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NABARD

Grade B - (Phase 1)

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Agriculture Rural Development

SIERRA INNOVATIONS

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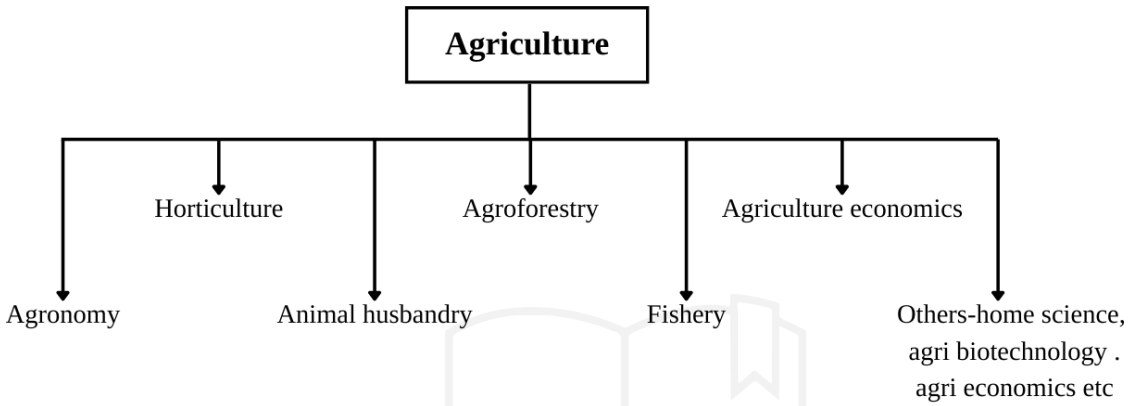
1 CHAPTER Agriculture

- 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

Crops and their Classification

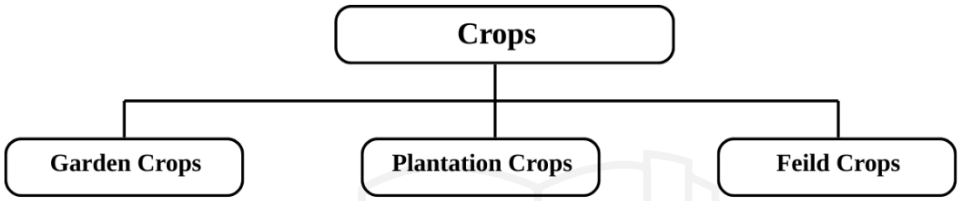
A crop is any plant or plant product grown and harvested for profit or subsistence, such as wheat, rice, and pulses.

Need for Classification

- It helps in understanding crop habitat, adaptation, life cycle, nutrient needs, and pest resistance.
- Facilitates appropriate production techniques and management practices for higher productivity with minimal input.

Main Classes of Crops

- As per the range of cultivation, crops are grouped into three main classes.



1. **Garden Crops**: are the crops grown on a small scale in gardens (e.g., kitchen and flower gardens).
2. **Plantation Crops**: are the crops grown on a large scale, typically perennials (e.g., tea, coffee).
3. **Field Crops**: are the crops grown on a vast scale, mostly seasonal (e.g., rice, wheat, pulses).

Classification of Field Crops

1. **Botanical Classification**
   - ✓ **Monocotyledons**: A plant having only one seed leaf or cotyledon in each of its seeds. Such plants have shallow roots, narrow leaves and tillering ability. (e.g., cereals like rice, wheat).
   - ✓ **Dicotyledons**: A plant having two seed leaves or cotyledons in each of its seeds. Such plants have a deep taproots, broad leaves and branching ability. (e.g., cotton, mustard).
2. **Based on Origin**
   - ✓ **Native**: Crops grown within their native geographical area. For example, rice, barley, mustard, sugarcane and cotton grown in India are native to India.
   - ✓ **Exotic**: Crops introduced from other regions. For example, tobacco, apple, maize, etc.
3. **Season of Growth**
   - ✓ **Kharif (Monsoon)**
     - Crops are sown in June-July and harvested in September-October.
     - Require high temperatures and the onset of the monsoon for sowing, and are harvested during the retreat of the monsoon.
     - Ideal growth temperature is between 30°C to 38°C.
     - Maximum temperature tolerance is between 45°C to 50°C.
     - Examples include rice, millets, soybeans, cotton, groundnut, and sorghum.
   - ✓ **Rabi (Winter)**
     - Crops are sown in October-November and harvested in March-April.
     - Require low temperatures during sowing and growth, but high temperatures during ripening.
     - Ideal growth temperature is between 25°C to 30°C.
     - Minimum temperature range is between 0°C to 5°C.
     - Examples include wheat, barley, oats, canola, lentil, and mustard.

