

# **Model Syllabus**

*Post Graduate*

in

# **Agricultural Meteorology**



*Association of Agrometeorologists*

*<https://agrimetassociation.org/>*



Association of **Agrometeorologists**

<https://www.agrimetassociation.org/>

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*Anand, Gujrat, India*



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*WMO, Geneva, Switzerland*

### ***Preface***

*Agricultural Meteorology integrates knowledge from a variety of scientific disciplines in order to determine how cropping systems are affected by weather and climate, and how cropping systems themselves affect weather and climate. The level of education and skills of students is insufficient to cope with new or aggravating problems, and there is a clear need for trained intermediaries who are equipped with services to assist the farming community in effectively dealing with these problems. Effective education and training in Agricultural Meteorology at the postgraduate level can ensure a continuous stream of well-informed intermediaries to serve the farming community.*

*There is an urgent need to review carefully the syllabus in Agricultural Meteorology at the postgraduate level and to ensure that the syllabus is fully revised to include new and emerging issues, and that adequate education and training material is prepared to serve the revised syllabus. Hence, the Association of Agrometeorologists (AAM) has come to set a goal to revise and update the syllabus in Agricultural Meteorology devised by Indian Council of Agricultural Research under its Broad Subject Matter Area (BSMA) Syllabus revision/recommendations.*

*The Association is deeply indebted to Prof (Dr) V Geethalakshmi, Vice Chancellor, TNAU, Coimbatore, Prof BV Ramana Rao, former PC - AICRP on Agrometeorology, ICAR-CRIDA, Hyderabad and Dr Surender Singh, Professor (Agril Meteorology), CCS HAU Hisar and Convener for their vision and continuous efforts to prepare the document on Model Syllabus in Agricultural Meteorology for MSc & PhD Programme in India. I wish to place on record the valuable inputs by all the content contributors and expert reviewers in revising and articulating curriculum in the light of technological developments and employability prospects in Agricultural Meteorology and allied sciences.*

*I earnestly hope that this document will be a reference curriculum to meet the needs and motivate different stakeholders.*

*5<sup>th</sup> January, 2024*

*KK Singh*



*Dr Surender Singh*

**Former Vice President-Association of Agrometeorologists**

*Professor - Agrometeorology, CCS HAU Hisar*

*Expert Member - Agrometeorology, WMO, Geneva, Switzerland*

### **Overview**

*Agricultural Meteorology, because it deals with various aspects of agricultural sustainability, approaches to managing natural resources and areas of concern in global change and environmental quality, is a very relevant science for addressing some of the most important issues facing society today and in the future. A revised and expanded curriculum in agricultural meteorology is needed to prepare post graduate students to deal effectively with solving current and future agricultural and environmental problems. Accordingly after an extensive parley among the experts and concerned senior fraternity for furtherance of discipline of Agricultural Meteorology, Association of Agrometeorologists decided to further restructure, revise and update the existing Broad Subject Matter Area (BSMA) PG Syllabus in the discipline of Agricultural Meteorology devised by Indian Council of Agricultural Research.*

*Taking over the responsibility of coordinating the exercise of refurbishing and drafting of model syllabus, various senior domain experts with explicit proficiency in designated courses in India and elsewhere were approached. The relevant contents thus received was further shared among all the PG Students, faculty members, learned luminaries and stakeholders in the discipline for further fine-tuning of model syllabus.*

*I express my gratefulness to Dr KK Singh, President Association of Agrometeorologists for giving me the opportunity to contemporize and accomplish the foregoing task in a short span of one month time. I am extremely thankful to all the subject content experts listed in the document for their stupendous contribution in updating, restructuring and articulating model syllabus.*

*I also take this opportunity to express a deep sense of gratitude to Dr YS Ramakrishna, former Director, CRIDA, Hyderabad; Dr TN Balasubramanian, founder Head (Agril Meteorology), TNAU, Coimbatore; Prof BV Ramana Rao, Dr GGSN Rao and Dr VUM Rao, all former Project Coordinators, AICRP on Agrometeorology, ICAR-CRIDA for their expert opinion, prophet guidance and precious input for further fine-tuning of the syllabus in its model form.*

5<sup>th</sup> January, 2024

Surender Singh  
Convener



***Model Syllabus***  
***in***  
***Agricultural Meteorology***

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*Model Syllabus*  
*in*  
*Agricultural Meteorology*  
*for*  
**MSc & PhD Programmes**

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***Vision***

*Association of Agrometeorologists (AAM) vision is to create a progressive pedagogy in Agricultural Meteorology to prepare future professionals, address increasingly adverse weather and climate challenges in ensuring sustainable agricultural production using the entire product portfolio available from the National Hydrological and Meteorological Services.*

***Mission***

*Our Mission is to evolve a broad academic program for agrometeorological operational excellence fostering strong student commitment to learning and community outcome.*

***Scope***

*Based on the present-day observations and review of the problems of graduates from Agricultural Meteorology that they suffer across the nation, the Association of Agrometeorologists (AAM) has come to set a goal to revise the syllabus of both MSc and PhD in Agricultural Meteorology to empower the Agro-met graduates of SAUs to compete both at National and Inter National level to get their lion share in the community. The revision of syllabus of Agricultural Meteorology has been done by the Senior Experts in the discipline of AAM to make it more contextual and pertinent to cater the needs of students in terms of global competitiveness and employability in the discipline. Many existing courses have been upgraded with addition and deletion based on contents from the ARS/Net Syllabus and Broad Subject Matter Area (BSMA) Syllabus devised by Indian Council of Agricultural Research, New Delhi.*



**Agricultural Meteorology**  
*Course Structure – At a Glance*  
**Master’s Degree Programme**

*Modified/Revised*

Course No.	Course title	Credit hours	Sem.
AGMET 501*	Fundamentals of Meteorology	3+1	I
AGMET 502*	Fundamentals of Agricultural Meteorology	2+1	I
AGMET 503*	Micrometeorology and Instrumentation	2+2	I
AGMET 504*	Weather Forecasting and Operational Agricultural Meteorology	2+1	II
AGMET 505	ET, Soil Water Balance and Hydrometeorology	2+1	I
AGMET 506	Crop Weather Models	2+2	II
AGMET 507	RS and GIS Applications in Agricultural Meteorology	2+1	II
AGMET 508	Database Management and Applications of Modern Technologies in Agril Meteorology	0+3	II
AGMET 509	ICT Applications in Agricultural Meteorology	2+1	II
AGMET 510	Weather Systems and Spatial Dynamics of Plant Insect-Pests & Diseases	2+1	I
AGMET 511	Agrometeorology of Plantation Crops	2+0	I
AGMET 512	Strategic Use of Climatic Information	2+1	II
AGMET 591	Master’s Seminar	1+0	I, II
AGMET 599	Master’s Research	30	I, II

\*Core Courses for Master’s Programme



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**AGMET 501 (3+1) : Fundamentals of Meteorology Sem-I**

**Theory**

**Unit I: Radiation**

Laws of radiation, radiant flux and flux density; Planck's law, Stephan-Boltzman law, Wien's displacement law; Kirchoff's law, Beer's law and Lambert's Cosine law; Solar radiation as source energy to run the atmospheric engine. Sun-earth system. Solar constant, length of day; Short and long wave radiation. Direct and diffuse radiation. Albedo. Depletion of solar radiation in the atmosphere – radiation balance in the atmosphere. astronomical and atmospheric factors Affecting Solar radiation, greenhouse effect. Units for measurement of radiation parameters. Structure of the upper atmosphere, troposphere. tropopause, stratosphere, ionosphere

**Unit II: Temperature**

Atmospheric temperature. Heat transfer; convection, conduction and radiation processes. Units for thermal conductivity, diffusivity and resistance. Concepts of specific heat at constant volume and pressure; Laws of thermodynamics. Latent heat and sensible heat. Factors affecting temperature at a place. Variation of temperature with height in the atmosphere. Potential temperature and virtual temperature. Terrestrial heat balance (Earth and atmosphere). Advection, soil temperature variations with depth, heat waves and cold waves.

**Unit III: Wind and Pressure**

Gas laws, pressure gradient, isobars, Equations of motion. Hydrostatic equation; Coriolis force, geostrophic wind, gradient wind and cyclostrophic wind; Pressure systems; Cyclones and anticyclonic motions: trough, ridge and col; Variation of wind and pressure with height. Thermal wind; Turbulence, Vorticity and Atmospheric waves. Land and sea breeze; Mountain and valley winds; Contour charts (Isobars/isotherms/isogons/isotachs), entropy, T-phi gram; Buys Ballot's law, Horse Latitudes, dust and snow storms

**Unit IV: Thermodynamics & Moisture in the atmosphere**

Vapor pressure and atmospheric humidity parameters, their units and their relationships (Absolute humidity, specific humidity, relative humidity, mixing ratio and dew point temperature; Saturation deficit (vapour pressure deficit); Psychrometric equation, Thermal Conductivity and Diffusivity, Resistance, Radiation, Light intensity and water vapour, Condensation processes; Dew, frost, fog, mist, haze, Cloud and hail; Bergeron-Findeisen theory; Moist and dry adiabatic processes and lapse rates; stability criteria of the atmosphere. Clouds, their description and classification; Thunderstorms and dust storms; Precipitation types and processes; artificial rain making. Air masses and fronts; Tropical and Extra tropical cyclones. T-φ gram, thermal instability, Thunder and lightning processes; Evapotranspiration estimation using Thornthwaite and Penman's methods, Pan evaporation, microclimates, aerosols, smog





### Unit VI: General Climatology

General circulation of the atmosphere – Hadley and Walker Cells. Climatology of Seasonal distribution of radiation, rainfall. Temperature, sunshine, wind and pressure over India and globally.

Climatic classification - Koppen and Thornthwaite; Continental, maritime and monsoon climates. Cyclones and cyclonic tracks over the Indian region; Western disturbances and their role in temperature and rainfall events over India. Drought climatology. rainfall variability in time and space, atmospheric drought – its intensity and duration, Moisture availability indices; Heat and cold waves; El-Niño, La Nina, Southern Oscillation Index and their impact on Indian rainfall systems. Thornthwaite's Water balance, Wet and Dry spells, Climatic/ Agroclimatic/ Ecological zones classification of India,, extra tropical systemes / fronts, Aurora Borealis, Arctic and Antarctic (Polar )climate conditions, Glaciers. MJO, Rossby waves, Di-pole systems.

