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IBPS

(Specialist Officer)

Agricultural Field Officer (Scale - I)

Volume - 4

(Pre + Mains)

Agriculture and Allied Sector

SIERRA INNOVATIONS

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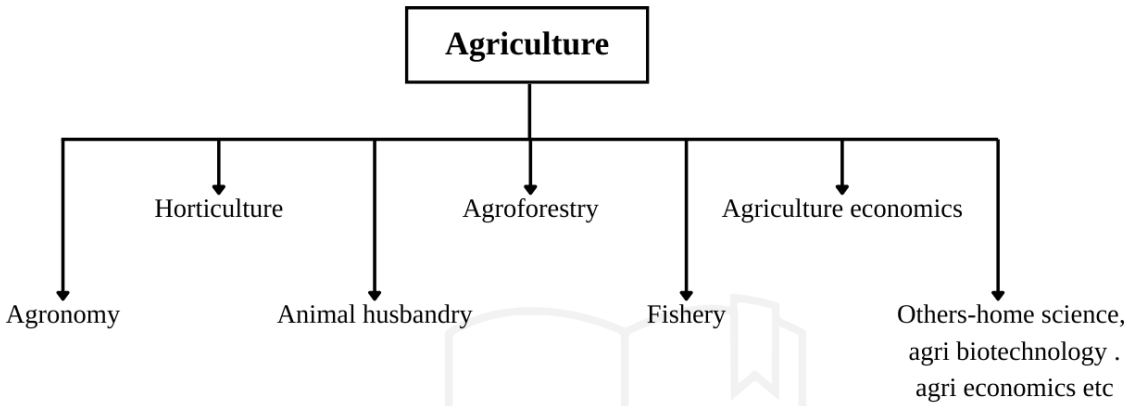
1 CHAPTER Agriculture

- The term agriculture is derived from the Latin words *ager/agri* (soil) and *cultura* (cultivation), it encompasses crop production, livestock farming, fisheries, horticulture, etc.
- Agriculture's origin is not singular but can be traced back to the earliest evidence of planned crop sowing and harvesting in Egypt and India.

Branches of Agriculture



1. **Agronomy**
   - ✓ This term is derived from the Greek word *agros* (field) and *nomos* (to manage), it involves soil, water, and crop management to enhance productivity.
   - ✓ It includes the discipline of soil science, plant breeding, entomology, crop physiology, plant ecology, and pathology.
   - ✓ *The key principles are related to* cropping systems, tillage, nutrient, water, weed, pest management, harvesting, and storage.
2. **Horticulture**
   - ✓ This term is derived from the Latin word *hortus* (garden) and *cultura* (cultivation), it focuses on the cultivation of fruits, vegetables, flowers, and spices.
   - ✓ The branches of horticulture includes:
     - **Pomology**: deals with cultivation and management of fruit (e.g., apples, bananas).
     - **Olericulture**: deals with cultivation of vegetable crops (e.g., tomatoes, okra).
     - **Floriculture**: deals with cultivation of flowers (e.g., roses, marigolds).
     - **Viticulture**: deals with cultivation of wine crops (e.g., grapes).
     - **Arboriculture**: deals with cultivation of trees and shrubs for ornamental purposes.
     - **Landscape Gardening**: deals with designing and arranging gardens for beautification.
3. **Animal Husbandry**
   - ✓ It involves the management and breeding of domestic animals for utility purposes such as food, fiber, sports, and power.
   - ✓ Branches include cattle rearing (domestication of cow for milk), buffalo domestication, poultry (for meat and milk), piggery, and goat domestication.
4. **Agroforestry**
   - ✓ Agroforestry is a sustainable system combining food crops (annuals), tree crops (perennials), and/or livestock on the same land.
   - ✓ Practices vary based on the local culture, economic, and ecological conditions.

5. **Fishery**
   - ✓ It focuses on the production, distribution, and consumption of fish and seafood, including capture or cultivation of fish species in marine or freshwater.
6. **Agriculture Engineering**:
   - ✓ It focuses on designing farm machinery, planning farm structures, managing soil, water supply, irrigation, erosion control, and processing farm products.

2 CHAPTER Agronomy

- **Agronomy** is considered the "mother branch" among all branches of agriculture.
- The term is derived from two Greek words: *Agros*, meaning "field," and *Nomos*, meaning "to manage".
- It is defined as an agricultural science that deals with the **principles and practices of crop production and field management**.
- Agronomy is a synthesis of several disciplines, including crop science (plant breeding, physiology), soil science (fertilizers, manures), and environmental science (meteorology and ecology).

Scope and Importance

- **Impact on Life:** Agronomy affects every person through the food we eat, the fibers in our clothing, and even the fuel (like ethanol) that runs our vehicles.
- **Resource Management:** It explores methods to provide a favorable environment for crops to achieve higher productivity through the efficient use of soil fertility, water, and labor.
- **Scope:** Its scope includes identifying proper cultivation seasons, restoring soil fertility, controlling weeds, and developing new technology to overcome moisture stress in dryland conditions.
- **Information for Farmers:** It equips farmers with invaluable knowledge on how to nurture plants in specific environments and how to handle challenges like pests, erosion, and climate conditions.