- ✓ **Zaid**
  - Those crops which are planted in February- March and harvested in May- June. Example- cucumber, melon, tobacco etc.

4. **On the basis of life Period**
   - ✓ **Annuals**: crops which complete life cycle in one season or same year (e.g., cereal crops).
   - ✓ **Biennials**: Life cycle completes in two years (e.g., sugarbeet, onion).
   - ✓ **Perennials**: Live for multiple years (e.g., agave, elephant foot).
5. **Cultural Practices**
   - ✓ **Irrigated Crops**: crops which require irrigation (e.g., sugarcane, paddy).
   - ✓ **Dry Farming**: crops grown with natural precipitation (e.g., sorghum, bajra).
   - ✓ **Monocropping**: Growing the same crop repeatedly on the same land.
   - ✓ **Intercropping**: Growing multiple crops together on the same land (e.g., sorghum + black gram).
   - ✓ **Mixed Cropping**: Growing two or more crops without a fixed pattern (e.g., sorghum + green gram).
6. **Agronomical / Economical Aspects**
   - ✓ **Food Crops**: It includes cereals, pulses, edible oilseeds, fruit crops (e.g., mango, banana).
   - ✓ **Non-food Crops**: It includes forage, fiber crops, medicinal plants, and spices (e.g., tobacco, cotton).
   - ✓ **Special Purpose Crops**: It includes cash crops, cover crops, windbreaks, silage crops (e.g., cotton, sunflower, maize).
7. **Climatic Conditions**:
   - ✓ **Tropical Crop**: Require hot and humid conditions (e.g., sugarcane, coconut).
   - ✓ **Sub-tropical Crop**: Tolerate some frost (e.g., rice).
   - ✓ **Temperate Crop**: Require cooler temperatures (e.g., wheat, barley).
8. **Photoperiod**
   - ✓ Crop development, including leaf production, flowering, and reproductive stages, is influenced by sunlight duration.
   - ✓ This phenomenon is called photoperiodism. Based on the length of available sunlight, crops are classified into three categories:
     - **Long Day Plants**: Require a long duration of sunlight (maximum 12 hours) for both vegetative and reproductive stages. If exposed to short daylight, their vegetative growth may continue, but reproductive growth will be delayed.
       - ☞ Examples: Wheat, barley, oats.
     - **Short Day Plants**: Require less than 10 hours of daylight for reproductive growth.
       - ☞ Examples: Rice, sorghum, maize.
     - **Day Neutral Plants**: Do not require specific day lengths for growth and development. The duration of sunlight has no impact on their growth phases.
       - ☞ Examples: Cotton, sunflower.
9. **Growth Habit**:
   - ✓ **Determinate**: Plants which initiate their reproductive growth after completing vegetative growth. Examples: Wheat, barley and rice etc.
   - ✓ **Indeterminate**: Plants whose vegetative and reproductive stages continue simultaneously. Examples: Tomato, cucumber, watermelon and soybean etc.
10. **Pollination**
    - ✓ **Self-pollinated Plants (Autogamy)**: Pollen is transferred from the anther to the stigma of the same flower on the same plant. Usually, 1-3% cross-pollination occurs in these plants.
      - Examples: Rice, wheat, green gram, black gram, soybean.
    - ✓ **Cross-pollinated Plants (Allogamy)**: Pollen is transferred from the anther of one flower to the stigma of another flower, either on the same plant or a different plant.
      - Examples: Maize, bajra, sunflower, brassica.

11. Mode of Propagation

- ✓ **Sexually Propagated Plants**: Propagated through seeds.
  - Examples: Rice, wheat, green gram, black gram, soybean, maize, barley.
- ✓ **Asexually Propagated Plants**: Propagated using specialized parts or methods like cuttings, grafting, and layering.
  - Examples: Sugarcane, ginger, potato.

