EduTap

Agrometeorology

Crop Weather Advisory

Part 2

Contents

1 Crop Weather Advisory

- ✓ Weather plays an important role in agricultural production. Besides rainfall, others weather parameters are also playing an important role in influencing agricultural production.
- ✓ The advanced prediction of these weather events and crop planning (Crop Weather Advisory) based on prediction would help the farmer enormously reduce crop losses under aberrant weather situations and take up suitable contingency measures.

2 Indian Meteorological Department:

- ✓ The **India Meteorological Department** (**IMD**), also referred to as the Met Department, is an agency of the **Ministry of Earth Sciences** of the Government of India. It is the principal agency responsible for meteorological observations, weather forecasting and seismology.
- ✓ It was **established in 1875.**
- ✓ IMD is **headquartered in Delhi**.
- ✓ IMD is also **one of the six Regional Specialised Meteorological Centres of the World Meteorological Organization** (headquartered in Geneva, Switzerland).
- ✓ It has the responsibility for **forecasting, naming and distribution of warnings for tropical cyclones** in the Northern Indian Ocean region, including the Malacca Straits, the Bay of Bengal, the Arabian Sea and the Persian Gulf.

2.1 Mandate of IMD:

- ✓ To take **meteorological observations** and to **provide current and forecast meteorological information** for optimum operation of weather-sensitive activities like **agriculture, irrigation, shipping, aviation, offshore oil explorations** etc.
- ✓ To **warn against severe weather phenomena** like tropical cyclones, dust storms, heavy rains, snow, heat waves etc which cause destruction to life and property.

- ✓ To **provide meteorological statistics** required for agriculture, water resources management, industries, oil exploration and other nation-building activities.
- ✓ To **conduct and promote research in meteorology and allied disciplines.**
- ✓ To **detect and locate earthquakes** and to evaluate seismicity in different parts of the country for development projects.

2.1.1 Agricultural meteorology division of the IMD:

- ✓ This division was **established under IMD at Pune in 1932** in order to provide direct services to the farming community of the country.
- ✓ The **prime objective** is to **minimize the impact of adverse weather on crops** and to make use of crop-weather relationships to boost agricultural production.
- ✓ **Services of the Division:**
  - I. Gramin Krishi Mausam Seva
  - II. Dissemination of Agromet advisories
  - III. Feedback & Awareness of Agromet Service
  - IV. Training Programme to AMFUs (Agro-Met Field Units)

2.2 Agrometeorological services

- ✓ All **agrometeorological and agro-climatological information** that can be **directly applied to improve and/or protect the livelihood of farmers** in agricultural production may be considered to belong to agrometeorological services.
- ✓ This improvement/protection **applies to yield quantity, quality** and **income** while safeguarding the agricultural resource base from degradation
- ✓ The **Agromet Advisory Services** provide a very **special kind of inputs to the farmers** as advisories that can make a tremendous difference to the agriculture production by taking the advantage of benevolent weather and minimize the adverse impact of malevolent weather.

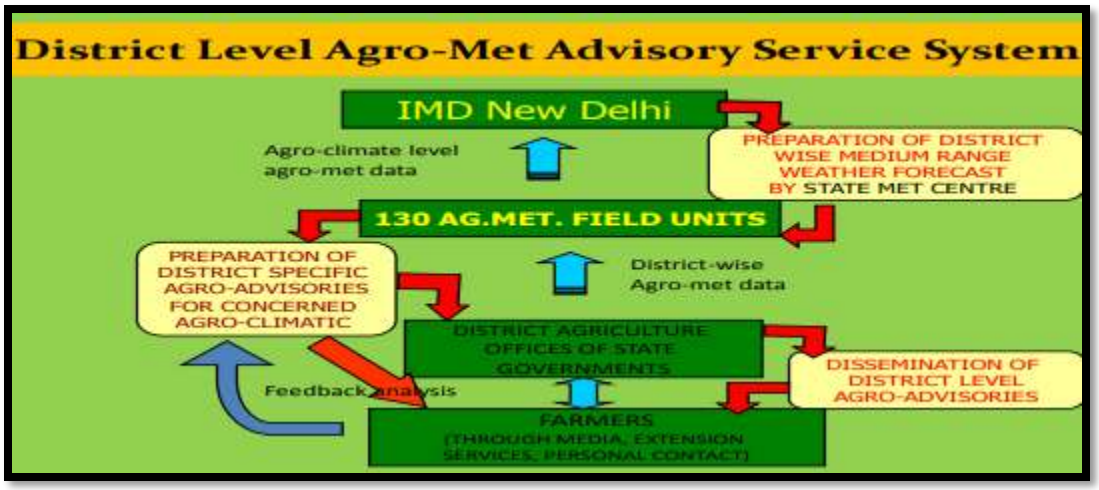
2.3 Integrated Agro-meteorological Advisory Service (IAAS) program of India