Classification of Field Crops

- Field crops are herbaceous plants grown on a large scale for agricultural purposes, primarily grains, forage, sugar, oil, and fiber. They are classified in several ways:
  - ✓ **By Climate:**
    - **Tropical Crops:** Thrive in warm, humid weather (e.g., rice, sugarcane).
    - **Temperate Crops:** Prefer cool weather and can endure cold (e.g., wheat, potato).
  - ✓ **By Season:**
    - **Kharif:** Sown in June-July; harvested in September-October (e.g., maize, groundnut).
    - **Rabi:** Sown in October-November; harvested in March-April (e.g., wheat, mustard).
    - **Zaid:** Sown in February-March; harvested in May-June (e.g., black gram, sesame).
  - ✓ **By Life Cycle (Ontogeny):**
    - **Annuals:** Complete their life cycle in one season (e.g., wheat, rice).
    - **Biennials:** Require two years to complete their cycle (e.g., onion, sugar beet).
    - **Perennials:** Persist for more than two years (e.g., sugarcane, mango).
  - ✓ **By Agronomic Use:** Includes **grain crops** (edible grasses), **pulse/legume crops** (rich in protein and nitrogen-fixing), **oilseed crops**, **fiber crops**, and **root and tuber crops**.

Factors Affecting Crop Production

Factors influencing crop growth are categorized into internal and external:

- **Internal Factors:** These are related to the **genetic makeup** of the plant, such as high yielding ability, early maturity, and resistance to pests or drought.
- **External Factors:** These include **climatic factors** (precipitation, temperature, humidity, solar radiation, wind), **edaphic factors** (soil moisture, air, temperature, and organic matter), **biotic factors** (harmful and beneficial organisms), and **physiographic factors** (topography and slope).

Cropping Systems and Rotation

- A **cropping system** refers to the combination of crops grown on a farm in time and space.
- **Monoculture:** Growing only one major crop on the same land year after year.
- **Multiple Cropping:** Growing two or more crops in a year. This includes **intercropping** (simultaneous growth on the same field) and **sequential cropping** (one after another).
- **Relay Cropping:** Planting a second crop after the first has reached its reproductive stage but before it is harvested (e.g., maize-potato).
- **Multistoried Cropping:** Growing crops of different heights together (e.g., growing pineapple or ginger under coconut trees).

Crop Rotation

- **Crop rotation** is the planned order of growing different crops on the same piece of land over time to maintain soil fertility. Key principles include:
  - ✓ Rotating deep-rooted crops with shallow-rooted ones.
  - ✓ Following leguminous crops with non-leguminous ones.
  - ✓ Rotating exhaustive crops (like potato) with restorative crops (like black gram).

Tillage and Tilth

- **Tillage** is the physical manipulation of soil using tools to create **tilth**, a physical condition favorable for seed germination and growth. **Jethro Tull** is known as the father of tillage.
- **Preparatory Cultivation:** Conducted before sowing; includes primary tillage (ploughing to open hard soil) and secondary tillage (finer operations like harrowing).
- **Zero Tillage:** A potential sustainable technology where the soil is not disturbed, reducing labor and water loss, though it may increase herbicide use.

Dryland Farming

- **Dryland Agriculture** involves growing crops entirely under rainfed conditions.
- **Classification:** It is grouped by annual rainfall into **Dry Farming** (<750 mm), **Dryland Farming** (750–1150 mm), and **Rainfed Farming** (>1150 mm).
- **Significance:** In India, dryland agriculture provides 95% of pulses and 75% of oilseeds.
- **Drought Resilient Techniques:** Methods include **bunding**, **strip cropping**, **stubble mulching**, and selecting drought-tolerant crops like millets.

Seed Science and Technology

- **Seed technology** involves improving the genetic and physical characteristics of seeds through variety development, processing, and certification.
- **Seed vs. Grain:** A seed is a scientifically produced mature ovule with guaranteed pedigree and purity, whereas grain is a commercial product saved for sowing with unknown varietal purity.
- **Seed Processing:** Harvested seeds undergo drying, winnowing, sieving, cleaning (grading), treatment (with fungicides/insecticides), and packaging to ensure high quality for farmers.

Modern Trends: Precision and Organic Farming

- **Precision Farming:** Utilizing innovative tools like GPS and GIS to manage field variability and apply the right amount of inputs at the right time.
- **Climate-Smart Agriculture (CSA):** An approach that sustainably increases productivity and enhances resilience to climate change while reducing greenhouse gas emissions.
- **Organic Farming:** A production system that avoids synthetic fertilizers and pesticides, relying instead on ecological processes and biodiversity. Components include crop rotation, use of manure, and bio-fertilizers.

3 CHAPTER

Climate and Meteorology

- Crop growth and development are largely influenced by environmental factors, especially climate and soil.
- The success or failure of crops is closely linked to weather conditions during the crop period. Therefore, understanding climatic factors and their interaction with crops is essential for successful agriculture.

Important Terminologies

1. **Weather:**
   - ✓ Weather refers to the state or condition of the atmosphere at a specific place and time.
   - ✓ It represents day-to-day variations in the lower atmosphere
   - ✓ It is localized and short-term in nature (village, city, etc.)
   - ✓ **Examples:** Rainy day, cold night, hot afternoon, sunny or foggy day
2. **Climate:**
   - ✓ Climate is the generalized or average weather condition of a region over a long period.
   - ✓ It applies to larger areas such as zones, states, or countries
   - ✓ It is studied over months, seasons, or years
   - ✓ **Examples:** Tropical climate, monsoon climate
3. **Meteorology:**
   - ✓ Meteorology is a branch of physics that studies the physical processes occurring in the atmosphere that lead to weather formation.
4. **Agricultural Meteorology:**
   - ✓ It is a branch of applied meteorology that studies the interaction between weather/climate and agricultural production.
   - ✓ Focuses on crop response to environmental conditions
   - ✓ Includes agroclimatology, weather forecasting, and use of instruments
5. **Climatology:**
   - ✓ Climatology is the science that studies the factors controlling the distribution and characteristics of climate over the Earth's surface.
6. **Agroclimatology:**
   - ✓ Agroclimatology deals with the relationship between climatic conditions and agricultural production.
   - ✓ Includes study of weather instruments and forecasting in agriculture

Atmosphere

- The atmosphere is the gaseous envelope surrounding the Earth. It is a colorless, odorless, and tasteless mixture of gases extending up to about 1600 km above the Earth's surface.
- About 99% of the total atmospheric mass is concentrated within 40 km from the Earth's surface.

