Agriculture and Rural Development for NABARD, IBPS, JRF, SRF, ARS, IRMA, SET, NET ETC Pdf For Competitive exams.

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Syllabus- Unit 1- Agriculture and Rural Development for NABARD, IBPS, JRF, SRF, ARS, IRMA, SET, NET etc

Agriculture: definition, meaning and its branches, Agronomy: definition, meaning and scope of agronomy. Classification of field crops. Factors affecting on crop production, Agro Climatic Zones; Cropping Systems: Definition and types of cropping systems. Problems of dry land agriculture; Seed production, seed processing, seed village; Meteorology: weather parameters, crop-weather advisory; Precision Farming, System of Crop Intensification, organic farming

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Agriculture: definition, meaning and its branches

Definition

- The word Agriculture has been derived from two Latin words *ager* or *agri* meaning *soil* and *culta* meaning *cultivation*.
- **Agriculture** may also be defined as an activity of cultivating plants, trees and animals to cater human needs such as food, fibre, fuel and economic gain.
- **Agriculture includes** the work of cultivating the soil, producing crops, planting forest plants/trees, raising livestock and rearing fishes.
- **Agriculture is defined as an art, science and business of producing crops and livestock for economic purposes.**
- As an art it embraces knowledge of the way to perform the operations of the farm in a skill full manner, as a science it requires knowledge of crop breeding, hybridization, bio-fortification, climate, soil type etc and as economics it encompasses management of land, labor, water, capital and market to maximize the returns and minimize the ecological footprints.

Contribution of Agriculture in Indian Economy

- Agriculture plays a vital role in India’s economy.
- Over 58 per cent of the rural households depend on agriculture as their principal means of livelihood.
- As per the 2nd advance estimates by the Central Statistics Office (CSO), the share of agriculture and allied sectors (including agriculture, livestock, forestry and fishery) is expected to be 17.3 per cent of the Gross Value Added (GVA) during 2016-17 at 2011-12 prices.
- Agriculture provides raw materials to various industries of national importance. Sugar industry, Jute industry, Cotton textile industry, Vegetable Oil, Food Processing and Paper and Pulp Industry are examples of some such industries which depend on agriculture for their development.
• Agriculture also acts as a market for Industrial Products
• India is the largest producer, consumer and exporter of spices and spice products.
• India's fruit production has grown faster than vegetables, making it the second largest fruit producer in the world.
• India's horticulture output, is estimated to be 287.3 million tonnes (MT) in 2016-17 after the first advance estimate.
• It ranks third in farm and agriculture outputs. Agricultural export constitutes 10 per cent of the country's exports and is the fourth-largest exported principal commodity.
• The agro industry in India is divided into several sub segments such as canned, dairy, processed, frozen food to fisheries, meat, poultry, and food grains.

Revolutions in Agriculture

<table>
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<th>Production</th>
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<tbody>
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<td>Food Grain Production</td>
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<td>Black/Brown Revolution</td>
<td>Non Conventional Energy</td>
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<td>Blue Revolution</td>
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<td>Golden Revolution</td>
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</tr>
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<td>Grey Revolution</td>
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</tr>
<tr>
<td>Pink Revolution</td>
<td>Meat</td>
</tr>
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<td>Red Revolution</td>
<td>Tomatoes</td>
</tr>
<tr>
<td>Round Revolution</td>
<td>Potato</td>
</tr>
<tr>
<td>Silver Revolution</td>
<td>Eggs</td>
</tr>
<tr>
<td>White Revolution</td>
<td>Milk Production</td>
</tr>
<tr>
<td>Yellow Revolution</td>
<td>Oilseeds Production</td>
</tr>
</tbody>
</table>

Production Data: 2016-17

As per the 2\textsuperscript{nd} Advance Estimates of the production data of major crops for 2016-17 released by the Department of Agriculture, Cooperation and Farmers Welfare is as under:
**Foodgrains** – 271.98 million tonnes (record)

Rice – 108.86 million tonnes (record)
Wheat – 96.64 million tonnes (record)
Coarse Cereals – 44.34 million tonnes (record)
Maize – 26.15 million tonnes (record)
Pulses – 22.14 million tonnes (record)
Gram – 9.12 million tonnes
Tur – 4.23 million tonnes (record)
Urad – 2.89 million tonnes (record)

**Oilseeds** – 33.60 million tonnes (record)
Soyabean – 14.13 million tonnes
Groundnut – 8.47 million tonnes
Castorseed – 1.74 million tonnes

**Cotton** – 32.51 million bales (of 170 kg each)

**Sugarcane** – 309.98 million tonnes

**Branches of Agriculture**

Agriculture has the following seven branches viz.,

1. **Agronomy** – Agronomy is the branch of agriculture sciences dealing with principles and practices of crop production and field management. Agronomy is mainly based on following basic principles Agro meteorology, Soils and Tillage, Soil and Water Conservation, Dryland Agriculture, Mineral Nutrition of Plants, Manures and
Fertilizers, Irrigation Water Management, Weed Management, Cropping and Farming Systems, Sustainable Agriculture.

2. **Horticulture** - Deals with the production of fruits, vegetables, flowers, ornamental plants, spices, condiments and beverages.

3. **Forestry** - Forestry is defined as the theory and practice of all that constitutes the creation, conservation and scientific management of forests and the utilization of their resources.

4. **Animal husbandry** - Deals with agricultural practice of breeding and raising livestock in order to provide food for humans and to provide power (draught) and manure for crops.

5. **Fishery science** - Deals with practice of breeding and rearing fishes including marine and inland fishes, shrimps, prawns etc. in order to provide food, feed and manure.

6. **Agricultural Engineering** - Deals with farm machinery for filed preparation, inter-cultivation, harvesting and post harvest processing including soil and water conservation engineering and bio-energy.

7. **Home Science** - Deals with application and utilization of agricultural produces in a better manner in order to provide nutritional security, including value addition and food preparation.

Each of these branches are independent units in themselves which would be unfolded in later chapters.

**Agronomy**

**Definition**

- Agronomy is derived from a Greek word ‘agros’ meaning ‘field’ and 'nomos' meaning ‘management’.
- It is defined as an agricultural science which deals with principles and practices of crop production and field management.
It deals with principles & practices of soil, water & crop management and involves study of methods which provide favorable environment to the crop for higher productivity.

Hence, it is the branch of agricultural science which deals with the principles and practices of crop production for **obtaining maximum economic returns** from a unit area in a definite period **without deteriorating the fertility** status of the soil.

**Scope of Agronomy**

- **Agronomy** is considered as the primary branch of agriculture.
- The central theme of agronomy is of **soil-crop-environment relationship**.
- It is an integrated and applied aspect of different disciplines of pure sciences and its scope includes:

1. **Use of Agrometeorology for identification of Cropping System**

   Agrometeorology is the study of weather and use of weather and climate information to enhance crop production.

   It mainly involves the interaction of meteorological and hydrological factors, on one hand and agriculture, which encompasses horticulture, animal husbandry, and forestry on the other.

   Pune is the centre of Indian Agricultural Meteorology Division under IMD.

2. **Proper methods of cultivation** like soil preparation and tillage are needed to reduce the cost of cultivation and maximize the yield and economic returns.

3. **Mineral Nutrition, Manures & Fertilizers**
Availability and judicious application of mineral, nutrition, Manures & Fertilizers to get maximum yield and simultaneously counter soil degradation.

In this regard Government of India has floated **Soil Health Card Scheme** and **Paramparagat Krishi Vikas Yojana** to promote Organic Farming.

4. **Weed management**

Selection, time & method of application of herbicides for the control of weeds.

5. **Irrigation Water Management**

*Water management practices* play greater role in present day crisis of water demand and Agronomy answers the questions such as ‘how much water to apply?’ and ‘when to apply?’

6. **Extension of Agriculture in Dry land Areas**

Dry lands are the Areas which receive an annual rainfall of 750 mm or less and there is no irrigation facility for raising crops.

Dry land Farming is the **scientific management of soil, moisture and crops** under dry lands without irrigation.

7. **Sustainable Agriculture**

Sustainable agriculture can be defined as a form of agriculture aimed at meeting the food and fuel needs of the present generation without endangering the resource base for the future generations.
It includes study of Impact of Improved Crop Production Technology, Factors Affecting Ecological Balance, Evaluation of Sustainable Agriculture, Sustainable Utilization of Land Resources, Water Resources and Biodiversity, Integrated Nutrient Management and Enhancing Sustainability of Dryland Agriculture.

**Classification of field crops**

- All objects are named and classified for practical purposes. Human beings, animals, birds, and insects have special names and classes. Even non-living entities have their names and classes.
- A special set of terms and names is associated with every business, trade, and profession. Crop plants are no exception.
- Classification helps in the identification of related crop plants used for various purposes such as food, feed, and fiber. Moreover, classification is essential for orderly reference and avoiding confusion in identification.

**Classification types used in crops**

Based on different factors, the classification is as follows:

**Based on Ontogeny (Life cycle)**

- **Annual**
  
  A plant which live within a short period of time, for a few weeks or months, perpetuated by seed, and which die soon after producing seeds; a plant which germinate, grow, flower, produce seed, and die all in one season. Examples: rice, corn, cowpea, mungbean, squash.

- **Biennial**
  
  A plant which requires two growing seasons to complete its life cycle, the first for vegetative growth and accumulation of food reserves, and the second for the production of reproductive parts. It grows from a seed, produces flower and seed and then dies in two growing seasons. Examples: bulb onion, cabbage, carrot, celery, raddish.
• Perennial
A plant that lives indefinitely, including all trees and shrubs and many herbaceous plants with underground stems (e.g. corm, rhizome, tuber) like banana and clump-forming grasses. Perennial plants continue growing and produce seeds year after year, either from a single plant or, in herbaceous plants, from succeeding re-growth.

Based on economic use (Agronomic)

a) Cereals:
Cereals are the cultivated grasses grown for their edible starchy grains. Larger grains are used as staple food – Rice, wheat, maize, barley, oats etc. Cereal grain is excellent energy rich food for humans and serves the staple food in almost every country and region.

b) Millets:
Millets are small grained cereals and the staple food in drier regions of the developing countries. They are grown in areas where productivity and economics is less important. These are staple food for people of poor countries.
For example, in India, pearl millet is a staple food in Rajasthan.
Millets are broadly classified into two groups:

<table>
<thead>
<tr>
<th>Major millets</th>
<th>Minor millets</th>
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<tbody>
<tr>
<td>Sorghum / Jowar</td>
<td>Barnyard millet</td>
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<td>Pearl millet / Bajra</td>
<td>Common millet</td>
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<tr>
<td>Finger millet / Ragi</td>
<td>Foxtail millet</td>
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<tr>
<td></td>
<td>Kodo millet</td>
</tr>
<tr>
<td></td>
<td>Little millet</td>
</tr>
</tbody>
</table>

c) Pulses:
Pulses are seeds of leguminous plants used as food and are rich in protein. Pulses are preferred for their protein rich value & also economic important in cropping system. The wastes or stalk is used as green manure and has high value as cattle feed.