12. Mode of Respiration:

- ✓ **C3 Plants**
  - Plants fix CO2 and form a 3- carbon molecule and 3- phosphoglyceric acid (3 PGA).
  - This pathway was discovered by Calvin and his co-workers (Bassham and Calvin, 1957).
  - Plants with this pathway of carbon assimilation are called C3 pathway plants. These plants do exhibit photo-respiration.
  - Such plants cannot utilize light, temperature water and CO2 effectively, therefore they are called Inefficient plants.
  - Examples: wheat, oat, rye, soybean and cotton etc.
- ✓ **C4 Plants**
  - In these plants, the first product of photosynthesis is a 4- Carbon molecule called Oxalo acetate.
  - Plants fix CO2 via Hatch and Slack pathways. These plants do not exhibit photorespiration.
  - Such plants can utilize light, temperature water and CO2 effectively, therefore they are called Efficient plants. Examples: Sugarcane, maize and sorghum etc.
- ✓ **CAM Plants**
  - CAM Plants fix CO2 into 4- carbon acids called malate as do the C4 plants. Fixation occurs at night when stomata open.
  - CAM plants grow in deserts and have succulent fleshy leaves and stems with low transpiration and water requirement. Examples: Pine apple and Preckly pear etc.

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

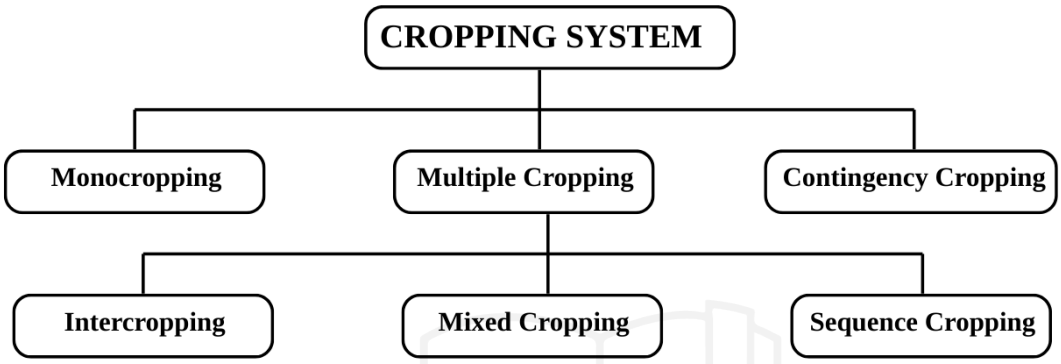
- This region covers 37% of the agricultural land and contributes to 57% of the total agricultural production.
- It is primarily located in northern India, including Punjab, Haryana, Uttar Pradesh, Bihar, and West Bengal. In this ecosystem, the water needs of crops are met through artificial irrigation.
- **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

Cropping System

- Cropping system means the proportion of an area under various crops at a point of time in a unit area. It indicates the yearly sequence & spatial arrangement of crops.
- It is an important component of the farming system as it interacts with all the available farm resources. For example, soil, water, microbes, etc.

Types of Cropping System



Mono-Cropping

- ✓ It refers to growing the **same crop repeatedly on the same piece of land.** It is practised due to climatological & socio-economic conditions or due to specialization of a farmer in growing a particular crop.
- ✓ **Example:** The wheat belt of Punjab–Haryana and the sugarcane belt of western Uttar Pradesh.
- ✓ **Advantages**
  - ✓ It allows specialisation and makes mechanisation easier.
  - ✓ It is convenient for harvesting with the help of machinery.
- ✓ **Disadvantages**
  - ✓ It leads to soil nutrient depletion and increases the risk of pests and diseases.
  - ✓ It reduces fertility and productivity of the soil in the long term.

Multiple Cropping

- ✓ It involves **growing more than one crop on the same land within a year**.
- ✓ Types of Multiple cropping include Intercropping, mixed cropping, and sequence cropping.

Double Cropping: It is growing two crops sequentially. For example: Rice-Wheat, Groundnut-Wheat.
Triple Cropping: Three crops are grown annually, usually in high-input, well-irrigated areas. For example: Rice-Rice-Vegetables in Tamil Nadu.