Composition of the Atmosphere

- A sample of clean, dry air consists mainly of:
  - ✓ Nitrogen – 78%
  - ✓ Oxygen – 21%
  - ✓ Argon – 0.9%
  - ✓ Carbon dioxide – 0.03%

- Trace gases such as neon, helium, methane, krypton, hydrogen, and ozone are present in very small quantities.
- The lower atmosphere also contains water vapour, ranging from 0 to 4% by volume, which varies with location and weather conditions.

Structure of the Atmosphere

- Based on vertical temperature variation, the atmosphere is broadly divided into four major layers.
- These layers do not have sharp boundaries due to continuous mixing of gases.

1. Troposphere

- ✓ The lowermost layer of the atmosphere, extending from the Earth's surface up to about 8 - 18 km
- ✓ Thickness is greater at the equator and lesser at the poles
- ✓ All weather phenomena such as clouds, fog, dew, mist, and rainfall occur in this layer
- ✓ Temperature decreases with the height and at the boundary that is tropopause temperature is -60 degree celsius.

2. Stratosphere

- ✓ It lies above tropopause.
- ✓ It is above 18 km in height and extends up to 50 km height.
- ✓ It is dust free, cloudless and the warmest layer.
- ✓ Temperature increases with increase in height.
- ✓ Presence of ozone layer in this region prevents the earth surface and organism from UV rays coming from the sun.

3. Mesosphere

- ✓ It lies above the stratosphere.
- ✓ The mesosphere is separated from the stratosphere by a thin layer called stratopause.
- ✓ Decrease in temperature with increase in altitude (height).
- ✓ It extends from 50 km to 80 km.

4. Thermosphere

- ✓ It is separated by mesopause from mesosphere.
- ✓ Outermost layer that merges with the space.
- ✓ There is a presence of ions in its lower layer hence called an ionosphere.
- ✓ Long range communication satellites are placed in this layer due to the presence of charged ions.

Weather Elements

- To describe the state of weather at a particular place and time, various atmospheric elements are considered.

1. Solar Radiation:

- ✓ Solar radiation is the incoming energy received from the sun
- ✓ The sun emits a nearly constant amount of energy, known as the **solar constant**, which is about **1.94 cal/cm²/min**
- ✓ Solar radiation reaches the Earth in the form of electromagnetic waves
- ✓ The instrument used to measure total incoming solar radiation is called a **pyranometer**

1.1 Photosynthetically Active Radiation (PAR):

- ✓ PAR refers to the portion of solar radiation with wavelengths between **400–700 nm**, which is utilized by plants for photosynthesis
- ✓ It is measured above the crop canopy using **tube solarimeters**

2. Temperature:

- ✓ Temperature is the degree of hotness or coldness of a substance, determined by the level of molecular activity
- ✓ It is measured using a **thermometer**

2.1 Modes of Heat Transfer:

- ✓ **Conduction:** Transfer of heat through direct molecular contact (mainly in solids)
- ✓ **Convection:** Transfer of heat through the movement of fluids such as liquids and gases
- ✓ **Radiation:** Transfer of heat in the form of electromagnetic waves without the need for a medium

3. Wind:

- ✓ Wind is the horizontal movement of air from a high-pressure area to a low-pressure area
- ✓ Wind speed (velocity) is measured using an **anemometer**
- ✓ Wind direction is measured using a **wind vane**

4. Humidity:

- ✓ Humidity refers to the amount of water vapour present in the air.
  - **a. Absolute Humidity:**
    - ☞ It is the actual mass of water vapour present per unit volume of air
    - ☞ **Formula:** Absolute Humidity = (Mass of water vapour) / (Volume of air)
  - **b. Specific Humidity:**
    - ☞ It is the mass of water vapour per unit mass of air (including water vapour)
    - ☞ Expressed in grams of water vapour per kilogram of air
    - ☞ **Formula:** Specific Humidity = (Mass of water vapour) / (Mass of air including vapour)
  - **c. Relative Humidity:**
    - ☞ It is the ratio of the actual amount of water vapour present in the air to the amount required for aturation at a given temperature and pressure
    - ☞ Expressed as a percentage
    - ☞ **Formula:** Relative Humidity = (Actual water vapour / Saturation water vapour) × 100
    - ☞ Measured using **wet bulb and dry bulb thermometers**

5. Atmospheric Pressure:

- ✓ Atmospheric pressure is the force exerted by the weight of the air column per unit area, extending from the Earth's surface to the upper limits of the atmosphere.
- ✓ Measured using an **aneroid barometer** and recorded continuously by a **barograph**

6. Rainfall:

- ✓ Rainfall is a form of precipitation in which water falls as liquid drops larger than 0.5 mm in diameter.
- ✓ Diameter of raindrops ranges from 0.5 to 4 mm
- ✓ About 70% of India's rainfall is received from the **South-West Monsoon**

Important Terms:

- ➢ **Dry spell:** A continuous rainless period of more than 10 days (light soils) or 15 days (heavy soils)
- ➢ **Rainy day:** A day receiving more than 2.5 mm rainfall
- ➢ **Sowing rain:** Rainfall of more than 20 mm (especially in July) suitable for sowing operations.
- ➢ **Effective rainfall:** The portion of rainfall that is actually available for crop use after losses due to runoff, evaporation, and deep percolation.