- ✓ India's Integrated Agro-meteorological Advisory Service (AAS) program is one of the largest agrometeorological information programs globally.
- ✓ The Indian Meteorological Department (IMD) started broadcasting weather services for farmers via **radio in 1945**.
- ✓ Agrometeorological advisories were **initiated in 1976**, providing state-level forecast-based guidance to farmers based on short-range weather forecasts from the IMD.
- ✓ However, the one-day advance advisories were inadequate for planning agricultural practices and precautions, requiring longer lead times.
- ✓ **Medium-range weather forecasts (3-10 days in advance)** tailored to specific locations hold greater significance for farmers in agriculture.
- ✓ **The NCMRWF was established in 1988** to develop operational **Numerical Weather Prediction (NWP)** models for forecasting weather in the medium range.

- ✓ **Agro Meteorological Field Units (AMFUs)** were created in all 127 agroclimatic zones across the country to disseminate forecasts and provide advisory services.
- ✓ The IMD assumed leadership of the AAS in 2007 and launched the **District-level Agrometeorological Advisory Service (DAAS) in 2008,** offering relevant weather information and management advisories at the district scale.

2.4 District-level Agrometeorological Advisory Service (DAAS)

- ✓ DAAS generates **district-level agrometeorological advisories** based on weather forecasts.
- ✓ It is a **multi-institutional project** involving various stakeholders, including ICAR, SAUs, KVKs, Department of Agriculture and Cooperation, State Departments of Agriculture, Horticulture, Animal Husbandry, Forestry, development NGOs, and media agencies.
- ✓ The program provides meteorological, agricultural, extension, and information dissemination services.
- ✓ Tailoring information to farmer needs at a district scale is achieved through Agro-Meteorological Field Units in each of the 131 agro-climatic zones.



2.5 How is the weather forecasting done?

- ✓ IMD issues **district-level 5-day weather forecasts twice a week** using a Multi-Model Ensemble technique.
- ✓ Forecasts include parameters like rainfall, maximum and minimum temperatures, wind speed and direction, relative humidity, cloudiness, and weekly cumulative rainfall.
- ✓ These forecasts are disseminated to **Regional Meteorological Centres and Meteorological Centres** of IMD in different states.
- ✓ Experts in these centres enhance the forecast products by considering local synoptic conditions and climatology.
- ✓ The value-added forecast is communicated to **130 AMFUs** located within SAUs, ICAR Institutes, and Indian Institutes of Technology.

- ✓ Agro-met field units receive the forecast and prepare advisories based on it.
- ✓ The prepared advisories are disseminated to farmers through a multi-channel dissemination network.

2.6 AAS (Agro-meteorological Advisory Service) Bulletins at different levels:

- ✓ Agromet Advisory Bulletins are issued **at district, state, and national levels**.
- ✓ **District-level bulletins** are prepared by 130 Agro-Met Field Units (AMFUs) and provide crop-specific advisories for field crops, horticultural crops, and livestock. They are issued twice a week, on Tuesdays and Fridays.
- ✓ **State-level bulletins**, jointly prepared by State Meteorological Centre and AMFUs, combine district bulletins to identify distressed districts and plan the supply of farm inputs like seeds, irrigation water, fertilizer, and pesticides.
  - ✓ State-level bulletins are important for the weekly Crop Weather Watch Group meetings and are used by government departments and organizations involved in agriculture.
- ✓ **National Agromet Advisory Bulletins** are created by the National Agromet Advisory Service Centre, using inputs from different states. These bulletins help identify crop stress in different regions of the country and provide suitable advisories.