I. Intercropping

- ✓ Intercropping means **growing two or more crops simultaneously on the same field** with planned row arrangements.
- ✓ **Example:** Maize & Cowpea, Sugarcane & Onion.
- ✓ **Benefits:** Efficient use of space, reduced production risk, improved soil cover, and higher overall returns.
- ✓ Based on number of plant population intercropping is divided into two parts:
  1. Additive series
  2. Replacement series

- ✓ **Additive Series:**
  - In the additive series, the population of the main crop (base crop) is maintained at 100%, while the geometry of the main crop is adjusted to accommodate the intercrop.
  - For example, in a 10:1 ratio of wheat and mustard, 10 rows of wheat are planted with 1 row of mustard. In this system, the population of the intercrop is very low.
- ✓ **Replacement Series:**
  - In the replacement series, the population of the main crop is reduced to create space for the intercrop.
  - Both crops are considered component crops in this system. For example, in a 1:1 ratio of castor and red gram, both crops are grown in equal proportions.
- ✓ **Based** on the arrangement of crops in fields it is divided into 4 groups.
  1. Parallel Cropping
  2. Companion Cropping
  3. Multi-storeyed Cropping
  4. Synergistic Cropping

  Parallel Cropping: In parallel cropping, two crops are selected that have different growth habits and do not compete with each other. This allows both crops to reach their full yield potential. For example, moong or urad with maize.

  Companion Cropping: In companion cropping, the yield of one crop is not affected by the other. Both crops maintain their full yield potential, similar to when they are grown as pure crops. The standard plant populations for both crops are maintained. For example, mustard, wheat, or potato with sugarcane.

  Multi-storeyed Cropping: Multi-storeyed cropping refers to the practice of growing plants of varying heights in the same field simultaneously. This method is commonly used in orchards and plantation crops to maximize the use of solar energy, even under normal planting densities. For example, Eucalyptus, papaya, and berseem grown together.

Advantages of the Multi-Storey Cropping System

- ✓ Maximizes production from small plots, helping farmers cope with land shortages and significantly increasing income per unit area.
- ✓ Reduces the risk of crop yield loss.
- ✓ Improves the physical properties and overall health of the soil.
- ✓ Incorporating legumes into the cropping pattern helps maintain soil fertility through nitrogen fixation.
- ✓ A variety of crops can be grown, providing a balanced diet for the family.
- ✓ High-density planting suppresses weed growth.
- ✓ Protects crops from climatic challenges such as excessive rainfall, soil erosion, and landslides.
- ✓ Helps maintain ecological balance.
- ✓ Creates favorable micro-climate conditions beneficial for winter crops.
- ✓ Optimizes the use of available resources.
- ✓ Contributes to ecological balance.

Challenges in Adopting

- ✓ Drought conditions.
- ✓ Insufficient funds.
- ✓ Lack of technical knowledge on cropping systems.
- ✓ Timely availability of inputs.
- ✓ Pest and disease outbreaks.
- ✓ Lack of irrigation facilities.
- ✓ Limited labor availability.

Synergistic Cropping: In synergistic cropping, the combined yields of two crops grown together are higher than the yields of each crop when grown separately on the same unit area. For example, sugarcane and potato.

Reasons to Practice Intercropping:

1. Acts as insurance against the failure of one crop in rainfed conditions.
2. Increases productivity per unit area.
3. Provides stability in production.
4. Ensures efficient utilization of available resources.

Principles of Intercropping:

- ✓ The crops grown together should have complementary effects rather than competitive ones.
- ✓ The subsidiary crop should be of shorter duration and grow quickly, utilizing the early slow-growing period of the main crop, and should be harvested when the main crop begins to grow.
  - *Example:* Autumn-planted sugarcane remains dormant after germination until February, during which crops like potato, berseem, lucerne, mustard, etc., can be successfully grown as companion intercrops.
- ✓ Component crops should share similar agronomic practices.
- ✓ Erect-growing crops should be intercropped with cover crops, such as pulses, to reduce soil erosion and control weed growth.
- ✓ Component crops should have different root depths to avoid competition for nutrients, water, and root respiration. For example, one crop should have shallow roots, and the other should have deeper roots.
- ✓ The plant population of the main crop should be maintained, while the plant population of subsidiary crops can be adjusted based on the situation's demand.
- ✓ Crops with similar pest and disease pathogens or parasite infestations should not be intercropped together.
- ✓ The planting method and management should be simple, time-efficient, cost-effective, and profitable, ensuring wider adoption.
  - *Example:* Maize intercropped with green gram, black gram, or groundnut.

Requirements for Intercropping:

1. The peak nutrient demand periods for the main crop and intercrop should not overlap.
2. There should be minimal competition for light between the crops.
3. Both the main crop and intercrop should be complementary in nature.
4. The difference of maturity between intercrops should be at least 30 days.