Examples:
- Bengal gram
- Black gram
- Cowpea
- Green gram
- Horse gram
- Kesari
- Lentil
- Peas
- Red gram

d) Oil seeds:

Oilseeds are rich in fatty acid and are cultivated for the production of vegetable oil. They are used for edible or industrial or medicinal purposes. Examples:

- Castor
- Groundnut
- Linseed
- Mustard
- Niger
- Rapeseed
- Safflower
- Sarson
- Sesame
- Sunflower
e. **Sugar crops**

These are the crops cultivated for sugar. Juice is extracted from stem of sugarcane and is used for making jaggery or sugar. Tubers and tops are used as a fodder for cattle feed.

Examples:

- Sugarcane - *Saccharum officinarum*
- Sugar beet

f) **Fiber crops:**

These plants are grown for obtaining fiber. Cotton is the most important fiber crop of the world and is used for making garments. The fiber obtained from stems of Jute is used for making gunny bags, ropes. Sunnhemp is used for both stem fibre and as a green manure crop.

g) **Fodder / Forage:**

Fodder refers to vegetative matter, fresh or preserved, utilized as feed for animals. It includes hay, silage, pasturage and fodder.

Grasses - *Bajra napier* grass, guinea grass, fodder sorghum, fodder maize.

Legumes - Lucerne, *Desmanthus*, etc.

h) **Spices and condiments:**

These crop plants or their products are used for flavour, taste and add colour to the fresh or preserved food.

Example: Ginger, garlic, fenugreek, cumin, turmeric, chillies etc

i) **Medicinal plants:**

These crops used for preparation of medicines. Examples: Ashvagandha, Tulsi, mint. etc.

j) **Beverages:**
Products of crops used for preparation of mild, agreeable and simulating drinking. Examples are Tea, coffee, cocoa etc.

**Scientific or botanical classification**

Carolus Linnaeus, a Swedish botanist, was responsible for the botanical system of classification. Botanical or scientific names of plants which consist of genus and species are universally accepted.

Botanical classification is based upon similarity of plant parts and flower structure. This is the most important way of classification because it determines to what extent the plants are relatives.

Field crops belong to the “spermatophyte”, or seed plant, division of “plant kingdom”, which includes plants reproduced by seeds.

Within this division, the common crop plants belong to the subdivision of “Angiosperm”, which are characterized by producing seeds with coats (covered seed).

The “angiosperm”, are then divided into two classes, namely,

a. **Monocotyledons** - All the grasses, which include the cereals and sugarcane are monocotyledons.

b. **Dicotyledons** - The legumes and other plants except the grasses are classified as dicotyledons.

Example:

<table>
<thead>
<tr>
<th>Group</th>
<th>Grass (Wheat)</th>
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<tbody>
<tr>
<td>Kingdom</td>
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<td>Spermatophyta</td>
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<td>Sub-division</td>
<td>Angiospermae</td>
</tr>
<tr>
<td>Class</td>
<td>Monocotyledonae</td>
</tr>
<tr>
<td>Order</td>
<td>Graminales</td>
</tr>
<tr>
<td>Family</td>
<td>Gramineae</td>
</tr>
<tr>
<td>Tribe</td>
<td>Hordeae</td>
</tr>
<tr>
<td>Genus</td>
<td>Triticum</td>
</tr>
</tbody>
</table>
Based on seasons

Crops are grouped under the seasons in which their major field duration falls.

a) Kharif crops:

Kharif crops are grown during June-July to September-October. They require a warm wet weather during their major period of growth and shorter day length for flowering.
Ex. Paddy, maize, castor, groundnut, Cotton, Sugarcane, Soyabean

b) Rabi crops:

Rabi crops is the winter crop; sown in October end and harvested in March-April every year.
Ex. Wheat, mustard, barley, oats, potato, bengal gram, berseem, cabbage and cauliflower.

c) Zaid crops:

Zaid crops are grown during February-March to May-June. Such crops require warm dry weather for growth and longer day length for flowering. Ex. Black gram, green gram, cowpea etc.

Based on climatic condition

- Tropical crop : Coconut, sugarcane
- Sub-tropical crop : Rice, cotton
- Temperate crop : Wheat, barley
- Polar crop : All pines, pasture grasses

Based on mode of pollination

- Naturally self-pollinated crops
The predominant mode of pollination in these plants is self-pollination in which both pollen and embryo sac are produced in the same floral structure or in different flowers but within the same plant. Examples: rice, most pulses, okra, tobacco, tomato.

- **Naturally cross-pollinated crops**

Pollen transfer in these plants is from the anther of one flower to the stigma of another flower in a separate plant, although self-pollination may reach 5 percent or more. Examples: corn and many grasses, avocado, grape, mango, many plants with unisexual or imperfect flowers.

- **Both self- and cross-pollinated crops**

These plants are largely self-pollinated but varying amounts of cross-pollination occur. Examples: cotton and sorghum.

**Based on growth habitat**

- **Herbs**

Succulent plants with self-supporting stems. Examples: aglaonema, banana, dumbcane, sugarcane, tomato.

- **Vines**

Herbaceous climbing or twining plants without self-supporting stems. Examples: cucumber.

- **Lianas**

Woody climbing or twining plants which depend on other plants for vertical support to climb up to the top of the canopy. These climbers often form bridges between the forest canopy. Examples: Climbing bamboo, grape, Jade vine.

- **Shrubs**

Small trees or tree-like plants, generally less than 5 meters in height but by other authorities it is restricted to small, erect, woody plants which produce several trunks from the base. Examples: Barbados cherry, pink jasmine.

- **Trees**
Plants having erect and continuous growth with a large development of woody tissue, with a single distinct stem or trunk, reaching a height of 5 meters or more. Examples: durian, mango.

**Based on Mode of Reproduction**

- **Sexual**
  Plants that develop from a seed or spore after undergoing union of male and female gametes. Examples: palms and ferns.

- **Asexual**
  Plants which reproduce by any vegetative means without the union of the sexual gametes or by apomixis. Examples: red mombin (sineguelas), breadfruit, mangosteen.

**Based on leaf retention**

- **Evergreen**
  Plants that maintain their leaves throughout the year. Abscissed leaves are continually replaced by new flushes. Examples: pines, banana, papaya, palms and most tropical plants.

- **Deciduous**
  Plants which naturally shed off or lose leaves annually for extended periods. Natural leaf shedding is pronounced in deciduous trees of temperate regions.

**Based on ecological adaptation or habitat**

- **Aquatic, hydrophyte or hydrophytic plant**
  A plant adapted to growing in water or waterlogged soil. It may grow entirely submerged, partly submerged or floating, or anchored to the ground in bogs, swamps, or beside the edges of ponds, lakes or streams. Examples: lotus, water lily, mangrove species.

- **Epiphyte or epiphytic plant**
  A plant that grows aboveground on another plant but is not parasitic, usually deriving only physical support from the host and obtaining nourishment from the air and other
sources. Some have roots that take moisture and minerals leached from the canopy of trees and others catch rain and debris in special hollow leaves. The most common epiphytes belong to the pineapple, orchid, and fern families.

- **Halophyte or halophytic plant**

  A plant that is able to grow in habitats excessively rich in salts or under saline conditions. eg mangrove species, Coconut, cashew and tamarind have varying levels of tolerance to saline conditions.

- **Lithophyte or lithophytic plant**

  A plant adapted to growing on rocks or in rocky terrain with little humus, absorbing nutrients from the atmosphere, rain, and decaying matter which accumulate on the rocks.

- **Mesophyte or mesophytic plant**

  A terrestrial plant which is adapted to moderate conditions for growth, i.e. not too dry and not too wet (e.g. corn and most commercially-grown crops).

- **Parasite or parasitic plant**

  A plant which grows on another plant from which it takes part or all nourishment.

- **Sciophyte or sciophytic plant**

  A plant that is adapted to low light intensity or shade, e.g. most ferns and mosses, black pepper, cacao, coffee, hot pepper, gingers, and many orchids can tolerate or require shade.

- **Terrestrial or land plant**

  A plant which grows on land, rooting in the soil. It has aerial parts, collectively called shoot, and an underground part called root which absorbs most of its water and nutrient needs from the soil. Most agricultural crops are terrestrial and are further sub-classified into various groups such as halophytes, mesophytes, sciophytes and xerophytes depending on climatic and special adaptations.

- **Xerophyte, xerophytic or xeric plant**
A plant which is adapted to conditions with little or no water. Examples: adelfa, bromylads, euphorbias, cacti.

Factors affecting on crop production
The multiple factors which affect the Crop Production are as follows:

<table>
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<th>Internal Factors</th>
<th>External Factors</th>
</tr>
</thead>
<tbody>
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<td>Genetic/ Heredity factors</td>
<td>1. Climatic factors</td>
</tr>
<tr>
<td></td>
<td>2. Edaphic factors</td>
</tr>
<tr>
<td></td>
<td>3. Biotic factors</td>
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<tr>
<td></td>
<td>4. Physiographic factors</td>
</tr>
<tr>
<td></td>
<td>5. Socioeconomic factors</td>
</tr>
</tbody>
</table>

Internal Factors (Genetic/Heredity factors)
The increase in crop yields and other desirable characters are related to genetic make-up of plants.
The following characters are less influenced by environmental factors since they are governed by genetic make-up of crop:

- High yielding ability
- Early maturity
- Resistance to lodging
- Drought, flood and salinity tolerance
- Tolerance to insect pests and diseases
- Chemical composition of grains (oil content, protein content)
- Quality of grains (fineness, coarseness)
- Quality of straw (sweetness, juiciness)
External factors

A. Climatic factors

A large portion of yield is attributed to the influence of climatic factors. The following are the atmospheric weather variables which influences the crop production.

1. Precipitation

- Precipitation includes all water which falls from atmosphere such as rainfall, snow, hail, fog and dew.
- Rainfall is one of the most important which determine the choice of a cultivated species in a place. In heavy and evenly distributed rainfall areas crops like rice is grown in the coastal plains of India and tea, coffee and rubber are grown in the Western Ghats.
- Low and uneven distribution of rainfall is common in dry-land farming where drought resistance crops like pearl millet, sorghum and minor millets are grown.
- Distribution of rainfall is more important than total rainfall to have longer growing period
- Yields are not always directly proportional to the amount of rainfall as excess above optimum rainfall reduces the yield.