- ✓ **A typical Agromet Advisory Bulletin enables farmers to reap benefits of benevolent weather and minimize or mitigate the impacts of adverse weather.**

2.6.1 Components of Agro-meteorological Advisory Service bulletin

- ✓ **District-specific weather forecast for the next 5 days**, including information on rainfall, cloud cover, maximum/minimum temperature, wind speed/direction, and relative humidity.
- ✓ **Forewarning of hazardous weather events** (such as cyclones, hailstorms, heatwaves, cold waves, droughts, and floods) that could affect crops, along with suggestions to protect the crops.
- ✓ **Information on soil moisture status** and guidance for irrigation, fertilizer application, and herbicide usage based on the weather forecast.
- ✓ **Advisories on optimal dates for sowing/planting** and recommendations for intercultural operations throughout the crop cycle, from pre-sowing to post-harvest activities.
- ✓ **Forewarning system for major pests and diseases** of principal crops, along with advice on plant protection measures.
- ✓ **Techniques for manipulating the crop's microclimate**, such as shading, mulching, surface modification, shelter belts, and frost protection, to safeguard crops under stressful conditions.
- ✓ **Livestock advisory on health, shelter, and nutrition.**

- ✓ **Overall, the bulletins issued are encoded in a format and language which is easy to comprehend by the farmer.**

2.7 Advisory Dissemination mechanism:

- ✓ The agromet district advisories, generated by 130 AMFUs, are **being disseminated to the farmers through mass media (Radio, Print and TV), Internet etc.**
- ✓ A mechanism has also been **developed to obtain feedback from the farmers** on quality of weather forecast, relevance and content of agromet advisory and effectiveness of information dissemination system.

Concept Check Questions

Q. All agrometeorological and agro-climatological information that can be directly applied to try to improve and/or protect the livelihood of farmers in agricultural production may be considered as _____.

A. Weather services
B. Meteorology services
C. Agrometeorological services
D. Specialized services
E. None of the above

Answer: Agrometeorological services

Explanation:

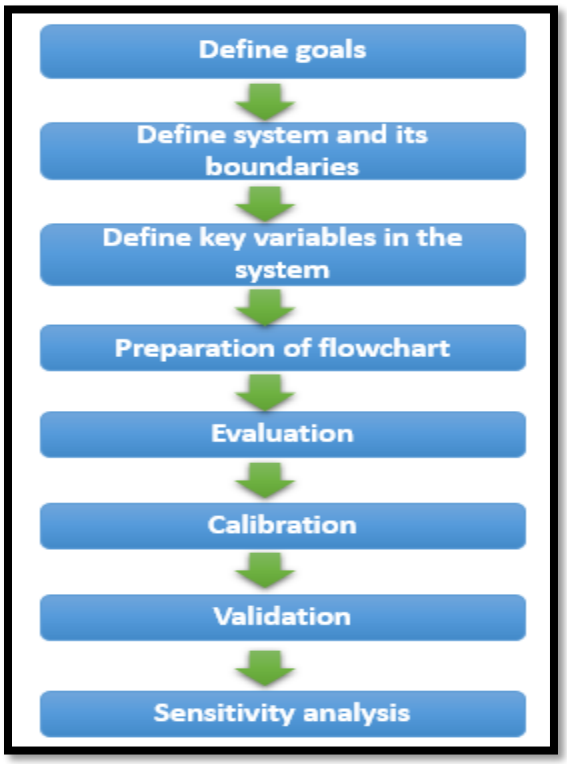
• All agrometeorological and agro-climatological information that can be directly applied to try to improve and/or protect the livelihood of farmers in agricultural production may be considered to belong to agrometeorological services.

• The Agromet Advisory Services provide a very special kind of inputs to the farmers as advisories that can make a tremendous difference to the agriculture production by taking the advantage of benevolent weather and minimize the adverse impact of malevolent weather.

3 Crop-Weather modelling:

- ✓ It is a **representation of a crop through mathematical equations** explaining the **crops interaction with both above ground and below ground environment.**
- ✓ Crop-weather modelling, firstly used by BAIER in 1979, refers to the techniques that can be used to determine the likely effects of weather on crop, its growth and production.
- ✓ It is not wrong to say that they are computer programs that mimic the growth and development of crops.