7. El Niño and La Niña:

- ✓ **El Niño:** Refers to abnormal warming of the Pacific Ocean, often leading to weaker South-West monsoon rainfall in India
- ✓ **La Niña:** Opposite of El Niño, characterized by cooler Pacific Ocean conditions, generally associated with better monsoon rainfall

8. Cloud Formation:

- ✓ As air rises, it expands due to lower pressure and cools
- ✓ When it cools to the saturation point, water vapour condenses, leading to cloud formation

Weather Forecasting:

- Weather forecasting is defined as the prediction of the probable future state of the atmosphere at a given place and time.
- The **India Meteorological Department (IMD)** was established in 1875 with headquarters at Pune
- The **Agricultural Meteorology Division** was started in 1932 to study crop–weather relationships
- India has five regional forecasting centres: **Chennai, Mumbai, Nagpur, Delhi, and Kolkata**
- These centres issue **weather bulletins** indicating monsoon onset, intensity, duration, breaks, and adverse weather, which are broadcast through radio and television in regional languages

Essentials for Weather Forecasting:

- Accurate and systematic data recording
- Careful analysis of synoptic charts
- Comparison with past similar weather situations
- Preparation of weather charts at regular intervals (24 hours)
- Drawing quick, accurate, and reliable conclusions

Methods of Weather Forecasting:

1. **Synoptic Method:**
   - ✓ Based on detailed analysis of current weather data over a large area
   - ✓ Compares present conditions with past similar situations
   - ✓ Assumes weather will behave similarly to past patterns
   - ✓ Suitable for **short-range forecasts**
2. **Statistical Method:**
   - ✓ Uses regression and relationships between weather parameters
   - ✓ Predictions based on physical interactions among variables
   - ✓ IMD uses multiple parameters (e.g., 16 for rainfall prediction)
   - ✓ Suitable for **both short- and long-range forecasts**
3. **Numerical Weather Prediction (NWP):**
   - ✓ Uses mathematical models and equations based on physical laws
   - ✓ Incorporates data on airflow, pressure, temperature, etc.
   - ✓ Suitable for **medium-range forecasts**

Types of Weather Forecasting (Based on Time Period):

1. **Nowcasting:** Forecast for current conditions and up to a few hours (less than 24 hours)
2. **Short-Range Forecast:**
   - ✓ Valid up to **72 hours (3 days)**
   - ✓ Based on current weather systems and recent observations
3. **Medium-Range Forecast:**
   - ✓ Valid for **4–10 days** (up to 7 days in tropical regions)
   - ✓ Provides general trends with moderate accuracy
4. **Long-Range Forecast:**
   - ✓ Covers **30 days to an entire season**
   - ✓ Includes seasonal forecasts
5. **Extended-Range Forecast:**
   - ✓ Lies between medium and long range
   - ✓ Typically from **10 days up to 1 month**

Time Period of Weather Forecasting

S. No	Range Of Weather Forecast	Time Period
1.	Now casting	Few hours ahead but less than 24 hours
2.	Short range	Up to 72 hours
3.	Medium range	4 to 10 days
4.	Extended range	From 10 days to month or till one season
5.	Long range	30 days to a season

Forecasting Information for Agriculture

1. **Sunshine:**
   - ✓ Forecasts of sunshine help farmers plan operations such as harvesting and drying of crops
   - ✓ Sunshine is expressed as the percentage of available sunlight during the day (cloudiness level)
   - ✓ **Categories:**
     - **Sunny day:** 90–100% sunshine (clear sky)
     - **Partly cloudy / scattered clouds:** 50–90% sunshine
     - **Considerable cloudiness:** 20–50% sunshine
     - **Mostly cloudy:** Less than 20% sunshine
2. **Precipitation (Rainfall):**
   - ✓ Rainfall forecast is the most crucial component for Indian agriculture
   - ✓ Helps in decisions related to sowing, irrigation, and crop management
3. **Dew:**
   - ✓ Dew forecasts are classified into six categories: Very light, Light, Moderate, Heavy, Very heavy and Wet
   - ✓ Important for understanding moisture conditions affecting crops, pests, and diseases

Colour Code for Weather Warnings

The following colour codes are used in weather warnings for bringing out the severity of the weather phenomena expected.

WARNING (TAKE ACTION)
ALERT (BE PREPARED)
WATCH (BE UPDATED)
NO WARNING (NO ACTION)

warning signs for extreme weather

Cardinal Temperature

It is the minimum, optimum and maximum temperature required for the crop growth. Every crop has different cardinal temperature.

Cardinal Temperature for Crops

Crops	Minimum	Optimum	Maximum
Oat	4 - 5	25	30
Maize	8 - 10	32 - 35	40 - 44
Sorghum	8 - 10	32 - 35	40
Pearl millet	8 - 10	30 - 32	40
Berseem	3 - 4.0	25 - 27	32
Wheat	3 - 4.5	25	30
Rice	10 - 12	30 - 32	36 - 38

4 CHAPTER

Agroclimatic Zones

- An agro-climatic zone is a land area characterized by a uniform climate and length of growing period (LGP), making it suitable for specific crops and cultivars.
- This classification by the Planning Commission of India (1989) categorizes the country into various agro-climatic regions based on climate, rainfall, temperature, topography, cropping patterns, and water resources.

