B.Sc. (Hons.) in

Climate Change and Environmental Science

degree programme

SYLLABUS

College of

Climate Change and Environmental Science

Kerala Agricultural University

Vellanikkara. Thrissur. Kerala. 680 656.

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April 2021

B.Sc. (Honors) Climate Change and Environmental Science

Degree nomenclature	: B.Sc. (Honors) Climate Change and Environmental Science
Eligibility criteria	: Students having passed Plus Two/Higher Secondary/ equivalent examination with Physics, Chemistry and Mathematics/Biology with a minimum of 50% marks except for SC/ST communities.
Selection through	: NEET ranks from candidates who have studied bio/maths
Medium of instruction	: English
Intake	: 30 students per year

The Semester wise distribution of courses

SEMESTER I

Sl. No.	Catalogue No.	NAME OF COURSE	CREDIT
1.	SAAS 1101	Mathematics	1+1
2.	SAAS 1102	Introduction to Forestry	2+1
3.	SAAS 1103	Introduction to Agriculture	2+1
4.	SAAS 1104	Introduction to Statistics	1+1
5.	SAAS 1105	Introductory Animal Husbandry	1+1
6.	ENVS 1101	Introduction to Environmental Science	2+0
7.	ENVS 1102	Environmental Chemistry	2+1
8.	CLIM 1101	Introduction to Earth system	2+0
9.	EARS 1101	Thermo and Fluid Dynamics	2+1
10.	SAAS 1106	Comprehension and communication skills in English	0+1*
11.	SAAS 1107	NCC/NSS/Physical Education and Yoga Practice 1	0+1*
		TOTAL	15+9=24

* non-credit courses

SEMESTER II

Sl. No.	Catalogue No.	NAME OF COURSE	CREDIT
1.	SAAS 1208	Vector Calculus	2+1
2.	SAAS 1209	Fundamentals of Computer Science	1+1
3.	SAAS 1210	Introduction to Soil Science	1+1
4.	SAAS 1211	Economics and Entrepreneurship Development	2+0
5.	ENVS 1203	Environmental Biochemistry	2+1
6.	EARS 1202	Physical Meteorology	2+0
7.	EARS 1203	Physical Oceanography	2+1
8.	CLIM 1202	Climate System- Past, Present and Future	2+1

9.	CLIM 1203	Fundamentals of Agrometeorology and Weather Forecasting	2+1
10.	SAAS 1212	Communication Skills and Personality Development	0+1*
11.	SAAS 1213	Physical Education and Yoga Practice 2	0+1*
		TOTAL	16+9=25

* non-credit courses

SEMESTER III

Sl. No.	Catalogue No.	NAME OF COURSE	CREDIT
1.	SAAS 2114	Applications of Computer Programming in Climate Sciences	1+1
2.	SAAS 2115	Plant Physiology	1+1
3.	SAAS 2116	Soil and Water Conservation	1+1
4.	SAAS 2117	Crop improvement for Climate Change	2+0
5.	SAAS 2118	Climate Smart Agriculture	2+0
6.	SAAS 2119	Forest Ecology and conservation biology	2+1
7.	SAAS 2120	Fundamentals of Crop Protection	2+1
8.	ENVS 2104	Environmental Economics and Sustainable Development	1+1
9.	CLIM 2104	Tropical Meteorology	2+1
10.	CLIM 2105	Environmental Geoscience	2+1
		TOTAL	16+8=24

SEMESTER IV

Sl. No.	Catalogue No.	NAME OF COURSE	CREDIT
1.	EARS 2204	Global Physical Climatology	2+1
2.	EARS 2205	Geomatics	1+2
3.	EARS 2206	Air-Sea Interaction	1+1
4.	ENVS 2205	Wetland Ecology and Management	2+0
5.	ENVS 2206	Environmental Pollution and Toxicology	1+1
6.	CLIM 2206	Climate change: the Indian Scenario	2+0

7.	SAAS 2221	Statistical methods and Experiment Design	2+1
8.	SAAS 2222	Biotechnology and Climate Change	2+1
9.	SAAS 2223	Restoration Ecology	1+1
		TOTAL	14+8=22

SEMESTER V

Sl. No.	Catalogue No.	NAME OF COURSE	CREDIT
1.	ENVS 3107	Environmental Law and Policy	2+0
2.	ENVS 3108	Environmental Microbiology	2+1
3.	ENVS 3109	Solid & Hazardous Waste Management	1+1
4.	CLIM 3107	Weather Modification and Disaster Management Strategies	2+0
5.	CLIM 3108	Climate Projections	2+1
6.	SAAS 3124	Introduction to Fisheries Oceanography	1+1
7.	SAAS 3125	Principles and Practices of Extension	1+1
8.	EARS 3107	Remote Sensing and its application in Climate Science	2+1
9.	EARS 3108	Climate Dynamics	2+1
		TOTAL	15+7=22

SEMESTER VI

Sl. No.	Catalogue No.	NAME OF COURSE	CREDIT
1.	EARS 3209	Ocean and Atmosphere Modelling	2+1
2.	EARS 3210	Climate Change and Polar Science	2+1
3.	ENVS 3210	Environmental Planning and Management	1+1
4.	CLIM 3209	Governance, Law and policy in Disaster Management	2+1
5.	CLIM 3210	Renewable Energy and Green Technology	2+1
6.	CLIM 3211	Natural Resource Management	2+0
7.	CLIM 3212	Climate Change Mitigation and Adaptation	2+1

8.	CLIM 3213	Carbon Management and greenhouse gas mitigation	2+1
9.	ENVS 3211	Environmental Impact Assessment	1+0
		TOTAL	16+7=23

SEMESTER VII (Student Ready – Climate and Environment Work Experience)

Sl. No.	Catalogue No.	NAME OF COURSE	CREDIT
1	CEWE 4101	Climate and Environment Work Experience (CEWE)	0+20
2	SAAS 4125	Educational Tour I (All Kerala)	0+1*
		Total	21

CEWE 4101 **Climate and Environment Work Experience (CEWE) -** 0+20

General orientation

Industrial Placement

Socio-economic survey & Village attachment

Attachment with Institutes/KVK/Industries/companies as internees

Report Preparation, Presentation and Evaluation

Orientation

Conducting various exercises for exposing the students on the recent trends in the field of Climate change and Environmental Science, transactional analysis, personality development, soft skills etc. and to prepare students for the rigours of professional life after completing B.Sc.(CC & ES) programme.

Placement with Industrial/local self-government organisation

Attachment with Climate Change and Environmental Science related industries. Works to be undertaken includes study the nature of industrial and business organization.

Socio Economic Surveys and Village Attachment:

Data collection, use of PRA techniques with respect to village profile including socio-economic and cultural status, and the climate changes and environmental related challenges being faced by the villagers. Benchmark survey of the resources available in the village (cropping pattern, home steads, biodiversity etc.), Schedule development, tabulation, analysis and preparing plan of work.

Understanding carbon footprint of the village and preparing a plan for making the village carbon neutral, through the participation of the villagers.

Attachment with KAU research stations/KVKs/ Institutes/ as internees

During this module the students are expected to learn about the functioning of these stations/KVKs/institutes and facilitate to address and mitigate the climate change related issues there.

Report Writing and Presentation

Compilation of the work/experience detailing the objectives, places and persons visited, work done, experiences/skills gained and suggestions for improvement of training. Presentation of the report before faculty. The assessment will be based on Project Report evaluation and viva-voce.

SEMESTER VIII (Student Ready – Experiential Learning)

Sl. No.	Catalogue No.	NAME OF COURSE	CREDIT
1	CEWE 4202	Experiential Learning	0+10
2	CEWE 4203	Project work	0+10
3	SAAS 4226	Educational Tour II (All India)	0+1*
		Total	21
		Grand total	**182**

CEWE 4202 **Experiential Learning (0+10)**

CEWE 4203 **Project Work (0+10)**

This course shall provide the B.Sc. (Hons) Climate Change and Environmental Science students an understanding of the principles and procedures of the experimental design, layout, analysis and interpretation of data and technical writing. Each student shall work on a specific research project to be identified with the help of the supervising teacher. They shall also prepare and present a proposed plan of work (PPW) specifying the objectives and procedures of the study and present the same before an audience consisting of faculty and students. The research work will be conducted leading to the preparation of a project report in the format and style of M.Sc. thesis. Evaluation will be done based on the quality of work, quality of report and its presentation before an audience consisting of faculty and students.

Every week the students should write a report of their activities and submit to the concerned field work supervisor on Mondays. The supervisor conducts individual and group conferences every week regularly. At the end of the semester Viva Voce is conducted by an external examiner and marks are awarded.

Class room credits	- 136
Total non-credit courses	- 6
Credits for Student Ready	- 40
Grand total (including NC courses)	= 136+6+40 = 182

THE DEPARTMENT-WISE LIST OF COURSES

DEPARTMENT OF CLIMATE CHANGE AND ADAPTATION

Catalogue No.	Name of the course	Credits
CLIM 1101	Introduction to Earth system	2+0
CLIM 1202	Climate System- Past, Present and Future	2+1
CLIM 1203	Fundamentals of Agrometeorology and Weather forecasting	2+1
CLIM 2104	Tropical Meteorology	2+1
CLIM 2105	Environmental Geoscience	2+1
CLIM 2206	Climate change; The Indian Scenario	2+0
CLIM 3107	Weather Modification and Disaster Management Strategies	2+0
CLIM 3108	Climate Projections	2+1
CLIM 3209	Governance, Law and policy in Disaster Management	2+1
CLIM 3210	Renewable Energy and Green Technology	2+1
CLIM 3211	Natural Resource Management	2+0
CLIM 3212	Climate Change Mitigation and Adaptation	2+1
CLIM 3213	Carbon Management and greenhouse gas mitigation	2+1
	Total credits	**26+9 = 35**

DEPARTMENT OF ENVIRONMENTAL SCIENCE

Catalogue No.	Name of the course	Credits
ENVS 1101	Introduction to Environmental Science	2+0
ENVS 1102	Environmental Chemistry	2+1
ENVS 1203	Environmental Biochemistry	2+1
ENVS 2104	Environmental Economics and Sustainable Development	1+1
ENVS 2205	Wetland Ecology and Management	2+0

ENVS 2206	Environmental Pollution and Toxicology	1+1
ENVS 3107	Environmental Law and Policy	2+0
ENVS 3108	Environmental Microbiology	2+1
ENVS 3109	Solid & Hazardous Waste Management	1+1
ENVS 3210	Environmental Planning and Management	1+1
ENVS 3211	Environmental Impact assessment	1+0
	Total credits	**17+7=24**

DEPARTMENT OF EARTH SCIENCE

Catalogue No.	**Name of the course**	**Credits**
EARS 1101	Thermo and Fluid Dynamics	2+1
EARS 1202	Physical Meteorology	2+0
EARS 1203	Physical Oceanography	2+1
EARS 2204	Global Physical Climatology	2+1
EARS 2205	Geomatics	1+2
EARS 2206	Air-Sea Interaction	1+1
EARS 3107	Remote Sensing and its Application in Climate Science	2+1
EARS 3108	Climate Dynamics	2+1
EARS 3209	Ocean and Atmosphere Modelling	2+1
EARS 3210	Climate Change and Polar Science	2+1
	Total credits	**18+10=28**

DEPARTMENT OF SUPPORTIVE AND ALLIED SUBJECTS

Catalogue No.	**Name of the course**	**Credits**
SAAS 1101	Mathematics	1+1
SAAS 1102	Introduction to Forestry	2+1
SAAS 1103	Introduction to Agriculture	2+1
SAAS 1104	Introduction to Statistics	1+1
SAAS 1105	Introductory Animal Husbandry	1+1

SAAS 1106	Comprehension and communication skills in English	0+1*
SAAS 1107	NCC/NSS/Physical Education and Yoga Practice 1	0+1*
SAAS 1208	Vector Calculus	2+1
SAAS 1209	Fundamentals of Computer Science	1+1
SAAS 1210	Introduction to Soil Science	1+1
SAAS 1211	Economics & Entrepreneurship Development	2+0
SAAS 1212	Communication Skills and Personality Development	0+1*
SAAS 1213	Physical Education and Yoga Practice 2	0+1*
SAAS 2114	Application of Computer Programming in Climate Sciences	1+1
SAAS 2115	Plant Physiology	1+1
SAAS 2116	Soil and Water Conservation	1+1
SAAS 2117	Crop Improvement for Climate Change	2+0
SAAS 2118	Climate Smart Agriculture	2+0
SAAS 2119	Forest Ecology and conservation biology	2+1
SAAS 2120	Fundamentals of Crop Protection	2+1
SAAS 2221	Statistical methods and Experiment Design	2+1
SAAS 2222	Biotechnology & climate change	2+1
SAAS 2223	Restoration Ecology	1+1
SAAS 3124	Introduction to Fisheries Oceanography	1+1
SAAS 3125	Principles and practices of Extension	1+1
	Total credits	**31+22=53**

Student Ready - Climate and Environmental Work Experience

Catalogue No.	**Name of the course**	**Credits**
CEWE 4101	Climate and Environment Work Experience (CEWE)	0+20
SAAS 4125	Educational Tour I (All Kerala)	0+1*
	Total	**21**

SEMESTER VIII (Student Ready – Experiential Learning)

Catalogue No.	Name of the course	Credits
CEWE 4202	Experiential Learning	0+10
CEWE 4203	Project work	0+10
SAAS 4226	Educational Tour II (All India)	0+1*
	Total	21
	Grand total	**182**

Class room credits	-	136
Total non-credit courses	-	6
Credits for Student Ready	-	40
Grand total (including NC courses)	-	**136+6+40 = 182**

DEPARTMENT OF CLIMATE CHANGE AND ADAPTATION

CLIM 1101 Introduction to Earth system 2(2+0)

Theory

The Earth System, Spheres of the Earth System- Atmosphere, Hydrosphere, Lithosphere, Biosphere -Tectonic plates -primary and secondary plates,- Concept of minerals and rocks, controls on formation of landforms., The Earth's Crust and Mantle, Roles of Various Components of the Earth System in Climate, The Hydrologic Cycle, The Carbon Cycle, Carbon in the Atmosphere, Carbon in the Biosphere, Carbon in the Oceans, Carbon in the Earth's Crust, Oxygen in the Earth System, Sources of Free Oxygen, A Brief History of Climate and the Earth System, What controls our planets temperature, Formation and Evolution of the Earth System, evolution and the biosphere; biogeochemical cycles*;* the atmosphere, its origin and structure; the function of the atmosphere and the dynamic of climates; concept of residence time and rates of natural cycles, Principles of Catastrophism, Geophysical fields.Earth surface processes materials the human footprint – from *Homo habilis*to *Homo informatic*;; devising an ecological recipe for the Earth – the Gaia hypothesis. National efforts to counteract climate change

Theory

1	General introduction about earth system (Sun and solar system, Earth, rotation and revolution)
2-3	Formation and Evolution of the Earth System,
4-5	Evolution and the biosphere; biogeochemical cycles
6-8	Spheres of earth system
9-10	Tectonic plates -primary and secondary
11-12	Concept of minerals and rocks,
13	Controls on formation of landforms

14	The Earth's Crust and Mantle,
15	Roles of Various Components of the Earth System in Climate
16	**MID SEMESTER EXAMINATION**
17	The Hydrologic Cycle
18	The Carbon Cycle, Carbon in the Atmosphere,
19	Carbon in the Biosphere, Carbon in the Oceans,
20	Carbon in the Earth's Crust,
21	Oxygen in the Earth System, Sources of Free Oxygen,
22	A Brief History of Climate and the Earth System
23	What controls our planets temperature,
24	The atmosphere, its origin and structure
25	The function of the atmosphere and the dynamic of climates
26	Concept of residence time and rates of natural cycles
27	Principles of Catastrophism
28	Geophysical fields
29	The human footprint – from Homo habilis to Homo informatic
30-32	Geological time scale
33	National efforts to counteract climate change
34-35	Gaia hypothesis.
36	**SEMESTER EXAMINATION**

Suggested Readings

Kump, L.R., Kasting, J.E. and Crane, R.G., 2010: The Earth System. Prentice Hall, 420pp.

PrasadaRao, G.S.L.H.V. 2008. Agricultural Meteorology. PHI Learning Private Limited. New Delhi, India. 324p

CLIM 1202 Climate System- Past, Present and Future 3(2+1)

Theory

Origin of the atmosphere, its function and outlines the major climate states that the Earth has experienced during its history: Components of the climate system- atmosphere, ocean, cryosphere, landmass and biomass; feedback mechanisms, elements and factors of climate and their interactions, Season, Equinox, solistics, solar control, geographical control, oceanic and continental influences. Koppen climate classification -Greenhouse gases, global warming; Heat balance and radiative forcing;- Climate predictability - future climate – key concerns arising out of most recent projections,– major international and national efforts to minimize climatic change and their effects. Climate of India, changes in atmospheric composition and causes of warming over the last 200 years; and climate; global icehouse and greenhouse states;long term climate change - the Milankovitch mechanism; anthropogenic impacts on the climate system. Climate change over India since the last 100-150 years. Global climate changes in terms of temperature and rainfall.