2. Temperature

- Temperature is a measure of intensity of heat energy. The range of temperature for maximum growth of most of the agricultural plants is between 15 and 40°C.
- Germination, growth and development of crops are highly influenced by temperature.
- Physical and chemical processes within the plants are governed by air temperature and affect leaf production, expansion and flowering.
The minimum, maximum (above which crop growth ceases) and optimum temperature of individual's plant is called as **cardinal temperature**.

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<thead>
<tr>
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<tbody>
<tr>
<td>Rice</td>
<td>10</td>
<td>36-38</td>
<td>32</td>
</tr>
<tr>
<td>Wheat</td>
<td>4.5</td>
<td>30-32</td>
<td>20</td>
</tr>
<tr>
<td>Maize</td>
<td>8-10</td>
<td>40-43</td>
<td>20</td>
</tr>
<tr>
<td>Sorghum</td>
<td>12-13</td>
<td>40</td>
<td>25</td>
</tr>
<tr>
<td>Tobacco</td>
<td>12-14</td>
<td>35</td>
<td>29</td>
</tr>
</tbody>
</table>

3. **Atmospheric Humidity (Relative Humidity - RH)**

- Water present in the atmosphere in the form of invisible water vapour is normally known as humidity. Relative humidity is the ratio between the amount of moisture present in the air to the saturation capacity of the air at a particular temperature.
- Relative humidity influences the water requirement of crops
- Relative humidity of 40-60% is suitable for most of the crop plants.
- When relative humidity is high there is chance for the outbreak of pest and disease.

4. **Solar radiation**

- From germination to harvest and even post harvest crops are affected by solar radiation. All physical process taking place in the soil, plant and environment are dependent on light
- Solar radiation is very important in photosynthetic mechanism of plants and controls the distribution of temperature and there by distribution of crops in a region.
- Photoperiodism is a response of plant to day length
- Phototropism -- Response of plants to light direction. Eg. Sunflower
- Photosensitive – Season bound varieties depends on quantity of light received
5. Wind velocity

- The basic function of wind is to carry moisture (precipitation) and heat.
- It not only supplies moisture and heat but also supplies fresh CO$_2$ for the photosynthesis.
- Wind dispersal of pollen and seeds is natural and necessary for certain crops.
- Wind causes soil erosion, increases evaporation and contribute to the spread of pest and diseases.
- Wind movement for 4 – 6 km/hour is suitable for crops but when wind speed is enormous then there is mechanical damage of the crops as it can removes leaves and twigs and damages crops like banana, sugarcane etc.

6. Atmospheric gases on plant growth

- CO$_2$ is important for Photosynthesis, Carbon dioxide is taken by the plants by diffusion process from leaves through stomata
- Nitrogen is one of the important major plant nutrient, Atmospheric N is fixed in the soil by lightning, rainfall and N fixing microbes in pulses crops and made available to plants
- O$_2$ is important for respiration of both plants and animals while it is released by plants during Photosynthesis
- Certain gases like SO$_2$, CO, CH$_4$, HF released to atmosphere are toxic to plants.

B. Edaphic Factors (Soil)

Plants grown in land completely depend on soil on which they grow. The soil factors that affect crop growth are

1. Soil moisture

- Water is a principal constituent of growing plant which it extracts from soil and water also helps in chemical and biological activities of soil including mineralization.
- Available moisture will be more in clayey soil than sandy soil
Nutrient availability and mobility increases with increase in soil moisture content.

2. Soil air

- Aeration of soil is absolutely essential for the absorption of water by roots, germination of seeds, respiration of roots and microorganisms and decomposition of organic matter.
- Potato, tobacco, cotton, linseed, tea, and legumes need higher \( O_2 \) in soil air.
- Rice requires low level of \( O_2 \) and can tolerate waterlogged (absence of \( O_2 \)) condition.

3. Soil mineral matter

The mineral content of soil is derived from the weathering of rocks. Minerals are sources of plant nutrients eg; Ca, Mg, S, Mn, Fe, K etc.

4. Soil Organic matter

It increases the water holding capacity of the soil and is a source of food for most microorganisms.

Organic acids released during decomposition of organic matter enables mineralization process thus releasing unavailable plant nutrients.

5. Soil organisms:

The raw organic matter in the soil is decomposed by different microorganisms which in turn releases the plant nutrients.

Atmospheric nitrogen is fixed by microbes in the soil and is available to crop plants through symbiotic (Rhizobium) or non-symbiotic (Azospirillum) association.

6. Soil reaction (pH)
Soil reaction is the pH (hydrogen ion concentration) of the soil. Soils may be acidic (<7.0), neutral (=7.0), saline and alkaline (>7.0)

Soil pH affects crop growth and neutral soils with pH 7.0 are best for growth of most of the crops.

Soils with low pH is injurious to plants due high toxicity of Fe and Al and also interferes with availability of other plant nutrients.

7. Soil Temperature
Soil temperature affects the physical and chemical processes going on in the soil like rate of absorption of water and solutes (nutrients), germination of seeds, controls the microbial activity and growth rate of underground portions of the crops like tapioca and sweet potato.

Cold soils are not conducive for rapid growth of most of agricultural crops.

C. Biotic Factors

Other plants and animals of the locality cause beneficial and harmful effects on the crop plants being grown at that place.

Plants are competitive or complimentary in nature when grown together.

Competition between plants occurs when there is demand for nutrients, moisture and sunlight particularly when they are in short supply or when plants are closely spaced

When different crops of cereals and legumes are grown together, mutual benefit results in higher yield (synergistic effect)

Animals such as soil fauna like protozoa, nematode, snails, and insects help in organic matter decomposition, while using organic matter for their living.

Insects and nematodes cause damage to crop yield and considered as harmful organisms.

Honey bees and wasps help in cross pollination and increases yield and considered as beneficial organisms.
**Burrowing earthworm** facilitates **aeration and drainage** of the soil as ingestion of organic and mineral matter by earthworm results in constant mixing of these materials in the soils. Large animals like cattle; goats etc. cause damage to crop plants by grazing.

**D. Physiographic factors**

Topography means the nature of surface earth like Plain, Plateau or Mountain. Increase in altitude cause a decrease in temperature and increase in precipitation and wind velocity like in hills and mountains.

Steepness of slope results in run off of rain water and loss of nutrient rich top soil. Exposure to light and wind: a mountain slope exposed to low intensity of light and strong dry winds may results in poor crop yields (coastal areas and interior pockets).

**E. Socio-economic factors**

Societal and cultural aspects play an important role in determining the inclination towards farming and members available for cultivation. Like Kashmiri are engage in agricultural activity while Bakarwals living in the same environmental milieu go for Nomadic life style.

Appropriate choice of crops by human beings to satisfy the food and fodder requirement of farm household like Jats in Ganga plains settle for sugarcane and grain cultivation, Sainis go for Vegetable and Ahirs like to grow fodder crops.

The economic condition of the farmers greatly decides the input/ resource mobilizing ability which vary with the marginal, small, medium and large farmers.

**Agro-climatic zones**

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.

Agro-climatic conditions mainly refer to soil types, rainfall, temperature and water availability which influence the type of vegetations.
Objectives of Identifying Agro-Climatic Zones

- In order to maximize the production from the available resources and prevailing climatic conditions, need-based, location specific technology needs to be generated.
- Delineation of agro-climatic zones based on soil, water, rainfall, temperature etc. is the first essential step for sustainable production.
- The planning aims at scientific management of regional resources to meet the food, fibre, fodder and fuel wood without adversely affecting the status of natural resources and environment.
- This kind of systematic approach may help the country in planning and optimizing land use and preserving soils and environment.

India exhibits a variety of land scopes and climatic conditions those are reflected in the evolution of different soils and vegetation. These also exists a significant relationship among the soils, land form climate and vegetation.

- The object of present study is to delineate such regions as uniform as possible introspect of physiographic, climate, length of growing period (LPG) and soils for macro level and land use planning and effective transfer of agro - technology.

Planning of Agro climatic zones of India

Several attempts have been made to delineate major agro-ecological regions in respect to soils, climate, physiographic and natural vegetation for macro-level planning on a more scientific basis. They are as follows.

- Agro-climatic regions by the Planning Commission
- Agro-climatic zones under National Agricultural Research Project (NARP)
- Agro-ecological regions by the National Bureau of Soil Survey & Land Use Planning (NBSS & LUP)
Agro-climatic regions by the Planning Commission

The Planning Commission, as a result of the mid-term appraisal of the planning **targets of the Seventh Plan**, has divided the country into **15 broad agro-climatic zones** based on physiography, soils, geological formation, Climate, cropping patterns, and development of irrigation and mineral resources for broad agricultural planning and developing future strategies. Fourteen regions were in the main land and the remaining one in the islands of Bay of Bengal and the Arabian Sea. The main objective was to integrate plans of the agro-climatic regions with the state and national plans to enable policy development based on techno-agro-climatic considerations. In the agro-climatic regional planning, further sub-regionalization was possible based on agro-ecological parameters.
1. Western Himalayan zone

- This zone consists of three distinct sub-zones of Jammu and Kashmir, Himachal Pradesh and Uttarakhand. The region consists of skeletal soils of cold region, podsolic mountain meadow soils and hilly brown soils. Soils are generally silty loams in the valleys.
- The high altitude alpine pastures, locally known as ‘dhoks’ or ‘margs’, are used by the Gujjars, Bakarwals and Gaddis to rear their sheep, goats, cattle and horses. The economy is largely agrarian.
- There is alluvial soil in the valleys of Kashmir, Kullu and Dun, and brown soil in the hills. The valley floors grow rice, while the hilly tracts grow maize in the kharif season. Winter crops are barley, oats, and wheat. The region supports horticulture, especially apple orchards and other temperate fruits such as peaches, apricot, pears, cherry, almond, litchi, walnut, etc. Saffron is grown in this region.

2. Eastern Himalayan zone

- Sikkim and Darjeeling hills, Arunachal Pradesh, Meghalaya, Nagaland, Manipur, Tripura, Mizoram, Assam and Jalpaiguri and Coochibihari districts of West Bengal fall under this region.
- This is a zone of high rainfall and high forest cover. The red-brown soil is not highly productive therefore Jhuming or shifting cultivation is practiced in nearly one-third of the cultivated area and this has caused denudation and degradation of soils with the resultant heavy runoff, massive soil erosion and floods in lower reaches and basins.
- The main crops are rice, maize, potato, tea. There are orchards of pineapple, litchi, oranges and lime.
- Infrastructural facilities in the region need to be improved and shifting cultivation controlled by developing terrace farming.