Agro-climatic Regions of India

1. **Western Himalayan Zone**
   - ✓ **Regions Covered**: Jammu & Kashmir, Himachal Pradesh, Uttar Pradesh hills
   - ✓ **Features**:
     - Steep, undulating land with silty loam soil prone to erosion.
     - Cold region soils: podzolic mountain meadow soils and hilly brown soils.
   - ✓ **Crops**: Almond, walnut, apple, apricots, and wheat.
   - ✓ **Livestock**: Goat, yak, sheep.
2. **Eastern Himalayan Zone**
   - ✓ **Regions Covered**: Sikkim, Darjeeling hills, Arunachal Pradesh, Meghalaya, Nagaland, Assam, and others.
   - ✓ **Features**:
     - High rainfall, dense forests, and shifting cultivation.
     - Vulnerable to soil erosion and floods.
   - ✓ **Crops**: Tea, rice, maize, vegetables, shifting cultivation.
   - ✓ **Livestock**: Pig, sheep, cattle, Mithun breed.
3. **Lower Gangetic Plains Zone**
   - ✓ **Region**: West Bengal
   - ✓ **Features**:
     - Alluvial soil is prone to flooding.
   - ✓ **Crops**: Rice, jute, vegetables like cauliflower.
   - ✓ **Livestock**: Cattle, sheep, fishery.
4. **Middle Gangetic Plains Zone**
   - ✓ **Regions**: Eastern Uttar Pradesh, Bihar
   - ✓ **Features**:
     - High rainfall, irrigated lands (39% of gross cropped area).
     - Cropping intensity: 142%.
   - ✓ **Crops**: Rice, wheat, mustard, sugarcane, vegetables.
   - ✓ **Livestock**: Cattle, buffalo, sheep, poultry.
5. **Upper Gangetic Plains Zone**
   - ✓ **Region**: Uttar Pradesh
   - ✓ **Features**:
     - Irrigation through canals and tube wells, with potential groundwater exploitation.
6. **Trans-Gangetic Plains Zone**
   - ✓ **Regions**: Punjab, Haryana, Delhi, Chandigarh, Rajasthan
   - ✓ **Features**:
     - Highest net sown area, irrigation, cropping intensity, and groundwater usage.

- ✓ **Crops**: Rice, wheat, millets, mustard, sugarcane.
- ✓ **Livestock**: Cattle, buffalo, goat, piggery, poultry.

7. **Eastern Plateau and Hills Zone**
   - ✓ **Regions**: Madhya Pradesh, West Bengal, inland Orissa
   - ✓ **Features**:
     - Shallow to medium-depth soils, undulating topography.
     - Irrigation mainly from tanks and tube wells.
   - ✓ **Crops**: Wheat, ragi, sorghum, potato.
   - ✓ **Livestock**: Cattle, goat, sheep.
8. **Central Plateau and Hills Zone**
   - ✓ **Regions**: Madhya Pradesh, Uttar Pradesh, Rajasthan
   - ✓ **Features**:
     - 1/3rd land not suitable for cultivation, low irrigation and cropping intensity.
     - Need for alternate high-value crops.
   - ✓ **Crops**: Cotton, wheat, millets (bajra, jowar), soyabean, pulses.
   - ✓ **Livestock**: Poultry, cattle, goat, sheep.
9. **Western Plateau and Hills Zone**
   - ✓ **Regions**: Maharashtra, parts of Madhya Pradesh, Rajasthan
   - ✓ **Features**:
     - Average rainfall: 904 mm, 65% net sown area.
     - Irrigated area: 12.4%.
   - ✓ **Crops**: Jowar, cotton, sugarcane, rice, bajra, potato.
   - ✓ **Livestock**: Cattle, goats, poultry, piggery.
10. **Southern Plateau and Hills Zone**
    - ✓ **Regions**: Andhra Pradesh, Karnataka, Tamil Nadu (semi-arid zones)
    - ✓ **Features**:
      - 81% dryland farming, cropping intensity: 111%.
    - ✓ **Crops**: Millets, cotton, rice, wheat, vegetables, spices.
    - ✓ **Livestock**: Drought-resistant breeds of cattle, goat, buffalo.
11. **East Coast Plains and Hills Zone**
    - ✓ **Regions**: Tamil Nadu, Andhra Pradesh, Orissa
    - ✓ **Features**:
      - Coastal soil, alluvial soils, high rainfall intensity.
    - ✓ **Crops**: Rice, fishery (Godavari basin), spices and condiments.
12. **West Coast Plains and Ghats Zone**
    - ✓ **Regions**: Tamil Nadu, Kerala, Karnataka, Maharashtra, Goa
    - ✓ **Features**:
      - Varied rainfall and soil types.
    - ✓ **Crops**: Cashew, millets, sugarcane, rice, spices, ginger, turmeric.
    - ✓ **Livestock**: Fishery, cattle, poultry, goat.
13. **Gujarat Plains and Hills Zone**
    - ✓ **Region**: Gujarat
    - ✓ **Features**:
      - Arid region with low rainfall.
      - 32.5% irrigated area.
    - ✓ **Crops**: Groundnut, cumin, millets.
    - ✓ **Livestock**: Goat, cattle, camel, poultry.
14. **Western Dry Zone**
    - ✓ **Region**: Rajasthan (9 districts)

- ✓ **Features**:
  - Hot, sandy desert, erratic rainfall, high evaporation.
  - Groundwater is often deep and brackish.
- ✓ **Crops**: Millets, mustard.
- ✓ **Livestock**: Goat, cattle (Karenj breed), sheep.