Theory

1-3 Introduction to the origin of the atmosphere

4 Functions of the atmosphere

5-6 Elements and factors of climate and their interactions: Temperature, Atmospheric pressure, wind, airmasses, Humidity, types of humidity, precipitation- types, visibility, fog, mist, haze,
cloudiness, solar radiation;

7	Factors affecting climate
8-9	Major climate states that Earth experienced during its history- greenhouse and icehouse earth
10-12	Components of climate system and their interaction (atmosphere, ocean, cryosphere, landmass and biomass
13-14	Feedback mechanisms in the climate system - Cloud, water vapor, vegetation, aerosol, ice-albedo,
15	Season, Equinox, solstice, solar constant
16	**MIDTERM EXAMINATION**
17-18	Heat balance and radiative forcing
19-20	Koppen climate classification
21	Greenhouse gases, global warming
22	Climate predictability – IPCC -future climate
23-24	key concerns arising out of most recent projections
25-26	Cloud Genera- types
27-29	Major international and national efforts to minimize climatic change and their effects
30	Climate of India
31	Changes in atmospheric composition and causes of warming over the last 200 years

32	Long term climate change - the Milankovitch mechanism
33	Anthropogenic impacts on the climate system
34	Climate change over India since last 100-150 years
35	Global climate changes in terms of temperature and rainfall.
36	**SEMESTER EXAMINATION**

Practical

Detailed graphical representation of geological time scales and its relationship with the climate system, Graphical representation of the historical CO2 changes and its future projections in different scenarios, introduction to weather instruments-recording, computation of climatic normals, Climate Change over India since last 100-150 years and its effects on agriculture and allied fields: Exercises using IPCC CMIP-5 data, Comparison with IPCC CMIP-6 data for the above scenarios:

PRACTICAL SCHEDULE

1-4	Detailed Flowchart representation of geological time scales and its relationship with the climate system
5-6	Graphical representation of the historical CO2 changes and its future projections in different scenarios
7-9	introduction to weather instruments-recording

10-11 computation of climatic normals,

12-14 Exercises using IPCC CMIP-5 data, Comparison with IPCC CMIP-6data for different RCP scenarios:

15-17 Climate Change over India since last 100-150 years and its effects on agriculture and allied fields:

18 Practical Examination

Suggested Readings

Hartmann, D.L., 2015. *Global physical climatology* (Vol. 103). Newness.

McGuffie, K. and Henderson-Sellers, A., 2014. *The climate modelling primer*. John Wiley & Sons.

Peixoto, J.P. and Oort, A.H., 1992. Physics of climate.

Ruddiman, W.F., 2001. *Earth's climate: past and future*. Macmillan.

Scorer, R.S. and Scorer, R.S., 1997. *Dynamics of meteorology and climate* (p. 81). Chichester: Wiley.

Sellers, W.D., 1965. *Physical climatology* (No. 551.6 S467). University of Chicago Press.

Trewartha, G.T., 1954. *An introduction to climate* (No. QC981 T65 1954).

Wallen, C.C., 1970. *World survey of climatology* (Vol. 5). Elsevier.

CLIM 1203 Fundamentals of Agrometeorology and Weather forecasting 3(2+1)

Theory

Meaning and scope of agricultural meteorology; Earth atmosphere- its composition, extent and structure; Atmospheric weather variables; Atmospheric pressure, its variation with

height; Wind, types of wind, daily and seasonal variation of wind speed, cyclone, anticyclone, land breeze and sea breeze; Nature and properties of solar radiation, solar constant, depletion of solar radiation, short wave, longwave and thermal radiation, net radiation, albedo; Atmospheric temperature, temperatureinversion, lapse rate, daily and seasonal variations of temperature, vertical profile of temperature, Energy balance of earth; Atmospheric humidity, concept of saturation, **v**apour pressure, process of condensation, formation of dew, fog, mist, frost, cloud;Precipitation, process of precipitation, types of precipitation such as rain, snow, sleet,and hail, cloud formation and classification; Artificial rainmaking. Monsoon mechanismand importance in Indian agriculture, Weather hazards – drought, floods,frost, tropical cyclones and extreme weather conditions such as heat-wave and cold wave.

Agriculture and weather relations; Modifications of crop microclimate, climatic normal for crop and livestock production. Weather forecasting- tools of weather forecasting, types of weather forecasting, methods of weather forecasting, weather advisories and their uses. Climate change, climatic variability, global warming, causes of climate change and its impact on regional and national Agriculture.

Lecture Schedule- Theory

1-2	Agricultural meteorology – definition, types of meteorology, objectives, scales, their importance to crop production and future scope. (I)
3	Earth atmosphere- its composition, extent and structure
4-5	Atmospheric pressure – diurnal and seasonal variation – pressure systems of the world – causes of variation – isobar – low, depression, anticyclone, tornado, hurricane and storms.
6-7	Wind – wind systems of the world – inter tropical convergence zones (itcz) – Types of wind-effect of wind on crop production - cyclone, anticyclone, land breeze and sea breeze, mountain breeze and valley breeze
8-9	Nature and properties of solar radiation, solar constant, short wave, longwave and thermal radiation, net radiation, albedo
10	Atmospheric temperature, temperature inversion, lapse rate, daily and seasonal variations of temperature, vertical profile of temperature
11	Energy balance of earth
12-13	Atmospheric humidity, concept of saturation, vapour pressure, process of condensation, formation of dew, fog, mist, frost, cloud
14	Precipitation, process of precipitation, types of precipitation such as rain, snow, sleet, and hail
15	cloud formation and classification of clouds
16-17	Artificial rainmaking – Mechanisms
18	Mid Term Examination

19-21	Monsoon mechanism and importance in Indian agriculture
22	Weather hazards –drought, floods, frost, tropical cyclones and extreme weather conditions such as heat-wave and cold wave.
23	Modifications of crop microclimate-Shelterbelts, windbreaks, mulches, shade nets, greenhouses
24	Climatic normal for crops
25	Weather forecasting- definition, Services, Importance.
26-27	Tools of weather forecasting, types of weather forecasting.
28	Methods of weather forecasting
29	Weather advisories and their uses
30	Climate change- definition, causes
31-32	Climate change- impacts
33	Climatic variability, global warming
34-35	Causes of climate change and its impact on regional and national Agriculture.
36	Final Examination

Practical

Study the establishment of Agrometeorological Observatory, site selection of observatory, exposure of instruments and weather data recording. Measurement of sunshine duration. Measurement of maximum and minimum air temperatures, its tabulation, trend and variation analysis. Measurement of soil temperature and computation of soil heat flux. Determination of relative humidity. Determination of dew point temperature. Measurement of atmospheric pressure and analysis of atmospheric conditions. Measurement of wind speed and wind direction, preparation of wind rose. Measurement, tabulation and analysis of rain. Measurement of evaporation. Analysis of rainfall pattern of Kerala, annual rainfall analysis, assessment of drought year. Applications of weather forecasting; Preparation of weather based agro-advisories based on weather forecast using various approaches , Preparation of station weather plots and synoptic charts, Working of WRF models

Practical Schedule

1	Study the establishment of Agrometeorological Observatory, site selection of observatory, exposure of instruments and weather data recording
2	Calculation of time
3	Measurement of Temperature – Stevenson's screen, Dry bulb temperature, wet bulb temperature, maximum and minimum air temperatures, its tabulation, trend and variation analysis.
4	Measurement of Temperature (II)- Thermograph, Tabulation, trend and variation analysis of temperature data
5	Measurement of soil temperature and computation of soil heat flux.
6	Determination of relative humidity and dewpoint temperature: different types of psychrometers, Hygrometer, hygrograph, thermo-hygrograph
7	Measurement of sunshine duration: sunshine recorder
8	Measurement of solar radiation
9	Measurement of atmospheric pressure and analysis of atmospheric conditions.
10	Measurement of wind speed and wind direction, preparation of wind rose.

11	Measurement, tabulation and analysis of rain
12	Measurement of evaporation.
13	Analysis of rainfall pattern of Kerala, annual rainfall analysis, assessment of drought year.
14	Applications of weather forecasting
15	Preparation of weather based agro-advisories based on weather forecast using various approaches.
16	Preparation of station weather plots and synoptic charts
17	Working of WRF models
18	Practical Examination

Suggested Readings

Annette Bolger. 2010. *Science of Weather and Environment*. Oxford Book Company, Jaipur

Das, P.K. 1968. *The Monsoons*. NBT, New Delhi

Frederick. K. Lutgens, Edward.J.Tarbuck.1989.The *Atmosphere- An Introduction to Meteorology*. Prentice Hall, New Jersey Khadekar, S.R. 2001. Meteorology. Agromet publishers, Nagpur

Mavi, HS, 1986. *Introduction of Agrometeorolgy*. Oxford & IBH Publishing Co. New Delhi

Prasada, G.S.L.H.V., Rao, V.U.M. and Rao, G.G.S.N., 2010. Climate Change and Agriculture Over India. PHI Learning Pvt. Ltd..

Rao, G.P., 2008. Agricultural meteorology. PHI Learning Pvt.

Ltd. Rama Sastry, A.A., 1984. Weather and weather forecasting.

Sachati, A.K. 1985. *Agricultural Meteorology — Instruction-cum-practical manual*, NCERT, New Delhi.

Sellus, W.D. 2015. *Physical Climatology*. New India Publishing Agency, New Delhi

Singh, S.V. ed., 1999. Proceedings of the National Workshop on Dynamical Crop Simulation Modeling for Agrometeorological Advisory Services [conducted by NCMRWF at New Delhi, 4-6 January 1999]. Nat. Centre for Medium Range Weather Forecasting.

Varshneya, M.C. and Balakrishna Pillai, B. 2003. *Textbook of Agricultural Meteorology*. ICAR, New Delhi

Venketaraman, S. and Krishnan, A. 1992. *Crops and weather*. ICAR, New Delhi

Watts, A., 2016. Instant Weather Forecasting: You Can Predict the Weather. Bloomsbury Publishing.

Wegman, E.J. and DePriest, D.J. eds., 1980. Statistical analysis of weather modification experiments (Vol. 3). M. Dekker.

CLIM 2104 Tropical Meteorology 3 (2+1)

Theory

Tropical Meteorology: Hadley cell, trade winds, trade wind inversion, tropical convection, tropical precipitation and its spatial and temporal variation. equatorial trough, ITCZ, easterly waves, convective systems, tropical cyclones: their structure and development, Gray's parameter, CISK, tropical easterly jet stream. quasi-biennial oscillation (QBO). Pre-monsoon: cyclonic storms, tracks, and frequencies; dust-storms, north-westers, heat waves, pre-monsoon thunderstorms. Monsoon: monsoon over Asia, Australia and Africa; SW and NE monsoons over India; monsoon trough, onset and advance of monsoon, active and break monsoon, strong and weak monsoon, synoptic features associated with onset, break active and weak monsoons and their prediction. Tibetan anti-cyclone, off-shore vortices and trough, low level jet, Mascarene high, monsoon depression, mid-tropospheric cyclone, floods and draughts, westerly disturbances and their influence on monsoonal circulation, withdrawal of monsoon. Post monsoon: cyclonic storm tracks, frequency, northeast monsoon circulation and rainfall. Variability of monsoon –Intra seasonal variation, Madden-Julian oscillation(MJO), El-Nino and Southern Oscillation (ENSO), Indian Ocean

dipole and Equinox, Inter annual variation (IAV).

Lecture schedule

1	Introduction to Hardley Cell, Trade winds and their properties
2	Tropical cyclones: Introduction and basics
3-5	Tropical cyclones: Their structure and development in details
6	Tropical cyclones: CISK theory and explanations
7	Tropical cyclones: Effect of Tropical cyclones in details
8	Tropical cyclones: Movement and path explanations
9	Introduction and properties of Norwesters and Dust Storms
10	Definition and properties of Equatorial Trough, ITCZ and Easterly waves
11-12	Monsoons: Monsoons over Asia properties
13-14	Tropical Monsoon precipitation (spatial and temporal variations)
15	Monsoons over Australia and Africa
16-17	El-nino and Southern Oscillation (ENSO) and effect on global climate
18	**Midterm Examination**
19-20	South-West and North-East Monsoon over India
21-22	Indian Ocean dipole (IOD) and effect on Indian Summer Monsoon Rainfall
23	Explanation to Monsoon Trough, Onset and advance of monsoons
24-25	North Atlantic Oscillation (NAO)and effect on global climate
26-27	Explanation - Active and break monsoon, strong and weak monsoon
28-29	Introduction and explanation to Heat waves and their properties
30-31	Predictability of monsoon, tibetananti cyclone,off shore vorticesandoffshore trough
32-33	Madden Julian Oscillation (MJO) and effect on global climate
34-35	Low level jet streams, Mascaraine high and monsoon depression
36	**Final Theory Examination**

Practical

Weather Codes - Plotting of Charts- Chart reading, Analysis of scalar fields, Surface

chart analysis, Streamline and isotach analysis, Analysis of constant pressure charts, Analysis of thickness charts and thermal wind, Vertical time/cross section analysis, Analysis of tropical weather systems/surface and upper air, *Tropical Cyclone, Monsoon Depressions, Active and Break Monsoon, Western Disturbance, North-east Monsoon/Easterly wave*, Analysis of frontal depression, Ross by waves and their prognosis, Jet stream situations, Analysis and forecast of Route weather and Wind /temperature at different heights, Analysis of NCEP/NCAR data using GRADS.

Practical Schedule

1 Introduction to weather codes and explanations

2 Weather Stations in India and their details

3 Plotting on Weather maps details

4 Surface chart analysis – Exercise I

5 Surface Chart analysis – Exercise II

7 Surface Chart analysis – Exercise III

8 Isopleths – introduction and explanations

9 Identification of Isolines

10 Drawing exercise of Isolines

11 Introduction to NCEP/NCAR data analysis

12 Introduction to GrADS

13 Hands on exercise on GrADS in computers -I

14 Hands on exercise on GrADS in computers -II

15 Analysis of NCEP/NCAR data using GrADS – I

16 Analysis of NCEP/NCAR data using GrADS – II

17 Analysis of NCEP/NCAR data using GrADS – III

18 Final Practical Examination

Suggested Readings

Anthes, R.A., 1982. Tropical cyclones: Their evolution, structure and effects: Boston.

American Meteorological Society.

Asnani, G.C., 2005. *Tropical meteorology*. GC Asnani.

Chang, C.P. and Krishnamurti, T.N. 1987. *Monsoon meteorology*. New York: Oxford University Press ; Oxford

Houze Jr, R.A., 2014. *Cloud dynamics*. Academic press.

Philander, G.S., 1990. *El Niño, La Niña, and the southern oscillation*. San Diego: Academic Press.

Rao, Y.P., 1976. Southwest Monsoon, Met. *Monograph, Synoptic Meteorology*, (1), p.366.

Shaw, D.B., 1978. Meteorology over the tropical oceans. *Nature*, *276*(5687), pp.445-446.

Smithson, P.A., 1982. Meso-scale atmospheric circulations. BW Atkinson, Academic Press, London, 1981. No. of pages: 495, Price:£ 32.40. *International Journal of Climatology*, *2*, pp.303-304.

CLIM 2105 Environmental Geosciences 3(2+1)

Theory

The Earth and the Solar System: Milky way and the solar system. Modern theories on the origin of the Earth and other planetary bodies. Earth's orbital parameters, Kepler's laws of planetary motion, Geological Time Scale; Space and time scales of processes in the solid Earth, atmosphere and oceans. Age of the Earth. Radioactive isotopes and their applications in earth sciences. Basic principles of stratigraphy. Theories about the origin of life and the nature of fossil record. Earth's gravity and magnetic fields and its thermal structure: Geoid, spheroid; Isostasy.

Earth Materials: Gross composition and physical properties of important minerals and rocks; properties and processes responsible for mineral concentrations; nature and distribution of rocks and minerals in different units of the earth and different parts of India.

Surface features and Processes Physiography of the Earth; weathering, erosion, transportation and deposition of Earth's material; formation of soil, sediments and sedimentary rocks;

energy balance of the Earth's surface processes; physiographic features and river basins in India.

Interior of the Earth, Deformation and Tectonics Basic concepts of seismology and internal structure of the Earth. Physicochemical and seismic properties of Earth's interior. Concepts of stress and strain. Behavior of rocks under stress; Folds, joints and faults. Earthquakes – their causes and measurement. Interplate and intraplate seismicity. Paleo magnetism, sea floor spreading and plate tectonics.