Advantages of Intercropping:

- ✓ Nutrients are efficiently utilized from different layers of the soil. For example, a cereal-legume mixture benefits from the efficient fixation of atmospheric nitrogen into the soil.
- ✓ Total biomass production per unit area and time is increased by making full use of land, including inter-row spaces that would otherwise be left for weed growth. This leads to higher profit per unit area.
- ✓ The fodder value, both in quantity and quality, increases when non-legume crops are intercropped with legumes, such as Napier + cowpea or Napier + berseem.
- ✓ It provides crop yields in installments, reducing marketing risks.
- ✓ It ensures optimal use of labor, machinery, and power throughout the year, offering steady employment.

Disadvantages of Intercropping:

- ✓ Fertilizer management becomes challenging as the nutrient requirements of different crops vary.
- ✓ Harvesting becomes difficult due to the varying seeding times of the crops.
- ✓ Certain crop combinations can suppress the growth of another crop and may contribute to the spread of insect pests and diseases.

II. Mixed Cropping

- ✓ Mixed cropping involves **growing two crops together without any row pattern**.
- ✓ **Example:** Sorghum & Pigeon Pea, Millets & Pulses.

Characteristics

1. Seeds of different crops are mixed in specific proportions and sown together.
2. This practice is mostly followed in the dryland regions of India.
3. The primary objective is to meet the family's needs for vegetables, cereals, pulses, etc.
4. Mixed cropping is typically subsistence in nature.

Principles of Mixed Cropping:

When selecting crops for mixed cropping, the following points should be considered:

- ✓ Legumes should be sown alongside non-legumes, such as arhar with jowar or gram with wheat.
- ✓ Tall-growing crops should be paired with short-growing crops, e.g., maize with mung or urd.
- ✓ Deep-rooted (tap-rooted) crops should be sown with shallow-rooted or adventitious crops.
- ✓ Bushy crops should be grown with erect crops.
- ✓ Crops susceptible to similar insects, pests, and diseases should not be grown together.
- ✓ The mixture should consist of both short- and long-duration crops.

Advantages of Mixed Cropping:

- ✓ Reduces the risk of crop failure.
- ✓ Meets daily requirements for food grains, oilseeds, pulses, etc.
- ✓ Improves soil fertility when legumes are included as minor crops.
- ✓ Ensures better distribution of labor throughout the cropping period.
- ✓ Increases overall monetary returns.
- ✓ Provides a well-balanced cattle feed.
- ✓ Acts as a safeguard against pests and diseases.
- ✓ Fully utilizes space and available plant nutrients.

Disadvantages

- ✓ Sometimes control of pests, diseases and weeds become difficult
- ✓ Sometimes affects the yield of main crop
- ✓ Harvesting with the help of machinery is not possible

Sequence Cropping

Sequence cropping refers to growing two or more crops in succession on the same piece of land within a farming year. Depending on the number of crops grown, it is termed as double cropping (2 crops), triple cropping (3 crops), quadruple cropping, etc.

Examples of Double Cropping: Rice-linseed, Rice-vegetables and Soybean-wheat

Crop Rotation

- ✓ Crop rotation refers to the **sequential cultivation of different crops** to maintain soil fertility.
- ✓ **Example:** Cereal → Legume → Oilseed sequence.
- ✓ It improves soil structure and helps break pest and disease cycles.

Relay Cropping

- ✓ Relay cropping involves **sowing the next crop before the previous one is harvested**.
- ✓ **Example:** Urad in standing rice, Mustard in standing cotton.
- ✓ It saves time and enhances land productivity.

Advantages (Relay Cropping):

- ✓ Ensures better utilization of residual moisture and applied fertilizers
- ✓ Reduces overall cost of cultivation
- ✓ Lowers expenditure on fertilizers and irrigation
- ✓ Requires less labour
- ✓ Early sowing helps reduce incidence of pests, diseases, and weeds

Disadvantages:

- ✓ Higher risk of crop failure
- ✓ Mechanical harvesting becomes difficult
- ✓ Limited availability of skilled labour
- ✓ Possibility of increased incidence of pests, diseases, and weeds in some conditions

Ratoon Cropping:

Ratoon cropping refers to raising a subsequent crop from the regrowth of roots or stalks after the first harvest. It is an important method of intensive cropping, where more than one harvest is obtained from a single sowing or planting due to regrowth from basal buds on the stem. In this system, the stubbles of the original crop are left in the field to produce new tillers, which develop into the next crop. Examples include sugarcane, hybrid jowar, hybrid bajra, and redgram.

Alley Cropping:

Alley cropping is a system in which crops like jowar, maize, bajra, or other arable crops are grown in the alleys (spaces between rows) of leguminous shrubs such as subabul (*Leucaena leucocephala*).