15. **Islands Zone**
- ✓ **Regions**: Andaman & Nicobar, Lakshadweep
- ✓ **Features**:
  - Equatorial climate, 3000 mm rainfall over 8-9 months, forested land.
- ✓ **Crops**: Palm oil, rice, spices, agroforestry, agrofishery systems.
- ✓ **Livestock**: Fishery.

Agro-Ecological Zones of India

- ➢ Agro-ecosystems are modified ecological systems used by humans to produce food, fiber, and other agricultural products.
- ➢ These zones are classified mainly based on rainfall, physiography, soils, and irrigation water availability.

Five Agro-Ecosystems of India

1. **Arid**: Severe water deficit, covers 38.7 million hectares (m ha).
2. **Rainfed**: Occasional water deficit, covers 67 m ha.
3. **Irrigated**: No water deficit, covers 52 m ha.
4. **Coastal**: Sandy soil, prone to cyclones, 8129 km of coastline.
5. **Hill & Mountain**: Steep slopes, covers 27.5 m ha.

Arid Ecosystem

- ➢ This ecosystem spans 38.7 m ha in India, with 31.7 m ha under hot arid conditions and 7 m ha under cold arid conditions.
- ➢ **Features**:
  - ✓ Low rainfall and high evapotranspiration.
  - ✓ Extreme temperature variations.
  - ✓ Degraded soil with low organic matter.
  - ✓ **Crops**: Pearl millet, sesame, green gram, mustard.
  - ✓ **Livestock**: Drought-tolerant cattle, goat, sheep.
  - ✓ **Livelihood**: Dryland agriculture and animal husbandry.
  - ✓ **Water harvesting**: Traditional systems like Khadin.

Rainfed Ecosystem

- ➢ It covers most of the agricultural area in India. This area receives annual rainfall of 500 mm to 1500 mm.
- ➢ The agricultural system is highly dependent on rainfall for irrigation.
- ➢ **Features:**
  - ✓ Rainfall is erratic and low.
  - ✓ Soils are degraded with low fertility, primarily due to flooding, waterlogging, and excessive leaching of nutrients.
  - ✓ The region experiences harsh temperature conditions.
  - ✓ In rainfed ecosystems, soil acidity is a major constraint.
  - ✓ Frequent dry spells occur during the crop season, often caused by breaks in the monsoon or its early withdrawal.
  - ✓ Irrigation is crucial during dry spells to ensure crop survival.
  - ✓ The dominant soil types in this region are Alfisols and Vertisols.
  - ✓ The primary livestock in the region includes cattle and sheep.

Coastal Ecosystem

- It includes deltas of rivers like Ganga, region between eastern ghat and Bay of Bengal and region between western ghats and Arabian sea.
- **Features:**
  - ✓ The region is highly fragile, making it prone to cyclones, floods, tidal waves, and vulnerable to municipal and industrial waste.
  - ✓ It experiences heavy rainfall, particularly during the southwest monsoon, with high intensity.
  - ✓ The region has higher humidity levels and lower diurnal temperature variations.
  - ✓ The coastal agroecosystem supports various activities such as agriculture, aquaculture, marine fishing, agroforestry, silviculture, and agri-horticulture.

Hill and Mountain Ecosystem

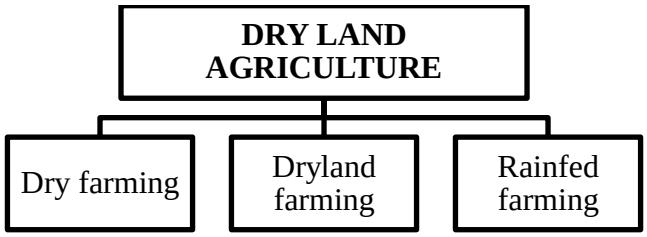
- This ecosystem is located in north west Himalaya and north east Himalaya region
- **Features:**
  - ✓ The region features steep slopes, interspersed with nearly level lands in the valleys.
  - ✓ Soils on the hill and mountain slopes tend to be acidic and lateritic.
  - ✓ There is significant soil erosion in the area.
  - ✓ The valley soils are alluvial, ranging from loam to sandy loam.
  - ✓ This region experiences high rainfall, high humidity, and low solar radiation, creating ideal conditions for pests and diseases.
  - ✓ A large portion of this region is dedicated to plantation crops.

Irrigated Ecosystem

- This region covers 37% of the agricultural land and contributes to 57% of the total agricultural production.
- It is primarily located in northern India, including Punjab, Haryana, Uttar Pradesh, Bihar, and West Bengal. In this ecosystem, the water needs of crops are met through artificial irrigation.
- **Features:**
  - ✓ The irrigated ecosystem is marked by a great diversity in soil, water, and climatic resources.
  - ✓ Overuse of surface and groundwater resources for agriculture leads to issues like waterlogging, soil salinity, and a rising water table.
  - ✓ The high use of chemical fertilizers and monocropping (such as the rice-wheat rotation) is degrading the native fertility of the soil.

5 CHAPTER Dryland agriculture

- Dryland agriculture is grouped into three categories on the basis of the amount of rainfall received in the regions.



Dry Farming

- It is defined as the cultivation of crops where rainfall is less than 750 mm per annum. It is practiced in the arid regions of the country.
- The main features of this region includes:
  - ✓ Prolonged dry spells are very common during crop period.
  - ✓ More frequent crop failures.
  - ✓ High Evo transpiration (moisture loss)
  - ✓ Very low moisture present in soil.
  - ✓ Less socio-economic development.
  - ✓ High saline soil
  - ✓ Cropping period is highly dependent on the rainfall
- Major regions of dry farming include Western Rajasthan, Bundelkhand region, Gujarat and the arid regions of the country.