Oceans and Atmosphere Hypsography of the continents and ocean floor –continental shelf, slope, rise and abyssal plains. Physical and chemical properties of sea water and their spatial variations. Residence times of elements in sea water. Ocean currents, waves and tides, important current systems, thermohaline circulation and the oceanic conveyor belt. Major water masses of the world's oceans. Biological productivity in the oceans. Motion of fluids, waves in atmospheric and oceanic systems. Atmospheric turbulence and boundary layer. Structure and chemical composition of the atmosphere, lapse rate and stability, scale height, geopotential, greenhouse gases and global warming. Cloud formation and precipitation processes, air- sea interactions on different space and time scales. Insolation and heat budget, radiation balance, general circulation of the atmosphere and ocean. Climatic and sea level changes on different time scales. Coupled ocean-atmosphere system, El Nino Southern Oscillation (ENSO). General weather systems of India, - Monsoon system, cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India. Marine and atmospheric pollution, ozone depletion.

Mineral Resources and the Environment Resources and reserves - Minerals and Population - Marine minerals - Recycling of resources – Environmental impacts of mineral resource extraction and processing.

Human impact of earth's environment: Civilization as a global geosystem – fossil fuel resources – alternative energy – global change – Earth system engineering and management.

Lecture Schedule

1-2	TheEarthandtheSolarSystem:Milkywayandthesolarsystem.Moderntheorieson theoriginoftheEarthandotherplanetarybodies.
3	Earth'sorbitalparameters,Kepler's lawsofplanetarymotion
4	GeologicalTimeScale
5	Spaceandtimescalesofprocesses in the solid Earth, atmosphere and oceans. Age of the Earth.
6-8	Radioactive isotopes and their applications in earth sciences. Theories about the origin of life and the nature of fossil record. Earth's gravity and magnetic fields

	and its thermal structure: Geoid, spheroid;Isostasy.
9	Basic principles of stratigraphy
10-11	EarthMaterials:Grosscompositionandphysicalpropertiesofimportantmineralsand rocks; properties and processes responsible for mineral concentrations
12-13	Nature and distribution of rocks and minerals in different units of the earth and different parts of India.
14	Surface features and Processes Physiography of the Earth; weathering, erosion, transportation and deposition of Earth's material, formation of soil
15-16	Sediments and sedimentary rocks; energy balance of the Earth's surface processes
17	Physiographic features and river basins in India
18	***Midterm Examination***
19-20	Interior of the Earth, Deformation and Tectonics Basic concepts of seismology and internal structure of the Earth. Physicochemical and seismic properties of Earth's interior. Concepts of stress and strain. Behavior of rocks under stress
21-22	Folds, joints and faults. Earthquakes – their causes and measurement. Interplate and intraplate seismicity. Paleo magnetism, sea floor spreading and plate tectonics.
23-25	OceansandAtmosphereHypsographyofthecontinentsandoceanfloor–continental shelf, slope, rise and abyssal plains. Physical and chemical properties of sea water and their spatial variations. Residence times of elements in sea water. Ocean currents,wavesandtides,importantcurrentsystems,thermohalinecirculationandthe oceanic conveyor belt. Major water masses of the world's oceans. Biological productivity in the oceans. Motion of fluids, waves in atmospheric and oceanic systems.
26-28	Climatic and sea level changes on different time scales. Coupled ocean-atmosphere system, El Nino Southern Oscillation (ENSO). Marine and atmospheric pollution, ozone depletion.
29-31	General weather systems of India, - Monsoon system, cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India.
32-34	Mineral Resources and the Environment Resources and reserves - Minerals and Population - Marine minerals - Recycling of resources – Environmental impacts of mineral resource extraction and processing.
35	Human impact of earth's environment: Civilization as a global geosystem – fossil fuel resources – alternative energy – global change – Earth system engineering and management.
36	**Final theory exam**

Practical

Clinometer and Brunton Compass- Map orientation, Elements of map reading, fore bearing and back bearing-Topographic sheets: scale, legends- types and categories, interpretation of contours and identification of natural landscape elements, scale measurements, slope calculation- Determination of latitude and longitude from toposheets, measurement of distance between two points- Construct sketches, cutaway section of earth and earth spheres, Plate boundaries- Determination of epicentre of an earthquake- Stereoscope and stereo-pairs – identification of landforms- Visit to a local area to document environmental grassland/hill/mountain- Visit a local polluted site - Urban/Rural/Industrial/Agricultural Study of common plants, insects, birds etc-Study of simple ecosystem- pond, river, hill slopes, etc.

Practical Schedule

1-2	Clinometer and Brunton Compass- Map orientation, Elements of map reading, fore bearing and back bearing
3-5	Topographic sheets: scale, legends- types and categories, interpretation of contours and identification of natural landscape elements, scale measurements
6 - 8	Slope calculation- Determination of latitude and longitude from toposheets, measurement of distance between two points
9-11	Construct sketches, cutaway section of earth and earth spheres, Plate boundaries
12-13	Determination of epicentre of an earthquake- Stereoscope and stereo-pairs; identification of landforms
14-15	Visit to a local area to document environmental grassland/hill/mountain; Visitalocalpollutedsite- Urban/Rural/Industrial/AgriculturalStudyofcommonplants, insects, birds etc
16-17	Study of simple ecosystem- pond, river, hill slopes,etc
18	***Practical Examination***

Suggested Readings

Botkin, D.B. and Keller, E.A., 1998. *Environmental science: earth as a living planet* (No. Ed. 2). John Wiley & Sons Ltd.

Fetter CW. 1990.*Applied Hydrogeology* CBS New Delhi 592 p

Frossard E 2006. *Function of Soils for Human Societies and the Environment* Geological Society London 199 p

Grotzinger et al 2007 *Understanding Earth* WH Freeman New York 579 p Henson R 2007 *The Rough Guide to Weather* Rough Guides Ltd London 444 p

http://www.pord.ucsd.edu/~ltalley/sio210/introduction/index.html Accessed 13 Sept 2010

Hudson TL et al 1999 *Metal Mining and the Environment* American Geological Institute Virginia 68 p

Krishnan MS 1976 *Geology of India and Burma* CBS New Delhi 433 p

Masters, G.M. and Ela, W.P., 2008. *Introduction to environmental engineering and science* (No. 60457). Englewood Cliffs, NJ: Prentice Hall.

Michel D and Pandya A 2010 *Coastal Zones and Climate Change* The Henry L. Stimson Center Washington DC, 122p

Pielou EC *The Energy of Nature* University of Chicago Press Chicago 259 p

Silver J 2009 *Global Warming and Climate Change Demystified* McGrawHill New York 306 p

Soman K 2001 *Geology of Kerala* Geological Society of India Bangalore 430 p

Stewart RH 2007 *Introduction to Physical Oceanography* 353p. (http://oceanworld.tamu.edu/home/course_book.htm) Accessed 13 Sept 2010.

Stewart RH 2007 *Environmental Science in the 21st Century: A New Online Environmental Science Book for College Student.*

CLIM 2206 Climate change; the Indian Scenario 2(2+0)

Theory

A weekly 2-hour seminar format – student driven - with the course aim of providing an understanding of the wider issues embedded in the climate future debate: environmental decisions in the light of uncertainty; adaptation and mitigation to proposed climate futures; food security; health and future climate states; energy futures; population growth, climate and the future resource base; the fate of developing countries; India and China in a future world.

1 Extreme weather events in India (Temperature)

2 Extreme weather events in India (Precipitation)

3 Extreme weather events in India (Landslides)

4	How Kerala is prone to climate change (Climate crisis in Kerala)
5	Weather forewarnings
6	Disaster Management Structure in India
7	Energy resources in India
8	Climate Change: Impacts on fisheries
9	Climate Change: Impacts on forest
10	Climate Change: Impacts on agriculture
11	Climate Change: Impacts on livestock sector
12	Climate Change: Impacts on health
13	Climate Change: Impacts on wetlands
14	Climate Change: Impacts on marine biodiversity
15	Carbon sequestration: Concepts and techniques
16	Environment protection laws in India
17	National Action plans in India (Climate change) & Adaptation and mitigation strategies for climate change in India
18	**Mid Term Examination**
19	Impact of climate change on river basins in India
20	Fate of India or other developing nations in the future world
21	Climate change and Population growth
22	Climate change and Food security

23 Climate Change: Impacts on Wildlife

24 Biodiversity conservation in a changing climate

25 Marine pollution

26 Ocean acidification

27 Air pollution

28 Water pollution

29 Noise pollution

30 Soil pollution

31 Impact of Climate change on Indian monsoon

32 Conference of Parties

33 Climate policies and Climate politics

34 Climate change and migration of living beings

35 Carbon accounting

36 **Final Examination**

Suggested Readings

Parry, M., Parry, M.L., Canziani, O., Palutikof, J., Van der Linden, P. and Hanson, C. eds., 2007. *Climate change 2007-impacts, adaptation and vulnerability: Working group II contribution to the fourth assessment report of the IPCC* (Vol. 4). Cambridge University Press.

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K.B., Tignor, M. and Miller, H.L., 2007. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change.

CLIM 3107 Weather modification and disaster management strategies 2(2+0)

Theory

Historical reviews of weather modification, present status of weather modification for agriculture; atmospheric composition and greenhouse effect. Theories of weather modification; scientific advances in clouds and electrical behaviour of clouds; hails suppression, dissipation of fog, modification of frost intensity and severe storms; shelter belts and wind breaks, mulches and anti-transpirants; protection of plants against climatic hazards; air and water pollution; meteorological conditions in artificial and controlled climates - green, plastic, glass and animal houses etc.

Natural Disasters - Meaning and nature of natural disasters, their types and effects. Floods, drought, cyclone, earthquakes, landslides, avalanches, volcanic eruptions,Heat and cold waves, Climatic change: Global warming, Sea level rise, Ozone depletion.

Man Made Disasters- Nuclear disasters, chemical disasters, biological disasters, building fire, coal fire, forest fire, oil fire, air pollution, water pollution, deforestation, Industrial wastewater pollution, road accidents, rail accidents, air accidents, sea accidents.

Quantification of risk assessment and management in agricultural systems. Challenges for developing coping strategies including transferring risks through insurance schemes. The role that insurances can play in risk spreading and transfer.

Disaster Management- Efforts to mitigate natural disasters at national and global levels. International strategy for disaster risk reduction. Concept of disaster management, national disaster management framework; financial arrangements; role of NGOs, Community-based organizations, and media. Central, state, district and local administration; Armed forces in disaster response; Disaster response: Police and other organizations.

Lecture Schedule-Theory

1 Historical reviews of weather modification- Ancient weather science in India

2 Weather Modification research in India

3 Present status of weather modification for agriculture

4 Atmospheric composition and greenhouse effect

5	Scientific advances in clouds and electrical behaviour of clouds
6	Hails suppression, dissipation of fog, modification of frost intensity and severe storms
7	Microclimate modification structures: shelter belts and wind breaks, mulches and anti-transpirants.
8	Air pollution
9	Water pollution
10	Meteorological conditions in artificial and controlled climates - green, plastic, glass and animal houses etc.
11	Green House structure
12	Natural Disasters - Meaning and nature of natural disasters, their types and effects.
13	Floods, drought,
14	Cyclone
15	Earthquakes, landslides
16	Avalanches, volcanic eruptions, Heat and cold waves
17	Climatic change: Global warming, Sea level rise
18	Mid Term Examination
19	Climatic change: Ozone depletion.
20	Man Made Disasters- Nuclear disasters,
21	Chemical disasters and biological disasters
22	Building fire, coal fire, forest fire, oil fire
23	Deforestation
24	Road accidents, rail accidents, air accidents, sea accidents.

25-26 Agricultural risk management – I

27-28 Agricultural risk assessment-I

29 Agricultural Insurance

30 Disaster Management- Efforts to mitigate natural disasters at national levels.

31 Disaster Management- Efforts to mitigate natural disasters at global levels.

32 International strategy for disaster risk reduction.

33 Concept of disaster management, national disaster management framework; financial arrangements role of NGOs, Community-based organizations, and media.

34 Central, state, district and local administration.

35 Armed forces in disaster response, Disaster response: Police and other organizations

36 Final Examination

Suggested Readings

Anonymous 2003. *Critical Issues in Weather Modification Research Board of Atmospheric Science and Climate*. National Research Council, USA.

Bishnoi OP. 2007. *Principles of Agricultural Meteorology*. Oxford Book Co. Chritchfield HJ. 1994. *General Climatology*. Prentice Hall.

Gupta, H.K. ed., 2003. *Disaster management*. Universities Press.
Hodgkinson PE & Stewart M. 1991. *Coping with Catastrophe: AHandbook of Disaster Management*. Routledge

Lenka D. 1998. *Climate, Weather and Crops in India*. Kalyani.

Mavi HS & Graeme J Tupper 2004. *Agrometeorology: Principles and Applications of Climate Studies in Agriculture*. The Haworth Press.

Mavi HS. 1994. *Introduction to Agrometeorology*. Oxford & IBH. Menon PA. 1989. Our Weather. National Book Trust.

Pearce RP. 2002. *Meteorology at the Millennium*. Academic Press.

Prasada Rao, G.S.L.H.V. 2008. *Agricultural Meteorology*. PHI Learning Private Limited. New Delhi, India. 324p

Prasada Rao, G.S.L.H.V., Rao, G.G.S.N. and Rao, V.U.M. 2010. Climate Change and Agriculture in India. PHI Learning Private Limited. New Delhi, India

Rosenberg NJ, Blad BL &Verma SB. 1983. *Microclimate – The Biological Environment*. John Wiley & Sons.

Samra JS, Pratap Narain, Rattan RK & Singh SK. 2006. *Drought Management in India. Bull. Indian Society of Soil Science 24,* ISSS, New Delhi. Gupta HK. 2003. Disaster Management. Indian National Science Academy. Orient Black swan.

Sharma VK. 2001. *Disaster Management. National Centre for Disaster Management, India*.

CLIM 3108 Climate Projections 3(2+1)

Theory

A weekly 3-hour seminar format – student driven – with the course aim of providing a critical understanding of the IPCC report, "Climate Change 2007: the physical science basis": historical overview of climate change science; changes in atmospheric constituents and radiative forcing; indicators of global climate change; paleoclimate; coupling between changes in the climate system and biogeochemistry; climate models and their evaluation; understanding and attributing climate change; global and regional climate projections, Basic ideas on Bioclimatology and Applied Climatology.

Theory

1 Introduction to climate projections and its scope &significance

2-3 Different climate models – GCM , RCM etc.

4-5 strengths and limitations of climate models and their uncertainties

6-7 key factors and drivers influencing future climate change

7-9 Representative Concentration Pathways (RCPs)

	Shared Socioeconomic Pathways (SSPs)
10-11	Regional Climate Projection and Downscaling
12	Climate Projections and Water Resources Management: Assessing Changes in Precipitation Patterns and Hydrological Systems
13	Climate Projections and Energy Systems: Assessing Impacts on Energy Demand and Renewable Energy Potential
14	Extreme Weather Events in Climate Projections: Understanding Changes in Frequency and Intensity
15	Climate Projections in Impact Assessment
16	Climate Feedbacks and Tipping Points
17	**MID SEMESTER EXAMINATION**
18	Basic ideas on Bioclimatology and AppliedClimatology.
19-20	Implications of Climate Change on Water Resources
21-22	Impacts of Climate Change on Agriculture and Food Security
23	Climate Change Policies and International Agreements
24	Regional Climate Projections: Understanding the Spatial Variability of Future Climate Change
25	Climate Projections and Carbon Budgets: Assessing the Limits for Mitigation and Stabilization
26	Climate Projections and Urban Resilience: Planning for Climate Change Impacts and Adaptation in Cities
27	Climate Projections and Global Temperature Rise: Assessing the Impacts of Different Emission Scenarios
28-29	Climate Change and Energy Transition: Renewable Energy, Carbon Pricing, and Mitigation Policies
30	Climate Change and Economic Impacts: Cost of Inaction, Green Economy, and Sustainable Development Goals
31-32	Future Perspectives on Climate Change: Technological Innovations, Policy Pathways, and Global Cooperation.