3.1 What are the steps involved in crop-weather modelling?



3.2 Important variables used in the system

1. **State Variables:** Those which can be measured. Example: Soil Moisture content, crop yield
2. **Rate Variables:** Rates of different processes operating in a system. Example: Photosynthetic rate, Transpiration rate etc.
3. **Driving Variables:** Variables which are not part of the system, but they affect the system. Example: Sunshine, Rainfall.
4. **Auxiliary Variables:** These variables are the intermediated products. Example: Dry matter partitioning, water stress.

3.3 Types of Models

✓ Depending upon the **purpose for which it is designed the models** are classified into different groups or types, they are:

Model Type	Description
Statistical	Expresses the relationship between yield or yield components and weather parameters using statistical techniques. Examples include step-down regressions and correlation analysis.
Mechanistic	Explains the relationship between weather parameters and yield, taking into account influencing dependent variables. These models are based on physical selection.

Deterministic	Estimates the exact value of the yield or dependent variable. These models have defined coefficients.
Stochastic	Includes a probability element for each output, providing different outputs with associated probabilities for a given set of inputs. Defines the yield or state of the dependent variable with probabilities.
Dynamic	Includes time as a variable, where both dependent and independent variables have values that change over a given period of time.
Static	Does not include time as a variable. Dependent and independent variables have constant values over a given period of time.
Phenological	Predicts crop development from one growth stage to another, based on accumulated heat limits.

✓ **Two important terms in the process of development of model are:**

1. **Model calibration:**
   Calibration is adjustment of the system parameters so that simulation results reach a predetermined level, usually that of an observation.
2. **Model validation:**
   The model validation stage involves the confirmation that the calibrated model closely represents the real situation. The procedure consists of a comparison of simulated output and observed data that have not been previously used in the calibration stage.

3.4 Some important Crop weather models running in India

Model	Description	Application
CERES	Crop simulation models used for various crops like Rice, Maize, Sorghum, Wheat in different regions of India.	Crop yield simulation and analysis in different regions.
DSSAT	Decision Support System used for assessing the impact of climate change on rice and developing adaptation strategies in the western zone of Tamil Nadu.	Evaluating climate change impact on rice production.
PRECIS	Generates high-resolution climate change information and can be applied in any region of the world.	Studying climate change impacts in different regions.
InfoCrop-RICE	Simulation analysis to quantify the impact of increased temperatures and elevated CO2 on rice yield.	Assessing the impact of temperature and CO2 on rice.

CROPGRO-Groundnut	Model used to quantify the impact of climate change on the productivity of groundnut in Anantapur, Mahboobnagar, and Junagadh.	Evaluating climate change impact on groundnut productivity.

3.4.1 Other crop models reported

Models	Details
REALSOY	Soyabean
IRRIGATE	Irrigation scheduling model
COTTOM	Cotton
GWM	General weed model in row crops
CropSyst	Wheat and other crops
LUPINMODE	Lupine
SIMPOTATO	Potato
WOFOST	Wheat and maize, water and nutrient
WAVE	Water and Agrochemicals
ORYZA1	Rice, Water
EPIC	Erosion productivity impact calculator
SIMCOY	Corn
QCANE	Sugarcane, potential conditions
AUSCANE	Sugarcane, potential & water stress conditions, erosion

Concept Check Questions

Q. _____ is a representation of a crop through mathematical equations explaining the crops interaction with both above ground and below ground environment.