Types of Alley Cropping:

1. **Food-cum-fodder system:** Produces food grains (pulses, cereals, oilseeds) along with fodder for livestock
2. **Food-cum-mulch system:** Provides food grains as well as crop residues used as mulch for soil and water conservation
3. **Food-cum-pole system:** Produces food along with wood for fuel, timber, and furniture

Advantages:

- ✓ Ensures better utilization of natural resources
- ✓ Reduces the cost of cultivation
- ✓ Improves soil fertility and overall productivity
- ✓ Helps in reducing incidence of pests and diseases
- ✓ Provides both food for humans and fodder for animals

Disadvantages:

- ✓ Competition for resources such as moisture, nutrients, light, and space
- ✓ Higher chances of pest, disease, and weed incidence
- ✓ Increased risk of crop failure
- ✓ Overall yield may be reduced

Contingency Cropping:

Contingency cropping refers to the practice of growing an alternative suitable crop in place of the usual crop due to delayed onset of rainfall. Generally, such crops yield less compared to normally grown crops.

Companion Cropping:

Companion cropping is a type of polyculture in which two plant species are grown together in a way that they mutually benefit each other by enhancing positive interactions and reducing negative effects. This system improves overall crop performance, and techniques like **push–pull technology** for pest and weed management are based on this concept.

Components of Companion Cropping:

1. Trap crop
2. Repellent crop
3. Masking plant
4. Camouflage crop

Trap Crop: Trap crops are plants grown to attract pests away from the main (target) crop. Once pests accumulate on the trap crop, they can be controlled through methods such as burning, tilling, or applying insecticides, or the crop may simply be left untreated to contain the pests.
Examples: Napier grass as a trap crop for stem borer; marigold attracts thrips away from tomato crops
Repellent Crop: Repellent crops are plants that release chemical compounds which repel or deter insect pests from the main crop.
Examples: Basil planted with tomato helps reduce thrips infestation; onion repels pests such as arthropods, mites, and aphids.
In push–pull strategy, repellent crops "push" pests away from the main crop, while attractive (trap) crops "pull" them.

Masking Plants:
Masking plants release volatile substances that mask the odor of the host plant, thereby interfering with the ability of pests to locate it.
Example: Infestation by cabbage root fly is reduced when peas, ryegrass, or clover are grown along the borders.

Camouflage Plants:
Camouflage plants are those that physically and visually obscure the main crop, making it difficult for pests to identify and attack it.
Example: Intercropping with cabbage helps reduce pest incidence by concealing the host plant.

Crop Rotation

- Crop rotation is the practice of growing different crops in succession on the same piece of land within a specific time period.
- The goal is to maximize profits with minimal investment while maintaining soil fertility.

Principles of Crop Rotation

- Crops with tap roots should be followed by those with fibrous root systems.
- Leguminous crops should be grown after non-leguminous crops, as legumes fix atmospheric nitrogen into the soil and add organic matter. Non-legumes, on the other hand, deplete soil fertility.
- More exhaustive crops, such as potato, sugarcane, and maize, should be followed by less exhaustive crops, as the former require more inputs like better tillage, fertilizers, irrigation, and pest control.
- Crop selection should be demand-driven, focusing on crops that are needed by the local population and can be easily sold.
- Crop selection should be problem-oriented. For example, on sloped lands prone to soil erosion, alternate cropping of erosion-prone crops (e.g., millet) and erosion-resisting crops (e.g., legumes) should be adopted.
- In dry or partially irrigated areas, crop selection should favor drought-tolerant crops. Similarly, in low-lying flood-prone areas, crops that tolerate water stagnation, such as paddy and jute, should be chosen.
- Crop selection should align with the financial conditions of the farmer.
- The selected crops should be suitable for the soil and climatic conditions of the region.
- Crops from the same family should not be grown in succession, as they can act as alternate hosts for insects, pests, and disease pathogens. For example, Johnson grass can thrive with gramineous crops year-round.
- An ideal crop rotation provides maximum employment for the family and farm labor, ensures efficient use of machines and equipment, and ensures timely agricultural operations.

Advantages of Crop Rotation

- Agricultural operations can be carried out on time for all crops due to reduced competition, making supervisory work easier.
- Soil fertility is enhanced through nitrogen fixation, promoting microbial activity, preventing the accumulation of toxins (such as HCN), and maintaining the soil's physical and chemical properties.