33 Climate Change and Extreme Weather Events: Hurricanes, Floods, and Droughts

34-35 Climate Projections and Social Vulnerability: Assessing Differential Impacts and Equity Considerations

36 **SEMESTER EXAMINATION**

Practical

Numerical weather prediction, Climate models and their evaluation, Climate models on bioclimatology and applied climatology, RCP Data analysis, Asia specific Climate predictions

1-3 Numerical weather prediction

4-6 Climate models and their evaluation

7-9 Climate models on bioclimatology and applied climatology

10-12 RCP Data analysis, Asia specific Climate predictions

13-15 Evaluation of recent IPCC reports

16-17 Field Study/Case Study

18 PRACTICAL EXAMINATION

Suggested Readings

Prasada Rao, G.S.L.H.V.2008. *Agricultural Meteorology*. PHI Learning Private Limited. New Delhi, India. 324p

Prasada Rao, G.S.L.H.V., Rao, G.G.S.N. and Rao, V.U.M. 2010. *Climate Change and Agriculture in India*. PHI Learning Private Limited. New Delhi, India

Solomon, S. Qin, D. Manning, M.Chen, Z. Marquis, M. Averyt, K.B. Tignor, M and Miller, H.L. (eds.), 2007: *Climate Change 2007: the physical science basis*. Contribution of Working Group I to the *Fourth Assessment Report of the Intergovernmental panel on Climate Change 2007*

CLIM 3209 Governance, Law and policy in Disaster Management 3(2+1)

Theory

Public Administration: Introduction,Evolution and status of the discipline, Comparative public Administration and Development administration, public and private Administration. Basic concepts and Theories of Administration, Administrative behavior, Accountability and Control, Financial administration, Union Government and Administration in India, State and District Administration in India, state and District administration, Local Government. Disaster Management Policies: Policies in Disasters-Its significance, principles, policy options and approaches, essential components, command and coordination in disaster management-Incident Command system. National Disaster management Policy.

Disaster Decision Making: Disaster planning, Public Administration/ Policy and Emergency Management, Incident Command Centre, Training Need analysis and Human Resource Development plan, current trends in disaster preparedness. Contingency planning, community Emergency response team, Community relations for Environmental and emergency managers, Contingency planning for business and Industry, International disasters. Rules and regulations in disaster management: Disaster management Act, Role of the union and states in Disaster management Loss Assessment standards, public budgeting and finance systems; state and local finances- CRF (Calamity relief fund)/ NCCF (Natural Calamity Contingency Fund)/ CMDRF (Chief Ministers Disaster Relief Fund)- Norms, National, State and District Disaster Mitigation Fund & National, State and District Disaster response Fund. Disaster Management Plans: The 5 year Plan-The Planning process-Components of Disaster Management Plan.The risk analysis.- Resource identification-vulnerability assessment - Use of Planning Format- Contents of a Plan-Writing the basic plan- Plan annexes-Plan appendices- Element coordination.DDMPS-SDMPS-NDMA Guidelines-Introduction to Advanced Planning Techniques- Use of Plan, Evaluation Instrument- Evaluating the Hazard/Vulnerability Analysis- Organizational involvement Criteria for review of completed plans-

Emergency Operation Centre: Emergency Operation Centers and their role in IMS EOC and command post interface. BOC location, design, layout; Secondary considerations, BOC management: organizing, staffing, coordination, communication. BOC operations: Developing and using SOPS briefings, and financial support. Early Warning Systems, Communications Principles & Systems Analog & Digital Satellite & Terrestrial Communications-Concept of Modulation: Amplitude, Phase & Frequency Modulation

Techniques (AM/PM/FM) Radio Broadcast Systems- AM Radio Systems-FM Systems-telecommunications Networks-Effect of disasters on wire line and wireless communication links under catastrophe. Management Information Systems: Simulation and exercising, simulation theory and regulatory requirements. Types of exercise: table top, functional, full scale, Use of exercise; case studies of saliency to preparedness.

Lecture Schedule – Theory

1-2	Public Administration: Introduction, Basic concepts and Theories of Administration, Administrative behavior
3-4	Public administration: Evolution and status of the discipline, Comparative public Administration and Development administration, public and private Administration.
5-6	Concept of Accountability and Control in public administration, financial administration, Union Government and Administration in India, State and District Administration in India, state and District administration, Local Government.
7-8	Disaster Management Policies: Policies in Disasters-Its significance, principles, policy options and approaches, essential components, command and coordination in disaster management-Incident Command system. National Disaster management Policy.
9-11	Disaster Decision Making: Disaster planning, Public Administration/ Policy and Emergency Management, Incident Command Centre, Training Need analysis and Human Resource Development plan, current trends in disaster preparedness.
12 -13	Contingency planning, community Emergency response team, Community relations for Environmental and emergency managers, Contingency planning for business and Industry, International disasters.
14 - 17	Disaster Management Plans: The 5-year Plan-The Planning process-Components of Disaster Management Plan. The risk analysis. - Resource identification- vulnerability assessment - Use of Planning Format- Contents of a Plan-Writing the basic plan- Plan Annexes-Plan appendices- Element coordination.

18	**Midterm Examination**
19-21	Rules and regulations in disaster management: Disaster management Act, Role of the union and states in Disaster management Loss Assessment standards, public budgeting and finance systems; state and local finances- CRF (Calamity relief fund)/ NCCF (Natural Calamity Contingency Fund)/ CMDRF (Chief Ministers Disaster Relief Fund)- Norms, National, State and District Disaster Mitigation Fund & National, State and District Disaster response Fund.
22-23	DDMPS-SDMPS-NDMA Guidelines-Introduction to Advanced Planning Techniques- Use of Plan, Evaluation Instrument- Evaluating the Hazard/Vulnerability Analysis- Organizational involvement Criteria for review of completed plans-
24-26	Emergency Operation Centre: Emergency Operation Centers and their role in IMS EOC and command post interface. BOC location, design, layout; Secondary considerations, BOC management: organizing, staffing, coordination, communication.
26-27	BOC operations: Developing and using SOPS briefings, and financial support.
28-31	Early Warning Systems, Communications Principles & Systems Analog & Digital Satellite & Terrestrial Communications- Concept of Modulation: Amplitude, Phase & Frequency Modulation Techniques (AM/PM/FM) Radio Broadcast Systems- AM Radio Systems-FM Systems- telecommunications Networks-Effect of disasters on wire line and wireless communication links under catastrophe.
32-35	Management Information Systems: Simulation and exercising, simulation theory and regulatory requirements. Types of exercise: tabletop, functional, full scale, Use of exercise; case studies of saliency to preparedness.
36	**Final theory exam**

Practical

Training Need analysis and Human Resource Development plan, Developing and using SOPS briefings ,Early Warning Systems, Communications, Simulation and exercising, case studies of saliency to preparedness.

Practical Lecture Schedule

1-3	Training about relevant skills and tools needed to effectively respond to both natural and man-made disasters and resulting complex emergencies.
4-5	Human Resource Development plan
6-9	Training need analysis and field visit to Disaster affected area
10-11	Brief introduction to Synergized Standard Operating Procedures
12	Early Warning Systems
13-14	Communications, Simulation and exercising, case studies of saliency to preparedness.
15-17	Field investigation of natural disasters and complex emergencies
18	**Practical Examination**

Suggested Readings

Gupta, H.K. ed., 2003. *Disaster management*. Universities Press.

Laxmikanth, M. 2009. Public Administration, Tata McGraw hills Ltd. CRF and NCCF norms.

National Disaster Management Guidelines, Incident Response System. 2010. National Disaster Management Authority

The Disaster Management Act. 2005. Government of India.

CLIM 3210 Renewable Energy and Green Technology 3 (2+1)

Theory

Classification of energy sources, contribution of these sources in agricultural sector, Familiarization with biomass utilization for biofuel production and their application, Familiarization with types of biogas plants and gasifiers, biogas, bio-alcohol, bio-diesel and bio-oil production and their utilization as bio-energy resource, introduction of solar energy, collection and their application, Familiarization with solar energy gadgets: solar cooker, solar water heater, application of solar energy: solar drying, solar pond, solar distillation, solar photovoltaic system and their application, introduction of wind energy and their application.

Lecture Schedule - Theory

1-2 Introduction to energy, Classification of energy sources,

3-4 Contribution of energy sources in agricultural sector

5-6 India energy scenario

7-10 Familiarization with biomass utilization for biofuel production and their application

11-12 Familiarization with types of biogas plants

13-14 Types of Gasifiers

16-17 Biogas, bio-alcohol, bio-diesel and bio-oil production and their utilization as bio-energy resource

18 **Mid Term Examination**

19 Introduction of solar energy

20-22 Solar energy collection, Types of collectors

23-24 Efficiency calculation, Application of solar energy

25-26 Familiarization with solar energy gadgets: solar cooker

27 Familiarization with solar energy gadgets: solar water heater

28 Application of solar energy: solar drying

29 Application of solar energy: solar pond

30 Application of solar energy: solar distillation

31 Application of solar energy: solar photovoltaic system and

32 Application of solar photovoltaic systems

33-34 Introduction of wind energy

35 Applications of wind energy

36 Final examination – Theory

Practical

Energy input in agricultural production - biogas plant – different types, design of biogas plant. Biomass gasifier, Study of production process of bio-diesel, study of production

process of bio-fuel, study of briquetting, solar water heating, solar cookers, solar pumping, solar dryers, Design of solar dryers, solar photovoltaic cell characteristics, study of types of wind mills.

Lecture Schedule - Practical

1 GHG accounting

2 Design and development of GHG inventories

3-5 Establishing GHG boundaries for an organization, Identifying emission sources, Tracking emissions over time, recalculations and establishing a base year, Setting GHG reduction targets

6 Inventory quality management

7-8 Preparing a GHG inventory report, Preparing for verification

9-10 Reporting emissions according to The Climate Registry's General Reporting Protocol

11-12 Carbon Footprint, assessment of carbon stock, Identifying key carbon emission sources, selecting mitigation measures for study, performing financial analysis for GHG mitigation

13-14 Hydropower and wind energy GHG project accounting,

15 Establishing the baseline scenario and selecting relevant GHGs,

16-17 Quantifying emissions and removals, Monitoring, documenting and reporting.

18. Practical examination

Suggested Readings

Kumar, S., Kumar, V. and Sahu, R.K. 2016. *Fundamentals of Agricultural Engineering*. Kalyani Publishers, New Delhi.

Mathur, A.N. and Rathore, N.S. 1992. *Biogas production, management and utilization*. Himanshu Publication. Delhi.

Ojha, T.P. and A.M.Michael. *Principles of Agricultural Engineering, Vol.I*. Jain Brothers New Delhi.

Rai, G.D. 2013. *Non-Conventional Energy Sources*, Khanna Publishers, Delhi.

Rathore N. S., Kurchania, A. K., Panwar, N. L. 2007. *Renewable Energy, Theory and Practice*, Himanshu Publications.

Sukhatme, S.P. and Nayak, J.K. 2012. Solar Energy: *Principles of Thermal Collection and Storage*, Tata Mc-Graw Hill Education Pvt. Ltd., New Delhi

Tiwari, G.N. and Ghoshal, M.K. 2005. *Renewable Energy Resources: Basic Principles and Applications*. Narosa Pub. House. Delhi.

CLIM 3211 Natural Resource Management 2(2+0)

Theory

Sustainable Management- Introduction, Concepts and dimension, Theories and definitions Role of environmental Planning nad Management in Sustainable Development, Management of Biological Resources, Resource Management, Agriculture and land resources, Irrigation, Water resources (aqua culture, sea farming), Wild life resources, Forest resources, Mineral resources, Coastal zone, Coastal Zone Management, Law Sea and Coastal Regulation Zone (CRZ) act, Problems associated with Coastal ecosystem, Coastal Zone Management plans for Kerala, Remote sensing techniques for marine resource management, Biological Resource for health Management, Medicinal Plants, Identification of Problems and development, Sustainable Management strategies for biological resource with particular reference to Kerala, Management of Ecosystems, Management strategies for various ecosystems-grassland, wetland, estuaries, mangroves , coastal, forest and mountain, Ecotourism, Eco-development for management, Social and human interference management, Case studies.

Lecture Schedule- Theory

1	Introductory class
2	Resources, types of resources (natural, human made and human)
3, 4	Natural Resources, classifications
5, 6	Conservation of natural resources
7	Natural Resource Management; definition; objectives

8	Resource Management: Land
9	Resource Management: water
10	Resource Management: agriculture
11	Resource Management: forest and wild life
12	Resource Management: energy
13	Resource Management: minerals &oils
14	NRM Approach and ownership regime
15	Management of Ecosystems
16, 17	Management strategies for various ecosystems-grassland, wetland, estuaries, mangroves , coastal, forest and mountain
18	**Midterm Examination**
19	Coastal Zone; Indian; Kerala
20, 21	Coastal Zone Management, Law Sea and Coastal Regulation Zone (CRZ) act, Problems associated with Coastal ecosystem
22	Coastal Zone Management plans for Kerala
23	Resource for health Management
24	Integrated natural resource management (INRM)
25	Sustainable Management- Introduction, Concept of Sustainable development
26	Core elements of sustainable development
27, 28	Requirements of Sustainable Development, Scope of sustainable development (dimensions)
29, 30	Role of environmental Planning and Management in Sustainable Development

30	Role of environmental Planning and Management in Sustainable Development
31, 32	Sustainable Management strategies for biological resource with particular reference to Kerala
33	Eco-development for management, Ecotourism
34, 35	Case studies
36	**Final Examination**

Suggested Readings

Brotherton, I., 1992. Natural resource management of water and land: By Edward O. Gangstad. Van Nostrand Reinhold, New York, 1990. 192 pp. ISBN 0 442 00481 8 (hbk).

Deal, K.H., 2010. *Wildlife and Natural Resource Management*. Cengage Learning.

Environmental Problem of the Marine and Coastal areas of India-A Natural Report,1985, UNEP.

Ferguson, I.S., 1996. *Sustainable forest management*. Oxford University Press Australia.

Grant, W.E., Pedersen, E.K. and Marín, S.L., 1997. *Ecology and natural resource management: systems analysis and simulation*. John Wiley & Sons.

Gupta, R.S., 2016. *State of the marine environment in the South Asian Seas Region*. UNEP.

Krausman, P.R., 2002. Introduction to wildlife management. Printice Hall

Mitchell, B., 1997. Resource and Environmental Management Addison Wesley Longman Limited.

Nuberg, I., George, B. and Reid, R. eds., 2009. *Agroforestry for natural resource management*. CSIRO publishing.

PuniaBijender, K., 1994. Tourism Management Problems and Prospects.

Ryding, S.O.1994.Environmental Management hand book, IOS Press, Amsterdam

Sinha, R.K (Ed), 1996. Marine Resources and Applicable laws. Common wealth Publishers, New Delhi

Troeh, F.R., Hobbs, J.A. and Donahue, R.L., 1980. Soil and Water Conservation for Productivity and Environmental Production. *Soil and Water Conservation for Productivity and Environmental Production.*

Walter. R et al,1992. Global Biodiversity Strategy .UNEP.

CLIM 3212 Climate Change Mitigation and Adaptation 3(2+1)

Theory

Introduction to Climate Change Mitigation, Introduction to Climate Change Mitigation and Low Carbon Development Strategic Frameworks and Policy Approaches for Mitigation and Low Carbon Development, Sectors with High Mitigation Potential, International Initiatives to Support Climate Change Mitigation, Introduction to Climate Change Adaptation, Introduction to Climate Change Adaptation, Conducting a Vulnerability Assessment, Identifying and Selecting Adaptation Options, Linking Adaptation and Development Planning, International Initiatives to Support Climate Change Adaptation, Introduction to Climate Change Finance, Introduction to Climate Change Finance, National Climate Change Finance, International Climate Change Finance, Introduction to Planning for Climate Change, Introduction to Climate Change Planning, The Role of National and Sectoral Institutions in Climate Change Planning The Role of Sub-National Institutions in Climate Change Planning, A Methodology for Climate Change Planning, International Initiatives to Support Climate Change Planning. National adaptation Plan (NAP).

Lecture Schedule - Theory

1	Course Introduction
2	climate variability and climate change
3	Climate Change: effects and Consequences
4	Potential impacts of climate change on various sectors
5	Concept of climate change adaptation and mitigation
6	Adaptation and mitigation strategies (general)
7	Factors stopping us from mitigating climate change

8,9	International efforts to combat climate change
10,11	India's Efforts to Counter Climate Change
12	Circular Economy: Definition, Importance and Aspects
13	India and circular economy model
14	Climate Change Performance Index
15	Climate vulnerability and risk
16,17	Introducing terms related to Climate Change Vulnerability (Adaptive capacity, Climate stressors, Exposure, Non-climate stressors, Resilience, Sensitivity, Vulnerability assessment, Risk etc.)
18	**Mid Term Examination**
19, 21	Climate Change Vulnerability Assessments
22, 23	How can I assess vulnerability? A conceptual framework for vulnerability assessment
24	climate change vulnerability index
25	Climate change vulnerability index of India
26	Other indices related to climate change
27, 28	Risk, risk assessment
29, 30	Introduction to Climate Change Finance, International and National Climate Change Finance
31	National Adaptation Plan
32	Introduction to Climate Change Planning
33,34	The Role of National, Sub-National and Sectoral Institutions in Climate Change Planning

35 Case studies

36 **Final Examination**

Practical

Mini project: Identify a climate problem in your locality, understand the possible adaptation measures and prepare a proposal with a mitigation plan.