A. Climate models
B. Crop Climate modelling
C. Weather report
D. Crop Weather modelling
E. None of the above

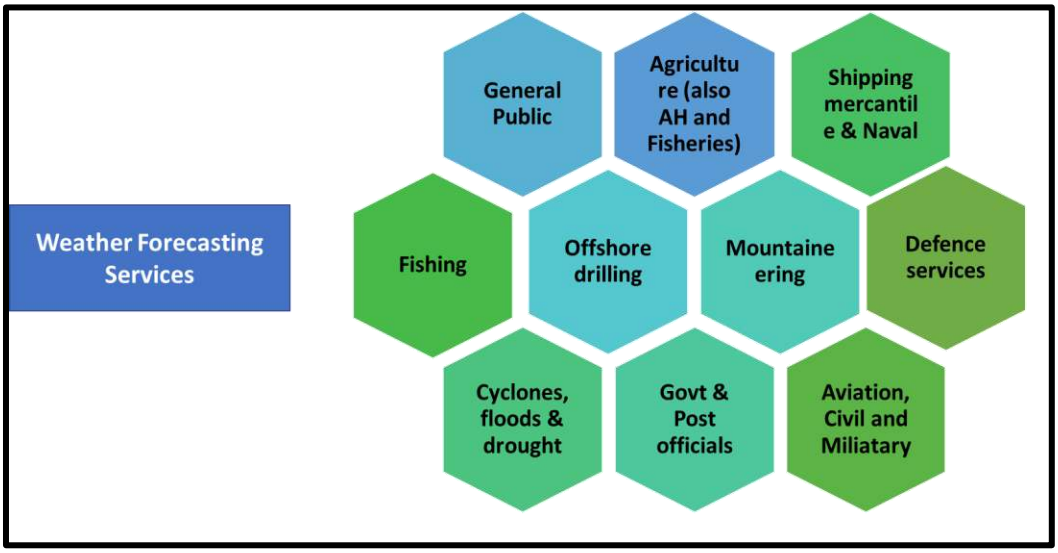
Answer: Crop Weather modelling

Explanation

- Crop weather modelling is a **representation of a crop through mathematical equations** explaining the **crops interaction with both above ground and below ground environment.**
- Crop-weather modelling, firstly used by BAIER in 1979, refers to the techniques that can be used to determine the likely effects of weather on crop, its growth and production.
- It is not wrong to say that they are computer programs that mimic the growth and development of crops.

4 Weather Forecasting:

- ✓ It means any **advance information about the probable weather in future**, which is obtained by evaluating the present and past meteorological conditions of the atmosphere.



4.1 Types of weather forecast:

Types of forecast	Validity period	Main users	Predictions
Short range	Upto 72 hours	Farmers marine agencies, general public	Rainfall distribution, heavy rainfall, heat and cold wave conditions, thunder storms etc.
a) Now casting	0 to 2 hours		
b) Very short range	0-12 hours		
Medium range	Beyond 3 days and upto 10 days	Farmers	Occurrence of rainfall, temperature
Long range	Beyond 10 days upto a month and a season	Planners	This forecasting is provided for Indian monsoon rainfall. The outlooks are usually expressed in the form of expected deviation from normal condition.

4.2 Weather Calender

- ✓ In order to **provide the farmers with an efficient weather service**, it is essential that the weather forecaster should be familiar with the crops that are grown in a particular agroclimatic zone.
- ✓ The type of forewarnings to be given depend on the stages of the crop.

- ✓ In case of farmers, **they should become familiar with weather bulletins and learn how to interpret.**
- ✓ To meet the above requirement, the **detailed information collected from the agricultural departments has been condensed by the IMD** and presented in a pictorial form known as crop weather calendar.
- ✓ This calendar has **three parts as follows:**

Section	Description
Top Part	Provides information about weather abnormalities and precautionary measures to be taken for the crop.
Middle Part	Gives information on normal weather conditions required for active crop growth, divided into sections such as rainfall, temperature, pan evaporation, and sunshine hours.
Bottom Part	Contains activities related to the crop and information about phenological stages of the crop and the corresponding months.

5 IMD Classification of the rainfall in India

- ✓ In the year 2016, the **IMD had come up with the revised terminologies** used in weather forecasting. **Below, we shall have a look at the earlier terminologies and the new ones**

New Terminology	Old Terminiology	Description
Normal	Normal	Percentage departure of realized rainfall is within plus minus 10% of the Long Period Average (lpa).
Below Normal	Below Normal	Percentage departure of realized rainfall is < 10% of the Long Period Average.
Above Normal	Above Normal	Percentage departure of realized rainfall is > 10% of the Long Period Average.
Deficient year	All India Drought Year	When the rainfall deficency is more than 10% and 20-40 % area of the country is under drough condition.
Large Deficient year	All India Severe Drought Year	When the rainfall deficency is more than 10% and when the spatial coverage of drought is more than 40%.