3. Lower Gangetic Plains zone

- West Bengal (except the hilly areas), eastern Bihar and the Brahmaputra valley lie in this region and soils are mostly alluvial
• This zone is prone to floods.
• The region has adequate storage of ground water with high water table.
• Rice is the main crop which at times yields three successive crops (Aman, Aus and Boro) in a year. Jute, maize, potato, and pulses are other important crops.

4. Middle Gangetic Plains zone

• The Middle Gangetic Plain is a region of high rainfall and includes large parts of Uttar Pradesh and Bihar.
• It is a fertile alluvial plain drained by the Ganga and its tributaries. About 39% of gross cropped area is irrigated and the cropping intensity is 142%.
• Rice, maize, millets in kharif, wheat, gram, barley, peas, mustard and potato in rabi are important crops.

5. Upper Gangetic Plains zone

• In the Upper Gangetic Plains region come the central and western parts of Uttar Pradesh and the Hardwar and Udham Nagar districts of Uttarakhand.
• Irrigation is through canals and tube wells. A good potential for exploitation of ground water exists.
• This is an intensive agricultural region wherein wheat, rice, sugarcane, millets, maize, gram, barley, oilseeds, pulses and cotton are the main crops.

6. Trans-Gangetic Plains zone

• This region (also called the Satluj-Yamuna Plains) extends over Punjab, Haryana, Chandigarh, Delhi and the Ganganagar district of Rajasthan. Semi-arid characteristics prevail over the region.
• The soil is alluvial which is highly productive.
Canals and tube-wells and pumping sets have been installed by the cultivators and the governments. The major characteristics of this area are: highest net sown area, highest irrigated area, high cropping intensity and high groundwater utilization.

Important crops include wheat, sugarcane, cotton, rice, gram, maize, millets, pulses and oilseeds etc.

The region has the credit of introducing Green Revolution in the country and has adopted modern methods of farming with greater degree of mechanisation.

The region is also facing the menace of water logging, salinity, alkalinity, soil erosion and falling water table.

7. Eastern Plateau and Hills zone

- This region includes the Chhotanagpur Plateau, extending over Jharkhand, Orissa, Chhattisgarh and Dandakaranya.
- Soils are red and yellow with occasional patches of laterites and alluviums.
- The region is deficient in water resources due to plateau structure and non-perennial streams. Rainfed agriculture along with Tank and Tube-well irrigation is practised for growing crops like rice, millets, maize, oilseeds, ragi, gram and potato.
- Integrated Watershed Development approach can be adopted to conserve soil and water.

8. Central Plateau and Hills zone

- The region is spread over Bundelkhand, Baghelkhand, Bhandar Plateau, Malwa Plateau, and Vindhyachal Hills. The topography is highly variable nearly 1/3rd of the land is not available for cultivation
- Semi-arid climatic conditions prevail over the region. Irrigation and cropping intensity are low. 75% of the area is rainfed grown with low value cereal crops.
- Soils are mixed red, yellow and black.
- Crops grown are millets, wheat, gram, oilseeds, cotton and sunflower.
In order to improve agricultural returns, measures to be adopted are water conservation through water saving devices like sprinklers and drip system; dairy development, crop diversification including horticulture crops, ground water development, reclamation of ravine lands.

9. Western Plateau and Hills zone

- Comprising southern part of Malwa plateau (Rajasthan and Madhya Pradesh) and Deccan plateau (Maharashtra).
- The average rainfall of the zone is 90 cm. The net sown area is 65% and irrigated area is only 12.4% with canals being the main source.
- This is a region of the regur (black) soil.
- Wheat, gram, millets, cotton, pulses, groundnut, and oilseeds are the main crops in the rain-fed areas, while in the irrigated areas, sugarcane, rice, and wheat are cultivated. Oranges, grapes and bananas are also grown.
- Attention should be paid to increasing water efficiency by popularizing water saving devices like sprinklers and drip system. The lower value crops of jowar, bajra and rainfed wheat should give way to high value oilseeds.

10. Southern Plateau and Hills zone

- This region falls in interior Deccan and includes parts of southern Maharashtra, the greater parts of Karnataka, Andhra Pradesh, and Tamil Nadu uplands from Adilabad District in the north to Madurai District in the south.
- It is an area of dry-zone agriculture and dry-land farming is adopted in 81% of the area where millets, oilseeds, and pulses are grown. Coffee, tea, cardamom and spices are grown along the hilly slopes of Karnataka plateau.
- Some of the area under coarse cereals may be diverted to pulses and oilseeds. Horticulture, dairy development and poultry farming should be encouraged.

11. East Coast Plains and Hills zone
• In this region are the Coromandal of Tamil Nadu and northern Circar coasts of Andhra Pradesh and Orissa.

• The soils are alluvial and coastal sand and are troubled by the problem of alkalinity. Irrigation is through canals and tanks.

• Main crops include rice, jute, tobacco, sugarcane, maize, millets, groundnut and oilseeds. Main agricultural strategies include improvement in the cultivation of spices (pepper and cardamom) and development of fisheries.

12. West Coast Plains and Ghats zone

• Extending over the Malabar coastal plains of Kerala, Canara coastal Plains of Karnataka and Konkan coastal plains of Goa and Maharashtra and the Sahyadris.

• The soils are laterite and coastal alluvial.

• Rice, coconut, oilseeds, sugarcane, millets, pulses and cotton are the main crops. The region is also famous for plantation crops and spices which are raised along the hill slopes of the Western Ghats.

13. Gujarat Plains and Hills zone

• This region includes the hills and plains of Kathiawar, and the fertile valleys of Mahi and Sabarmati rivers.

• It is an arid and semi-arid region and irrigated through tube wells and wells.

• Soils are regur in the plateau region, alluvium in the coastal plains, and red and yellow soils in Jamnagar area. Groundnut, cotton, rice, millets, oilseeds, wheat and tobacco are the main crops. It is an important oilseed producing region.

14. Western Dry Region:

• Extending over Rajasthan, West of the Aravallis, this region has an erratic rainfall of an annual average of less than 25 cm. Famine and drought are common features of this region.
• The desert climate further causes high evaporation and contrasting temperatures—28 °C to 45 °C in June and 5 °C to 22 °C in January.
• Bajra, jowar, and moth are main crops of kharif and wheat and gram in rabi. Livestock contributes greatly in desert ecology.
• The ground water is often deep and often brackish.

15. The Islands Region:
• Andaman and Nicobar Islands, Lakshadweep. These regions are typical equatorial with rainfall of 300 cm spread over eight to nine months. Largely
  • forest zone with undulated land.
  • The soils vary from sandy along the coast to clayey loam in valleys and lower slopes.
  • The main crops are rice, maize, millets, pulses, arecanut, turmeric and cassava. Nearly half of the cropped area is under coconut. The area is covered with thick forests and agriculture is in backward stage.

Agro-climatic zones under National Agricultural Research Project (NARP)

National Agricultural Research Project (NARP) was launched by ICAR for initiating agricultural research in the agro-climatic zones of the country. The objective was to set up or upgrade a zonal research station in each agro-climatic zone for generating location specific, need based research targeted for specific agro-ecological situations. The focus was on analyzing agro-ecological conditions and cropping patterns and come out with a programme directly targeted to solve the major bottle necks of agricultural growth in a zone based on natural resources, major crops, farming systems, production constraints and socio-economic conditions prevalent in that zone. Stress was on technology generation. In NARP, the country was divided into 127 agro-climatic zones.
Agro-ecological regions by the National Bureau of Soil Survey & Land Use Planning (NBSS & LUP)

Agro-ecological Regions - An agro-ecological zone is the land unit carved out of agro-climatic zone superimposed on landform which acts as modifier to climate and length of growing period.

The National Bureau of Soil Survey & Land Use Planning (NBSS&LUP) came up with 20 agro-ecological zones based on the growing period as an integrated criteria of effective rainfall, soil groups, delineated boundaries adjusted to district boundaries with a minimal number of regions. Subsequently, these twenty agro-ecological zones were sub-divided into 60 sub-zones.
1. Western Himalayas
2. Western Plain, Kachchh, and part of Kathiwara Peninsula
3. Deccan Plateau
4. Northern Plain and Central Highlands including Aravallis
5. Central Malwa Highlands, Gujarat Plains, and Kathiawar Peninsula
6. Deccan Plateau, hot semi-arid ecoregion
7. Deccan (Telengana) Plateau and Eastern Ghats
8. Eastern Ghats, Tamil Nadu Plateau and Deccan (Karnataka)
9. Northern Plain, hot sub-humid (dry) ecoregion
10. Central Highlands (Malwas, Budelkhand, and Eastern Satpura)
11. Eastern Plateau (Chattisgarh), hot sub-humid ecoregion
12. Eastern (Chotanagpur) Plateau and Eastern Ghats
13. Eastern Plain
14. Western Himalayas
15. Bengal and Assam plains
16. Eastern Himalayas
17. North Eastern Hills (Purvanchal)
18. Eastern Coastal Plain
19. Western Ghats and Coastal Plain
20. Island of Andaman Nicobar and Lakshadweep

Cropping seasons in India

The Indian cropping season is classified into 3 types -

**Kharif (monsoon)**

The kharif cropping season is from July -October during the south-west monsoon. The kharif crops include rice, maize, sorghum, pearl millet/bajra, finger millet/ragi (cereals), arhar (pulses), soyabean, groundnut (oilseeds), cotton etc.
**Rabi (winter)** - The Rabi cropping season is from October-March (winter). The rabi crops include wheat, barley, oats (cereals), chickpea/gram (pulses), linseed, mustard (oilseeds) etc.

**Zaid (summer)** - The crops grown between March and June are summer crops. Eg watermelon, cucumber, sunflower etc.
Cropping Pattern and Cropping Systems

Cropping Pattern refers to the yearly sequence and spatial arrangement of crops or of crops and fallow in a particular land area. Cropping Pattern is a description of the cropping cycle in a region/location.

The term ‘Cropping system’ is being used increasingly to denote a systems approach in agriculture incorporating sustainability (crop yields/profitability, soil health, integrated pest management, water issues etc).

Cropping system refers to cropping pattern as well as its interaction with resources; technology, environment etc.
Cropping system comprises all components required for the production of a particular crop and the interrelationships between them and environment.

In other words, a cropping system usually refers to a combination of crops in time and space.