Lecture Schedule - Practical

1 Identify a climate problem in your locality

2 Selection of Topic

3 Setting Objectives

4,5 Review of Literature

6,7 Setting plan/ Methodology

8-12 Execution of plans and collection of data

13-15 Data Analysis and Conclusion

16,17 Presentation

18 **Report submission (Assessment Exam)**

Suggested reading

Dubash, N. ed., 2012. *Handbook of climate change and India: development, politics and governance*. Routledge.

Kabisch, N., Korn, H., Stadler, J. and Bonn, A., 2017. *Nature-based solutions to climate change adaptation in urban areas: Linkages between science, policy and practice*. Springer Nature.

Ludwig, F., Kabat, P., van Schaik, H. and van der Valk, M. eds., 2012. *Climate change adaptation in the water sector*. Routledge.

Markandya, A. and Mishra, A. eds., 2011. *Costing adaptation: preparing for climate change in India*. The Energy and Resources Institute (TERI).

Shaw, R., Pulhin, J. and Pereira, J. eds., 2010. *Climate change adaptation and disaster risk*

reduction: Issues and challenges. Emerald Group Publishing.
Shukla, P.R., 2003. *Climate change and India: vulnerability assessment and adaptation*. Universities Press.
Taylor, M., 2014. *The political ecology of climate change adaptation: Livelihoods, agrarian change and the conflicts of development*. Routledge.
Ramachandra, T.V., 2012. Decentralised carbon footprint analysis for opting climate change mitigation strategies in India. *Renewable and Sustainable Energy Reviews, 16*(8), pp.5820-5833.

CLIM 3213 Carbon Management and greenhouse gas mitigation 3(2+1)

Theory

Basics of organizational GHG accounting GHG accounting principles, defining applications for GHG inventories, design and development of GHG inventories, establishing GHG boundaries for an organization, identifying emission sources, tracking emissions over time, recalculations and establishing a base year, setting GHG reduction targets, inventory quality management, preparing a GHG inventory report, preparing for verification, *optional* – reporting emissions according to the climate registry's general reporting protocol, the analytical fundamentals of carbon management, introduction and overview, why manage carbon?, preparing for carbon management, identifying key emission sources, selecting mitigation measures for study, performing financial analysis for GHG mitigation, GHG accounting for renewable energy projects, GHG standards and programs, hydropower and wind energy GHG project accounting, establishing the baseline scenario and selecting relevant GHGs, quantifying emissions and removals, monitoring, documenting and reporting, GHG information management systems, overview of greenhouse gas information management systems, organizational GHG accounting and GHG ims key concepts, planning and scope definition, requirements phase – overview, data collection and calculation methodology, requirements phase – inventory quality management, data analysis and reporting, user interface, integration and it considerations, evaluation phase, design phase, implementation phase, system development deployment

Lecture Schedule - Theory

1-2 Basics of organizational GHG accounting GHG accounting principles

3 Defining applications for GHG inventories

4 Design and development of GHG inventories

7-10 Establishing GHG boundaries for an organization, identifying emission sources, tracking emissions over time

11-12 Recalculations and establishing a base year, setting GHG reduction targets,

13-14 Inventory quality management, preparing a GHG inventory report, preparing for verification,

16-17 Optional – reporting emissions according to the climate registry's general reporting protocol

18 **Mid Term Examination**

19 The analytical fundamentals of carbon management, introduction and overview

20-22 Why manage carbon?, preparing for carbon management, identifying key emission sources, selecting mitigation measures for study, performing financial analysis 29 for GHG mitigation

23 GHG accounting for renewable energy projects

24 GHG standards and programs

25 Hydropower and wind energy GHG project accounting

26 Establishing the baseline scenario and selecting relevant GHGs

27 Quantifying emissions and removals, monitoring, documenting and reporting,

29-30 GHG information management systems, overview of greenhouse gas information management systems

30-32 Organizational GHG accounting and GHG ims key concepts, planning and scope definition, requirements phase – overview, data collection and calculation methodology

33-34 requirements phase – inventory quality management, data analysis and reporting, user interface, integration and it considerations

35 evaluation phase, design phase, implementation phase, system development deployment.

36 Final examination – Theory

Practical

GHG accounting, Design and development of GHG inventories, Establishing GHG boundaries for an organization, Identifying emission sources, Tracking emissions over time, recalculations and establishing a base year, Setting GHG reduction targets, Inventory quality management, Preparing a GHG inventory report, Preparing for verification, Reporting emissions according to The Climate Registry's General Reporting Protocol. Carbon Footprint, assessment of carbon stock, Identifying key carbon emission sources, selecting mitigation measures for study, performing financial analysis for GHG mitigation. Hydropower and wind energy GHG project accounting, Establishing the baseline scenario and selecting relevant GHGs, Quantifying emissions and removals, Monitoring, documenting and reporting.

Lecture Schedule - Practical

1 GHG accounting

2 Design and development of GHG inventories

3-5 Establishing GHG boundaries for an organization, Identifying emission sources, Tracking emissions over time, recalculations and establishing a base year, Setting GHG reduction targets

6 Inventory quality management

7-8 Preparing a GHG inventory report, Preparing for verification

9-10 Reporting emissions according to The Climate Registry's General Reporting Protocol

11-12 Carbon Footprint, assessment of carbon stock, Identifying key carbon emission sources, selecting mitigation measures for study, performing financial analysis for GHG mitigation

13-14 Hydropower and wind energy GHG project accounting

15 Establishing the baseline scenario and selecting relevant GHGs,

16-17 Quantifying emissions and removals, Monitoring, documenting and reporting.

18. Practical examination

Suggested Readings

Bellassen, V. and Stephan, N. 2015. *Accounting for carbon : monitoring, reporting and verifying emissions in the climate economy*. Cambridge: Cambridge University Press.

Jain, MK. Agricultural Scientist 2018. *Soil carbon management*. Jaipur: Oxford Book Company.

KasthuriranganGopalakrishnan, WynandJvdm Steyn and Harvey, J. 2014. *Climate change, energy, sustainability and pavements*. Berlin Springer.

Quan Cui 2018. *Carbon management*. Oakville, On., Canada: Delve Publishing.

Ravindranath, N.H. and Ostwald, M. 2008. *Carbon inventory methods : handbook for greenhouse gas inventory, carbon mitigation and round wood production projects*. Dordrecht: Springer.

Rohinton M, Emmanuel and Baker, K. 2012. *Carbon management in the built environment*. London ; New York: Routledge.

Tinsley, S. 2014. *Environmental management in a low carbon economy*. Abingdon, Oxon: Routledge, Taylor & Francis Group.

Venkatesh Bhardwaj 2009. *Emission of Green House Gases (GHG) from agriculture sector and measures for their mitigation*. Udaipur: Agrotech Pub. Academy.

Ybema, J.R. and Al, E. 2000. *Burden differentiation: GHG emissions, undercurrents and mitigation costs*. Patten: Netherlands Energy Research Foundation Ecn ; Oslo

DEPARTMENT OF ENVIRONMENTAL SCIENCE

ENVS 1101 Introduction to Environmental Science 2 (2+0)

Theory

Definitions and concepts in environmental sciences; ecology, ecosystem and environments; components of environment and their interactions, Structure and functions of ecosystems; biotic and abiotic interactions; energy flow and nutrient cycling in different eco-systems-trophic levels, food chain and food webs, primary and secondary productivity; biological building blocks; ecosystems of the world and biogeographic regions; agroclimatic regions; Biodiversity, types of biodiversity, genetic diversity, species diversity, nagoya protocol, biodiversity act/rules and intellectual property rights in the context of protection of plant varieties and farmer's right act, the convention on biological diversity. Climate change and climate variability and their impact on agriculture; crop modelling; soil-plant atmospheric interactions; soil and cropping patterns of India; emerging diseases and pests of crops; sustainable agriculture; greenhouse effect; global warming; GHGs emission and mitigation strategies to reduce their emission. Environmental pollution- soil, water and air, and their source and sink; impact assessment of environmental pollution on agriculture; evaluation of agroecosystem services; agricultural and non-agricultural wastes and their management. Human population growth, carrying capacity, ecological footprint, environmental cost of petroleum, oil and tar sands, biofuel, plastics. -Environmental issues; acts and legislation-United Nations Conference on the Human Environment (1972) Brundtland Commission (1983), The Rio Declaration on Environment and Development (1992), International Initiatives and national initiatives to conserve the environment, Environmental Impact Assessment (EIA), UNFCCC and IPCC, Green Development Initiative (GDI), National Action Plan on Climate Change (NAPCC); generation of biofuels from agriculture resources; water conservation strategies to improve agricultural productivity.

Lecture schedule

THEORY

1	Definitions and concepts in environmental sciences; ecology, ecosystem and environments; Brief introduction about the components of environment and their interactions
2	Structure and functions of ecosystems; biotic and abiotic interactions
3- 6	Energy flow and nutrient cycling in different eco-systems- trophic levels, food chain and food webs
7	Primary and secondary productivity; biological building blocks
8	Ecosystems of the world and biogeographic regions; agroclimatic regions
9	Biodiversity, types of biodiversity, genetic diversity, species diversity
10-11	Nagoya protocol, biodiversity act/rules and intellectual property rights in the context of protection of plant varieties and farmer's right act, the convention on biological diversity.
12-14	Climate change and climate variability and their impact on agriculture; crop modelling
15	Soil-plant atmospheric interactions
16	Soil and cropping patterns of India; Sustainable agriculture ; emerging diseases and pests of crops;
17	Greenhouse effect; global warming; GHGs emission and mitigation strategies to reduce their emission
18	**Midterm Examination**
19-22	Environmental pollution- soil, water and air, and their source and sink
23-25	Impact assessment of environmental pollution on agriculture; evaluation of agroecosystem services; agricultural and non-agricultural wastes and

	their management.
26-27	Human population growth, carrying capacity, ecological footprint
28	Environmental cost of petroleum, oil and tar sands, biofuel, plastics
29-30	Environmental issues; acts and legislation- United Nations Conference on the Human Environment (1972) Brundtland Commission (1983), The Rio Declaration on Environment and Development (1992)
31	Environmental Impact Assessment (EIA)
32-33	UNFCCC and IPCC, Green Development Initiative (GDI), National Action Plan on Climate Change (NAPCC)
34	Generation of biofuels from agriculture resources
35	Water conservation strategies to improve agricultural productivity
36	**Final theory exam**

Suggested reading

Chiras, D.D., 2009. Environmental science. Jones & Bartlett Publishers.

Etherington, J.R., 1975. Environment and plant ecology. John Wiley & Sons Ltd.

Houghton, J., 2009. Global warming: the complete briefing. Cambridge university press.

Kormondy, E.J., 1969. Concepts of ecology. Prentice-Hall.

Odum, E.P. and Barrett, G.W., 1971. Fundamentals of ecology. Philadelphia: Saunders.

Santra, S.C., 2005. Environmental Science (For Students of Indian Universities). New Central Book Agency (P) Limited.

Sinclair, T.R. and Weiss, A., 2010. Principles of ecology in plant production. CABI.

Singh, J.S., Gupta, S.R. and Singh, S.P., 2006. Ecology environment and resource conservation. Anamaya Publishers.

ENVS 1102 Environmental Chemistry 3 (2+1)

Theory

Fundamentals of environmental chemistry: Basic concepts of light and matter; quantum mechanics (relation between energy, wavelength and frequency), black body radiation, Kirchhoff's law, Boltzmann equation, spectroscopic concepts: Introduction to the concept of absorption and transmission of light, Beer–Lambert law, photo voltaic and solar cells; scattering of light, Rayleigh and Mia scattering. Basic concepts of pressure, force, work and energy; types of forces and their relation (pressure gradient, viscous, coriolis, gravitational, centripetal, and centrifugal force); concept of heat transfer, conduction, convection; concept of temperature, lapse rate (dry and moist adiabatic); laws of thermodynamics; concept of heat and work, Carnot engine, transmission of electrical power, efficiency of turbines, wind mills and hydroelectric power plants. Movement of pollutants in environment. Diffusion and dispersion, point and area source pollutants, pollutant dispersal; Gaussian plume model, mixing heights, hydraulic potential, Darcy's equation, types of flow, turbulence. Atomic structure, electronic configuration, periodic properties of elements (ionization potential, electron affinity and electronegativity), types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds); mole concept, molarity and normality, quantitative volumetric analysis. Thermodynamic system; types of chemical reactions; acids, bases and salts,

solubility products; solutes and solvents; redox reactions, concepts of pH and pE, electrochemistry, Nernst equation, electrochemical cells. Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, polarity of the functional groups, synthesis of xenobiotic compounds like pesticides and dyes, synthetic polymers. Atmospheric chemistry: Composition of atmosphere; photochemical reactions in atmosphere; smog formation, types of smog (Sulphur smog and photochemical smog), aerosols; chemistry of acid rain, case studies; reactions of NO2 and SO2; free radicals and ozone layer depletion, role of CFCs in ozone depletion. Water chemistry: Chemical and physical properties of water; alkalinity and acidity of water, hardness of water, calculation of total hardness; solubility of metals, complex formation and chelation; colloidal particles; heavy metals in water. Soil chemistry: Soil composition; relation between organic carbon and organic matter, inorganic and organic components in soil; soil humus; cation and anion exchange reactions in soil; nitrogen, phosphorus and potassium in soil; phenolic compounds in soil.

Lecture schedule

THEORY

1-2	Fundamentals of environmental chemistry: Basic concepts of light and matter; quantum mechanics (relation between energy, wavelength and frequency), black body radiation, Kirchhoff's law, Boltzmann equation
3	Spectroscopic concepts: Introduction to the concept of absorption and transmission of light, Beer–Lambert law
4	Photovoltaic and solar cells; scattering of light, Rayleigh and Mia scattering
5	Basic concepts of pressure, force, work and energy; types of forces and their relation (pressure gradient, viscous, Coriolis, gravitational, centripetal, and centrifugal force
6-8	Concept of heat transfer, conduction, convection; concept of temperature, lapse rate (dry and moist adiabatic); laws of thermodynamics; concept of heat and work, Carnot engine, transmission of electrical power,

	efficiency of turbines, wind mills and hydroelectric power plants.
9-10	Movement of pollutants in environment. Diffusion and dispersion, point and area source pollutants, pollutant dispersal; Gaussian plume model, mixing heights
11	Hydraulic potential, Darcy's equation, types of flow, turbulence.
12-13	Atomic structure, electronic configuration, periodic properties of elements (ionization potential, electron affinity and electronegativity), types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds)
14	Mole concept, molarity and normality, quantitative volumetric analysis. Thermodynamic system; types of chemical reactions; acids, bases and salts, solubility products; solutes and solvents
	Redox reactions, concepts of pH and pE, electrochemistry, Nernst equation electrochemical cells.
15	Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, polarity of the functional groups
16	Synthesis of xenobiotic compounds like pesticides and dyes, synthetic polymers
18	**Midterm Examination**
19-20	Atmospheric chemistry: Composition of atmosphere; photochemical reactions in atmosphere; smog formation, types of smog (Sulphur smog and photochemical smog)
21-22	Aerosols; chemistry of acid rain, case studies; reactions of NO2 and SO2; free radicals and ozone layer depletion, role of CFCs in ozone depletion.

23-25	Introduction to Water chemistry: Chemical and physical properties of water; alkalinity and acidity of water,
26-28	Hardness of water, calculation of total hardness; solubility of metals, complex formation and chelation; colloidal particles; Heavy metals in water
29-31	Soil chemistry: Soil composition; relation between organic carbon and organic matter, inorganic and organic components in soil;
32-34	Soil humus; cation and anion exchange reactions in soil; nitrogen, phosphorus and potassium in soil
35	Phenolic compounds in soil.
36	**Final theory exam**

Practical

Collection, processing and storage of effluent samples - Determination of chemical oxygen demand in waste water sample -Determination of dissolved oxygen in waste water sample- Determination of total dissolved salts in waste water sample- Analysis of waste water for heavy metals- Determination of sound level by sound level meter- Estimation of non-respirable dust in air by dust sampler- Visit to polluted site- observation and remedial measures

PRACTICAL

Lecture 1	Collection, processing and storage of effluent samples
Lecture 2-4	Determination of chemical oxygen demand in waste water sample

Determination of dissolved oxygen in waste water sample-

Lecture 5- 7

Lecture 8-9 Determination of total dissolved salts in waste water sample

Lecture 10-11 Determination of sound level by sound level meter

Lecture 12-14 Estimation of non-respirable dust in air by dust sampler

Lecture 15-17 Field visit to polluted sites- observation and remedial measures

Lecture 18 Practical Examination

Suggested Readings

Beard, J.M. 2013. Environmental Chemistry in Society (2nd edition). CRC Press.
Boeker, E. &Grondelle, R. 2011. Environmental Physics: Sustainable Energy and Climate Change. Wiley.
Botkin, D.B. and Keller, E.A., 1998. Environmental science: earth as a living planet (No. Ed. 2). John Wiley & Sons Ltd.
Connell, D.W. 2005. Basic Concepts of Environmental Chemistry (2nd edition). CRC Press.
Forinash, K. 2010. Foundation of Environmental Physics. Island Press.
Girard, J. 2013. Principles of Environmental Chemistry (3rd edition). Jones & Bartlett.
Harnung, S.E. & Johnson, M.S. 2012. Chemistry and the Environment. Cambridge University Press.
Hites, R.A. 2012. Elements of Environmental Chemistry (2nd edition). Wiley & Sons.
Manhan, S. E. 2000. Fundamentals of Environmental Chemistry. CRC Press.
Masters, G.M. and Ela, W.P., 2008. Introduction to environmental engineering and science (No. 60457). Englewood Cliffs, NJ: Prentice Hall.
Pani, B. 2007. Textbook of Environmental Chemistry. IK international Publishing House.