### Unit VII: Climate Change

Climate variability and change. Role of human interventions on climate change. Ozone depletion/hole; Recent trends in climate. surface ozone, climate change impacts on agriculture, society, CC mitigation strategies

#### Practical Exercises:

1. Experiment to verify Stefan-Boltzmann's Law
2. Determination of solar constant using Stephen Boltzmann law and by using Pyranometer, Pyrheliometer or solarimeter
3. Estimation of global radiation using Angstroms equation and sunshine recorder
4. Estimation of net short wave radiation using Angstroms equation and sunshine recorder
5. Estimation of net long wave radiation and total net radiation (short + long) using equations
6. Determination of soil heat flux using heat flux plates
7. Practice on Psychrometric charts/tables to calculate the dew point, RH from DB/WB thermometers or psychrometers
8. Practice on computing Psychrometric constant, VPD, SVP, specific humidity (q), Absolute humidity, mixing ratio (w), and actual vapor pressure for station data
9. Practice on computation of Moisture Index ( $I_m$ ), Aridity Index ( $I_a$ ), Humidity index ( $I_h$ ), Thermal Efficiency summer concentration of T-E index and classify given station on Thornthwaite's Classification Scheme; Rainy days, estimation of wet and dry spells and their durations
10. Determination of thermal conductivity (k) diffusivity of soil
11. Computation of drought intensity on the basis of rainfall departure and drought classification for a region/station data using IMD Criteria, Aridity Index, Weekly anomaly Index, Soil moisture stress
12. Computation of Palmer's Drought indices for a region or station, SPI
13. Computation of drought periods using soil moisture stress for a station/region (CAZRI Method)
14. Estimation of soil moisture by microwave remote sensing method
15. Use and hands on Weather Cock software program for various analysis modules for rainfall and temperature



16. Determining seasonal and annual variations in rainfall, air, temperature, sunshine radiations and humidity at a given station or region, drawing of graphs, histograms

**Resources (books, journals, documents, websites)**

**Books:**

- Rosenberg, NJ; Blad, BL and Verma, SB· 1983. *Microclimate - The Biological Environment*. Wiley. ISBN: 978-0471060666.Pp 495.
- Kakde JR. 1985. *Agricultural Climatology*. Metropolitan Book. Co.
- Mahi GS and Kingra PK. 2014. *Fundamentals of Agrometeorology*. Kalyani Publishers.
- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co,
- Mavi HS, and Tupper JC. 2004. *Principles & Applications of Climate Studies in Agric*. CRC Press.
- Ghadekar SR. 2016. *Meteorology* (14<sup>th</sup> Edition), Agromet Publication, Nagpur
- Varshneya MC and Pillai PB. 2003. *Text Book of Agricultural Meteorology*. ICAR.
- Balasubramanian, TN; Jagannathan, R and Geethalakshmi, V. 2022. *Agro-Climatology-Advances and Challenges*. Taylor & Francis. ISBN: 978-1000534504. Pp 332.
- Ghadekar SR. 2002. *Practical Meteorology: Data Acquisition Techniques and Instruments*, Agromet Publishers Nagpur. Pp 68.

**Journals:**

- Journal of Agrometeorology
- Mausam
- Agricultural and Forest Meteorology
- Journal of the Meteorological Society of Japan
- Current Science
- Italian Journal of Agrometeorology

**Websites**

- <https://mausam.imd.gov.in/>
- <https://www.ncmrwf.gov.in/>
- <https://www.tropmet.res.in/>

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**AGMET 502 (2+1): Fundamentals of Agricultural Meteorology Sem-I**

**Theory**

**Unit I:** Meaning and scope of Agricultural Meteorology, components of agricultural meteorology ,role and responsibilities of Agricultural Meteorologists.

**Unit II:** Importance of different weather parameters in Agriculture. Crop growth and development, crop phenology, monitoring crop phenology using the concepts of growing degree days, photothermal units, heliothermal units. Role of Meteorological processes in photosynthesis, respiration and net assimilation. Leaf area index, partitioning of dry matter.



**Unit III:** Biotic interferences to crop growth. Pests and diseases that occur during different phenophases and sporadic in nature. Influence of weather factors on pests and diseases, Crop weather calendars

**Unit IV:** Concepts of evaporation, soil evaporation, evapotranspiration and potential evapotranspiration. Effects of radiation and water use on crop growth, dry matter production and crop yields, crop coefficients, relationship between leaf area index and crop coefficient. Water requirement of crops, water deficit, moisture stress, drought impacts on crops, trees, grasses

**Unit V:** Concepts of surface energy budget and soil water balance, water deficit, moisture stress, drought impacts on crops, trees, grasses, and their applications in agriculture, cardinal temperatures

**Unit VI:** Optimum weather conditions suitable for growing different crops. Effect of extreme weather conditions like droughts, floods, heat waves, cold waves, strong winds, hail storms etc on crops.

**Unit VII:** Agricultural droughts, early season, mid season, terminal droughts, apparent droughts and permanent droughts. Agricultural drought monitoring indicators and indices viz., Standardized Precipitation Index (SPI); Standardized Precipitation Evapotranspiration Index (SPEI); Combined Drought Indicator (CDI). Principles and practices of Agricultural Drought Management in dryland agriculture. National drought management guidelines. Agronomic practices of crop management, post drought/flood management.

#### **Practical Exercises:**

1. Computation of thermal units, photo-thermal units, helio-thermal units
2. Phenological stages of crop development for different crops
3. Phenology of crops in relation to thermal units, photo-thermal units and helio-thermal units.
4. Measurement of leaf area index. Plotting leaf area index vs crop growth duration for some of the important crops
5. Computation of Potential evapotranspiration using Penman's method
6. Relationship between open pan evaporation and potential evapotranspiration during different months and seasons
7. Estimation of crop water requirements and its matching with normal rainfall distribution, identification of critical periods of moisture stress based on crop pheno stage and water needs, probabilities of dry and wet spell durations within growing season
8. Soil water balance, assessment of crop water use and calculation of water requirement satisfaction index
9. Study relationships between crop water use and biomass production and yield
10. Relationship between solar radiation and visible radiation
11. Radiation and water use efficiencies of crops
12. Meteorological drought, computation of dry spells and wet spells.
13. Computation of Standardized Precipitation Index (SPI); Standardized Precipitation Evapotranspiration Index (SPEI); Combined Drought Indicator (CDI) for agricultural drought monitoring
14. Characterization of early season, mid season and terminal agricultural droughts
15. Preparation of crop weather calendars



16. Interpretation of rainfall & thermal regimes for crop planning in rainfed and irrigated conditions.

**Resources (books, journals, documents, websites)**

**Books:**

- Varshneya MC and Pillai PB. 2003. *Text Book of Agricultural Meteorology*. ICAR.
- Balasubramanian, TN; Jagannathan, R and Geethalakshmi, V. 2022. *Agro-Climatology-Advances and Challenges*. Taylor & Francis. ISBN: 978-1000534504. Pp 332.
- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Prasada Rao, GSLHV. 2019. *Agricultural Meteorology* (Fifth Printing). PHI Learning Private Limited, New Delhi. ISBN: 978-8120333383. Pp 364.
- Kakde JR. 1985. *Agricultural Climatology*. Metropolitan Book Co.
- Mahi GS and Kingra PK. 2014. *Fundamentals of Agrometeorology*. Kalyani publishers.
- Mavi, HS and Tupper J. 2004. *Principles & applications of climate studies in agriculture*. CRC Press
- Ghadekar, SR. 2004. *A Text Book of Agrometeorology (Reprinted 2013)*. Agromet Publishers, Nagpur. Pp 218.
- Anonymous. 2016. *Manual for Drought Management*. Published by Dept of Agric, Coop & Farmers Welfare, Ministry of Agriculture & Farmers Welfare, Govt of India, New Delhi. Pp 154.

**Journals:**

- Journal of Agrometeorology
- Italian Journal of Agrometeorology
- Agricultural and Forest Meteorology
- Current Science

**Websites:**

- <https://www.imdagrimet.gov.in/>
- <https://www.fao.org/home/en>
- <https://www.droughtmanagement.info/>
- <https://www.ipcc.ch/>

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**AGMET 503 (2+2): Micrometeorology and Instrumentation Sem-I**

**Theory**

**Unit I:** Concept of macro, meso and micrometeorology; Properties of atmosphere near the earth's surface; Shearing stress, forced and free convection; molecular and eddy diffusion, advection, recording of standard meteorological observations, Automatic Weather Stations (AWS), meteorological Instruments Systems/sensors and Data loggers for weather monitoring

**Unit II:** Molecular and eddy transport of heat, water vapor and momentum between surface and overlaying atmosphere ; fluxes of mass, energy and momentum transfer, exchange coefficient; similarity hypothesis, Bowen's ratio and measurement of evapotranspiration using Bowen's ratio method



**Unit III:** Boundary layer, frictional velocity, roughness parameter and zero plane displacement, temperature instability, eddy covariant technique, Microclimate near the bare ground ; Inversion layers, Variation in microclimate under irrigated and rainfed conditions; Soil moisture and temperature variation with depth; Richardson's number, Reynolds analogy

**Unit IV:** Microclimatology of crops viz., rice and wheat; Micrometeorology of plant canopies; Distribution of temperature, humidity, vapor pressure and carbon dioxide; Inversion and its effect on smoke plume distribution, Radiation distribution and utilization by plant communities, leaf temperature and its biological effects, Influence of topography on microclimate

**Unit V:** Microclimate modification due to cultural practices, inter cropping, wind breaks, shelter belts, mulches ,protection from heat waves, cold waves; Microclimate of low meadows and grain fields, forests, orchards

**Unit VI:** Microclimate in glass houses, poly houses, poultry and cattle sheds

**Unit VII:** Spectral properties of vegetation, leaf temperature and its biological effects, light interception by crop canopies as influenced by leaf area index, leaf arrangement and leaf transmissibility, extinction coefficient and radiation use efficiency

**Unit VIII:** Effect of ambient weather parameters on crop growth, development and yield of crops; Remote sensing applications in micrometeorology.

**Practical Exercises:**

1. Standard meteorological observations recording and filling of weekly weather charts of all weather parameters along with standard meteorological weekly means
2. Determination of wind speed over and within crops, zero plane displacement for a crop
3. Boundary layer and micrometeorological measurements
4. Computation of momentum flux gradient
5. Computation of sensible heat flux
6. Computation of latent heat flux
7. Computation of CO<sub>2</sub> flux
8. Computation of values of roughness length for different crops
9. Modification of microclimate by different wind breaks
10. Determination of Bowen Ratio
11. Hands on micrometeorological methods on determination of Ep and ET
12. Working with datasets of Fluxnet- Global Network of Micrometeorological Tower sites
13. PAR interception in plant canopies, PAR distribution in plant canopies and its interpretation
14. Measurement of leaf area index and net radiation interception
15. Measurement evapotranspiration using gravimetric lysimeter
16. Measurement of evapotranspiration using volumetric lysimeter
17. Study of radiation interception ,reflection and transmission by the crop canopy



18. Measurement of profiles of air temperature, atmospheric humidity and vapor pressure within and outside crop canopy, use of infrared gun for measuring canopy -air temperature differences
19. Measurement of wind speed profile within and outside crop canopies; zero plane displacement and roughness parameters
20. Measurement of solar radiation profile, depletion of solar radiation within crop canopy,
21. Estimation of Percent of PAR to Short wave radiation, Steady State porometer
22. Measurement of soil heat flux in bare and cropped soils, soil temperature, earth (Lag) thermometers
23. Surface energy budget and estimation of Evapotranspiration
24. Measurement of evapotranspiration using Bowen's ratio method, soil moisture measurement, gravimetric, gypsum blocks, Neutron moisture meter methods
25. Evaluation of shelter belts and wind breaks in wind speed reduction
26. Evaluation of the effect of mulches on crop microclimate, Infrared tele-thermometer use.
27. Effect of leaf size and wind speed on sensible heat flux and convection
28. Estimation of evapotranspiration using aerodynamic method
29. Microclimate measurements in a glasshouse
30. Microclimate measurements in polyhouse and shade nets
31. Microclimate measurements in a poultry house
32. Microclimate measurements in dairy farm.

**Resources (books, journals, documents, websites)**

**Books:**

- Sutton, OG.1953. *Micrometeorology - A Study of Physical Processes in the Lowest Layers of the Earth's Atmosphere*. McGraw-Hill. Pp 333.
- Ghadekar SR (2020): *Introductory Micrometeorology*. Agromet Publication, Nagpur, ISBN: 978-9383502622. Pp 191.
- Monteith, JL.1972. *Survey of instruments for Micrometeorology*. London, International Biological Programme; Oxford, Blackwell Scientific. ISBN: 0632085207. Pp 264.
- Arya, SP. 2001. *Introduction to Micrometeorology*. Academic Press. ISBN: 978-0080489261. Pp 446.
- Law B, Massman, W and Lee, X. 2004. *Handbook of Micrometeorology-A Guide for Surface Flux Measurement and Analysis*. ISBN: 978-1402022654. Pp 250.
- Munn, RE. 2013. *Descriptive Micrometeorology*. Elsevier Science. ISBN: 978-1483282251. Pp 260.
- Edgar, W. and Middleton, K.1969. *Invention of the Meteorological Instruments*. Johns Hopkins Press. ISBN: 978-0608147079. Pp 362.
- Meteorological Office, Great Britain. 1956. *Handbook of Meteorological Instruments*, Part 1. H.M. Stationery Office. ISBN: 978-0114000998. Pp 458.