Combination in time occurs when crops occupy different growing period and combinations in space occur when crops are inter planted.

Thus, a cropping system comprises cropping pattern plus all components required for the production of a particular crop and the interrelationships between them and environment.

Cropping system is a critical aspect in developing an effective ecological farming system to manage and organize crops so that they best utilize the available resources (soil, air, sunlight, water, labour, equipments).

It represents cropping patterns used on a farm and their interaction with farm resources and farm enterprises and available technology which determine their makeup.

However these are two different concepts. ‘Cropping pattern’ and ‘cropping system’ are two terms used interchangeably.

Determining factors of cropping system

- **Physical aspects**
  Cropping system depends on the land, topography, slope, temperature, amount and reliability of rainfall and soils. For instance, in the rainfall scarce areas of Rajasthan, the farmers grow bajra, while in the Brahmaputra valley of Assam rice is the dominant crop. Likewise, cotton is grown in the regur (black earth) soil of Maharashtra and Gujarat, while the loamy soils of western Uttar Pradesh, Haryana and Punjab are ideally suited for wheat, rice and sugarcane crops.

- **Behavioural aspect**
  The perception and evaluation of environment is also important for guiding which crop should grow in certain region.
• **Socio-economic factors**

Financial resource base, land ownership, size and type of land holding, household needs of food, fodder, fuel, fibre and finance, and labour availability also determine the cropping system.

• **Infrastructure facilities**

Irrigation, transport, storage, trade and marketing, post-harvest handling and processing etc are deciding factors of cropping system.

**Types of cropping systems**

There are several types of cropping systems based on resources and technology available. These are as follows:

**Mono Cropping**

When only one crop is grown season after season; it's called Mono-cropping. The key disadvantage of Mono-cropping is that it would reduce soil fertility and damage the soil structure. Due to poor soil nutrients, the cultivator is needed to use chemical fertilizers to encourage production. The chemical fertilizers would disrupt the natural makeup of the soil and further aggravate the problem. Mono-cropping also allows spread of the pests and diseases.

**Intensive Cropping**

It is the growing of a number of crops on the same piece of land during the given period of time.

The turnaround time between one crop and another is minimized through modified land preparation.

It is possible when the resources are available in plenty. Cropping intensity is higher in intensive cropping system.
Crop intensification technique includes intercropping, relay cropping, sequential cropping, ratoon cropping, etc.

All such systems come under the general term multiple cropping.

**Multiple cropping**

It is the intensification of cropping in time and space dimensions.

Growing two or more crops on the same field in a year is known as Multiple Cropping.

**Forms of multiple cropping**

**Intercropping**

Growing two or more crops simultaneously on the same field. Crop intensification is in both time and space dimensions. There is intercrop competition during all or part of crop growth.

(a) *Mixed intercropping*: Growing two or more crops simultaneously with no distinct row arrangement. Ex: Sorghum, pearl millet and cowpea are mixed and broadcasted in rain fed conditions.

(b) *Row intercropping*: Growing two or more crops simultaneously where one or more crops are planted in rows. Often simply referred to as intercropping. Maize + green gram (1:1), Maize + black gram (1:1), Groundnut + Red gram (6:1)
(c) **Strip intercropping**: Growing two or more crops simultaneously in strips wide enough to permit independent cultivation but narrow enough for the crops to interact agronomically. Ex. Groundnut + redgram (6:4) strip.

(d) **Relay intercropping**: Growing two or more crops simultaneously during the part of the life cycle of each. A second crop is planted after the first crop has reached its reproductive stage of growth, but, before it is ready for harvest.
Advantages of intercropping

- Better use of growth resources including light, nutrients and water
- Improvement of soil health and agro-ecosystem
- Reduced pest and disease incidences
- Suppression of weeds
- Yield stability; even if one crop fails due to unforeseen situations, another crop will yield and gives income

Sequential cropping

Growing two or more crops in sequence on the same field in a farming year. The succeeding crop is planted after the preceding crop has been harvested. Crop intensification is only in time dimension. There is no intercrop competition.

(a) *Double, triple and quadruple cropping*: Growing two, three and four crops, respectively, on the same land in a year in sequence.

Ex. Double cropping: Rice: cotton;
Triple cropping: Rice: rice: pulses;
Quadruple cropping: Tomato: ridge gourd: *Amaranthus* greens: baby corn

(b) *Ratoon cropping*: The cultivation of crop re-growth after harvest, although not necessarily for grain. Ex. Sugarcane: ratoon; Sorghum: ratoon (for fodder).
**Crop Rotation**

In crop rotation, crops are changed from year to year according to a planned sequence. Crop rotation is considered to be a key principle of conservation agriculture. It improves the soil structure and fertility and also helps to control weeds, pests and diseases.

Legumes (such as groundnuts and beans) fix nitrogen in the soil. When their green parts and roots rot, this nitrogen can be used by other crops such as maize. The result is higher, more stable yields, without the need to apply expensive inorganic fertilizer.

**Dryland Agriculture**

Dryland agriculture is a type of farming practiced in arid and semi-arid areas without irrigation facilities.

The cultivation of crop occurs entirely under natural rainfall by planting drought-resistant crops and conserving the natural moisture of the soil.

It involves efficient system of soil and crop management in the regions of low and uneven distributed rainfall.
128 districts in India have been recognized as dryland farming areas. Of these, 91 Districts are spread in the states of Madhya Pradesh, Chhattisgarh, Uttar Pradesh and Tamil Nadu, representing typical dry farming tracts. Rest of the Districts belongs to Central Rajasthan, Saurashtra region of Gujarat, Vidharbha region of Maharashtra and rain shadow region of the Western Ghats.

Based on the amount of rainfall received; dryland agriculture can be grouped into three categories:

(i) **Dry farming:** It is production of crops without irrigation in areas where annual rainfall is less than 75 cm. Crop failures are more frequent under dry farming condition owing to prolonged dry spells during crop period. The growing season is less than 200 days. It is generally practiced in arid regions of the country.

(ii) **Dryland farming:** cultivation of crops in areas receiving rainfall above 75 cm is known as dryland farming. Dry spell during crop duration occurs, but crop failures are less frequent. Semi-arid regions are included under this category.

(iii) **Rainfed farming:** It is practice of crop cultivation without irrigation in areas receiving 115 cm rainfall, mostly in sub-humid and humid areas. Here chances of crop failure and water stress are very less.

**Significance of dryland agriculture in India**

- The total land area of India is 329 million hectares of which 144 million hectares is arable land, of this **94 million hectares fall under dry lands** constituting **65% of dryland** and rainfed area produce **40% of the total food grains** that feeds **40% of the total population**.

- Almost **80% of maize and Jowar, 90% of Bajra** and approximately **95% of pulses** and **75% of oilseeds** are obtained from dryland agriculture. In addition to these, **70% of**
cotton is produced through dryland agriculture. Dryland areas also contribute significantly to wheat (33%) and paddy (66%) production. Therefore Drylands contribute immensely in the food security of the country.

- The biggest employer in our country, the cotton mills are fed by raw cotton grown mostly in dryland areas. Increasing production of cotton subsequently leads to increase in exports of cotton goods. The improvement of production of oilseeds in these regions will save valuable foreign exchange reserves. By enhancing the productivity of crops like jowar, bajra and ragi which are mainly grown in dryland farming would increase the nutrient consumption levels of our nation.

- More than 75% of the farmers engaged in dry farming are small and marginal. Therefore, improvement in dry farming would raise the economic status of farmers thus helping in poverty alleviation.

- These areas have potential for fodder production to feed the cattle population which is an integral component of farming practice of this region.

- Providing importance to these areas can solve the problems of pulses, oilseeds and cotton. The dryland areas have also tremendous potentiality of increased food grain production. Thus enhanced agricultural production in these areas would boost the agriculture based economy of India. Moreover, it would also be helpful in eliminating the problem of hunger and malnutrition prevailed in below poverty line society of the country.

- Dryland farming is highly important to ensure the economic stability of a region. In the absence of this farming practice, vast tracts of lands in the world would be left barren and unproductive therefore populations residing in the arid areas of the world
would have to be completely dependent on external sources of food to meet their dietary needs. This would **adversely impact a nation's economy as self-sufficiency**, in terms of production of food grains to feed the country’s population, would be lost.

- Today, as the effects of **climate change** grips the world and the problem of **desertification intensifies**, more farmers across the world are planning to utilize the methods of dryland farming to cultivate their own crop fields. In the near future, many arable lands of today might have to completely depend upon dryland farming methods to sustain their agricultural outputs.

**Problems of dry land agriculture**

Dry farming crops are characterized by very low and highly variable and uncertain yields. Crop failures are quite common. These are mainly due to the following causes:

- **Inadequate and uneven distribution of rainfall:**

  In general, the rainfall is low and highly variable which results in uncertain crop yields. Besides its uncertainty, the distribution of rainfall during the crop period is uneven, receiving high amount of rain, when it is not needed and lack of it when crop needs it.

- **Late onset and early cessation of rains:**

  Due to late onset of monsoon, the sowing of crop are delayed resulting in poor yields. Sometimes the rain may cease very early in the season exposing the crop to drought during flowering and maturity stages which reduces the crop yields considerably.

- **Prolonged Dry spells during the crop period**

  Long breaks in the rainy season are important feature of Indian monsoon. These intervening dry spells when prolonged during crop period reduces crop growth and yield and when unduly prolonged crops fail.
• **Low moisture retention capacity**

The crops raised on red soils and coarse textured soil suffer due to lack of moisture whenever prolonged dry spells occur due to their low moisture holding capacity.

• **Low Fertility of Soils**

Drylands are not only thirsty, but also hungry too. Soil fertility has to be increased, but there is limited scope for extensive use of chemical fertilizers due to lack of adequate soil moisture.

**Measures to enhance agricultural production in dryland areas**

1. **Conservation of stored soil moistures** with practices like deep tillage, surface cultivation and stubble mulching need to be practiced.

2. **Rainwater Harvesting** for use in dry periods like digging of farm ponds.
3. Watershed a natural hydrological unit is a good device for water harvesting. **Proper watershed management** can check further degradation of ecosystem, restoration of degraded lands and also increases the productivity of land.

4. **Soil conservation** by contour bunding, terracing, land sloping and land levelling and also by practicing conservational tillage (zero tillage and minimum tillage).

5. **Judicious use of available water** with incorporating practices like drip irrigation to save water, lining of canals to minimize water loss etc.