ENVS 1203 Environmental biochemistry 3(2+1)

Theory

Air pollution: Particulate matter, compounds of carbon, Sulphur, nitrogen and their interactions, methods of their estimation, their effect on atmosphere. Water pollution: Types of water bodies and their general characteristics, major pollutants in domestic, agricultural and industrial wastes, methods of their estimation, effects of pollutants on

plants and animals. Pollution of water by microorganisms, bacteriological analysis of water-sewage treatment-home and industrial. Chemical toxicology: Toxic chemicals in the environment, impact of toxic chemicals on enzymes. Biochemical effects of Ar, Pb, Cd. Hg. Biochemical effects of CO, NOx, SOx, pesticides. Bioremediation for environmental cleanup. Biomass utilization and microbial degradation. Chemistry of Biomolecules**:** **C**arbohydrates: Occurrence, classification, structure, properties and biological importance. Proteins: Classification, structure and properties, biological importance, coagulation and denaturation of proteins. Lipids: Structure, distribution and biological importance of fats and fatty acids. Nucleic acids: Structure of purines, pyrimidines, nucleosides and nucleotides. Structure, types and biological role of RNA and DNA. Vitamins: water soluble and fat soluble vitamins and their importance. Enzymes: Classification, nomenclature and general properties like effects of pH, substrate and temperature on enzyme catalysed reactions. concept of Michaelis - Menten, inhibition of enzyme activity. Mechanism of catalysis , Enzyme regulation, immobilized enzymes. PLANT BIOCHEMISTRY: Photosynthesis: structure and organisation of chloroplast ,electron transport chain. Calvin cycle , photosynthetic efficiency and plant productivity. Nitrogen Metabolism : Nitrogen fixation, nitrogenase complex, electron transport chain and mechanism of action of nitrogenase , NIF genes. Water and mineral balance in plants. Structure, function and mechanism of action of phytohormones. Defence system in plants.

Lecture schedule

THEORY

1	Introduction: History of Air pollution and episodes, Sources of air pollution and types, fate of pollutants
2	Air pollutants Classification: Particulate matter, Gaseous pollutants [Compounds of carbon, Sulphur, Nitrogen] and their interactions
3	Effects of Air Pollution on human beings, plants and animals and Properties.
4	Global Effects - Greenhouse effect, Ozone depletion, heat island, Photochemical smog, Acid rain

5-6	Air Pollution control for particulate matter- Arresters and Scrubbers Advantages and Disadvantages
6-7	Air Pollution control for Gaseous pollutants - Combustion, absorption and adsorption Advantages and Disadvantages
8-9	Air Quality Sampling and Monitoring: Stack sampling, instrumentation and methods of analysis of SO2, CO etc, legislation for control of air pollution
10-11	Water pollution: Types of water bodies and their general characteristics
12-13	Definition; Classification of major water pollutants (domestic, agricultural and industrial wastes), Source and impacts of water pollution
14	Prevention and control of water pollution- sewage treatment, bacteriological analysis, Water quality standards
15	Toxic chemicals in the environment, impact of toxic chemicals on enzymes
16	Biochemical effects of Ar, Pb, Cd. Hg. CO, NOx, SOx, pesticides
17	Bioremediation for environmental clean-up; Biomass utilization and microbial degradation
18	**Midterm Examination**
19	Carbohydrates: Occurrence, Classification, Structure, Properties and biological importance
20	Proteins: Occurrence, classification, Structure, Properties and biological importance
21	Lipids: Occurrence, classification, Structure, Properties and biological importance

22-23	Nucleic acids: Occurrence, classification, Structure of purines, pyrimidines, Structure of nucleosides and nucleotides
24	Vitamins: Water soluble and Fat soluble; their importance
25-27	Enzymes: Definition, Structure, Classification, Action, Mechanism, Factors and Function
28	Photosynthesis: structure and organisation of chloroplast
29-30	Calvin cycle; Electron transport chain
31	Photosynthetic efficiency and plant productivity
32	Nitrogen Metabolism: Introduction and Nitrogen Cycle (Brief Explanation), Nitrogen fixation, Nitrogenase complex
33	Electron transport chain and mechanism of action of nitrogenase, NIF genes
34	Water and mineral balance in plants
35	Structure, function and mechanism of action of phytohormones; Defence system in plants
36	**Final theory exam**

Practical

Determination of pH of a solution, Preparation of various buffers, Preparation of normal and molal solutions, Estimation of protein, Estimation of fat, Estimation of carbohydrate, Colour reactions of protein &Colour reactions of carbohydrate, Chromatographic analysis, Electrophoretic separation, Estimation of P&K in soil samples.

PRACTICAL

1	Stoichiometric Calculations

2	Measurement of pH using pH meter
3- 4	Preparation of Biological Buffers
5-6	Preparation of normal and molal solutions
7-8	Estimation of protein
9	Estimation of fat
10-12	Estimation of carbohydrate
13	Qualitative test of protein
14	Qualitative test of carbohydrate
15	Qualitative test of Fat
16	Estimation of P in soil samples
17	Estimation of K in soil samples
18	**Practical Examination**

Suggested readings

Arora, M. Environmental management of toxic and hazardous waste.

Botkin, D.B. and Keller, E.A., 1998. Environmental science: earth as a living planet (No. Ed. 2). John Wiley & Sons Ltd.

Khopkar, S. M. 1993. Environmental pollution analysis, 1st Edition, Wiley Eastern.

Lehninger, A.L. 2004. Principles of Biochemistry, 4th edition, W.H Freeman and Company.

Mahajan, S.P., 1985. Pollution control in process industries. Tata McGraw-Hill Education.

Masters, G.M. and Ela, W.P., 2008. Introduction to environmental engineering and science (No. 60457). Englewood Cliffs, NJ: Prentice Hall.

Mido, Y. and Satake, M., 2003. Chemicals in the environment. InToxic metals, eds. MS Sethi and SA Iqbal.

Ramteke, D.S. and Moghe, C.A., 1988. Manual on water and wastewater analysis, National Environmental Engineering Research Institute (NEERI). Nagpur, India.

Rao, C.S. Pollution Control Engineering, John Wiley & Sons Inc.

Stryer, L. 2002. Biochemistry, 5th edition, W.H. Freeman and Company.

Tyagi, O.D. and Mehra, M., 1994. A Text Book of Environmental Chemistry 1st. Anmol publication, pp.289-290.

Voet, V. and Voet J.G. 2004. Biochemistry, 3rd edition, John Wiley, New York.

Wark, K. and Warner, C.F., 1998. Air pollution: its origin and control. Addison-Wesley. Environmental chemistry, B. K. Sharma.

ENVS 2104 Environmental Economics and Sustainable Development 2(1+1)

Theory

Environmental Economics – Introduction: From economics to Environmental Economics Definition and scope of Environmental Economics ,Basic theories of EE - Material Balance Approach and law of entropy, Welfare aspects of Environmental Economics - Principle of maximum social welfare - Pareto Criterion, Externalities- types and importance problem of second best and solution to Externality - Market failure - solution. Properties of public goods, Environment Cost- Benefit Analysis (CBA), Environmental education Sustainable Development: From problems to crises- Depletion of resources and degradation of environment, From modern development to Sustainable Development - WCED, Strategies and Policies for SD. Sustainable human development index, Sustainability pillars, Gandhian model of SD, Education for sustainable development, Definition, Importance of sustainable production and consumption. Sustainable Consumption: Definition, importance, relevance for developing countries - Difference between Sustainable Consumption from Sustainable Development and Sustainable Production - key issues for promoting Sustainable Consumption - Can Sustainable

Consumption be used to address other problems - UN Guidelines Sustainable Consumption, Sustainable Consumption Tools, Sustainable living and values, Education for sustainable consumption, Eco – School

Lecture schedule

THEORY

1	Environmental Economics – Introduction: From economics to Environmental Economics Definition and scope of Environmental Economics
2	Basic theories of EE - Material Balance Approach and law of entropy
3	Welfare aspects of Environmental Economics - Principle of maximum social welfare - Pareto Criterion
4	Externalities- types and importance problem of second best and solution to Externality - Market failure - solution. Properties of public goods
5	Environment Cost- Benefit Analysis (CBA)
6-8	Environmental education Sustainable Development: From problems to crises- Depletion of resources and degradation of environment, From modern development to Sustainable Development - WCED, Strategies and Policies for SD
9	**Midterm Examination**
10-11	Sustainable human development index, Sustainability pillars, Gandhian model of SD
12-13	Education for sustainable development, Definition, Importance of sustainable production and consumption. Sustainable Consumption: Definition, importance, relevance for developing countries
14	Difference between Sustainable Consumption from Sustainable Development and Sustainable Production - key issues for promoting

	Sustainable Consumption
15	Sustainable Consumption Can be used to address other problems
16	UN Guidelines Sustainable Consumption, Sustainable Consumption Tools
17	Sustainable living and values, Education for sustainable consumption, Ecoschool
18	**Final theory exam**

Practical

Material balance approach, Law of Entropy, Maximum Social welfare Pareto Criterion, Environment Cost Benefit Analysis, Policies for SD, Gandhian Model of SD, Sustainable Consumption Tools, Sustainable living and values.

PRACTICAL

1-2	Material balance approach
3	Law of Entropy
4- 5	Maximum Social welfare Pareto Criterion
6-9	Environment Cost Benefit Analysis
10-11	Policies for SD
12-14	Gandhian Model of SD
15-16	Sustainable Consumption Tools

17 Sustainable living and values

18 Practical Examination

Suggested Readings

Bowers, J. 1997. Sustainability and Environmental Economics. Longman, Singapore.

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Karpagam, M. 1991. Environmental Economics. Sterling Pub., New Delhi

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World Commission on Environment and Development. 1987. Our Common Future.

ENVS 2205 Wetland Ecology and Management 2(2+0)

Theory

Chemistry in real marine environments, important features of biogeochemical cycles, specific examples of the carbon cycle, macronutrient cycles, and iron in the ocean. Important chemical concepts that provide a mechanistic understanding of the behaviour of elements in the ocean, such as redox, solubility, kinetics and equilibria. Marine environment – ecological factors – light- temperature, salinity, Classification of marine environment. Fundamental concepts in biological and chemical oceanography to understand energy and material transformations in estuarine, coastal and open ocean habitats. Structure and function of marine ecosystems, biogeochemical cycles, and human impacts. System energetic, chemical kinetics, continuity of mass and energy balances, ocean-atmosphere feedbacks, biogeochemical regimes, understanding of the ocean as a habitat for life, and the major characteristics of ocean biota and ocean ecosystem, concepts of ecosystem structure and functioning, concepts of evolutionary adaptation and of population and community ecology. Interaction between abiotic and biotic processes. Impacts of human activity on ocean ecosystems Land Ocean interactions in coastal zone, Environmental impact assessment, types of EIA, Coastal regulation zone and acts, baseline studies, collection of primary and secondary data / information. Identification of sources for organic and inorganic pollutants in estuarine, coastal and oceanic environments, mechanisms of introduction and dispersal; chemical and biological behavior and removal processes; regional and global scale effects. Define marine ecology, highlight key patterns of distribution and diversity in the marine environment. Ecological processes and interactions, benthic ecosystems in the intertidal zone, in particular rocky, muddy and sandy shores. Zonation patterns and the physiological adaptations of littoral organisms to substrate type, tidal exposure, immersion cycles and temperature regimes. The diversity and ecology of tropical and polar habitats. Productive shelf waters and oligotrophic subtropical gyres, upper ocean processes as controls and limits to phytoplankton primary production at regional and global scales. Transfer of Photosynthetically-fixed carbon through the major food web consumers including zooplankton and fish, and bacterial decomposition of detritus via the microbial loop. Ultimate recipients of water column production in coastal waters, the bottom-dwelling benthic communities.

Lecture schedule

THEORY

1	Chemistry in real marine environments
2-3	Important features of biogeochemical cycles, specific examples of the carbon cycle, macronutrient cycles, and iron in the ocean. biogeochemical cycles and human impacts.
4	Important chemical concepts that provide a mechanistic understanding of the behaviour of elements in the ocean, such as redox, solubility, kinetics and equilibria.
5	System energetic, chemical kinetics, continuity of mass and energy balances, ocean-atmosphere feedbacks, biogeochemical regimes
6	Structure and function of marine ecosystems
7	Marine environment – ecological factors – light- temperature, salinity, Classification of marine environment
8-9	Fundamental concepts in biological and chemical oceanography to understand energy and material transformations in estuarine, coastal and open ocean habitats.
10-12	Understanding of the ocean as a habitat for life, and the major characteristics of ocean biota and ocean ecosystem, concepts of ecosystem structure and functioning
13	Define marine ecology, highlight key patterns of distribution and diversity in the marine environment.
14-15	Ecological processes and interactions, benthic ecosystems in the intertidal zone, in particular rocky, muddy and sandy shores. The diversity and ecology of tropical and polar habitats.
16-17	Productive shelf waters and oligotrophic subtropical gyres, upper ocean processes as controls and limits to phytoplankton primary production at regional and global scales.

18	Midterm Examination
19-20	Transfer of Photosynthetically-fixed carbon through the major food web consumers including zooplankton and fish, and bacterial decomposition of detritus via the microbial loop.
21-23	Zonation patterns and the physiological adaptations of littoral organisms to substrate type, tidal exposure, immersion cycles and temperature regimes.
24-25	Ultimate recipients of water column production in coastal waters, the bottom-dwelling benthic communities
26-27	Concepts of evolutionary adaptation and of population and community ecology
28-30	Identification of sources for organic and inorganic pollutants in estuarine, coastal and oceanic environments, mechanisms of introduction and dispersal; chemical and biological behavior and removal processes; regional and global scale effects.
31-32	Interaction between abiotic and biotic processes. Impacts of human activity on ocean ecosystems Land Ocean interactions in coastal zone
33-35	Environmental impact assessment, types of EIA, Coastal regulation zone and acts, baseline studies, collection of primary and secondary data / information.
36	Final theory exam

Suggested Readings

Kamphuis, J.W., 2020. Introduction to coastal engineering and management (Vol. 48). World Scientific.

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Lieske, E. and Myers, R., 2002. Coral reef fishes: dynamics and diversity in a complex ecosystem. Academic Press.

Miller, C.B., 2009. Biological oceanography. John Wiley & Sons.

Naskar, K., 2004. Manual of Indian mangroves. Daya Pub. House

Schlesinger, W.H. and Bernhardt, E.S., 2013. Biogeochemistry: an analysis of global change. Academic press.

Simpson, J.H. and Sharples, J., 2012. Introduction to the physical and biological oceanography of shelf seas. Cambridge University Press.

Singh, V.P. and Odaki, K., 2004. Mangrove ecosystem: structure and function. Scientific Publishers.