Long Period Average (LPA): *Averages of rainfall received between 1961 and 2010 (50 years) are termed as the Long Period Average or LPA and are considered as normal. This is computed to be 88cm.*

5.1 Criteria to classify the Seasonal Rainfall

- ✓ The rules have been **changed to classify seasonal rainfall**. IMD has introduced **6 new categories replacing old four rainfall categories (excess, normal, deficient and scanty).**

5.1.1 The new categories are

1. **Large Excess**: 60 percent and more above of the long period average (lpa)
2. **Excess**: between 20 percent and 59 percent more and above of the long period average (lpa)
3. **Normal**: minus 19 percent to plus 19 percent above of the long period average (lpa)
4. **Deficient**: minus 20 percent to minus 59 percent of the long period average (lpa)
5. **Large deficient**: below 60 percent of the long period average (lpa)
6. **No Rain**: 0 percent of the long period average (lpa)

- ✓ Average annual rainfall of India: (annual all India rainfall in mm 1901-2003 from India Meteorological department, IMD series & Indian Institute of Tropical Metrology, IITM Series) indicates that both the series show identical movement with the rainfall figures of IMD **(average 1183 mm or 119 cm)**

5.2 Certain standardized key terms given by the IMD

1. **Heat wave:** When the temperature is greater than 4.5-degree C above usual temperatures for the particular region.
2. **Severe heat wave:** When the temperature greater than or equal to 47-degree C.
3. **Cold wave:** When the temperature is less than 4.5-degree C than usual temperatures for the region.
4. **Severe cold wave:** When minimum temperature is 2-degree C or lower.

6 Weather aberrations

- ✓ **Weather aberrations may cause physical damage to crops and soil erosion**. The quality of crop produce during movement from field to storage and transport to market depends on weather.
- ✓ Bad weather may affect the quality of produce during transport, and the viability and vigour of seeds and planting material during storage. Thus, **there is no aspect of crop culture that is immune to the impact of weather**.
- ✓ Weather factors contribute to optimal crop growth, development and yield.
- ✓ One of the most important weather aberrations is Drought.

6.1 Drought

- ✓ Drought is the **consequence of a natural reduction** in the **amount of precipitation over an extended period of time**, usually a season or more in length, often associated with other climatic factors (viz. high temperatures, high winds and low relative humidity) that can aggravate the severity of the drought event.

6.2 Different types of drought:

Type	Description
Meteorological Drought	Seasonal rainfall over an area is less than 75% of its long-term average. Classified as "moderate drought" (rainfall deficit between 26-50%) or "severe drought" (deficit exceeding 50% of the normal).
Hydrological Drought	Prolonged meteorological drought leads to hydrological drought, causing depletion of surface water and drying up of inland water bodies (lakes, reservoirs, streams, rivers) and a decrease in the water table level.
Agricultural Drought	Inadequate soil moisture and rainfall impact crop growth, leading to extreme crop stress, yield loss, and wilting of plants.
Socio-Economic Drought	Abnormal water shortage affects the overall economy of a region, leading to unemployment, migration, discontent, and other societal problems. Meteorological, hydrological, and agricultural drought can contribute to socio-economic drought.

6.3 How does the India Meteorological Department monitor the Agricultural Drought?

- ✓ IMD has developed aridity indices to monitor agricultural drought scenario in the country based on rainfall, potential evapotranspiration and actual evapotranspiration using water budgeting method.
- ✓ **Let us have a look at the index used:**
  - India Meteorological Department (IMD) **monitors the incidence, spread, intensification and cessation of drought (near real-time basis)** on a **weekly time scale over the country** based on **Aridity Anomaly Index**.
  - It also issues **Weekly Drought Outlook**, based on this index, which **indicates the impending drought scenario in the country in the subsequent week.**
  - Based on aridity anomaly index, **weekly Aridity Anomaly Reports** and maps for the Southwest Monsoon Season for the whole country and for the Northeast Monsoon Season for the five meteorological sub-divisions are prepared.
  - These Aridity Anomaly maps/reports **help to assess the moisture stress** experienced by growing plants and to monitor agricultural drought situation in the country.