6. **Nutrient management** by adopting best **Agronomic practices** like mixed cropping and crop rotation which increase the yield. **Integrated nutrient management** need to be practiced with special emphasis on use of **bio-fertilizers** to maintain the soil fertility.

7. **Integrated weed management** and **Integrated pest management** need to be adopted to control weeds and pests, respectively.

8. Dryland areas have to be supplemented with **non-form occupation** like animal husbandry, fisheries, poultry, social forestry and cottage for the development of these areas by increasing the income of the farmers.

9. **Promoting alternate land use system** like alley cropping, pasture management, tree farming, silvi-pastoral management systems and agro-horticultural system which are more relevant to dryland situations have to be adopted for successful dryland farming system.

**Seed production, seed processing, seed village**

Seed is the basic and most critical input for sustainable agriculture. The response of all other inputs depends on quality of seeds to a large extent. It is estimated that the direct contribution of quality seed alone to the total production is about 15 – 20% depending upon the crop and it can be further raised up to 45% with efficient management of other inputs. A major re-structuring of the seed industry by Government of India through the
National Seed Project was carried out, which strengthened the seed infrastructure that was most needed and relevant around those times.
Seed Production in India

The Indian seed programme largely adheres to the limited generations' system for seed multiplication in a phased manner. The system recognizes three generations namely breeder, foundation and certified seeds and provides adequate safeguards for quality assurance in the seed multiplication chain to maintain the purity of the variety as it flows from the breeder to the farmer.

Breeder Seed

Breeder seed is seed or vegetative propagating material directly controlled by the originating or sponsoring plant breeder of the breeding programme or institution and/or seed whose production is personally supervised by a qualified plant breeder and which provides the source for the initial and recurring increase of foundation seed. Breeder seed shall be genetically so pure as to guarantee that in the subsequent generation i.e. certified foundation seed class shall confirm to the prescribed standards of genetic purity. The other quality factors of breeder seed such as physical purity, inert matter, germination etc. shall be indicated on the label on actual basis. Breeder seed production is the mandate of the Indian Council of Agricultural Research (ICAR) and is being undertaken with the help of ICAR Research Institutions, National Research Centres and All India Coordinated Research Project of different crops.

ICAR also promotes sponsored breeder seed production programme through the National Seeds Corporation (NSC) / State Farms Corporation of India (SFCI), State Seeds Corporation (SSCs), Krishi Vigyan Kendras (KVKs) etc.

There has been a steady increase in the production of breeder seed over the years.

Foundation Seed

Foundation seed shall be the progeny of Breeder seed or be produced from foundation seed, which can be clearly traced to Breeder seed. Thus foundation seed can even be
produced from foundation seed during the production of Foundation Seed the minimum seed certification standard shall be the same for both foundation seed stage-I and II. The certification tag shall be white colour for both foundation seed stage-I and II. The production of foundation seed stage I and II shall be supervised and approved by the certification agency and be so handled as to maintain specific genetic identity and genetic purity and shall be required to confirm to certification standards specified for the crop / variety being certified.

Certified Seed

Certified seed shall be the progeny of foundation seed and its production shall be so handled as to maintain specific genetic identity and purity according to the standards prescribed for the crop being certified. Certified seed may be the progeny of certified seed provided this reproduction does not exceed three generations beyond foundation seed stage-I.

Seed Processing

Seed processing is a vital part of the seed production needed to move the improved genetic materials of the plant breeder into commercial channels for feeding the rapidly expanding world population. The farmer must get the quality seed that is free from all undesired materials because farmer's entire crop depends on it.

Seed can seldom be planted in the condition in which it comes from the growers. In fact, many seed lots contain weed or crop seed or inert material that make them unfit for sale without processing. Crop seed also frequently have stems, awns, clusters or other structures, which prevent from flowing through the drill freely.

Seed processing is that segment of the seed industry responsible for upgrading seed (Fig. 1), improving planting condition of seed, and applying chemical protectants to the seed.
Advantages of seed processing

- Facilitate uniform marketing by providing storage from harvest time until the seed is needed for planting.
- Improve seed marketing by improving seed quality
- Make possible more uniform planting rates by proper sizing
- Prevent crops from disease by applying chemical protectants
- Prevent spread of weed seed
- Reduces seed losses by drying

Processing Machines

Brief descriptions of the processing machines used in a seed processing plant are given hereunder.

**Scalper:** A scalper can be used to rough clean seed when trash content is high. The scalper basically consists of a vibrating or rotating screen or sieve. The screen perforations are large enough to allow the rough seed to pass through readily while large inert material is scalped off and removed from the seed lot.

**Air screen cleaner:** The air screen cleaner is the basic machine in almost all seed processing plants. The air screen cleaner uses three cleaning principles viz aspiration, scalping and grading. A common air screen cleaner for processing seed uses two air blasts and two screens. The first air system removes dust and light chaff before the seed reaches the first screen. The first screen allows the good seed to drop onto the second screen. The large foreign material rides over the first screen and is discarded. The second screen is a grading screen.

**Specific gravity separator:** Seed of same size and general shape can often be separated because they differ in specific gravity. This difference is very useful in removing light
immature seed or heavy sand and rocks to improve the purity and germination of crop seed.

**Indented cylinder:** Seed of the same width and thickness can sometimes be separated by taking advantages of difference of length. Indented cylinder can do very precise separation by using length difference. The indented cylinder separator is a rotating almost horizontal cylinder with a movable horizontal separating trough mounted inside it. Thousand of half round indents line the inside surface of cylinder.

**Elevator:** Elevator is used for conveying seed from one machine to another machine. It will lift the seed from the ground vertically upward and discharge it from top to the different machines. This type of elevating machines requires less power and floor area.

**Seed Village**

A village, wherein trained group of farmers are involved in production of seeds of various crops and cater to the needs of themselves, fellow farmers of the village and farmers of neighboring villages in appropriate time and at affordable cost is called "a seed village".

**Concept**

- Increasing the seed production
- Increasing the seed replacement rate
- Organizing seed production in cluster (or) compact area
-Replacing existing local varieties with new high yielding varieties.
- Self sufficiency and self reliance of the village
- To meet the local demand, timely supply and reasonable cost

**Features**

- Facilitates fast spread of new cultivars of different kinds
Increased confidence among the farmers about the quality because of known source of production

Producer and consumer are mutually benefited

Seed availability at affordable cost even lesser than market price

Seed is available at the door steps of farms at an appropriate time

Seed Village Scheme

To upgrade the quality of farmer-saved seed, which is about 80-85% of the total seed used for crop production programme, financial assistance is provided for distribution of foundation/certified seed at 50% cost of the seed of crops for production of certified/quality seeds only and for training on seed production and technology to the farmers.

The seed produced in these seed villages are preserved/ stored till the next sowing season. In order to encourage farmers to develop storage capacity of appropriate quality, assistance is given to farmers for making/procuring of Pusa Bin/Mud bin/Bin made from paper pulp for storing of seed produced by the frames on their farms.

Meteorology: weather parameters, crop-weather advisory

Meteorology: Definition

Meteorology is a scientific study that focuses on the atmosphere and weather processes including forecasting. Observable weather events, also known as meteorological phenomena, are included in the study of meteorology. Conventional meteorological studies include water vapor, temperature, and air pressure as well as the gradients of each and how each of these variables interacts with one another. Meteorology also studies how
these variables change throughout time. Most of the Earth's weather occurs within the troposphere.

Agricultural meteorology studies how weather affects plant development, animal development, plant distribution, crop yield and the efficiency of water use. This type of meteorology studies the energy balance of natural ecosystems and managed ecosystems for similarities and differences. Those in this field are also looking into how vegetation may affect the weather and climate.

**Importance of Meteorology for Crop Production**

- Cost effective ploughing, harrowing, weeding etc.
- Effective environmental protection.
- Efficient harvesting of all crops.
- Efficient management of soils which are formed out of weather action.
- Helps in planning cropping patterns/systems.
- Judicious irrigation to crops.
- Managing weather abnormalities like cyclones, heavy rainfall, floods, drought etc.

This can be achieved by

- Protection: When rain is forecast avoid irrigation. But, when frost is forecast apply irrigation.
- Avoidance: Avoid fertilizer and chemical sprays when rain is forecast
- Mitigation: Use shelter belts against cold and heat waves.

- Reducing losses of applied chemicals and fertilizers.
- Reducing or eliminating outbreak of pests and diseases.
- Selection of sowing dates for optimum crop yields.

**Meteorology: weather parameters**

The weather parameters for Meteorology are solar radiation, temperature, soil temperature and light, radiation.

- Solar Radiation
The flux of radiant energy from the sun is solar radiation. Heavenly bodies emit short wave radiation and near surfaces including earth emit long wave radiation. Crop production is exploitation of solar radiation. Solar radiation can be split into three broad spectra:

1. **Shorter than visible range:**
   - The effects are detrimental when plants are exposed to these radiation.
   - The UV rays of this segment reaching to the earth are very low and it is normally tolerated by the plants.

2. **Higher than visible wavelength**
   - It has thermal effect on plants
   - In the presence of water vapor, this radiation supplies the necessary thermal energy to the plant environment.

3. **Visible spectrum**
   - All plant parts are directly or indirectly influenced by the light
   - Intensity, quality and duration are important for normal plant growth
   - It affects the yield, total weight of plant structures, size of the leaves and root development.
   - Light affect the production of tillers, the stability, strength and length of culms
   - Light is indispensable to photosynthesis

Critical stages of plant growth for light
- Radiation intensity during the third month of Maize plant
- Barley – flowering period
- Rice – 25 days prior to flowering
Light

Light is the visible portion of the solar spectrum with wavelength range is from 0.39 to 0.76μ. Light is one of the important climatic factors for many vital functions of the plant. It is essential for the synthesis of the most important pigment i.e. Chlorophyll which regulates the important physiological functions. The characteristics of light viz. intensity, quality, duration and direction are important for crops. The duration of light has greater influence than the intensity for canopy development and final yield. It has a considerable importance in the selection of crop varieties. The response of plants to the relative length of the day and night is known as photoperiodism. The plants are classified based on the extent of response to day length which is as follows.

- **Long day plants**
  The plants which develop and produce normally when the photoperiod is greater than the critical minimum (greater than 12 hours) like Potato, Sugarbeet, Wheat, Barley etc.

- **Short day plants**
  The plants which develop normally when the photoperiod is less than the critical maximum (less than 12 hours) like Rice, Sorghum, cotton, Sunflower

- **Day neutral plants / Indeterminate**
  Those plants which are not affected by photoperiod like Tomato, Maize, etc.

Air Temperature

Temperature is defined as, “The measure of speed per molecule of all the molecules of a body”. It is the intensity aspect of heat energy.