ENVS 2206 Environmental Pollution and Toxicology (1+1)

Theory

Air Pollution and management Natural and anthropogenic sources of pollution. Primary and Secondary pollutants. Transport and diffusion of pollutants. Gas laws governing the behavior of pollutants in the atmosphere. Indoor air pollution, Methods of monitoring and control of air pollution S02, NO, CO, SPM. Effects of pollutants on human beings, plants, animals, materials and on climate. Acid Rain. Smog, Air quality Standards, Air Sampling techniques. Identification of aeroallergens. Air-borne diseases and allergies. Water Pollution and management Types of water pollution-surface and ground water, Origin and Sources, Nutrients and Eutrophication, Organic matter - sources and degradation, Microbial pollution, Coastal and Marine pollution-Oil spills, Thermal pollution, Movements of contaminants in ground water , Impacts of water pollution, Heavy metals and other POPs in aquatic systems - cycling and interactions, Water quality parameters-physical, chemical and biological, Management of point and non- point sources of water pollution, Monitoring of quality parameters, Sampling and analysis, Water quality standards, Tracers – dyes and isotopes in pollution monitoring, water pollution control. Soil Pollution and management Soil quality parameters, sampling, Physico-chemical analysis of soil quality. Soil Pollution Control. Industrial waste effluents and heavy metals, their interactions with soil components. Soil micro-organisms and their functions, Degradation of different insecticides, fungicides and weedicides in soil. Different kinds of, synthetic fertilizers (NP & K) and their interactions with different components of soil. Noise Pollution and Management Characteristics of noise, sources, Effects of noise,

Standards, Measurement and control. Radioactive pollution: Radioactivity in the environment – natural and anthropogenic, Nuclear weapons, nuclear waste, Impacts on the environment, Management of radioactive waste

Lecture schedule

THEORY

1	Air Pollution and management Natural and anthropogenic sources of pollution. Primary and Secondary pollutants. Transport and diffusion of pollutants. Gas laws governing the behavior of pollutants in the atmosphere.
2	Indoor air pollution, Methods of monitoring and control of air pollution S02, NO, CO, SPM.
3	Effects of pollutants on human beings, plants, animals, materials and on climate. Acid Rain. Smog,
4	Air quality Standards, Air Sampling techniques.
5	Identification of aeroallergens. Air-borne diseases and allergies.
6	Water Pollution and management Types of water pollution-surface and ground water, Origin and Sources
7	Organic matter - sources and degradation; Nutrients and Eutrophication
8	Microbial pollution; Coastal and Marine Pollution-Oil spills
9	**Midterm Examination**
10	Thermal pollution, Movements of contaminants in ground water, impacts of water pollution, Heavy metals and other POPs in aquatic systems - cycling and interactions

11	Water quality parameters-physical, chemical and biological, Management of point and non- point sources of water pollution, Monitoring of quality parameters, Sampling and analysis, Water quality standards, Tracers – dyes and isotopes in pollution monitoring
12	Water pollution control.
13	Soil Pollution and management Soil quality parameters, sampling, Physico-chemical analysis of soil quality.
14	Industrial waste effluents and heavy metals, their interactions with soil components. Soil Pollution Control.
15	Soil micro-organisms and their functions, Degradation of different insecticides, fungicides and weedicides in soil. Different kinds of, synthetic fertilizers (NP & K) and their interactions with different components of soil.
16	Noise Pollution and Management Characteristics of noise, sources, Effects of noise, Standards, Measurement and control.
17	Radioactive pollution: Radioactivity in the environment – natural and anthropogenic nuclear weapons, nuclear waste, Impacts on the environment, Management of radioactive waste
18	**Final theory exam**

Practical

Air Sampling techniques. Identification of aeroallergens. Air-borne diseases and allergies, Water sampling and analysis, Water quality standards, Heavy metal analysis in water samples, Microbial analysis of water, Estimation of COD in water, Sampling and Physico-chemical analysis of soil quality, Heavy metal analysis of soil and fertilizers, Noise pollution measurement

PRACTICAL

1	Air Sampling techniques.
2	Identification of aeroallergens.
3	Air-borne diseases and allergies
4-5	Water sampling and analysis
6	Water quality standards
7	Heavy metal analysis in water samples
8-9	Microbial analysis of water
10-11	Estimation of COD in water
12-15	Sampling and Physico-chemical analysis of soil quality
16	Heavy metal analysis of soil and fertilizers
17	Noise pollution measurement
18	**Practical Examination**

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Abbasi, S.A., 1999. Environmental pollution and its control. Cogent International, Philadelphia/Pondicherry, xi.

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Sarkar, B., 2002. Heavy metals in the environment. CRC press.Sharma B K Kaur H , Water pollution, Krishna prakashan Meerut

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ENVS 3107 Environmental Law and Policy 2(2+0)

Theory

Brief History of Environmental Regulations in the World up to 1990, Role of UN Environmental Policies and Laws, Stockholm Declaration – 1972: Hague Declaration – 1989; Rio Declaration – 1992, Fundamental Principles of International environmental Laws. Environmental Policy in India- Environmental Legislation Protection Laws in India –

Ancient and Pre- Independence, Forest policies and Legislation in Pre – independence Period, Environmental Legislation in Post – Independence Period, Constitutional and Legislative Provisions in India-Fundamental principle; 42nd Amendment Act; Direct Principles, Fundamental Rights, Environmental Legislations (General), Environmental Protection Act of 1986. 2.5 Judicial Remedies and Procedures, Tort Law, Public Nuisance, Public Interest Litigation, Freedom of information, Forest Law, Public Nuisance, Public interest Litigations, Freedom of Information. Laws Relating to control of Pollution and Environment in India- Water Act and Related Acts, Rules and Regulations, Air Act – Related Acts, Rules and Regulations, Noise and Land Pollution Rules and Regulations, Rules and Notification made under Environmental (Protect) Act 1986 – Rules of Hazardous Microorganisms. Bio–medical waste, Recycled Plastics, Ozone Depleting Substances, Solid Waste Management, etc. Forest and Wild Life Protection Act and Rules, International Organization, Conservations and Protocols- United Nations, GEMS, UNEP, GEF, WCN etc. Antarctica Convention, Stockholm Convention, Rio Conference and Conventions, Ramsar Convention, Kyoto Protocol, Rio+10 earth Watch Green Peace etc. Information, Education and Communication- Environmental education/awareness, lifestyle changes and consumerism. Values and ethics, Gaia hypothesis, Information Networks – ENVIS Centers – INFOTERA etc. Role of NGO's in the Implementation of Environmental Policies. Communication and Management.

Lecture schedule

THEORY

1-2	Brief History of Environmental Regulations in the World up to 1990, Role of UN Environmental Policies and Laws, Stockholm Declaration – 1972; Hague Declaration 1989; Rio Declaration – 1992
3	Fundamental Principles of International environmental Laws. Environmental Policy in India
4-5	Environmental Legislation Protection Laws in India –Ancient and Pre-Independence, Forest policies and Legislation in Pre – independence Period, Environmental Legislation in Post – Independence Period

6	Constitutional and Legislative Provisions in India-Fundamental principle; 42nd Amendment Act; Direct Principles, Fundamental Rights
7	Environmental Legislations (General), Environmental Protection Act of 1986. 2.5 Judicial Remedies and Procedures
8	Tort Law, Public Nuisance, Public Interest Litigation, Freedom of information
9	Laws Relating to control of Pollution and Environment in India- Water Act and Related Acts, Rules and Regulations
10	Air Act – Related Acts, Rules and Regulations
11-12	Noise and Land Pollution Rules and Regulations, Rules and Notification made under Environmental (Protect) Act 1986
13-15	Rules of Hazardous Microorganisms. Bio–medical waste, Recycled Plastics, Ozone Depleting Substances, Solid Waste Management, etc.
16-17	Forest Law –Forest and Wild Life Protection Act and Rules
18	Midterm Examination
19-22	International Organization, Conservations and Protocols- United Nations, GEMS, UNEP, GEF, WCN etc.
23-25	Antarctica Convention, Stockholm Convention, Rio Conference and Conventions, Rio+10
26-28	Ramsar Convention, Kyoto Protocol, Earth Watch Green Peace etc.
29-32	Information, Education and Communication- Environmental education/awareness, lifestyle changes and consumerism. Values and ethics, Gaia hypothesis

33-34	Information Networks – ENVIS Centers – INFOTERA etc. Role of NGO's in the Implementation of Environmental Policies.
35	Communication and Management
36	**Final theory exam**

Suggested Readings

Chakrabarti N.K., 1994. Environmental Protection and the Lawn Ashish Publishing House, New Delhi.

Nagore, A.P., 1996. Biological Diversity & International Environmental Law ABH Publishing Corporation, New Delhi.

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ENVS 3108 Environmental Microbiology 3(2+1)

Theory

Microorganisms in the environment; General account of microorganisms in the environment - bacteria, fungi, protozoa, actinomycetes, algae and viruses - characteristic features and role in the environment. Morphology and Ultra structure of Bacteria. Plasma membrane, cell wall, flagella, pili, capsule, slime layer, glycocalyx, nucleoid, ribosomes and Cytoplasmic inclusions. Basis of Gram staining. Nutrition -Autotrophy and Heterotrophy- nutritional diversity among prokaryotes. Microbial Growth– Growth curve, Methods of measurement of microbial growth. Continuous culture systems - chemostat and turbidostat. Factors

affecting the growth of bacteria. Physical and chemical control of bacterial growth. Antibacterial agents and chemotherapy.

Microbiological Techniques: Use and care of microscopes, Isolation, purification maintenance and characterization of aerobic, microaerophilic and anaerobic bacteria - use of different types of media and culture techniques • Identification of bacteria using different methods - phonetic and phylogenetic approach. Microorganisms and the Environment. Winogradsky column, Physiological status of microorganisms in the environment. Organic substrate use by microorganisms, Foreign derived microorganisms-Survival and Fate, Microorganisms in extreme environments, Nature of marine and freshwater environments, Nutrient levels, gradients/surfaces and biofilms, Microbial mats, Microbial community and important microorganisms in marine and freshwater environments.

Microorganisms in soil and water ecosystems; Water borne diseases – pathogens involved - routes of infection and control measures, Microbial analysis of water quality - faecal indicator bacteria - coliforms, faecal streptococci, Waste water treatment. The environment of soil microorganisms, Soil microorganisms with plants - the rhizosphere, Rhizobium, mycorrhizae, actinorrhizae, triprite association, fungal and bacterial endohoytes of plants, Agrobacterium, Pesticides and microorganisms, Role of microbes in Bio-geochemical cycles ,Soil microorganisms interaction with the atmosphere, Bioremediation of pollutants in the environment- heavy metals, pesticides, organic and inorganic pollutants etc. Molecular biology, Genetic engineering and Tissue culture; Microbial Nucleic acids, Structure, properties and interactions. Genetic control of metabolism, Genetic regulation in prokaryotic and eukaryotic microbes, Recombinant DNA (rDNA) techniques, DNA extraction and purification, DNA sequencing - polymerase chain reaction (PCR) technique, Plasma vectors and Gene cloning Applications of Genetically modified microorganisms in clean-up of environment, Genetically engineered microorganisms - fate and effects.

Lecture schedule

THEORY

1-2	Microorganisms in the environment; General account of microorganisms in the environment - bacteria, fungi, protozoa, actinomycetes, algae and viruses - characteristic features and role in the environment.

3	Morphology and Ultra structure of Bacteria. Plasma membrane, cell wall, flagella, pili, capsule, slime layer, glycocalyx, nucleoid, ribosomes and Cytoplasmic inclusions.
4	Basis of Gram staining.
5	Nutrition -Autotrophy and Heterotrophy- nutritional diversity among prokaryotes.
6-7	Microbial Growth– Growth curve, Methods of measurement of microbial growth. Continuous culture systems - chemostat and turbidostat. Factors affecting the growth of bacteria. Physical and chemical control of bacterial growth.
8	Antibacterial agents and chemotherapy.
9-10	Microbiological Techniques: Use and care of microscopes, Isolation, purification maintenance and characterization of aerobic, microaerophilic and anaerobic bacteria - use of different types of media and culture techniques
11	Identification of bacteria using different methods - phonetic and phylogenetic approach.
12-13	Microorganisms and the Environment. Winogradsky column, Physiological status of microorganisms in the environment.
14-15	Organic substrate uses by microorganisms, Foreign derived microorganisms-Survival and Fate, Microorganisms in extreme environments
16	Nature of marine and freshwater environments, Nutrient levels, gradients/surfaces and biofilms, Microbial mats.
17	Microbial community and important microorganisms in marine and freshwater environments

18	**Midterm Examination**
19-21	Microorganisms in water ecosystems: Water borne diseases – pathogens involved - routes of infection and control measures, Microbial analysis of water quality - faecal indicator bacteria - coliforms, faecal streptococci.
22-23	Waste water treatment
24-25	Microorganisms in soil ecosystems: The environment of soil microorganisms, Soil microorganisms with plants - the rhizosphere, Rhizobium, mycorrhizae, actinorrhizae, triprite association, fungal and bacterial endohoytes of plants, Agrobacterium
26-27	Pesticides and microorganisms; Bioremediation of pollutants in the environment- heavy metals, pesticides, organic and inorganic pollutants etc.
28	Role of microbes in Bio-geochemical cycles, Soil microorganisms interaction with the atmosphere
29-30	Molecular biology, Genetic engineering and Tissue culture; Microbial Nucleic acids, Structure, properties and interactions.
31	Genetic control of metabolism, Genetic regulation in prokaryotic and eukaryotic microbes, Recombinant DNA (rDNA) techniques
32	DNA extraction and purification, DNA sequencing - polymerase chain reaction (PCR) technique
33	Plasma vectors and Gene cloning
34	Applications of Genetically modified microorganisms in clean-up of environment
35	Genetically engineered microorganisms - fate and effects.
36	**Final theory exam**

Practical

Familiarization of common laboratory equipment's, glassware's and misc. Items used in Microbiology laboratory. Use and care of student's microscope. Isolation of microorganisms (bacteria, fungi, actinomycetes and algae) from environment (soil/ water). Purification of microorganisms. Gram staining and endospore staining. Determination of viable and total number of microorganisms in soil and water. Effect of temperature, pH and oxygen on microbial growth. Determination of bacterial growth curve. Estimation of BOD of water. Determination of microbial quality of water using MPN technique. Detection of bacteriophages and human pathogens in sewage water. Detection of human pathogens in sewage water. Detection of ammonification and nitrification processes in soil. Enumeration of rhizosphere microorganisms and determination of rhizosphere effect. Determination of soil enzyme activities – Dehydrogenase and urease activity

PRACTICAL

1	Familiarization of common laboratory equipment's, glassware's and misc. Items used in Microbiology laboratory. Use and care of student's microscope.
2	Isolation of microorganisms (bacteria, fungi, actinomycetes and algae) from environment (soil/ water).
3	Purification of microorganisms.
4	Gram staining and endospore staining.
5-6	Determination of viable and total number of microorganisms in soil and water.
7	Effect of temperature, pH and oxygen on microbial growth.
8	Determination of bacterial growth curve.
9	Estimation of BOD of water.

10-11	Determination of microbial quality of water using MPN technique.
12	Detection of bacteriophages and human pathogens in sewage water.
13-14	Detection of human pathogens in sewage water.
15	Detection of ammonification and nitrification processes in soil.
16	Enumeration of rhizosphere microorganisms and determination of rhizosphere effect.
17	Determination of soil enzyme activities – Dehydrogenase and Urease activity
18	**Practical Examination**

Suggested Readings

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ENVS 3109 Solid and Hazardous Waste Management 2(1+1)

Theory

Relevant Regulations: Municipal solid waste (management and handling) rules; hazardous waste (management and handling) rules; biomedical waste handling rules; fly-ash rules; recycled plastics usage rules; batteries (management and handling) rules. Municipal Solid Waste Management – Fundamentals: Sources; composition; generation rates; collection of waste; separation, transfer and transport of waste; treatment and disposal options. Hazardous Waste Management– Fundamentals: Characterization of waste; compatibility and flammability of chemicals; fate and transport of chemicals; health effects. Radioactive Waste Management– Fundamentals: Sources, measures and health effects; nuclear power plants and fuel production; waste generation from nuclear power plants; disposal options. Environmental Risk Assessment: Defining risk and environmental risk; methods of risk assessment; case studies. Physicochemical Treatment of Solid and Hazardous Waste: Chemical treatment processes for MSW (combustion, stabilization and solidification of hazardous wastes); physicochemical processes for hazardous wastes (soil vapour extraction, air stripping, chemical oxidation); groundwater contamination and remediation. Biological Treatment of Solid and Hazardous Waste: Composting; bioreactors; anaerobic decomposition of solid waste; principles of biodegradation of toxic waste; inhibition; co-

metabolism; oxidative and reductive processes; slurry phase bioreactor; in-situ remediation. Landfill design: Landfill design for solid and hazardous wastes; leachate collection and removal; landfill covers; incineration

Lecture schedule

THEORY

1	Municipal Solid Waste Management – Fundamentals: Sources; composition; generation rates; collection of waste; separation, transfer and transport of waste; treatment and disposal options.
2	Physicochemical Treatment of Solid Waste: Chemical treatment processes for MSW (combustion, stabilization and solidification of hazardous wastes)
3	Hazardous Waste Management– Fundamentals: Characterization of waste; compatibility and flammability of chemicals; fate and transport of chemicals; health effects.
4	Physicochemical processes for hazardous wastes (soil vapour extraction, air stripping, chemical oxidation)
5-6	Biological Treatment of Solid Waste and Hazardous Waste: Composting; bioreactors; anaerobic decomposition of solid waste; principles of biodegradation of toxic waste; inhibition; co-metabolism; oxidative and reductive processes; slurry phase bioreactor; in-situ remediation
7- 8	Landfill design: Landfill design for solid and hazardous wastes; leachate collection and removal; landfill covers; incineration
9	Midterm Examination
10-12	Radioactive Waste Management– Fundamentals: Sources, measures and health effects; nuclear power plants and fuel production; waste generation from nuclear powerplants; disposal options
13-14	Environmental Risk Assessment: Defining risk and environmental risk;

	Methods of risk assessment; case studies
15	Relevant Regulations: Municipal solid waste (management and handling) rules
16	Hazardous waste (management and handling) rules; Fly-ash rules
17	Biomedical waste handling rules; Batteries (management and handling) rules; recycled plastics usage rules
18	Final theory exam

Practical

Municipal Solid Waste Collection, Hands on experience on Collection equipment and automated Collection equipment, Waste Transfer, Recycling Solid Wastes, Recycling Progress and Statistics. Municipal Solid Waste Processing: Materials Recovery Facilities (MRF), Materials Separation and Processing at the MRF, Materials Flow in the MRF, Contamination Issue, Environmental Control. Composting MSW, Incineration of MSW General Siting and Design Criteria - Site investigations, Site Selection (NIMBY), Regulatory permitting process. Principles and Design of Transfer and Transport Facilities. Principles and Design of Sanitary Landfills - Landfilling methods, landfill cover and drainage/liner systems, leachate control and treatment systems. Principles and Design of Site remediation Facilities - Status, types, principles, equipment used, application ranges, comparisons of different site remediation technologies, Remedial investigations and feasibility studies, Soil remediation design examples, Groundwater remediation design examples.