### Journals:

- Journal of Geophysical Research: Atmospheres
- Theoretical and Applied Climatology
- Geophysical Research Letters
- Atmosphere
- Mausam
- International Journal of Biometeorology
- Journal of Agronomy
- Crop Science

### Websites:

- <https://www.mmm.ucar.edu/>
- [https://www.microstep-mis.com/web/products?category=meteorology\\_climatology](https://www.microstep-mis.com/web/products?category=meteorology_climatology)
- <https://education.nationalgeographic.org/resource/science-art-meteorology/>
- <https://www.fao.org/in-action/samis/agrometeorology/ar/>
- <https://community.wmo.int/en/activity-areas/agmp>

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### **AGMET 504 (2+1): Weather Forecasting and Operational Agril Meteorology Sem-II**

#### **Theory**

**Unit I:** Weather forecasting system: definition, scope and importance; types of forecasting: short, medium and long-range; study of synoptic charts with special reference to location of highs and lows, jet streams, synoptic features and weather anomalies and zones of thermal advection and interpretation of satellite pictures of clouds (cloud imageries) in visible and infra-red range; Synoptic charts and synoptic approach to weather forecasting, weather forecasting network.

**Unit II:** Approaches for weather forecasts: methods of weather forecasts - synoptic, numerical prediction, statistical, analogue, persistence and climatological approach, nano- technological approach, Indigenous Technical Knowledge (ITK) base- signals from flora, fauna, insects, birds, animals behavior; various methods of verification of location-specific weather forecast, satellite images, remote sensing, cloud top temperatures

**Unit III:** Special forecasts: special forecasts for natural calamities such as drought, floods, high winds, cold (frost) and heat waves, hail storms, cyclones and protection measures against such hazards.

**Unit IV:** Modification of weather hazards: weather modification for agriculture; scientific advances in artificial rain making, hail suppression, dissipation of fog and stratus clouds, modification of severe storms and electric behavior of clouds.

**Unit-V:** Monsoon: origin/mechanism. Indian monsoon and its seasonality. Onset, advancement and withdrawal/retreat in different parts of India. Monsoon trough, Monsoon depression and monsoon break. Factors affecting rainfall distribution over India during monsoon and other seasons, Meteorological



satellites for weather forecasts; Forecast of Indian monsoon rainfall; influence of El Nino and La Nina, MJO and other parameters on monsoon behaviour

**Unit VI:** Weather based advisories: Use of medium, long range forecast and vegetative indices based agro meteorological information for monitoring crop prospects and yield forecasts; interpretation of weather forecasts for soil moisture, farm operations, pest and disease development and epidemics, crops and livestock production; preparation of weather-based advisories and dissemination. Early warning systems for farm operations, sub-seasonal to seasonal (S2S) forecasts, Introduction to soil moisture models, crop growth models, statistical and heuristic models

**Practical Exercises:**

1. Determining criteria and declaring onset of monsoon rains in the given Agroclimatic zone
2. Determining criteria and declaration of sowing /planting dates on the basis of soil moisture storage in soil and continuity of wet spell in the given Agroclimatic zone
3. Soil moisture and water balance computation with weather data using Thornthwaite-Mather's book for the station/region; soil sample collection and soil moisture estimation using gravimetric method
4. Crop monitoring during growing season and quantitative crop yield assessment using Simple Crop Water Balance Method of FAO model (Frerre-Popove,1979)
5. Weather based forewarning of crop pests and diseases viz., Apple Scab, Potato blight, Leaf Spot in Groundnut & Downey Mildew in Grapevines (Simple models)
6. Weather based forewarning of crop pests and diseases (Computer aided) using suitable models
7. Preparation of crop weather calendar for major crop
8. Plant diseases forecast models, Percent disease index and weather forecast importance in model development
9. Insect-pests forecast and weather forecast importance in model development
10. Preparation of weather-based agro-advisories based on weather forecast using various approaches
11. Preparation of synoptic charts for the station and the region
12. Visit of IMD-Met Center for understanding forecasting techniques through instruments
13. Economic impact studies accrued through weather forecast, NCAER report
14. All India weather forecast bulletins and alerts
15. Dissemination mechanisms for end-users and stakeholders
16. Collection of ITK evidences related to weather for the region

**Resources (books, journals, documents, websites)**

**Books:**

- Watts A. 2011. *Instant Weather Forecasting*. Adlard Coles Nautical. Pp 64.
- Balasubramanian, TN; Jagannathan, R and Geethalakshmi, V. 2022. *Agro-Climatology-Advances and Challenges*. Taylor & Francis. ISBN: 978-1000534504. Pp 332.
- Rama Sastry AA. 1984. *Weather and Weather Forecasting*. Publication Division, GOI, New Delhi. Pp 207.





- Prasada Rao, GSLHV; Rao, VUM and Rao, DVS. 2019. *Climate Change and Agriculture: Causes, Impacts and Interventions*. New India Publishing Agency. ISBN: 978-9387973626. Pp 586.
- Singh SV, Rathore LS and Trivedi HKN. 1999. *A Guide for Agrometeorological Advisory Services*. DST, NCMRWF, New Delhi. Pp 201.
- Wegman EJ and DePriest DJ. 1980. *Statistical Analysis of Weather Modification Experiments*. M. Dekker Publisher. ISBN: 978-0824711771. Pp 145.

#### Journals:

- Journal of Climatology and Weather Forecasting
- Theoretical and Applied Climatology
- Atmospheric Research Journal
- Journal of Agrometeorology
- Agroclimatology

#### Websites:

- <https://mausam.imd.gov.in/>
- <https://www.tropmet.res.in/>
- <https://www.ncmrwf.gov.in/>
- <https://www.imdagrimet.gov.in/>

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### AGMET 505 (2+1): ET, Soil Water Balance and Hydrometeorology Sem-I

#### Theory

**Unit I:** Hydrological cycle, concepts of water balance, concepts of evaporation, evapotranspiration, reference evapotranspiration and potential evapotranspiration, consumptive use. Introduction to Ritchie and SPAW water balance models, Climatic classifications and drought

**Unit II:** Energy concept of soil water, hydraulic conductivity and soil water flux. Theory on hydraulic conductivity of saturated and unsaturated soils; physical factors concerning water movement in soil.

**Unit III:** Theories of evapotranspiration and their comparison; empirical, aerodynamic, energy balance Bowen's ratio approaches; Water balance - single and multilayered models; Measurement of evapotranspiration using volumetric and gravimetric lysimeter; canopy temperature based methods; advantages and disadvantages of different methods

**Unit IV:** Water use and water use efficiency, dry matter production and crop yield functions; Irrigation scheduling based on ET; Advective energy determination and its effect on crop water use; Physiological variation in relation to crop growth and development, weekly and monthly climatic water balance using book keeping procedure for drought analysis.

**Unit V:** Influence of microclimatic and cultural factors on soil water balance; Crop coefficients and its computation; use of crop coefficients, irrigation scheduling based on climatological approaches

**Unit VI:** Infrared tele-thermometers, Concept of stress degree days, Relationship between stress degree days and crop yields; Remote sensing techniques for determining evapotranspiration.



**Unit VII:** Water cycle and its phases (solid, vapor, liquid); water movement within the surface, subsurface-atmosphere continuum, cloud and precipitation formation, mechanisms involved in extreme precipitation (snow, ice, convective precipitation, and non-convective precipitation), floods, drought, and precipitation monitoring and forecasting

**Practical Exercises:**

1. Estimation of evapotranspiration based on weather data using empirical methods (Thornthwaite, Thornthwaite and Mather, Penman, Penman-Monteith, Blaney and Criddle methods) and compare ET computed with simple methods viz., Hargreaves, Makkink, Priestly and Taylor, Turc etc.
2. Simple soil water balance models
3. Thornthwaite Water balance model
4. Measurement of hydraulic conductivity of soil
5. Measurement of water storage in the root zone
6. Surface energy budget for measuring evapotranspiration
7. Aerodynamic method of measuring evapotranspiration
8. Bowen's ratio method of measuring evapotranspiration
9. Measuring advection effect on crop water use
10. Infrared tele-thermometer and computation of stress degree days
11. Relationship between LAI and crop coefficient
12. Measurement of ET using gravimetric and volumetric lysimeter
13. Soil moisture retention characteristics using pressure plate method
14. Estimation of crop water requirements during different stages of crop growth
15. Crop water use, irrigation scheduling and crop yield modeling

**Resources (books, journals, documents, websites)**

**Books:**

- Burman R and Pochop LO. 1994. *Evaporation, Evapotranspiration and Climatic Data*. Elsevier.
- Grace J.1983. *Plant Atmospheric Relationships: Outline Studies in Ecology*. Chapman & Hall.
- Mavi HS and Tupper JC. 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.
- Rosenberg NJ, Blad BL and Verma SB.1983. *Microclimate –The Biological Environment*. John Wiley & Sons. Pp 467.
- Subramaniam VP. 1982. *Water balance and its application*. Andhra University Press, Waltair, India. Pp 102.
- Shuttleworth JW. 2012. *Terrestrial Hydrometeorology*. Wiley. ISBN: 978-0470659373. Pp 448.
- Allen, RG; Pereira LS; Raes D and Smith M. 1998. Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage paper 56. ISBN 92-5-104219-5. <https://www.fao.org/3/x0490e/x0490e00.htm>



**Journals:**

- Journal of Agrometeorology
- Archives of Agronomy and Soil Science
- Agricultural Water Management
- Journal of Hydrometeorology
- Journal of Plant Ecology

**Websites:**

- <https://www.icrisat.org/>
- <https://www.iwmi.cgiar.org/>
- <http://www.iiwm.res.in/>
- <https://www.iwra.org/>

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**AGMET 506 (2+2): Crop Weather Models Sem-II**

**Theory**

**Unit I:** Impact of natural and induced variability of climate on crop production; system introduction; system analysis; characteristics of system; elements of system; types of systems; systems models

**Unit II:** Introduction and application to crop modeling, model building; types of models, Empirical and statistical crop weather models their application with examples; concept of crop growth model in relation to weather, soil, plant and other environmental related parameters and remote sensing inputs; growth and yield prediction models;

**Unit III:** Dynamic crop simulation models, e.g. DSSAT, InfoCrop, APSIM, CropSyst, etc; optimization, calibration and validation of models.

**Unit IV:** Weather data and physiology-based approaches to modeling of crop growth and yield; stochastic models; advantages and limitation of modeling.

**Unit V:** Survey surveillance and forecasting of Insect pest and diseases, development and validation of Integrated Pest Management (IPM) module, implementation and impact of IPM

**Practical Exercises:**

1. Working with weather data and physiology based approaches to modeling of crop growth and yield
2. Working with remote sensing inputs; growth and yield prediction models
3. Working with statistical and simulation models, DSSAT models, InfoCrop, APSIM, CropSyst, Oryza model etc
4. Working with forecasting models of pests and diseases
5. Working on optimization, calibration and validation of models
6. Discrete event simulation and Simulation from specific models applicable in agriculture.