6.4 Aridity Anomaly Index (AAI):

- ✓ Aridity is the **Thornthwaite's concept to describe water deficiency experienced by plants.**
- ✓ Thornthwaite gave the **following formula for computing aridity index (AI):**

$$AI = \frac{PE - AE}{PE} \times 100$$

- ✓ PE denotes the water need of the plants (which is called potential evapotranspiration).
- ✓ AE denotes the actual evapotranspiration and (PE-AE) denotes the water deficit.

6.5 What is the concept behind using this Index?

Note: We have seen in detail about Evapotranspiration while seeing the climatic classification given by Thornthwaite.

- ✓ Rainfall is initially used by plants for evapotranspiration.
- ✓ Excess rainfall that is not utilized by plants percolates into the soil and recharges it.
- ✓ Soil moisture recharge continues until the soil reaches its field capacity.

Field Capacity: *It is the amount of soil moisture or water content held in soil after excess water has drained away and the rate of downward movement has materially decreased, which usually takes place within 2-3 days after rain or irrigation.*

- ✓ Any remaining excess rainfall is considered as water surplus and becomes surface or deep drainage runoff.
- ✓ When rainfall is lower than the evapotranspiration demands, plants extract moisture from the soil until it becomes dry.
- ✓ The Aridity Index measures the water stress experienced by growing plants due to a shortage of available moisture (rainfall and soil moisture).
- ✓ Normal values of the Aridity Index are determined for different locations representing various agroclimatic zones in the country.
- ✓ Each week, the actual aridity is computed based on the weekly rainfall and soil moisture conditions.
- ✓ The difference between the actual aridity and the normal aridity (Actual - Normal) is calculated as an anomaly.
- ✓ A negative or zero anomaly indicates less arid/drought conditions compared to normal, while a positive anomaly indicates more arid/drought conditions.

The positive values of the anomalies have been classified into three different classes as follows:

Anomaly of Aridity Index	Agricultural Drought Intensity
1 – 25	Mild
26 - 50	Moderate
> 50	Severe

6.6 Significance of Aridity Anomaly Index (AAI)

- ✓ Aridity Anomaly Map **gives information about the moisture stress experienced by growing plant.**
- ✓ This analysis would **indicate qualitatively retardation in the plants growth and so poor yields.**
- ✓ Indirectly, this may also be helpful for irrigation scheduling, the amount and the time at which the water is badly needed by the plant.

Note: There is another index known as **SPI (Standardized Precipitation Index),** computation of which is done at a monthly time scale. Kindly note the full form of it.

Concept Check Questions

Q. As per the classification of annual rainfall, in India by IMD, rainfall received between 20 percent and 59 percent of the long period average (lpa) can be classified as _____ category.

A. Large excess
B. Normal
C. Excess
D. Deficient
E. None of the above

Answer: Excess

Explanation:

Criteria to classify the Seasonal Rainfall-

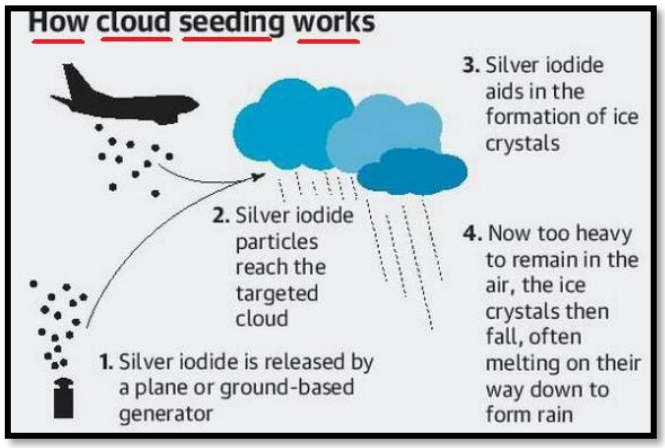
- Large Excess: 60 percent and above of the long period average (lpa)
- Excess: between 20 percent and 59 percent of the long period average (lpa)
- Normal: minus 19 percent to plus 19 percent of the long period average (lpa)
- Deficient: minus 20 percent to minus 59 percent of the long period average (lpa)
- Large deficient: below 60 percent of the long period average (lpa)
- No Rain: 0 percent of the long period average (lpa)

7 Weather Modification:

Weather modification refers to **willful manipulation of the climate or local weather**.