Dryland Farming

- It is defined as the cultivation of crops where rainfall is between 750mm and 1150 mm per annum. It is practised in the semi-arid regions of the country.
- The main features of this region includes:
  - ✓ Dry spell occurs during crop period
  - ✓ Less frequent crop failure
  - ✓ Salinity of soil
- Major regions of dryland farming include Rajasthan, Madhya Pradesh, Gujarat, Tamil Nadu, Andhra Pradesh and the semi-arid of the country.

Rainfed Farming

- It is defined as the cultivation of crops where rainfall is more than 1150 mm per annum. It is practised in humid regions of the country or regions receiving high rainfall.
- The main features of this region includes:
  - ✓ Crop failure is very rare
  - ✓ Very rare or no dry spell
  - ✓ Waterlogging is a major problem
  - ✓ Acidic soil is a constraint
- Major regions of rainfed farming include coastal areas, northern eastern states, etc.

- 143.8-million-hectare land is cultivated in India, out of which the irrigated area is 30.5% and 69.5% is under rainfed area.
- 75% pulses and oilseed, ⅔ rd of mustard, most of soybean and groundnut are grown under rainfed condition.

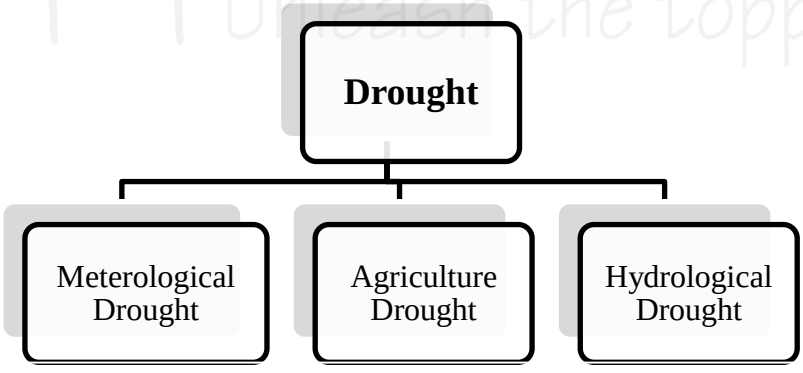
CONSTITUENT	DRYLAND FARMING	RAINFED FARMING
Rainfall Annually (mm)	Less than 800mm	More than 800 mm
Moisture Availability to The Crop	Shortage	Enough
Growing season (days)	Less then 200	More then 200
Growing regions	Arid, semi-arid, as well as uplands of subhumid & humid region	Humid & subhumid region
Cropping system	Single crop or intercropping	Intercropping or double cropping
Constrains	Wind & water erosion	Water erosion

Constraints in Dryland agriculture

- Inadequate or insufficient soil moisture is the primary constraint for crop cultivation in dryland regions.
- High temperatures combined with low and erratic rainfall patterns.
- Low groundwater table results in limited irrigation facilities such as tubewells and canals.
- Soil degradation due to low organic matter content.
- Poor soil fertility with deficiency of essential nutrients.
- High potential evapotranspiration (PET), leading to greater water loss.
- Significant loss of water through plant transpiration and soil evaporation.
- Generally, only a single crop or limited intercropping is practiced in one season.
- Low cropping intensity and lack of crop diversification.
- Soil salinity is a common issue in many dryland areas.
- Frequent dry spells often lead to crop failures.
- Agriculture is largely subsistence-oriented rather than profit-driven.

Drought and Moisture Stress

- Drought is defined as an extended period of deficit rainfall compared to normal rainfall of the region.
- Drought can be further classified as:



Meteorological Drought

- This occurs when there is a significant deficit in rainfall compared to the region's average.
- According to the IMD, a meteorological drought is defined as a condition where rainfall decreases by 25% or more over a specific period in a region.

Agriculture Drought

- This refers to an extended dry period in which the lack of rainfall causes insufficient moisture in the soil's root zone, leading to negative impacts on crop growth and yield.

Hydrological Drought

- A hydrological drought refers to an extended dry period that results in the significant depletion of surface water resources, including the drying up of reservoirs, lakes, streams, and rivers, the cessation of spring flows, and a decline in groundwater levels.

Moisture Stress

- It occurs when transpiration exceeds the rate of absorption of water by the plants.
- The major impact of low moisture includes:
  - ✓ **Incipient Wilting or Midday Depression** – This occurs when, after irrigation or rainfall, the rate of transpiration exceeds the rate at which water is absorbed from the soil, particularly during the hot midday hours of summer. This type of water deficit is typically short-lived.
  - ✓ **Permanent Wilting Point** – When soil moisture drops to -15 bar, plants begin to show wilting symptoms during the day, but they do not die.
  - ✓ **Ultimate Wilting Point** – When soil moisture reaches -6 MPa or -60 bar, the plant will die due to severe moisture stress.

- **Dry Spell**: A period of no rainfall lasting more than 10 days in sandy (light) soil areas and more than 15 days in clay (heavy) soil areas.
- **Drought**: A prolonged dry spell that leads to the wilting or drying of crops.
- **Desertification**: The process of land degradation in arid, semi-arid, and dry humid areas, caused by factors such as climatic conditions and human activities.

Soil Moisture

- It is defined as the amount of water present in the top soil at a given point of time. It is influenced by rainfall, soil texture and soil depth.

Methods to conserve soil moisture in dryland agriculture

1. Soil Moisture Storage

- ✓ **Reducing Runoff:** Water runoff increases during high-intensity rainfall due to low infiltration. To address this, more opportunity time should be provided for the runoff water to infiltrate, thereby increasing the rate of absorption.
- ✓ The application of **farmyard manure** enhances soil moisture by improving the soil's water-holding capacity.
- ✓ **Disc ploughing** during the summer and **contour bunding** help in enhancing soil moisture storage.
- ✓ The rate of infiltration can be increased by maintaining **mulches** and adding **crop residues** in the fields.