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**Resources (books, journals, documents, websites)**

**Books:**

- Makowski D; Jones, JW and Brun F. 2019. Working with Dynamic Crop Models - Methods, Tools and Examples for Agriculture and Environment; Third Edition.
- DeWit CT, Brouwer R and de Vries FWTP. 1970. *The Simulation of Photosynthetic Systems*. pp.7-70. In. Prediction and Measurement of Photosynthetic Activity. Proc. Int. Biological Programme Plant Physiology Tech. Meeting Trebon PUDOC. Wageningen.
- Duncan WG. 1973. SIMAI- *A Model Simulating Growth and Yield in Corn*. In: *The Application of Systems Methods to Crop Production* (DN Baker, Ed.). Mississippi State Univ. Mississippi.
- Frere M & Popav G. 1979. *Agrometeorological Crop Monitoring and Forecasting*. FAO.
- Balasubramanian, TN; Jagannathan, R and Geethalakshmi, V. 2022. *Agro-Climatology-Advances and Challenges*. Taylor & Francis. ISBN: 978-1000534504. Pp 332.
- Hanks RJ. 1974. *Model for Predicting Plant Yield as Influenced by Water Use*. Agron. J. 66: 660-665.
- Keulen H Van & Seligman NG. 1986. *Simulation of Water Use, Nitrogen Nutrition and Growth of a Spring Wheat Crop. Simulation Monographs*. PUDOC, Wageningen.
- Singh P. 2008. *Modeling of crop production systems: Principles and applications*. CRC Publishers. ISBN:978-1482280449. Pp 510.
- Cao, W, Jeffrey W and Wang, E. 2010. *Crop modeling and decision support*. Tsinghua University Press. ISBN: 978-3642011320. Pp 333.
- Peshin, R and Dhawan, AK. 2009. *Integrated Pest Management: Volume 2: Dissemination and Impact*. Springer Netherlands. ISBN: 9781402089909. Pp 628.

**Journals:**

- Agricultural Systems
- Journal of Agrometeorology
- Global Environmental Change
- Environmental Modeling & Software
- Mitigation and Adaptation Strategies for Global Change

**Websites:**

- <https://bigdata.cgiar.org/>
- <https://www.apsim.info/>
- <https://dssat.net/>
- <https://www.quantitative-plant.org/>
- <https://ncipm.icar.gov.in/>

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**AGMET 507 (2+1): RS and GIS Applications in Agricultural Meteorology Sem-II**

**Theory**

**Unit I:** Principle of remote sensing; components of remote sensing, sensors and sensing systems; active and passive remote sensing. microwave remote sensing

**Unit II:** Characteristics of electromagnetic radiation and its interaction with matter; spectral characteristics of earth's surface features; remote sensors in visible, infrared and microwave regions.

**Unit III:** Imaging and non-imaging systems; framing and scanning systems; resolution of sensors; satellite types and their launching vehicles, country specific space programmes.

**Unit IV:** Data acquisition system, data preprocessing, storage and dissemination; digital image processing and information extraction, visual and digital image interpretation. Introduction to GIS and GPS, Drone technology

**Unit V:** Microwave remote sensing; visual and digital image interpretation; introduction to GIS and GPS, Drone technology.

**Unit VI:** Digital techniques for crop discrimination and identification; crop stress detection, soil moisture assessment, inventory of ground water, satellite measurement of surface soil moisture and temperature; agricultural drought monitoring, monitoring of crop disease and pest infestation, use of satellite data in weather forecasting.

**Unit VII:** Land use/land cover mapping and planning; integrated watershed development; crop yield modeling and crop production forecasting, remote sensing in climate change studies

**Practical Exercises:**

1. Acquisition of maps
2. Field data collection and ground truthing
3. Computation of and radiation emission by recording surface temperatures
4. Measurement of different components of solar radiation from different crop
5. Prediction of crop yield using Remotely sensed data
6. Detection of water stress in crops using remote sensing technique
7. Measurement of spectral reflectance characteristics of different surfaces using spectro-radiometer
8. Software and hardware requirements and specification for remote sensing
9. Computation of the vegetation indices from the radiometric data
10. Estimation of Evapotranspiration using remotely sensed data
11. Computation of surface energy balance in a crop canopy
12. Determination of map and imagery scale
13. Time domain reflectometry
14. Visual Image Interpretation and analysis
15. Digital Image Interpretation – Image Classification
16. Image Processing Software Hands on



**Resources (books, journals, documents, websites)**

**Books:**

- Campbell, JB. 1996. *Introduction to Remote Sensing, 2<sup>nd</sup> ed.*, The Guilford Press, New York.
- Chang KT. 2002. *Introduction to Geographic Information Systems*. Tata McGraw Hill Publishing Co. ISBN: 978 0072382112. Pp 348.
- Georg J. 2005. *Fundamentals of Remote Sensing*. University Press (India).
- Jain AK. 1989. *Fundamentals of Digital Image Processing*, Prentice Hall of India.
- Lilisand, TM, Kiefer, RW and Chipman, JW. 2003. *Remote Sensing and Image Interpretation, 5<sup>th</sup> ed.*, John Wiley & Sons, Inc., New York.
- Nag P and Kudrat M. 1998. *Digital Remote Sensing*, Concept Publishing Company, New Delhi.
- Panda BC. 2008. *Principles and Applications of Remote Sensing*, Viva Publications.
- Patel AN and Surender Singh. 2004. *Remote Sensing: Principles and Applications*. Scientific Publ.
- Reddy Anji M. 2008. *Text Book of Remote Sensing and Geographic information System*, BS Publications, Hyderabad, ISBN: 978-6000019679. Pp 453.

**Journals:**

- Journal of Remote Sensing and GIS
- Journal of Agrometeorology
- Journal of Global Environmental Change
- Journal of the Indian Society of Remote Sensing
- Current Science
- International Journal of Geographical Information Science

**Websites:**

- <https://bhuvan.nrsc.gov.in/home/index.php>
- <https://www.nrsc.gov.in/>
- <https://mausam.imd.gov.in/>
- <https://www.sac.gov.in/Vyom/>
- <https://public.wmo.int/en>
- <https://www.usgs.gov/>

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**AGMET 508 (0+3): Database Management and Application of Modern Technologies in Agril Meteorology Sem-II**

Data analytic thinking, data driven decision making, types of data analysis, data categories, data cycle analytical thinking models

Data mining and data preparation, data sources, data cleaning, approaches for handling missing data, data transformation, data quality, data normalization, data standardization, data scaling and data encoding, feature selection

Types of data analytics, descriptive analytics, diagnostic analytics, predictive analytics, prescriptive analytics



### Practical Exercises:

1. Data driven modeling, prior knowledge, data preparation, data modeling process, over fitting and under fitting, evaluation of model, data validation, model analytics, testing and training data, validation and cross validation, errors and biases, bias and variance
2. Classifieds for predictive modeling, classification, using decision tree, building decision tree classification
3. Data clustering, clustering algorithms, K-means clustering cluster center, Dendrogram and Elbow curve for cluster visualization, equality of clustering
4. Advanced clustering techniques, hierarchical clustering, product segmentation using hierarchical clustering, DB Scan clustering.
5. Association and co-occurrences: Introduction correlation and association, complexity control, measuring surprise
6. Association and co-occurrences: Method of finding rules, native methods, Apriori algorithm, forming association rules +project
7. Machine learning concepts, expert system, supervised learning, unsupervised learning, reinforcement learning, deep learning
8. Supervised learning techniques. Data processing, data encoding, performance classifieds, SVM classifier, Naive Bayes classifier
9. Regression, linear regression, multiple linear regression, SLR
10. Advanced classification techniques, classification versus regression, logistic regression, credit classification, decision tree classifier, KNN classifier, Neutral networks, perceptron models
11. Ensemble methods for classification, random forest classifier, boosting classifier, Gradient Boosting Classifier, multiple model ML transformers
12. Advanced Regression methods, non linear regression, polynomial regression, support vector regression, decision tree regression, random forest regression, Ridge and Lasso regression, multivariate regression
13. Unsupervised learning clustering: clustering, similarity or distance measures, geometrical distance measures, Manhattan/Mahalanobis/Jaccard's, K-means, nearest neighboring, self-organizing maps, Kohonen network, effectiveness of clusters, Silhouette coefficient, feature selection in classification, particle swarm optimization, Ant colony optimization
14. Fundamentals of Artificial Intelligence (AI), Importance and evolution of AI, AI for industry transformation and business transformation, developing customer personas, classification, risks and limitations of AI, Ethical aspects, transformation of future job roles automation, Application of AI in agriculture, implementation of AI, AI strategies, AI advantages and limitations
15. Deep learning: concepts and applications
16. Introduction of generative AI, ML and DL, Neutral networks for generative AI

### *Resources (books, journals, documents, websites)*

#### **Books:**

- Arora, R. 2019. Database Management System (DBMS)-A Practical Approach. S. Chand Limited. ISBN: 978-8121932455. Pp 704.



- Ahmad, M and Nabi. F. 2021. Agriculture 5.0: Artificial Intelligence, IoT and Machine Learning. CRC Press. ISBN: 978-1000364439. Pp 242.
- Rathore, LS; Sivakumar, MVK; Attri, SD and Dash, SK. 2011. Challenges and Opportunities in Agrometeorology. Springer Berlin Heidelberg. ISBN: 978-3642193606. Pp 600.
- Sivakumar, MVK; and Motha, RP. 2008. Managing Weather and Climate Risks in Agriculture. Springer Berlin Heidelberg. ISBN: 978-3540727460. Pp 504
- Bernardi, M. 2019. Handbook on Climate Information for Farming Communities-What Farmers Need and what is Available. Food and Agriculture Organization of the United Nations. ISBN: 978-9251313701. Pp 171.

**Journals:**

- Journal of Database Management
- Machine Learning and Artificial Intelligence
- Machine Learning
- Journal of Machine Learning Research
- Journal of Agrometeorology
- Agricultural and Forest Meteorology

**Websites:**

- <https://cdsp.imdpune.gov.in/>
- <https://community.wmo.int/en/climate-data-management-systems-cdmss>
- <https://climsoft.org/>
- <https://www.iges.or.jp/en/projects/climate-databases>
- <https://www.nccs.nasa.gov/services/climate-data-services>

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**AGMET 509 (2+1): ICT Applications in Agricultural Meteorology Sem-II**

**Theory**

**Unit I: Introduction and Overview of ICT in Agricultural Meteorology**

Overview of Information and Communication Technologies (ICT) in agriculture; Concept of Digital Agriculture; Importance and relevance of ICT in agricultural meteorology – Farm advisory service, precision agriculture, Insurance and Finance sector and other user domain

**Unit II: Data analytics for Agrometeorological applications**

Introduction to Data Analytics; Types of Data Primary and Secondary data, Spatial (gridded) data, satellite data, etc.; Data Sources at national and global scale, IMD data supply portal, Open-source data service–NASA Power, Google Climate Engine, ECMWF, Copernicus data service etc. Indian Monsoon Data Assimilation and Analysis reanalysis (IMDAA) of NCMRWF

Exploratory Data Analysis (EDA)- Data cleaning and Quality Assessment, Missing Data and outlier Analysis, Data Visualization, Descriptive Statistics, Univariate, Bivariate and Multivariate Analysis, Correlation and Relationships, Feature Engineering, etc.





Introduction to Programming: Introduction to Python/R for Data Analytics; Data Structures and Libraries; Data Manipulation and Transformation; Data Analysis Techniques - Descriptive Analytics, Inferential Analytics, Predictive Analytics Fundamentals. Introduction to Machine Learning - Supervised and Unsupervised Learning Algorithms, Feature Extraction, Model Evaluation and Validation; Big Data Analytics- Introduction to Big Data, Hadoop and Spark Fundamentals, Data Processing at Scale; Time Series Analysis for climate trend

### **Unit III: Remote Sensing and GIS for crop monitoring**

Overview of Geoinformatics and its applications in agriculture; GIS and its components, Data models- vector, raster and attribute model, Projection systems,

Remote sensing – Digital Image Preprocessing (Atmospheric, Radiometric and Geometric corrections, LULC classification, extraction of spectral indices-NDVI, NDWI, EVI, SAVI etc.) Case studies on land cover mapping, Crop classification, Crop health monitoring Environmental impact assessment using multi-sensor satellite imageries; UAV application in agriculture Integration of multi-source spatial data from Satellite image, UAV, Field sampling and other secondary data; Geostatistical methods (Kriging and interpolation) and Overlay analysis for land evaluation and crop health monitoring

### **Unit IV: IoT and Sensor Networks for Precision Farming**

Sensors: Various types of sensors are used in crop and microclimate monitoring - soil moisture sensors, temperature and humidity sensors, pH sensors, GPS, Thermal scanner, cameras (multispectral), etc.– Working principles of sensors, Range of observations, limitations, sensor maintenance etc.