7.1 Cloud Seeding:

- ✓ **Exploding demand of water resources** and **continued population growth** has given rise to the problem of water scarcity in many regions of our planet.
- ✓ To **meet the demand of water resources scientist** have started using weather modification commonly called as cloud seeding.
- ✓ Cloud seeding is a **weather modification technique** which involves the **introduction of material into a cloud (using aircraft or ground-based generators)** with a view to encouraging the formation and growth of ice crystals or raindrops and, in turn, enhancing the precipitation (snow and/or rain) falling from the cloud.



- ✓ Cloud-seeding enterprises intending to create rain or snow basically try to spur on the condensation of water and **nudge the water to cling onto these introduced particles**, like silver iodine, or to **form more ice crystals by cooling the clouds' temperatures.**

7.2 There are two basic types of cloud seeding - Cold and Warm

- ✓ **Cold cloud seeding (glaciogenic seeding)** involves **adding particles** such as **silver iodide crystals or dry ice pellets** to the super-cooled (below freezing point) water already present in clouds to promote the formation of ice crystals. The ice crystals grow, fall and melt to below the freezing level to become raindrops.
- ✓ **Warm cloud seeding (hygroscopic seeding)** involves **adding salt particles (sodium, magnesium and calcium chlorides),** which **attract water** into or just below the base of suitable clouds to enhance the growth of cloud droplets by coalescence.

Coalescence process in precipitation:

- ✓ *In many parts of the world the air is too warm for ice crystals to form.*
- ✓ *This being the case, rain and snow cannot develop. Instead, tiny droplets form as they collide into one another creating larger and larger droplets.*
- ✓ *The coalescence of droplets into larger droplets can only take place if the droplets have an opposite electrical charge.*
- ✓ *That is to say that if one droplet has a positive charge and the other a negative charge, then they will coalesce (combine) upon collision.*
- ✓ *Otherwise they will just bounce off of one another.*

Concept Check Questions

Q._____ involves adding salt particles (sodium, magnesium and calcium chlorides), which attract water into or just below the base of suitable clouds to enhance the growth of cloud droplets by coalescence.

A. Warm cloud seeding
B. Hygroscopic seeding
C. Cold cloud seeding
D. Both 1 and 2
E. Both 2 and 3

Answer: Both 1 and 2

Explanation:

Warm cloud seeding (hygroscopic seeding) involves **adding salt particles (sodium, magnesium and calcium chlorides),** which **attract water** into or just below the base of suitable clouds to enhance the growth of cloud droplets by coalescence.

8 Weather Normal for various Agricultural Crops

Sl. No.	Crops	Optimum Temperature ° C		Day length	Rainfall (mm)	Altitude above MSL (m)
		Germination	Growth stage			
1	Rice	Min 10 ° C	22-25 (flowering) 20-21(grain formn) 20-25(ripening)		1500	<3000
2	Maize	35-44 ° C				
3	Sorghum	7-10	25-30	Short day		
4	Pearl millet		28-32		400-750	
5	Finger millet				500-1000	
6	Kodo millet				400-500	
7	Wheat	20-22	16-22		250-1800	<3500
8	Barley		12-15 (growth) 30(reproduction)	Long day	400-500	
9	Oats	15-25			380-1140	
10	Ground nut	27-30	24-27		500-1250	
11	Sesame	25-27		Short day	500-650	<1250
12	Castor	20-26		Long day	500-600	<3000
13	Sunflower	20-25			500-700	<2500
14	Rape seed and Mustard	18-25		Long day	300-400	
15	Safflower	15-16	25-30	Day neutral	600-900	
16	Soybean	15-32	30-33		600-650	1200-2000
17	Pigeon pea	20-30				
18	Green gram	15	20-40	Short day	600-1000	
19	Black gram					1500
20	Cow pea	12-15	21-35	Short day	600	
21	Bengal gram		15-25		600-1000	
22	Cotton	18	21-27	Day neutral	500	
23	Jute		27-40	Short day	1500	
24	Tobacco	28	25-35		500-1000	
25	Sugar cane		24-30	Long day	2000-2500	
26	Sugar beet	12-15	22-30	Long day		
27	Potato	18-20	18-20			