:- A system is an established way of doing Things

FARMING SYSTEM:- A farming system is an established way of operating a piece of land for raising crops, livestock or both.

It represents an appropriate combination of farm enterprizes i.e cropping (mono, multiple) systems, livestock, poultry, fisheries, forestry and the resources (land, water, manure, labour, capital) available to the farmer to raise them for increasing profitability

Each farm has a unique system which has evolved in relation to the environment, soil, social, economic conditions technology, marketing facilities, plant and animal genetic resources implements and labour availability

(2)

Although each farm has its own particular system but relatively similar systems can be grouped based on different criteria

## TYPES OF FARMING SYSTEMS

There are two broad type of farming systems with a third resulting from a combination of the two.

1. Arable production:. It means the growing of crops which require cultivation of soil.
2. Livestock rearing
3. Mixed Farming

Farming systems can also be classified on other criteria

Such as

1. Intensive farming
2. Extensive farming
3. Grassland farming
4. Diversified farming
5. Livestock & poultry farming
6. Truck farming
7. Dry farming
8. Fruit farming
9. Commercial farming system — commercial scale for marketing
10. Subsistence farming — Purpose is to produce food for family

A typical farmer in Pakistan raises food crops, cash crops, forage crops, and vegetables for home consumption or for market, rears cows, buffalos, goats or sheeps and poultry birds. He buys certain inputs like fertilizers, pesticides and sells certain ~~of~~ outputs which he produces for the market or which are in excess of his requirement

All these operations constitute a mixed farming system.

CROPPING SYSTEM. It represents cropping pattern used on a farm and their interaction with farm resources, other farm enterprises and available technology.

CROPPING PATTERN: It is the yearly sequence of crops in a particular region e.g cotton - wheat - cotton or cotton - fallow - cotton
Cotton - Sunflower - cotton is the cropping pattern in Multan region.
Maize - wheat or potato - fodder or wheat - cotton - Sugarcane in Faisalabad & Sargodha region

Spring potato: Jan. Feb.
Autumn: Sep. oct
Summer: Balochistan: March - May

CROPPING SCHEME: It is a plan according to which crops are grown on individual plots of a farm during a given period of time.

CROPPING INTENSITY: It refers to the ratio of actual cultivated area to the total farm area over a year e.g If a farmer has 12.5 acres of land, out of which 3 acres are sown in Kharif Season and 7 are grown in rabi season then the cropping intensity will be.

$$\text{Cropping intensity} = \frac{\text{Actual cropped area}}{\text{Total Farm area}} \times 100$$

$$= \frac{10}{12.5} \times 100 = 80\%$$