IoT architecture and design, Connectivity and data transmission - Wi-Fi, Bluetooth, cellular networks (3G/4G/5G), satellite based connections - their advantages and disadvantages; Data Processing and Storage- Edge computing vs cloud computing - advantages and disadvantages, Gateways and IoT Platforms; Actuators and Control Systems for automation of tasks; User Interface and Applications - web-based dashboards, mobile applications, or software tools; Data integrity and Security Measures

### **Unit V: ICT application for Decision Support Systems**

Crop modeling and simulation-Case studies with different crop models; Statistical modeling for disease pest forewarning; Weather based Decision Support Systems (DSS) for farmers- DSS implementations by Integrating Near real time weather data with crop models; ICT for Risk Management in Agriculture - - Insurance and financial services using ICT and agrometeorology; Real-time monitoring for drought management; design framework of ICT-based risk management system; Building user-friendly interfaces for farmers – Model framework, Development and dissemination of climate information services; Case studies on success stories

### **Practical Exercises:**

1. Working with Open-source Data Portals (a) NASA Power, (b) Google climate Engine, (c) World Harmonized soil data, (d) NCMRWF Reanalysis Data Service Web portal or any other platform – Registration, access and downloading climate data of your region of interest
2. Data visualization and trend analysis – Mann–Kendall and Sen's slope trend test, Moving average, ARIMA, Seasonal ARIMA (SARIMA) etc using Real Statistics spreadsheet, Python or R.



3. Hands On exercises with crop modeling: Customized data file (crop, weather and soil data) for different crop models (DISSAT, CERES, ORYZA etc.); Simulation of crop performance under different weather scenario. Generation of customized farm advisory.
4. Exploring Open-source GIS and RS software – Quantum GIS, SAGA, Orfeo Toolbox (OTB), GRASS, Map window, etc. (at least two softwares – QGIS and SAGA)
5. Register and login RS data portals - USGS, Copernicus Sci-hub, Earth data Login, Bhuvan, etc. Download Open-source RS images of Sentinel-2, Landsat-8, LISS-III, SRTM-DEM, Copernicus-DEM, Car5tosat-DEM etc.
6. Pre-processing Landsat and Sentinel images (using QGIS Semi-Automatic Classification plugin or SNAP toolbox)
7. Hands-on exercise in RS image analysis - Generating and analyzing vegetation index maps in SAGA (or QGIS)
8. Use of Mobile application in ICT – Kobo toolbox, Canopeo, Canopy capture etc. for field data collection
9. Lab sessions/Field trip/Hands-on exercise on deploying, calibrating, and maintaining ICT tools and network administration for field data collection (In collaborative with Computer Science Dept)

**Resources (books, journals, documents, websites)**

**Books:**

- Panda, BC. 2005. *Remote Sensing: Principles and Applications*. Viva Books Private ISBN:978 8176496308. Pp 288.
- Reddy, AM. 2014. *Textbook of Remote Sensing and Geographical Information Systems*, (4<sup>th</sup> ed). BS Publication. ISBN:978-9385433351. Pp 656.
- Thomas, Ralph WK and Chipman, J. 2004. *Remote Sensing and Image Interpretation*. Wiley. ISBN:978-0471152279. Pp 763.
- ICT in Agriculture - Connecting Smallholders to Knowledge, Networks and Institutions; (Pub) The World Bank Report Number 64605, (2013) ([https://cto.int/wp-content/themes/solid/\\_layout/dc/k-r/ICT\\_in\\_Ag\\_Sourcebook\\_web\\_light.pdf](https://cto.int/wp-content/themes/solid/_layout/dc/k-r/ICT_in_Ag_Sourcebook_web_light.pdf))
- E-Agriculture in Action, (Pub) The Food and Agriculture Organization of the United Nations and International Telecommunication Union, Bangkok, (2017)
- Digital Agriculture in action and artificial intelligence for agriculture The Food and Agriculture Organization of the United Nations and International Telecommunication Union, Bangkok, (2021)
- Principles of Geographic Information – An Introductory Textbook, (Pub) ITC, Netherland ([https://webapps.itc.utwente.nl/librarywww/papers\\_2009/general/principlesgis.pdf](https://webapps.itc.utwente.nl/librarywww/papers_2009/general/principlesgis.pdf))
- IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things (Pub)Cisco Press, 800 East 96<sup>th</sup> Street, Indianapolis, Indiana 46240 USA.

**Journals:**

- Computers and Electronics in Agriculture
- Journal of the Indian Society of Remote Sensing
- Geo-Spatial Information Science
- Smart Agricultural Technology



- European Journal of Remote Sensing
- GIScience & Remote Sensing
- Sensor- Open-Access Journal

**Websites:**

- <https://mausam.imd.gov.in/>
- <http://www.nicra-icar.in/nicrarevised/index.php/home1>
- <https://www.fao.org/family-farming/detail/en/c/1200067/>
- <https://www.sac.gov.in/Vyom/>
- <https://safoam.org.in/>
- <https://wmo.int/>

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**AGMET 510 (2+1): Weather Systems and Spatial Dynamics of Plant Insect-Pests & Diseases Sem-I Theory**

**Unit I: Weather and pests & diseases**

Weather systems and their role in pests (insects and diseases) infestation, Role of Agrometeorology and Biogeography in forecasting pests outbreak, insect movement in the atmosphere, intensification, Effect of weather & climate parameters on reproduction, growth, development, movements, food, habitat and dispersal of pests. Influence of weather & climate on migratory insects (Desert locust, BPH etc) and diseases (Karnal Bunt, Yellow Rust etc).

**Unit II: Weather changes for different pests & diseases**

Delineation of hotspot regions of insect pests and diseases across the country. Benevolent and malevolent weather conditions for salient insects & diseases of the concerned agro-climatic zones. Effects of sudden weather changes and extreme weather conditions on population built-up of the pest, heat stress and heat related mortality, climate change impact on insects and diseases.

**Unit III: Integrated pest management**

Biometeorology in integrated pest management program, modification of plant canopy and its impact of plant diseases, management of segments of disease triangle: environment manipulation and host manipulation, Soil borne pathogens, their biology, management and challenges, soil borne diseases and their control, abiotic factor in soil borne disease management, Managing of pests & diseases in controlled environment, Environmental management for pest and disease.

**Unit IV: Modeling and forecasting of pests & diseases**

Forecasting of pests; different types of models – statistical, simulation used for pest forecasting, basic data requirement of models, Thermal indices ( GDD, HTR etc.) for pest forecasting. stochastic models; advantages and limitations of pest forecasting models. Decision support systems (DSS) for important pests, weather based forewarning system for pests, Weather based advisories for pests (insects and diseases) development and epidemics. Crop-weather-insect/disease calendars (for respective states).



## Unit VI: Remote sensing and pests & diseases

Remote sensing and GIS techniques for the detection, surveillance and management of plant diseases and insect pests, spectral indices (NDVI, GNDVI etc.) and their use in pest detection. Spatial data analysis using RS and GIS softwares.

### Practical Exercises:

1. Identification of different insects and diseases of major crops
2. Daily observations on spore/larvae/adults counts of Insect pests in Agromet Observatory using specific and appropriate traps for their population and index calculation
3. Computation of degree days for insects forecasting using historical data
4. Computation of degree days for diseases forecasting using historical data
5. Calculation of comfort indices for major insects/diseases and preparation of climograph
6. To study relationships between insect population and different weather parameters
7. Calculation of continentally factors for different pests of major crops
8. Working with statistical models for pest forecasting
9. Working with simulation models for pest forecasting
10. Preparation of crop-weather-insect calendars for major insects
11. Preparation of crop-weather-disease calendars for major diseases
12. Preparation of weather-based agro-advisories for pest forecasting
13. To study disease initiation and their intensity, per cent disease index
14. To compute relationships between weather parameters and different insects
15. Collection of GPS point tagged disease and pest observations, Importing the data into GIS software and spatial analysis of the data.
16. Downloading remote sensing satellite data and spatial interpolation of disease and pest forewarning data from pest and disease models, Map creation for presentation of results

### Resources (books, journals, documents, websites)

#### Books:

- Yazdani, SS and Agarwal, ML. 1997. *Elements of Insect Ecology*. Narosa Publishing House. ISBN: 978-8173191077, Pp 210.
- Odum, EP. 1967. *Fundamentals of Insect Ecology*. Saunders Publisher. Pp 167.
- Dhaliwal GS and Arora R. 2003. *Principals of Integrated Pest Management*. Kalyani Publishers. ISBN: 978-8170969587. Pp 122.
- Jerry LH. 2012. *Biometeorology in Integrated Pest Management*, Elsevier Science. ISBN: 978-0323147965. Pp 502.
- Panda, BC. 2005. *Remote Sensing: Principles and Applications*. Viva Books Private ISBN: 978-8176496308. Pp 288.
- Francis JP and David C. 2007. *GIS Applications in Agriculture*. CRC Press. ISBN: 978-1138627611. Pp 203.



**Journals:**

- Aerobiologica
- Agricultural and Forest Meteorology
- Journal of Agrometeorology
- International Journal of Biometeorology
- Journal of Remote Sensing and GIS
- Mausam
- Remote Sensing of Environment
- Current Science
- Italian Journal of Agrometeorology

**Websites:**

- <https://mausam.imd.gov.in/>
- <https://www.ncmrwf.gov.in/>
- <https://www.tropmet.res.in/>
- <https://ncipm.icar.gov.in/>

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**AGMET 511 (2+0): Agrometeorology of Plantation Crops Sem-I**

**Theory:**

**Unit I:** History, development, scope and importance, altitudinal sequence of plantation crops – Hopkins Bioclimatic Law – Influence of geographical coordinates on plantation crops: coconut, cashew, cocoa, coffee, tea, cardamom, areca nut, black pepper, rubber, oil palm and other mixed crops like nutmeg, clove and cinnamon; important fruits and vegetables

**Unit II:** Photosynthetic productivity, leaf area index (LAI) - optimum LAI in plantation crops, canopy development; different stages of growth, growth curves, growth analysis in plantation crops.

**Unit III:** Multitier cropping systems in plantation/perennial crops – hill agriculture -agrotopoclimates– performance of plantation crops in traditional and non-traditional regions–microclimate of plantation crops- temperature vapour pressure and radiation profiles-soil moisture and soil temperature profiles in plantation crops

**Unit IV:** Phenology of plantation crops - influence of meteorological parameters on plantation crops – agrometeorological indices - response of plantation crops to weather extremes like floods, droughts, heat and cold waves - evapotranspiration and water requirement of plantation crops

**Unit V:** Climate variability and climate change effects and climate risk management in plantation crops – role of weather in premature bloom, heat units, chilling hours, insect pest and diseases, longer growing seasons and shifts in plant hardiness for of plantation crops

**Unit VI:** Climatic requirements for optimal growth and yield, in terms of quantity and quality, sensitive stages, carbon sequestration potential and adaptive strategies of plantation crops.