2. Tillage

- ✓ It enhances the water-holding capacity of the soil, reduces runoff, improves infiltration, and helps conserve soil moisture.
- ✓ **Subsoiling** is an effective practice for conserving soil moisture, especially during the fallow period, ensuring more water is available for winter crops.
- ✓ **Contour cultivation**, or cultivating along the slope, helps in retaining soil moisture.
- ✓ **Conservation furrows**, or opening furrows at 3-4 meter intervals between crop rows, reduce moisture loss.
- ✓ **Tied ridges** are also beneficial in conserving soil moisture.

3. Reduction in Evo-Transpiration

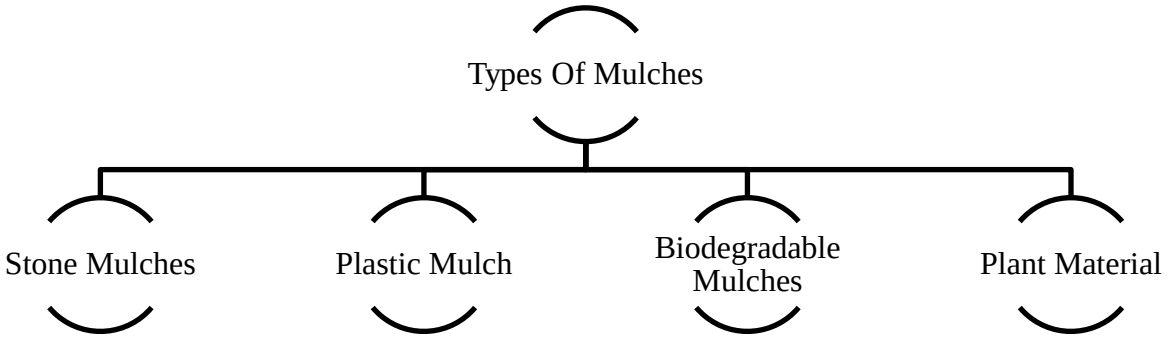
- ✓ It can be prevented by Shelter belts / Wind breaks, mulching, anti-transpirant and weed control.

3.1 Wind breaks / Shelter belts

- ✓ **Wind break:** are any structure artificial or natural which reduce & obstruct the wind speed.
- ✓ **Shelter belts:** is a long row of plants planted across the direction of wind. They do not obstruct the wind speed completely. Plants used as shelterbelts are casuarina, bamboo, etc.

3.2 Mulching

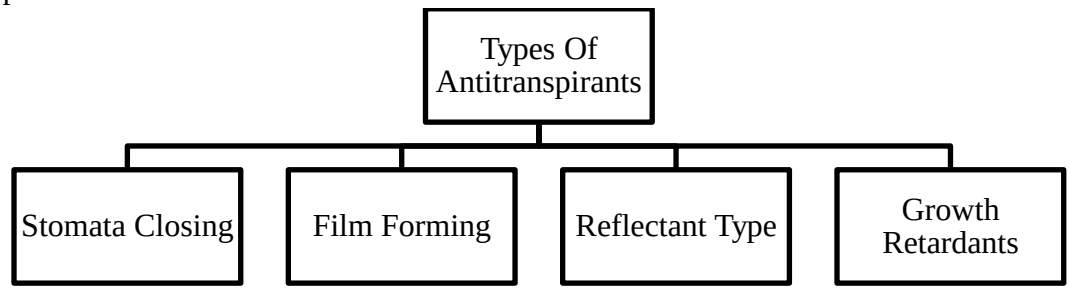
- ✓ Mulch is any material applied on the soil surface to reduce evaporation (60-75% water is lost due to evaporation) and increase soil moisture.
- ✓ It also ensures soil conservation, moderation of temperature, weed control, reduction in soil salinity, etc.



- ✓ **Stone Mulches**
  - It is application of sizable stones in a field which offers benefits for conservation of moisture in arid and semi-arid regions by reducing evaporation.
- ✓ **Plastic Mulches**
  - Material like polyethylene, polyvinyl chloride is used as mulching material.
  - Plastic mulching increases the soil temperature there by increasing the plant growth along with reduction in loss of soil moisture.
- ✓ **Biodegradable Mulches**
  - Polymers like poly lactic acid, poly butylene adipate octerephthalate, starch based polymer are used as a biopolymer and offer very less impact on the environment.
- ✓ **Plant Material**
  - Plant material like crop residue, straw, groundnut shells, etc act as a very good mulch material without any impact on the environment.
  - These materials also add organic material in the soil.

3.3 Antitranspirants

- ✓ It is any material applied to the transpiring plant surface like leaves, stems, etc. to reduce the water loss from plants.
- ✓ Nearly 99% of water absorbed by the plants is lost by absorption.
- ✓ **Advantage:** Useful for reducing the transplantation shock of nursery plants.
- ✓ **Disadvantage:** They generally reduce photosynthesis. Therefore, their use is limited to save the crop from death under severe moisture stress.



- ✓ **Stomata closing**
  - Stomata closing anti-transpirant function by closing the stomatal pores present on the leaves surface from which maximum transpiration occurs.
  - Examples -phenyl mercuric acetate and atrazine.
- ✓ **Film forming type**
  - The mode of action of film forming antitranspirant is that they form a thin waxy layer on the leaf surface and retard the escape of water from the leaves by formation of a physical barrier.