Factors affecting air temperature

- **Altitude**
- **Cloudiness**
- **Convection and turbulence etc.**
Role of temperature in crop production:

- Air temperature affects leaf production, expansion and flowering.
- Biochemical reactions in crops (double or more with each 10°C rise) are influenced by air temperature.
- Equilibrium of various systems and compounds is a function of temperature.
- Solubility of different substances is dependent on temperature.
- Temperature affects the stability of enzymatic systems in the plants.
- Temperature influences distribution of crop plants and vegetation.
- The diffusion rates of gases and liquid changes with temperature.
- The surface air temperature is one of the important variables, which influences all stages of crop during its growth development and reproductive phase.

Soil temperature

The soil temperature is one of the most important factors that influence the crop growth. The physiochemical as well as life processes of sown seeds, plant roots and micro organisms living in the soil are directly affected by the temperature of the soil. Under the low soil temperature conditions signification is inhibited and the intake of water by root is reduced. In a similar way extreme soil temperatures injures plant and its growth is affected.

Importance of soil temperature on crop plants:
The soil temperature influences many process.

- Affects the speed of reactions and consequently weathering of minerals
- Controls soil microbial activities and the optimum range is 18-30°C
- Governs uptake of water, nutrients etc needed for photosynthesis.
- Influences the germination of seeds and development of roots
- Influences the presence of organic matter in the soil (more under low soil temperature)
- Influences the soil structure (types of clay formed, the exchangeable ions present, etc)
- Plays a vital role in mineralization of organic forms of nitrogen (inc with inc in temp)

**Humidity**

The amount of water vapour that is present in atmosphere is known as atmospheric moisture or humidity.

**Absolute humidity:** The actual mass of water vapour present in a given volume of moist air.

**Specific humidity:** Weight of water vapour per unit weight of moist air.

**Relative Humidity:** The ratio between the amount of water vapour present in a given volume of air and the amount of water vapour required for saturation under fixed temperature and pressure. There are no units and this is expressed as percentage. In other terms it is the ratio of the air’s water vapour content to its maximum water vapour capacity at a given temperature expressed in percentage. The relative humidity gives only the degree of saturation of air. The relative humidity of saturated air is 100 per cent.

**Importance of Humidity on crop plants**

The humidity is not an independent factor. It is closely related to rainfall, wind and temperature. It plays a significant role in crop production.
The humidity determines the crops grown in a given region.

High humidity at grain filling reduces the crop yields.

High humidity can prolong the survival of crops under moisture stress. However, very high or very low relative humidity is not conducive to higher yields of crops.

High humidity reduces irrigation water requirement of crops as the evapotranspiration losses from crops depends on atmospheric humidity.

It affects the internal water potential of plants.

It influences certain physiological phenomena in crop plants including transpiration.

The humidity is a major determinant of potential evapotranspiration. So, it determines the water requirement of crops.

There are harmful effects of high humidity. It enhances the growth of some saprophytic and parasitic fungi, bacteria and pests, the growth of which causes extensive damage to crop plants.

Crop Weather Advisory

Growing uncertainties of weather and climate pose a major threat to food security of the country and thus warrant for farmers empowerment of informed decision in agricultural risk management. Besides the possible impacts of climate change also pose major challenges in agriculture sector in the country. The combination of long-term changes and the greater frequency of extreme weather events are also likely to have adverse impacts on the food production in the coming decades. India Meteorological Department has taken major initiative to implement innovative and state of art technologies which are essential to address the above mentioned issues of weather and climate on Indian agriculture and also to realize the present day needs of the farmers of the country and also to meet the demands of the poorer section of the country. India Meteorological Department (IMD) started Integrated Agro-Meteorological Advisory Service (IAAS) in the country for the benefits of farmers. Agro-meteorological service rendered by IMD, Ministry of Earth Sciences is an innovative step to contribute to weather information based crop/livestock management strategies and operations dedicated to enhancing crop production by
providing real time crop and location specific agromet services with outreach to village level. This indeed has a potential to change the face of India in terms of food security and poverty alleviation.

Crop Weather Advisory enables farmers to reap benefits of benevolent weather and minimize or mitigate the impacts of adverse weather are:

- Advisories on dates of sowing/planting and suitability of carrying out intercultural operations covering the entire crop spectrum from pre-sowing to post harvest to guide farmer in his day-to-day cultural operations.
- Advisory for livestock on health, shelter and nutrition
- District specific weather forecast, in quantitative terms, for next 5 days for weather parameters like rainfall, cloud, maximum/minimum temperature, wind speed/direction and relative humidity, including forewarning of hazardous weather events (cyclone, hailstorm, heat/cold waves, drought and flood etc) likely to cause stress on standing crop and suggestions to protect the crop from them
- Propagation of techniques for manipulation of crop's microclimate e.g. shading, mulching, other surface modification, shelter belt, frost protection etc. to protect crops under stressed conditions.
- Reducing contribution of agricultural production system to global warming and environment degradation through judicious management of land, water and farm inputs, particularly pesticides, herbicides and fertilizers
- Weather forecast based forewarning system for major pests and diseases of principal crops and advises on plant protection measures.
- Weather forecast based information on soil moisture status and guidance for application of irrigation, fertilizer and herbicides etc.
Precision Farming

Evolution of Precision Farming

Agricultural production system is an outcome of a complex interaction of seed, soil, water and agro-chemicals

Therefore, judicious management of all the inputs is essential for the sustainability of such a complex system.

The focus on enhancing the productivity during the Green Revolution coupled with total disregard of proper management of inputs and without considering the ecological impacts, has resulted into environmental degradation.

The only alternative left to enhance productivity in a sustainable manner from the limited natural resources at the disposal, without any adverse consequences, is by maximizing the resource input use efficiency.

The time has now arrived to exploit all the modern tools available by bringing information technology and agricultural science together for improved economic and environmentally sustainable crop production.

Precision Farming is generally defined as an Information and Technology based farm management system to identify, analyze and manage variability within fields for optimum profitability, sustainability and protection of the land resource.

In this mode of farming, new information technologies can be used to make better decisions about many aspects of crop production.

Precision farming involves looking at the increased efficiencies that can be realized by understanding and dealing with the natural variability found within a field.

The goal is not to obtain the same yield everywhere, but rather to manage and distribute inputs on a site specific basis to maximize long term cost/benefit. Applying the same inputs
across the entire field may no longer be the best choice. Precision farming is helping many farmers worldwide to **maximize the effectiveness of crop inputs**.

![Figure 1. Precision farming cycle.](image)

The practice of precision agriculture has been enabled by the advent of **GIS and GNSS (GPS, GLONASS, Galileo, IRNSS/NAVIC)**.

The farmer can locate their precise position in a field allows for the **creation of maps** of the spatial variability of as many variables as can be measured (e.g. crop yield, terrain features/topography, organic matter content, moisture levels, nitrogen levels, pH etc.).

Similar data is collected by **crop yield monitors** mounted on GPS-equipped combine harvesters, arrays of real-time vehicle mountable sensors that measure everything from chlorophyll levels to plant water status and satellite imagery.

This data is then used by **Variable Rate Technology (VRT)** including seeders, sprayers, etc. to optimally distribute resources. Precision agriculture has also been enabled by **affordable unmanned aerial vehicles**.
Precision farming distinguishes itself from traditional agriculture by its level of management wherein instead of managing whole fields as a single unit, management is customized for small areas within fields.

This increased level of management emphasizes the need for sound agronomic practices. Before shifting to precision agriculture management, it is essential to have a good farm management system in place. Precision agriculture is a systems approach to farming.
Geographical Information System (GIS) an information system that integrates, stores, edits, analyzes, shares, and displays geographic information. GIS applications are tools that allow users to create interactive queries (user-created searches), analyze spatial information, edit data in maps, and present the results of all these operations. Geographic information science is the science underlying geographic concepts, applications and systems.

Global Navigation Satellite System (GNSS) is a system that uses satellites to provide autonomous geo-spatial positioning. It allows small electronic receivers to determine their location (longitude, latitude, and altitude/elevation) to high precision. eg USA’s GPS, Russian GLONASS, Indian IRNSS/NAVIC, European Union’s Galileo and Chinese Beidou.
There is a lot of technology used to make modern agriculture more efficient. For example, some farmers use global positioning systems (GPS) and GPS-computer guided tractors and harvesters. Other geo-referenced site-specific practices may include:

- electromagnetic soil mapping
- soil sample collection
- crop yield data collection
- aerial imagery
- crop or soil colour index maps
- soil types
- soil characteristics
- drainage level
- potential yields

![Precision Farming Concept](image-url)

*Precision Farming Concept*

"The right input, the right amount, the right time and the right place"

Technologies employed:

- Remote sensing, satellite navigation system
- Geographical information systems
- Automatic yield recording systems
- Automatic soil sensor
- Variable Rate Technology
- Advanced agronomy
- Advanced farm management
Technologies for Precision Farming

In order to collect and utilize information effectively, it is important for anyone considering precision farming to be familiar with the modern technological tools available. The vast array of tools include hardware, software and the best management practices. These are described briefly in the following paragraphs.

**Global Positioning System (GPS) receivers:**

Global Positioning System satellites broadcast signals that allow GPS receivers to compute their location. This information is provided in real time, meaning that continuous position information is provided while in motion. Having precise location information at any time allows soil and crop measurements to be mapped. GPS receivers, either carried to the field or mounted on implements allow users to return to specific locations to sample or treat those areas.

**Yield monitoring and mapping:**

In highly mechanized systems, grain yield monitors continuously measure and record the flow of grain in the clean-grain elevator of a combine. When linked with a GPS receiver, yield monitors can provide data necessary for yield maps. Yield measurements are essential for making sound management decisions.

**Grid soil sampling and variable-rate fertilizer (VRT) application:**

Under normal conditions, the recommended soil sampling procedure is to take samples from portions of fields that are no more than 20 acres in area. Soil samples taken from random locations in the sampling area are combined and sent to a laboratory to be tested. The goal of grid soil sampling is to generate a map of nutrient requirement, called an application map. Grid soil samples are analyzed in the laboratory, and an interpretation of crop nutrient needs is made for each soil sample. Then the fertilizer application map is plotted using the entire set of soil samples. The application map is loaded into a computer mounted on a variable-rate fertilizer spreader. The computer uses the application map and
a GPS receiver to direct a product-delivery controller that changes the amount and/or kind of fertilizer product, according to the application map.

**Remote sensing:**
Remote sensing is collection of data from a distance. Data sensors can simply be hand-held devices, mounted on aircraft or satellite-based. Remotely-sensed data provide a tool for evaluating crop health.