**Resources (books, journals, documents, websites):**

**Books:**

- Rao, BVR 1988. *Operational Agricultural Meteorology*. Indian Society of Agronomy. IARI. New Delhi. 59p
- Rao, GSLHVP. and Nair, RR. 1988. *Agrometeorology of plantation crops*. Kerala Agricultural University. Thrissur. 187p
- Hebbar, KB., Naresh, KS. and Chowdappa, P. 2017. *Impact of Climate Change on Plantation Crops*. Daya Publishing House. ISBN: 978--9351248330. 253p.
- Rao, GSLHV.P. 2002. *Climate and Cashew*. Kerala Agricultural University. Thrissur, 100p
- Rao, GSLHVP. 2019. *Agricultural Meteorology* (5<sup>th</sup> Printing). PHI Learning Private Limited. New Delhi, 364p
- Venkataraman, S and Krishnan, A. 1992. *Crops and Weather*. ICAR, New Delhi. 586p

**Journals:**

- Agricultural and Forest Meteorology
- Journal of Agrometeorology
- Journal of Plantation Crops
- Indian Horticulture

**Websites:**

- <http://www.cropweatheroutlook.in/crida/agmet/aicrpam/aicrppg.html>
- <https://cpcri.icar.gov.in/>
- <https://www.imdagrimet.gov.in/>

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**AGMET 512 (2+1): Strategic Use of Climatic Information Sem-II**

**Theory**

**Unit I:** Introduction to climatic data sources, climatic data analysis, trend analysis, identifying trends and variability, downscaling and up scaling of data, and utilization of climatic information, history of climate-related disasters in the concerned continent/region/country/sub-region and their impacts and documentation;

**Unit II:** Selection of appropriate land use and cropping patterns: types and drivers of agricultural land use and cropping patterns based on climatic situation. Increasing awareness on potential climate hazards and mitigations: Climatic hazards and extreme weather events (Cyclone, Hailstorm, drought, flood, frost, heat and cold wave, hailstorm, lightning etc.), Impact of climatic hazard on agricultural production; efforts made in mitigating impacts of (future) disasters (prevention); trends discernible in occurrence and character of disasters, if any.

**Unit III:** Integrating climate information into strategic planning process, Risk assessment and its management based on climate projections and scenarios. Climate smart agriculture, Management of livestock, aquaculture, fisheries with adaptation and mitigation priorities, weather based crop management, strategies to minimize impact of climate change on agriculture.



**Unit IV:** Adoption of preparedness strategies: priority settings for preparedness strategies in agricultural production; preparedness for meteorological disasters in development planning; permanent adaptation strategies that reduce the vulnerabilities to hazards; preparedness as a coping strategy. dealing climate risk and its assessment, Strategy of mitigation and adaptation and risk transfer mechanism, Optimizing crop planning, disaster risk management-early warning systems and preparedness measures.

**Unit V:** Adoption of microclimate modification techniques: review of microclimate management and manipulation methods; history of microclimate modification techniques practiced in the continent/country/sub-region concerned; possible improvements in adoption of microclimate modification techniques, given increasing climate variability and climate change; local trends in adoption of such techniques. Integration of trees into Agro-ecosystem and microclimate modification

**Unit VI:** Protection measures against extreme climate: history of protection measures against extreme climate in the continent/region/country/sub region concerned; successes and difficulties experienced by farmers with present protection measures; outlook for present protection measures and possible alternatives; trends in protection methods against extreme climate.

**Unit VII:** Procurement of climate data, climatic data bank, Quality control aspect of climatic data, Communication of climate data to different stakeholders, Utilization of climatic information in agricultural, rural and associated sectors' planning & management

**Unit VIII:**

Challenges and opportunities in outreach of climate information for all; early warning for all on disaster risk information; hazard monitoring and forecasting; warning dissemination and communication; and disaster response capability.

**Practical Exercises:**

1. Outlook for present land use and cropping patterns and possible alternatives from environmental point of view
2. Recent trends in land use and cropping patterns
3. Agro-meteorological services to increase farmers design abilities of land use and cropping patterns
4. Systematic and standardized data collection on protection measures against extreme climate
5. Hands-on practical sessions using climate data analytic tools
6. Evaluating data interpretation skills.
7. Case studies for strategic planning based on climate data.

**Resources (books, journals, documents, websites)**

**Books:**

- Stewart, RB. 2000. *The Clean Development Mechanism: Building International Public- Private Partnership under Kyoto Protocol*. UNEP, UNDP Publ. Pp 101.
- Meyer L and Pachauri RK. 2015. *Climate Change - Synthesis Report*. IPCC. ISBN: 978-9291691432. Pp 151.



- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co.
- Pretty J and Ball A. 2001. *Agricultural Influence on Carbon Emission and Sequestration: A Review of Evidence and the Emerging Trading Options*. Univ. of Essex. Pretty JN. 1995. *Regenerating Agriculture: Policies and Practices for Sustainable and Self Reliance*. Earthscan.
- Srivastava, AK. and Yogranjan. 2020. *Climate Risk Management Sustainable Pulse Production*. Astral International Pvt. Ltd, New Delhi. ISBN: 978-9389605655
- Suresh PK. 2023. *Climate Change and Sustainable Agriculture*. NIPA, New Delhi. ISBN: 978-8119072439. Pp 394.

**Journals:**

- Climate Risk Management
- Journal of Climate
- International Journal of Climatology
- Journal of Agrometeorology

**Websites:**

- <https://climate.copernicus.eu/climtag-climate-information-tool-agriculture>
- <https://climatestrategies.org/>
- <https://careclimatechange.org/>
- <https://wmo.int/topics/climate>

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**Agricultural Meteorology**  
*Course Structure – At a Glance*  
**PhD Programme**  
*Modified/Revised*

Course No.	Course title	Credit hours	Sem.
AGMET 601*	Climate Change and Agricultural Sustainability	2+1	I
AGMET 602*	Air Pollution and Aerobiometeorology	2+1	I
AGMET 603* <sup>@</sup>	Computer Programming & Softwares for Agromet Data Management	2+1	II
AGMET 604	Climate Resilient Agriculture and Risk Management	2+0	II
AGMET 605	Analytical Tools and Methods for Agro-climatology	1+1	II
AGMET 606	Fisheries, Poultry and Livestock Production Meteorology	2+1	I
AGMET 607	Environmental Physics for Agricultural Meteorology	3+0	I
AGMET 608 <sup>#</sup>	Research and Publication Ethics	2+0	II
AGMET 691	Doctor's Seminar	1+0	I, II
AGMET 692	Doctor's Seminar	1+0	I, II
AGMET 699	Doctor's Research	75	I, II

\*Core Courses for PhD, <sup>#</sup> To be shared with PGS Courses, <sup>@</sup> To be shared with Computer Section



**AGMET 601 (2+1): Climate Change and Agricultural Sustainability Sem-I**

**Theory**

**Unit I: Basics of climate change**

Introduction to climate science: Atmosphere and climate, global energy budget, natural and manmade causes, climate feedback; Global climate: past, present, future; climate change indicators: temperature regime, precipitation regime, composition regime, extreme climatic/weather events

**Unit II: GHG gases and agricultural sustainability**

Major greenhouse gases and sources and sink, observations and measurements, global warming, greenhouse effect and its application for sustainability, responses to global warming for agri-ecosystems, different projections scenarios and food security & sustainability

**Unit III: Climate change impacts and assessment**

Impacts of climate change on various systems, primary sectors: agriculture, forestry, livestock and fisheries, Natural ecosystems: soil ecosystem, coastal & marine ecosystem, wetlands and mountain & hill ecosystems; Resources: water, energy and biodiversity, infrastructure and agri-financial sectors; impacts on livelihood options, urban and rural; different tools and techniques of impact assessment and vulnerability study, climate change vulnerability: vulnerability index, vulnerability assessment, uncertainties in climate change assessment.

**Unit IV: Mitigation and adaptation to climate change**

Concept of mitigation and adaptation, regional scenarios of climate change and variability, adaptive capacity of agro-ecosystem to climate change and extreme weather events; climate-resilient pathways, global institutional mechanisms, adaptive strategies and capacities, policy instruments for reducing GHG emissions, carbon capture and sequestration, energy systems, biofuels, waste management options relevant to mitigation and adaptation.

**Unit V: Climate Smart Technologies and interventions for Sustainable Agriculture**

Definition of climate smart agriculture and its characteristics, key principles of sustainability in agriculture, relevance of existing technologies with respect to climate change, various energy smart systems, interventions & technologies, digital applications for low emission and agricultural sustainability under diverse ecologies and cropping systems, local climate-smart practices for sustainability and food security.

**Unit VI: Climate change policy and environmental sustainability**

Climate policies in India: sector specific policies and policy instruments, environmental impact assessment and management: Conventions of climate change, international policies, protocols, treaties for climate change and emission issues, various meetings of Conference of Parties (CoP) of UNFCCC and their approved recommendations



### Practical Exercises:

1. Case studies on various climatic projections and consequences thereof in relation to agriculture
2. Trend analysis tools and methodologies for detecting climate change
3. Practices on advance methodology for assessing the impact of climate change on crops
4. Vulnerability studies and assessment using climate and sector specific data
5. Measurement of GHG emissions from crop field
6. Calculation of carbon foot print of different cropping systems
7. Demonstration of digital tools and apps for smart agriculture
8. Field visit and demonstration for climate resilient technologies
9. Practices on crop ecological models
10. Calculation of net primary and gross productivity

### Resources (books, journals, documents, websites)

#### Books:

- Jepma CJ and Munasinghe M. 1998. *Climate Change Policy: Facts, Issues and Analysis*. Cambridge Univ. Press.
- Stewart, RB. 2000. *The Clean Development Mechanism: Building International Public- Private Partnership under Kyoto Protocol*. UNEP, UNDP Publ. Pp 101.
- Meyer L and Pachauri RK. 2015. *Climate Change - Synthesis Report*. IPCC. ISBN: 978-9291691432. Pp 151.
- Mintzer IM. 1992. *Confronting Climate Change: Risks, Implications and Responses*. Cambridge Univ. Press.
- Pretty JN and Ball A. 2001. *Agricultural Influence on Carbon Emission and Sequestration: A Review of Evidence and the Emerging Trading Options*. Univ. of Essex.
- Pretty JN. 1995. *Regenerating Agriculture: Policies and Practices for Sustainable and Self Reliance*. Earthscan.
- Salinger J, Sivkumar MVK and Motha RP. 2005. *Increasing Climate Variability of Agriculture and Forestry*. Springer.
- Balasubramanian, TN; Jagannathan, R and Geethalakshmi, V. 2022. *Agro-Climatology-Advances and Challenges*. Taylor & Francis. ISBN: 978-1000534504. Pp 332.

#### Journals:

- Mitigation and adaptation to Global Changes,
- Climate Change,
- Climate Risk Management,
- Journal of Agrometeorology

#### Websites:

- <https://www.ipcc.ch/>
- [www.environment.gov.au/climate-change/climate-science-data/climate-science/ipcc](http://www.environment.gov.au/climate-change/climate-science-data/climate-science/ipcc)

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**AGMET 602 (2+1): Air Pollution and Aerobiometeorology Sem-I**

**Theory**

**Unit I:** Introduction to air pollution- history, definition: clean air definition; natural versus polluted atmosphere; atmosphere before the industrial revolution, Real time air quality index and National air quality index and standard; sources of air pollution, classification and properties of air pollutants, photochemical smog; pollutants, trace gases and acid rain

**Unit II:** Meteorological factors in the dispersion of air pollutants; topographical, geographical and large scale meteorological factors attached air pollution; Planetary Boundary Layer (PBL) and mixing layer; meteorological conditions and typical plume forms;

**Unit III:** Emissions from agriculture, air pollution forecasting – Gaussian diffusion models, Numerical dispersion models, effect of air pollution on biological organisms, plants; ozone layer depletion; air pollution control technologies; management of air pollution;

**Unit IV:** Definition and structure of aero-biometeorology, role of agrometeorology and biogeography in forecasting pests and disease outbreak, insect movement in the atmosphere, intensification, Effect of weather & climate parameters on reproduction, growth, development, movements, food, habitat and dispersal of pests and diseases. Influence of weather & climate on Migratory pests.

**Unit V:** Benevolent and malevolent weather conditions for salient pests & diseases of the concerned agro-climatic zones. Effects of sudden weather changes and extreme weather conditions on population built-up of the pest, heat stress and heat related mortality, climate change impact on pest and diseases.

**Unit VI:** Biometeorology in integrated pest and disease management program, modification of plant canopy and its impact of plant diseases, management of segments of disease triangle: environment manipulation and host manipulation, weather based forewarning system for pest and diseases.

**Unit VII:** Soil borne pathogens, their biology, management and challenges, soil borne diseases and their control, abiotic factor in soil borne disease management, Managing pests & diseases in controlled environment.

**Practical Exercises:**

- Measurement of different air pollutants
- Measurement of different air pollution gases, black carbon, surface ozone etc.
- Measurement of visibility
- To study the effect of temperature on vegetables, orchards and agricultural crops
- Identification of different insect- pests
- Pest population, observations and their index calculation Identification of various diseases
- Disease initiation and their intensity, percent disease index
- To draw relationship between weather parameters and pests and disease



**Resources (books, journals, documents, websites)**

**Books:**

- Scorer, RR. 2014. *Air Pollution Meteorology*. Elsevier Science. ISBN:978-1782424369. Pp 160.
- Venkatesan, G. and Thirumal, J. 2019. *Global Perspectives on Air Pollution Prevention and Control System Design*. IGI Global Publisher. ISBN:978-1522572909. Pp 345.
- Yazdani, SS and Agarwal, ML. 2002. *Elements of insect ecology*. Narosa Publishing House.
- Schowalter, TD. 2006. *Insect Ecology - An Ecosystem Approach*. Elsevier Science. ISBN:978-0080508818. Pp 576..
- Dhaliwal GS and Arora R. 2003. *Integrated pest management-Concepts and Approaches*. CABI Publisher. Pp 369.
- Jerry L, Hatfield and Thomason IJ. 1982. *Biometeorology in Integrated Pest- Management*, Academic press. Pp 491.

**Journals:**

- Air Quality, Atmosphere and Health
- Indian Journal of Air Pollution Control
- Aerobiologica
- Journal of Agrometeorology
- International Journal of Biometeorology

**Websites:**

- <https://www.tropmet.res.in/>
- <https://mausam.imd.gov.in/>
- <https://cpcb.nic.in/>
- <https://www.co2.earth/>
- <https://www.iqair.com/in-en/earth?nav=>

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**AGMET 603 (2+1): Computer Programming and Softwares for Agromet Data Management  
Sem-II**

**Theory**

**Unit I:** Functional units of computer, I/O devices, primary and secondary memories. Number systems: decimal, octal, binary and hexadecimal; Representation of integers, fixed and floating point numbers, Operator precedence, character representation; ASCII, Unicode.

**Unit II:** Computer Programming: History, Quality requirements, Readability of source code, Algorithmic complexity, Debugging, Programming languages

**Unit III:** Programming Fundamentals with C - Algorithm, techniques of problem solving, flowcharting, stepwise refinement; Constants and variables; Data types: integer, character, real, data types; Arithmetic expressions, assignment statements, logical expressions. Control flow

**Unit IV:** Programming Fundamentals with python - Syntax and semantics, Indentation, statements and control flow, Expressions, Programming examples, Libraries (Data Cleaning & Processing - Numpy,



Pandas; Data Visualization - Matplotlib, Seaborn; Machine Learning - Scikit Learn ; Deep Learning - Tensorflow), Development environments, Implementations, Reference implementation, Other implementations and Unsupported implementations

**Unit V:** Basics of Machine Learning- Artificial Intelligence (AI); Machine Learning (ML), Types and Algorithms of Machine Learning-Supervised Learning, Semi-Supervised Learning, Unsupervised Learning, Reinforcement Learning; Neural Network or Artificial Neural Network (ANN) and Machine Learning Use Cases

**Unit VI:** Data and information; types of data; climate, soil and crop data; Importance of database management, Softwares related to database management; data requirements; data collection and recording (Automatic and manual), Data structure/format; quality control of data through computer software; techniques of climatic data generation; missing data; introduction to different software for database management.

**Unit VII:** Processing and analysis of data and data products; value addition of data and data products; data users, public, commercial, academic or research. Availability, accessibility and security of data; evaluating the cost of data; e-management of data. Meta analysis: Advantages and problems, Steps, Approaches and methods, Applications.

**Practical Exercises:**

1. Types of instruments and data recording
2. AWS data retrieval, storage and transfer
3. Exposure to different software for Agromet data analysis; exposure to Statistical software
4. Temporal and spatial analysis of data; exposure to GIS
5. Value addition to data
6. Introduction to internet protocols
7. Uploading and downloading data, password and security of data
8. E-management of data
9. Introduction to computer programming
10. Introduction to machine learning, AI and ANN

**Resources (books, journals, documents, websites)**

**Books:**

- Sinha, PK and Sinha, P. 2004. *Computer Fundamentals*. BPB Publications. (6<sup>th</sup>Ed)
- Balaguruswamy, E. 2019. *Programming with ANSI C*. Tata McGraw Hill.
- Gottfried, B. 2017. *Programming with C*, Schaum Outline Series. Tata McGraw Hill.
- Kanetkar, Y. 1999. *Let Us C*. BPB Publ. Statistical Sciences: Computer Application 763
- Malvino, AP and Brown, JA. 2017. *Digital Computer Electronics*. Tata McGrawHill.
- Mano, MM. 1999. *Digital Logic and Computer Design*. Prentice Hall of India.
- Guido van Rossum. 1991. *Python - Programming Language*. Python Software Foundation.
- Miles, MB and Huberman, AM. 1994. *Qualitative Data Analysis*. Sage Publ.
- Panse, VG and Sukhatme, PV. 1983. *Statistical Methods for Agricultural Workers*, ICAR.
- Potter, GB. 1994. *Data Processing: An Introduction*. Business Publ.



- Kelleher, JD; Namee, BM and D'Arcy, A.2020. *Fundamentals of Machine Learning for Predictive Data Analytics-Algorithms, Worked Examples, and Case Studies* (2<sup>nd</sup> Edition). MIT Press. ISBN: 978-0262361101. Pp 856.
- Nelli F. 2023. *Python Data Analytics - With Pandas, NumPy, and Matplotlib*. Apress. ISBN: 978-1484295311. Pp 445
- Gureon A. 2019. *Hands-on Machine Learning with Scikit-Learn, Keras and Tensorflow. Concepts, Tools, and Techniques to Build Intelligent Systems*. O'Reilly Media. ISBN: 978-1492032595. Pp 856.

#### Journals:

- Journal of Computer Science
- Journal of open source software
- Science of Computer Programming
- International Journal of Data Mining
- Modeling and Management

#### Websites:

<https://programminghub.io/>  
<https://python.swaroopch.com/>  
<https://community.wmo.int/en/climate-data-management-systems-cdmss>  
<https://www.ncei.noaa.gov/cdo-web/>

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### **AGMET 604 (2+0): Climate Resilient Agriculture and Risk Management Sem-II**

#### Theory

**Unit I:** Climate resilient agriculture (CRA) – concept, scope and importance; History of CRA; Climate smart technologies for enhancing crop productivity and sustainability – weather smart (weather forecasts, crop diversification), water smart (rain water harvesting, SRI, aquifer recharge), carbon smart (organic agriculture, conservative agriculture), nutrient and pest smart (Site Specific Nutrient Management

**Unit II:** Integrated farming systems, harnessing microbial biodiversity, ecological engineering), energy smart (biomass recycling, use of solar energy) and knowledge smart (ICTs, Smart phone Apps, crop simulation models) etc; concept of climate smart village, CRA with special reference to India, success stories of CRA

**Unit III:** Description Controlled environment agriculture; types of growth environment- Indoor agriculture; greenhouse cultivation; vertical farming; protected cultivation; types of growing methods - Hydroponics; aquaponics; aeroponics and fogponics

**Unit IV:** Agricultural automation, diagnostic digital tools/sensors; robotics, drones etc

**Unit V:** Overview of risks in agriculture; Types of risks- Weather/Production risk; Price/ Market risk; Financial & Credit risk; Institutional risk; Technology risk; Personal risk; Risk Management Strategies-



Agricultural Insurance; support services insurance; Price Support Measures; Emerging Commodity Markets; Contract Farming as Price Risk Mitigation; bio-fuels, National drought management guidelines

**Unit VI:** Definition of climate finance- climate change related economic and environmental impacts, climate solutions; carbon pricing, Climate finance for mitigation, adaptation and emission reduction; market for investment in climate mitigation, adaptation, and resilience; climate change and futures market dynamics

**Unit VII:** Concept of climate justice; social, political, and economic elements of the climate justice; UN Framework Convention on Climate Change; climate justice at local, national, and global level

***Resources (books, journals, documents, websites)***

**Books:**

- Shanker, A; Srinivasarao, Ch; Shanker, C. 2018. *Climate Resilient Agriculture-Strategies and Perspectives*. InTech Open, Croatia. ISBN:978-9535138952, Pp 192.
- Prasada Rao, GSLHV; Varma, G and Beena, V. 2018. *Climate Resilient Animal Agriculture*. New India Publishing Agency, New Delhi. ISBN: 978-9386546180. Pp 462.
- Karaba, NN; Gangadharappa, NR and Belavadi, VV. 2017. *Agriculture Under Climate Change-Threats, Strategies and Policies*. Allied Publishers Pvt. Limited. ISBN:978-9385926372, Pp 490.
- Markandya, A, Rübhelke, D and Galarraga, I. 2017. *Climate Finance: Theory and Practice*. World Scientific Publishing Company. ISBN: 978-9814641821. Pp 376.
- Roser, D and Seidel, C. 2014. *Climate Justice - An Introduction*. Taylor & Francis. ISBN: 978-1317209522. Pp 240.

**Journals:**

- Sustainability
- Climate Risk Management
- Journal of Climate Finance
- Journal of Climate Resilience & Climate Justice

**Websites:**

- <http://www.nicra-icar.in/nicarevised/index.php/home1>
- <https://www.fao.org/climate-smart-agriculture/en/>
- <https://www.droughtmanagement.info/>
- <https://www.ifad.org/en/parm>
- <https://unfccc.int/topics/introduction-to-climate-finance>
- <https://www.un.org/sustainabledevelopment/blog/2019/05/climate-justice/>

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## **AGMET 605 (1+1): Analytical Tools and Methods for Agro-climatology Sem-II**

### **Theory**

#### **Unit I: Agroclimatic methods**

Review of agroclimatic methods; thermal time approach in agro climatology, heat unit and growing degree day concepts for crop phenology, crop growth and development, application to insect-pest development and prediction; cardinal temperatures; heat and radiation use efficiency of crop plants, agroclimatic requirements of crops.

#### **Unit II: Statistical analytical tools**

Statistical methods and their applications in climatology, measures of central tendency, skewness, kurtosis, homogeneity, correlation, regression and moving averages; probability analysis, Markov-chain and incomplete gamma distribution; assessment of frequency of extreme events.

#### **Unit III: Climate characterization**

Micro, meso and macro climates, characterization of agroclimatic elements, numerical characterization of climatic features, agroclimatic and agroecological regions of India. GIS fundamentals and applications in agroclimatic characterization.

#### **Unit IV: Climate change and crop response**

Impact of climate variability and change on crop production, Influence of climate on stress-response relations, time lags, hysteresis effect. Climate change adaptation and mitigation in agriculture.

#### **Unit V: Crop growth and yield estimation**

Crop growth and yield prediction through empirical and simulation models, incorporating weather, soil, plants and other environment related parameters as subroutine and remote sensing inputs in models, Forecasting models for insects and diseases.