Plant stress related to moisture, nutrients, compaction, crop diseases and other plant health concerns are often easily detected in overhead images. Electronic cameras can also record near infrared images that are highly correlated with healthy plant tissue.

New image sensors with high spectral resolution are increasing the information collected from satellites. Remote sensing can reveal in-season variability that affects crop yield, and can be timely enough to make management decisions that improve profitability for the current crop. Remotely-sensed images can help determine the location and extent of crop stress.

**Crop scouting:**
In-season observations of crop conditions may include: Weed patches (weed type and intensity); Insect or fungal infestation (species and intensity); Crop tissue nutrient status; Flooded and eroded areas using a GPS receiver on an all-terrain vehicle or in a backpack, a location can be associated with observations, making it easier to return to the same location for treatment. These observations also can be helpful later when explaining variations in yield maps.

**Geographic information systems (GIS):**
Geographic information systems (GIS) are computer hardware and software that use feature attributes and location data to produce maps. An important function of an agricultural GIS is to store layers of information, such as yields, soil survey maps, remotely sensed data, crop scouting reports and soil nutrient levels. Geographically referenced data
can be displayed in the GIS, adding a visual perspective for interpretation. In addition to data storage and display, the GIS can be used to evaluate present and alternative management by combining and manipulating data layers to produce an analysis of management scenarios.

Information management:

The adoption of precision agriculture requires the joint development of management skills and pertinent information databases. Effectively using information requires a farmer to have a clear idea of the business’ objectives and crucial information necessary to make decisions. Effective information management requires more than record-keeping analysis tools or a GIS. It requires an entrepreneurial attitude toward education and experimentation.
Benefits of Precision Farming:

1. **Reduce input cost** of chemical fertilizers, pesticides, weedicides, water and seeds.

2. **Enhances the sustainability of agriculture** and decreases the ecological foot prints by judicious use of water and chemicals.

3. **Improves the crop yield** thus imperative for **food-security and profitability** of the farmer.

4. Provide better information to the farmer thus aids in better and **timely decision making**.

Scope of Precision farming in India:

1. Will address the food security issue.

2. Improves both certainty and quantum of output thus improve the economic and social conditions of farmers and help in tackling the hunger and poverty.

3. Better management of soil and water thus help in achieving the goal of sustainable agriculture and India is worst affected by land degradation and water stress.
System of Crop Intensification (SCI)

System of Crop Intensification (SCI) – has emerged to apply to this next generation of agro ecological innovation.

The term usually refers to upland/ unirrigated crop production, where the principles and methods from System of Rice Intensification (SRI) are adapted and utilized to raise the productivity of land, labor, water and nutrients when cultivating other crops.

System of Crop Intensification (SCI) emphasizes growing bigger, healthier root systems, and enhancement of soil fertility through promotion of soil biota (the life in the soil).

SCI methodology is based on four main, interacting principles:

- Establishing plants early and quickly, to favor healthy and vigorous root and vegetative plant growth
- Maintaining low plant density to allow optimal development of each individual plant and to minimize competitions between plants for nutrients, water and sunlight
- Enriching soils with organic matter to improve nutrient and water holding capacity, increase microbial life in the soil, and to provide a good substrate for roots to grow and develop,
- Reducing and controlling the application of water, providing only as much water as necessary for optimal plant development and to favor aerobic soil conditions.

Based on these principles, farmers adapt SCI practices to their climate zone, and to their agro ecological and socioeconomic conditions. Most common adaptations respond to soil conditions, water control, changing weather patterns, access to organic inputs, the decision to practice fully organic agriculture or not, access to labor, mechanization, and other socioeconomic factors. The SCI principles have been applied to crops, such as wheat, sugarcane, finger millet, mustard, and pulses all of which show increased productivity over current conventional planting practices.
How System of Crop Intensification Works?

**Soil preparation and management**

Deep soil ploughing specifically done during the summer works wonders on increasing the crop yields. It also reduces weeds, soil pathogens and pests considerably.

**Crop spacing**

SCI focuses on reducing the crop density per acre based on plant type and variety. Decreasing the density of crop per acre and maintaining a specific distance between the plants ensures that adequate space, light, nutrients and water is available per plant. This results in better plant growth and in turn better yields. Healthier plants have a stronger "immune and response system" which helps produce "phytochemicals" that naturally support plant development and protect the plant from external stresses.

**Systematic Application of Organic Inputs**

SCI involves timely application/spraying of specially prepared organic inputs – one is "a growth promoter cum insect repellent and the other is a fertilizer" - prepared with cattle manure and locally available ingredients. The combination of the two, even in highly deteriorated soils, results in enhanced plant growth, good colour, new shoots and flowering and early crop maturity. Over 3 seasons of regular usage it improves soil fertility, microbial and organic content in the soil, soil texture and soil water holding capacity.

**Micro-nutrient foliar spray and basal applications**

Degraded soil conditions with less organic matter and microbial content do not bring in the desired results in plant yields immediately. SCI promotes spraying of micro-nutrient and basal applications to provide adequate nutrients needed in the interim. This is phased off as the soil health improves and eventually it is totally stopped.

**Advantages of System of Crop Intensification**

1. **SCI is Simple to Follow**, understand and can be practiced by all farmers. It also is a method that can work in any agro-ecological system. It thus can be widely
applied across varied crops and ecosystems. SCI uses locally available, **inexpensive organic inputs** and only initial use of micro-nutrient foliar spray and basal applications thus making it low input technique.

2. **SCI a Viable Intermediate to Organic Farming**: Yields in low external input farming or organic farming increase gradually and actually give results after three years. For a resource poor farmer this is unacceptable. SCI is thus highly suitable for poor farmers as the yields do not show a sudden decrease because initially small amounts of chemical micro-nutrients are used as fertilizers. Pesticide usage is also nil. Over three seasons, as the soil health improves, the usage of micro-nutrients tapers off and the farmer eventually practices pure organic farming without having to face the initial losses due to reduced yields.

3. **SCI is a Climate Adaptive Method**: SCI method increases the plant's resilience and adaptive capacity. The plants are much bigger, healthier with stronger root system. They are able to withstand, strong winds, and high intensity rainfall and endure much less damage. The plants also have higher tolerance to heat especially during the dry spells. Adequate amounts of phytochemicals in the plant’s system help combat climate induced stresses such as pest attacks better. The application of the specially prepared organic fertilizers in the soil increase the capacity of the soil to hold moisture, due to which even with lesser water availability crop yields do not get much affected.

4. **Regular weeding and top soil management operations** minimize water loss from soil: making more water available for the plants

5. **Initial micro-nutrient sprays support** plant growth: ensures no drop in yields and physiological disorders
6. Healthier plants mature faster resulting in early harvests, thereby utilizing water more efficiently more ‘crop per drop’.

Indian Experience

Case Study 1:

What is now called the **System of Wheat Intensification** (SWI) was first tested in northern **India in 2006** by farmers working with the **People’s Science Institute (PSI)**. First-year trials near **Dehradun**, using several varieties, showed average increases of **18% to 67%** in **grain yield** and **9% to 27%** higher **straw yields** (important for subsistence farmers as fodder) compared with the yields that farmers usually attained with conventional broadcast methods for crop establishment.

Impressed with these results, PSI began promoting SWI in the states of Uttarakhand and Himachal Pradesh. Starting with 50 farmers in 2007, the number of smallholders using SWI methods expanded to more than 12,000 by the 2011-2012 winter season. Average increases in grain yields from irrigated **SWI reached 80% to 100%** over usual farmers’ practice. Despite the need for higher labour investments in sowing and weeding operations, farmers found the ratio of benefits-to-costs with SWI management to be favourable due to the higher yields of grain and straw.

**Case Study 2:**

**System of Rice Intensification (SRI)**

Rice is the main food crop cultivated in **Koraput** (37.54% of total cropped area under paddy crop) and also the **staple food of people**. The concepts, principles and practices of SRI, developed for irrigated paddy production, have been extended to rain fed areas in Koraput, for unirrigated rice production. **Starting with 11 small farmers** in Kharif 2006, SRI is now being **adopted by 11,443 farmers in Koraput District**. The technology is popularized
through video disseminations, skill trainings, creation of cadre of service providers, demonstrations, input supports and felicitation of successful farmers.

SRI has increased productivity **contributing to food security of the small and marginal farmers.** The small holders continuing the SRI principles due to **less investment in inputs and water requirement.** In the on-going journey for scale up of SRI, the technology is further enriched through **empirical research and farmers' innovations.** The principle of SRI is now **adopted in other crops like finger millet, pulses and vegetables.** District level symposiums are organised every year to spread the learnings and recognise the innovative farmers.

![Image](image_url)

**Organic Farming**

As per the definition of the United States Department of Agriculture (USDA), “organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection”.

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FAO suggested that “Organic agriculture is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs”.

Organic farming system in India is not new and is being followed from ancient time. It is a method of farming system which primarily aimed at cultivating the land and raising crops in such a way, as to keep the soil alive and in good health by use of organic wastes (crop, animal and farm wastes, aquatic wastes) and other biological materials along with beneficial microbes (biofertilizers) to release nutrients to crops for increased sustainable production in an eco friendly pollution free environment.

Need of organic farming

With the increase in population, our compulsion would be not only to stabilize agricultural production but to increase it further in sustainable manner. The scientists have realized that the ‘Green Revolution’ with high input use has reached a plateau and is now sustained with diminishing return of falling dividends. Thus, a natural balance needs to be maintained at all cost for existence of life and property. The obvious choice for that would be more relevant in the present era, when these agrochemicals which are produced from fossil fuel and are not renewable and are diminishing in availability. It may also cost heavily on our foreign exchange in future.

The key characteristics of organic farming include

- Careful attention to the impact of the farming system on the wider environment and the conservation of wildlife and natural habitats
- Nitrogen self-sufficiency through the use of legumes and biological nitrogen fixation, as well as effective recycling of organic materials including crop residues and livestock manures
Protecting the long term fertility of soils by maintaining organic matter levels, encouraging soil biological activity, and careful mechanical intervention

Providing crop nutrients indirectly using relatively insoluble nutrient sources which are made available to the plant by the action of soil micro-organisms

The extensive management of livestock, paying full regard to their evolutionary adaptations, behavioural needs and animal welfare issues with respect to nutrition, housing, health, breeding and rearing

Weed, disease and pest control relying primarily on crop rotations, natural predators, diversity, organic manuring, resistant varieties and limited (preferably minimal) thermal, biological and chemical intervention
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