#### **Unit VI: Bioclimatology**

Bioclimatic concepts, comfort indices for human and animals (temperature, humidity index and wind chill etc.) and clothing insulation; climate, housing and site orientation; climatic normals for animal production.

#### **Practical Exercises:**

1. Determination of agroclimatic indices and its relation with crop growth and yield.
2. Determination of heat and radiation use efficiency of crops
3. Climatological data analysis using statistical analytical techniques
4. Analysis and prediction of climatological parameters by using frequency distribution
5. Computation of probability of occurrence of rainfall
6. Preparation and analysis of climograph
7. Preparation of crop weather calendars
8. Computation of continentality factor for climate characterization



9. Estimation of wind chill effect
10. Computation of human and animal comfort indices
11. Development of empirical statistical models for prediction of crop growth and yield
12. Development and validation of pest forecasting models using meteorological data
13. Working with crop simulation models for predicting crop phenology and yield
14. Working with GIS and its application in agroclimatic characterization
15. Demarcation and characterization of agroclimatic regions of India
16. Demarcation and characterization of agro-ecological regions of India

**Resources (books, journals, documents, websites)**

**Books:**

- Balasubramanian, TN; Jagannathan, R and Geethalakshmi, V. 2022. *Agro-Climatology-Advances and Challenges*. Taylor & Francis. ISBN: 978-1000534504. Pp 332.
- Mahi GS and Kingra PK. 2018. *Fundamentals of Agrometeorology and Climate Change*. Kalyani Publishers.
- Mavi HS and Tupper JC. 2004. *Principles and Applications of Climate Studies in Agriculture*. CRC Press.
- Mahi GS and Kingra PK. 2013. *Comprehensive Agrometeorology*. Kalyani Publishers.
- Ghadekar SR. 2016. *Meteorology* (14<sup>th</sup> Edition), Agromet Publication, Nagpur.
- Varshneya MC and Pillai PB. 2003. *Text Book of Agricultural Meteorology*. ICAR.
- Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co,

**Journals:**

- Journal of Agrometeorology
- Mausam
- Agricultural and Forest Meteorology
- Journal of the Meteorological Society of Japan
- Current Science
- Italian Journal of Agrometeorology

**Websites:**

- <https://mausam.imd.gov.in/>
- <https://www.ncmrwf.gov.in/>
- <https://www.tropmet.res.in/>

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**AGMET 606 (2+2): Fisheries, Poultry and Livestock Production Meteorology Sem-I**

**Theory**

**Unit I:** Concept of homeothermy and thermal stress in animals- zone of survival & thermo neutral zone - upper & lower critical temperature. Energy exchange processes between animals & its environmental. Physiological adaptation of animals and poultry under thermal stress.

**Unit II:** Effects of weather/climate on animal production, reproduction, milk production, sweating and panting, growth rate, grazing habit, food intake, sun burns and photosensitive disorders.



**Unit III:** Meteorological conditions prevailing in animal shed, poultry house and grain storage barns; heating, cooling and ventilation of these structures as governed by meteorological factors. Environmental modification within the shelters of livestock. Applications of biometeorological information for rational planning, design and management. Weather and animal diseases and parasites; diseases of poultry and its relation with weather and thermal comfort.

**Unit IV:** Livestock production, reproduction and welfare and climate change. Management of livestock and waste to reduce greenhouse gas emission. Adaptation strategies for sustaining production under changing climate.

**Unit V:** Weather information relevant to fisheries activities; for fish/shrimp farming activities as well as capture fisheries; weather systems and their effects on fisheries activities; pond construction and assessment of suitability of pond under prevailing weather; weather forecasting and climate changes impact on fisheries.

**Practical Exercises:**

1. Recording of physiological responses viz., respiration rate (RR), pulse rate (PR), rectal temperature (RT) & surface temperature (ST) of animals.
2. Measurement of meteorological parameters in the open and sheltered environment of livestock
3. Calculation of animal comfort zone index/ Temperature Humidity Index (THI) & its interpretation
4. Radiation of animal farm house and body/ assessment of adaptability of animals
5. Estimation of energy fluxes on animal body
6. Measurements of CO<sub>2</sub>, Nitrous oxide, ammonia, humidity and methane in animal farm house and poultry sheds
7. Preparation of climograph and its interpretation.
8. Use of infrared thermography (IRT) of animals

**Resources (books, journals, documents, websites):**

**Books:**

- GSLHV Prasada Rao, GG Varma and Beena (Eds). 2017. *Livestock Meteorology*. New India Publishing Agency- Nipa. Pp 542.
- Malik, PK, Bhatta, R; J. Takahashi, J; Kohn, RA and Prasad, CS.. 2005. *Livestock production and climate change*. CABI Publication. ISBN : 978-1780644325. Pp 395.
- Monteith L & Unsworth M. 2007. *Principles of Environmental Physics. 2nd Ed.* Academic Press.
- Takahashi J, Young BA, Soliva CR & Kreuzer M. 2002. *Greenhouse Gases & Animal Agriculture*.
- Gupta, SK. 2014. *Aquaculture and Fisheries Environment*. Discovery Publishing House Pvt Ltd; ISBN: 978-9350564080. Pp 226.
- Dinani, OP and Tiwari. SK. 2020. *New Horizons in Poultry Farming*. ISBN: 978-8194783589. Satish Serial Publishing House. Pp 332.
- Proc. 1<sup>st</sup> International Conference on Greenhouse Gases and Animal Agriculture.
- Tromp SW. 1980. *Biometeorology. The Impact of the Weather and Climate on Humans & their Environment*. (Animals & Plants). Heyden & Son Ltd.



**Journals:**

- Journal of Animal and Poultry Production
- Agricultural and Forest Meteorology,
- Journal of Animal Behaviour and Biometeorology,
- Journal of Agrometeorology
- Journal of Fisheries and Environment

**Websites:**

- <https://wmo.int/>
- <https://www.fao.org/>

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**AGMET 607 (3+0): Environmental Physics for Agricultural Meteorology Sem-I**

**Theory**

**Unit I:** Thermodynamics of the atmosphere. Physics of radiation: origin and nature of radiation, radiation geometry in Cartesian, spherical cylindrical coordinate systems, conservation principles for radiant energy; fluid motion: laminar and turbulent transfer, sustaining ozone layer and thinning of greenhouse gas band in the atmosphere

**Unit II:** Physics of evaporation: aerodynamic approach, energy balance approach and combination approach for evaporation estimates, fluctuation theory for turbulent transfer of momentum, heat and water vapour.

**Unit III:** Physics of soil water system: the concept of potential as applied to soil water system, total potential and components, movements of water on soil, fundamental equation, hydraulic conductivity, infiltration, field drainage and water vapour movement in soil.

**Unit IV:** Soil temperature and significance; thermal properties of soils; energy balance and mode of heat transfer in soils; factors affecting soil temperature; measurement of soil temperature; management of extreme soil temperatures.

**Unit V:** Physics of water use: a physical introduction to plant-water system and relationships, water transport through soil-plant-atmosphere systems, measurement of crop water use in terms of water conservation equation.

**Resources (books, journals, documents, websites)**

**Books:**

- Ghildyal BP and Tripathi RP. 1987. *Soil Physics*. Wiley Eastern and New Age Int’nal, New Delhi.
- Lal R and Shukla MK. 2004. *Principles of Soil Physics*, Marcel Dekker, New York
- Mason, N; Hughes, P. and McMullan , R.2001. *Introduction to Environmental Physics-Planet Earth, Life and Climate*. Taylor & Francis. ISBN:978-0748407651. Pp 384.
- Guyot, G. 1998. *Physics of the Environment and Climate*. Wiley. ISBN:978-0471968184. Pp 632.
- Costas G. H. and Nastos, P.T. 2012. *Advances in Meteorology, Climatology and Atmospheric Physics*. Springer Berlin Heidelberg. ISBN: 978-3642291722. Pp 1278.



**Journals:**

- Journal of Environment and Physics Sciences
- International Journal of Environment
- Journal of Physical Science and Environmental Studies

**Websites:**

- <https://up.ethz.ch/>
- <https://www.ictp.it/>
- <https://www.physics.ucr.edu/research/environmental-physics>
- <https://www.iop.org/physics-community/special-interest-groups/environmental-physics-group#ref>

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**AGMET 608 (2+0): Research & Publication Ethics Sem-II**

**Theory**

**Unit I:** Introduction to philosophy: definition, nature and scope, concept, branches

**Unit II:** Ethics: definition, moral philosophy, nature of moral judgments and reactions

**Unit III:** Scientific conduct: Ethics with respect to science and research, intellectual honesty and research integrity, Scientific misconducts- falsifications, fabrications and plagiarism (FFP): Redundant publications: duplicate and overlapping publications, salami slicing; selective reporting and misrepresentation of data

**Unit IV:** Publication ethics: Definition, introduction and importance. Best practices/standard setting initiatives and guidelines: COPE, WAME etc., conflicts of interest. Publication misconduct: definition, concept, problems that lead to unethical behaviour and vice versa, type, violation of publication ethics, authorship and contributor-ship, Identification of publication misconduct, complaints and appeals, predatory publishers and journals

**Unit V:** Open access publishing: open access publication and initiatives: SHERPA, RoMEO online resource to check publisher copy right and self-archiving policies; software tool to identify predatory publications developed by SPPU, Journal finder/journal suggestions tools viz, JANE, Elsevier Journal Finder, Springer Journal Suggester etc.

**Unit VI:** Publication misconduct: Group discussions- subject specific ethical issues, FFP, authorship, conflicts of interest, complaints and appeals examples and fraud from India and abroad. Software tools: Use of plagiarism software like Turnitin, Urkund and other open source software tools.

**Unit VII:** Database and Research metrics: Indexing data base, citation database, web of science, scopus etc. Impact factor of journal as per journal citation report, SNIP, SJR, IPP, Cite Score; Metrics: h-index, gindex, i10 index altmetrics



**Resources (books, journals, documents, websites)**

**Books:**

- Iphofen R. 2020. *Handbook of Research Ethics and Scientific Integrity* (Vol 1). Springer International Publishing. ISBN: 978-3030167585. Pp 1140.
- Gupta S and Kamboj S. 2020. *Research and Publication Ethics*. Alexis Press LLC. ISBN: 978-1645321132. Pp 150.
- Singh YK and Dubey B. 2021. *Introduction of Research Methods and Publication Ethics*. Friends Publications (India). Pp 218.
- Jerjes W, Hamoudi R and Hopper C. 2018. *The Power of Research - Best Practices and Principles in Research Integrity and Publication Ethics*. Kugler Publications. ISBN: 978-9062998852. Pp 258.

**Journals:**

- Journal of Research and Publication Ethics
- COPE: Committee on Publication Ethics

**Websites:**

- <https://publicationethics.org/>
- <https://onlineethics.org/cases/resources-research-ethics-education/topics-publication>

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**Learning Goals:**

- Summarize scholarly work in an area of study, as demonstrated by a literature review in a creative component, thesis, or dissertation.
- Construct hypotheses and/or objectives that advance disciplinary knowledge, as demonstrated by hypotheses and/or objectives proposed in a creative component, thesis, or dissertation.
- Conduct quantitative research, as demonstrated by work described in a creative component, thesis, or dissertation.
- Interpret research results and integrate them into existing disciplinary knowledge, as demonstrated by analyses and conclusions in a creative component, thesis, or dissertation.
- Clearly and accurately communicate research findings orally, visually (through the use of images and/or figures), and in writing, as demonstrated by oral presentations, and by the creative component, thesis, or dissertation.

**Epilogue:**

- The model syllabus in agrometeorology is based on contents from the ARS/Net Syllabus and Broad Subject Matter Area (BSMA) Syllabus devised by Indian Council of Agricultural Research, New Delhi.



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