Hazardous Waste Management - Determining the Hazardous Waste Generator Category, Hazardous Waste Transportation, Treatment, Storage, and Disposal. Incineration of Hazardous. Wastes: Incineration Devices, Air Pollution and its Control, Waste Treatment Prior to Land Disposal, Neutralization, Chemical Precipitation, Oxidation and Reduction, Sorption, Sorption Systems, Stabilization.

PRACTICAL

1	Municipal Solid Waste Collection, Hands on experience on Collection equipment and automated Collection equipment, Waste Transfer
2	Recycling Solid Wastes, Recycling Progress and Statistics.
3	Municipal Solid Waste Processing: Materials Recovery Facilities (MRF), Materials Separation and Processing at the MRF, Materials Flow in the MRF
4	Contamination Issue and prevention and Environmental Control
5	Composting MSW, Incineration of MSW
6	General Siting and Design Criteria - Site investigations, Site Selection (NIMBY), Regulatory permitting process.
7	Principles and Design of Transfer and Transport Facilities.
8	Principles and Design of Sanitary Landfills - Landfilling methods, landfill cover and drainage/liner systems, leachate control and treatment systems.
9-10	Principles and Design of Site remediation Facilities - Status, types, principles, equipment used, application ranges, comparisons of different site remediation technologies,
11-14	Remedial investigations and feasibility studies: Soil remediation design examples, Groundwater remediation design examples.
15	Hazardous Waste Management - Determining the Hazardous Waste Generator Category, Hazardous Waste Transportation, Treatment, Storage and Disposal
16	Incineration of Hazardous. Wastes: Incineration Devices, Air Pollution and its Control

17	Waste Treatment Prior to Land Disposal, Neutralization, Chemical Precipitation, Oxidation and Reduction, Sorption, Sorption Systems, Stabilization
18	**Practical Examination**

Suggested Readings

John Pichtel Waste Management Practices CRC Press, Taylor and Francis Group 2005.

LaGrega, M.D., Buckingham, P.L., and Evans, J.C. Hazardous Waste Management, McGraw Hill International Editions, New York, 1994.

Richard J. Watts, Hazardous Wastes - Sources, Pathways, Receptors John Wiley and Sons, New York, 1997.

Claus, W.G., 1989. Understanding microbes: A Laboratory Text book for Microbiology.

David C Sigee, 2005. Freshwater Microbiology - Biodiversity and dynamic interactions of microorganisms in the aquatic environment. John Wiley and Sons Ltd. England.

Eweis, J.B., Ergas, S.J., Chang, D.P. Y. and Schroeder, E.D., 1998. Bioremediation Principles, McGrawHill Publ.

Freifelder, D., 1987. Microbial Genetics. Johns and Barlett Publishers Inc.

Hawkins, J.D., 1996. Gene Structure and Expression, Third edition. Cambridge University Press, Oxford.

Jacquelyn G Black, 2005. Microbiology - Principles and Explorations – 6th Edition. John Wiley and Sons, USA

Lewin, B., 1998. Genes VI. Oxford University Press, Oxford.

Lynch, M. and Hobbie, J.E., 1988. Microorganisms in Action - Concepts and applications of Microbial Ecology. Blackwell Scientific Publications.

Masters, G.M. and Ela, W.P., 2008. Introduction to environmental engineering and science (No. 60457). Englewood Cliffs, NJ: Prentice Hall.

Pelcazr, M.J., Reid, R. and Chan, E.C.S., 1996. Microbiology. Tata Mc Graw Hill Publishing Co. Ltd., New Delhi.

Prescott, L.M., Harley, J.P. and Klein, D.A., 2006. Microbiology. WCB Publishers. (Latest editions available)

Salle, A.J., 1961. Laboratory Manual of Fundamental Principles of Bacteriology. Mc Graw Hill Book C, New York.

ENVS 3210 Environmental Planning and Management 2(1+1)

Theory

Basic Principles of Environment Management, Environment Planning and Management, Environmental Audit, Environmental quality standards (ISO standards) Environment Impact Assessment, Introduction, Definition, aim, principles and concepts, scope, Methods and steps, Adhoc method, Checklist Method, Werner Prestroit study, Smith study, Interaction Matrices- Network and overlays approach., EIA Process, Methods for preparing EIA, Socio-economic aspects, Making inventories, Sampling and Data process, Impact Prediction, Positive and negative impacts, Primary and secondary impacts, Impact on physical, social and biotic environments, EIA for different Environmental Programme, Industries, Urban Development, Land use, Energy Projects, Hydel, Thermal Nuclear, Oil & Gas, Solar and wind, EIA Case Studies, Environmental Planning and Management, Principles of EPM, Principles, concepts and scope of environmental planning, Ecological aspects of EPM, Steps in Environmental Planning, Identification and formulation of strategies of EPM, Environmental Analysis and EPM, Physical planning in relation to environment and land-use classification, EPM for, Town and urban lands, Rural and agricultural lands, Lands reclaimed, Wetlands, Mining areas, Industrial areas, Transportation and urban planning

Lecture schedule

THEORY

1	Basic Principles of Environment Management, Environment Planning and Management: Brief introduction
2	Environmental Planning and Management, Principles of EPM, Principles, concepts and scope of environmental planning
3	Ecological aspects of EPM
4	Steps in Environmental Planning, Identification and formulation of strategies of EPM
5	Environmental Analysis and EPM
6	Physical planning in relation to environment and land-use classification, EPM for, Town and urban lands
7	EPM for Rural and agricultural lands, Lands reclaimed, Wetlands
8	EPM for Mining areas, Industrial areas, Transportation and urban planning
9	Midterm Examination
10	Impact Assessment Introduction: Definition, aim, principles and concepts, scope
11	Methods and steps of EIA: Adhoc method, Checklist Method, Werner Prestroit study, Smith study, Interaction Matrices- Network and overlays approach
12	EIA Process, Methods for preparing EIA, Socio-economic aspects, Making inventories
13	Impact on physical, social and biotic environments

14	EIA for different Environmental Programme: Industries, Urban Development,landuse
15	EIA for different Environmental Programme: Energy Projects, Hydel, Thermal Nuclear, Oil & Gas, Solar and wind
16	Environmental quality standards (ISO standards), Environmental Audit
17	EIA Case Studies
18	**Final theory exam**

Practical

Environmental Audit, Environment Impact Assessment, Adhoc method, Checklist Method, Matrices, Network, overlays approach. Werner Prestroit study, Smith study. EIA Case Studies. Impact Prediction, Impact evaluation, Impact mitigation. EIA for different Environmental Programme: Industries, Urban Development, Land use, Energy Projects, Hydel, Thermal Nuclear, Oil & Gas, Solar and wind. Environmental Analysis, Environmental Planning and Management for Town and urban lands, Rural and agricultural lands, Lands reclaimed, Wetlands, Mining areas, Industrial areas, Transportation and urban planning

PRACTICAL

1	Environmental Audit
2	Environment Impact Assessment
3-4	Adhoc method, Checklist Method, Matrices, Network, overlays approach.
5	Werner Prestroit study, Smith study.
6	Impact Prediction, Impact evaluation, Impact mitigation.

7-8	EIA for different Environmental Programme: Industries, Urban Development, Land use
9-10	EIA for different Environmental Programme: Energy Projects, Hydel, Thermal Nuclear, Oil & Gas, Solar and wind.
11-12	EIA Case Studies.
13-15	Environmental Analysis
16	Environmental Planning and Management for Town and urban lands, Rural and agricultural lands, Lands reclaimed
17	Environmental Planning and Management for Wetlands, Mining areas, Industrial areas, Transportation and urban planning
18	**Practical Examination**

Suggested Readings

1)Abbasi, S.A., 2001. Water resources projects and their environmental impacts. Discovery Publishing House.

Botkin, D.B. and Keller, E.A., 1998. Environmental science: earth as a living planet (No. Ed. 2). John Wiley & Sons Ltd.

Brotherton, I., 1992. Natural resource management of water and land: By Edward O. Gangstad. Van Nostrand Reinhold, New York, 1990. 192 pp. ISBN 0 442 00481 8 (hbk).

Cauter, L.N,1981. Environmental Impact Analysis. Mc Graw Book Co ,New York. Glasson, J. and Therivel, R., 2013. Introduction to environmental impact assessment. Routledge.

Khadka, R.B., et al (Eds).1996. EIA- Training Manual for professionals and managers. Asian Regional Environmental Assessment Programme-IUCN, Nepal.

Madu, C.N., 2007. Environmental planning and management. World Scientific.

Masters, G.M. and Ela, W.P., 2008. Introduction to environmental engineering and science (No. 60457). Englewood Cliffs, NJ: Prentice Hall.
Stead, J.G. and Stead, W.E., 2013. Sustainable strategic management. ME Sharpe.
Wathern, P. ed., 2013. Environmental impact assessment: theory and practice. Routledge.

ENVS 3211 Environmental Impact Assessment 1 (1+0)

Theory

Classification of Pollution and Pollutants, Evolution of EIA (Global and Indian Scenario)- Elements of EIA — Screening – Scoping - Public Consultation - Environmental Clearance process in India - Key Elements in 2006 EIA (Govt. of India) Notification. Primary and Secondary Pollutants, air pollutants-sulfur dioxide- nitrogen dioxide, carbon monoxide, Impact of air pollutants on human, vegetation and environment, Ambient Air Quality Standards Classification and sources of Solid Waste, Characteristics, effects, e-waste, Effects of urbanization on land degradation, pesticide pollution.

Point and Non-point Source of Pollution, Major Pollutants of Water, Physical, chemical and biological characteristics of water, Water borne diseases, Water Quality standards.

Effects of urbanization on land degradation, Impact of Modern Agriculture on Soil, pesticide pollution, Effect on Environment. Sources of Noise, Effects of Noise, measurement of noise, Equivalent sound pressure level. Impacts of pollutants, types, scale of impact-Global, local pollutants. Climate change, Ozone layer depletion, Deforestation, land degradation Environmental impact assessment, Impact of development on vegetation and wild life, Need for EIA, EIA Procedure-Screening, Scoping, EIA procedure in India, Socio-economic impacts- Impact assessment Methodologies-Overlays, Checklist, Matrices, Fault Tree Analysis, Event Tree Analysis- Role of an Environmental Engineer- Public Participation, Standards for Water, Air and Noise Quality - Environmental Management Plan- EIA- Case studies of EIA

THEORY

1	Classification of Pollution and Pollutants, Primary and Secondary Pollutants, air pollutants-sulphur dioxide- nitrogen dioxide, carbon monoxide
2	Impact of air pollutants on human, vegetation and environment, Ambient Air Quality Standards
3-4	Impacts of pollutants, types, scale of impact-Global, local pollutants. Climate change, Ozone layer depletion, Deforestation, land degradation
5	Point and Non-point Source of Pollution, Major Pollutants of Water, Physical, chemical and biological characteristics of water, Water borne diseases, Water Quality standards.
6	Sources of Noise, Effects of Noise, measurement of noise, Equivalent sound pressure level.
7	Classification and sources of Solid Waste, Characteristics, effects, e-waste; Effects of urbanization on land degradation
8	Impact of Modern Agriculture on Soil, Pesticide pollution, Effect on Environment.
9	**Midterm Examination**
10	Elements of EIA — Screening – Scoping - Public Consultation; Evolution of EIA (Global and Indian Scenario)
11	Environmental Clearance process in India - Key Elements in 2006 EIA (Govt. of India) Notification.
12	Need for EIA, EIA Procedure-Screening, Scoping, EIA procedure in India, Socio-economic impacts- Impact assessment Methodologies-Overlays, Checklist, Matrices
13	Fault Tree Analysis, Event Tree Analysis

14	Environmental impact assessment, Impact of development on vegetation and wildlife
15-16	Role of an Environmental Engineer- Public Participation, Standards for Water, Air and Noise Quality
17	Environmental Management Plan; Case studies of EIA
18	**Final theory exam**

Suggested Readings

1) B.C Punmia , "Waste Water Engineering", Laxmi Publications Pvt. Ltd,

2) Dr. PN Modi, "Sewage Treatment & Disposal and Waste water Engineering", Standard Book House, New Delhi

3) John Glasson, RikiTherivel& S Andrew Chadwick "Introduction to EIA" University College London Press Limited

4) Larry W Canter, "Environmental Impact Assessment", McGraw Hill Inc., Newyork.

5) Mackenzie L Davis, Introduction to Environmental Engineering, McGraw hill Education (India)

6) Peavy H S, Rowe, D.R. Tchobanaglous "Environmental Engineering" Mc Graw Hill Education

7) Rau G J and Wooten C.D "EIA Analysis Hand Book" McGraw Hill

8) Robert A Corbett "Standard Handbook of Environmental Engineering" McGraw Hill

DEPARTMENT OF EARTH SCIENCE

EARS 1101 Thermo and Fluid Dynamics 3(2+1)

Theory

Gas laws and their application to the atmosphere-Equation of state for dry and moist air-humidity parameters-virtual temperature. First and second laws of thermo-dynamics-specific heats of gases-internal energy-adiabatic processes-potential temperature-entropy-reversible and irreversible processes-Carnot's cycle. Thermo-dynamics of water vapour-latent heat-the Clausius-Clapeyron equation. Thermo-dynamics of the atmosphere-dry adiabatic lapse rate-case of unsaturated moist air-saturated adiabatic lapse rate, pseudo-adiabatic cases-equivalent potential temperature-thermodynamics of the wet-bulb thermometer-wet-bulb potential temperature and saturation potential temperature. Basic concepts: fluid continuum, fluid properties, ideal fluid, actual fluids, types of flow; D' Alembert's Paradox; statics: pressure surface and body forces on a fluid element; fundamental equation of fluid statics: application to compressible and incompressible fluids, perfect gas equation, hydrostatic equation along the vertical, application to the atmosphere, Laplace's equation. Kinematics: Lagrangian and Eulerian methods of description of fluid flow, stream lines, streak lines and trajectories, Blaton's equation, steady and non-steady flow, decomposition of the field of motion in the vicinity of a point, translation, rotation, divergence and deformation, physical interpretation, application to plane motion, typical flow patterns, stream function, divergence and vorticity in different co-ordinate systems, material, local and convective derivatives. Dynamics: equation of continuity and its applications, non-viscous incompressible flow, Eulerian equations of motion, inertial and rotational frames of reference, Coriolis force, irrotational flow, velocity potential, integration of the equations of motion, Bernoulli's theorem and its applications. Circulation and vorticity, Stoke's theorem, Kelvin’s theorem, Helmholtz theorem, barotropic and baroclinic fluids, absolute and relative circulation; V.Bjerknes circulation theorem and its interpretation, potential vorticity-conservation, application to air flow over mountain barriers.

Theory Lecture Schedule

1	Gas laws and their applications, Boyle's law, Charle's law
2	Gas laws and their applications Gaslusac's law, Ideal gas law
3-4	Equation of state of Dry and moist air: Atmosphere, air parcel, dry air, moist air basics points
5	Definitions of Temperature, dry-bulb temperature, wet-bulb temperature, dew point temperature
6	Definitions: Potential temperature, virtual temperature, wet-bulb potential temperature
7-8	Humidity, absolute humidity, specific humidity, relative humidity
9-10	First and Second law of thermodynamics explanation
11-12	Adiabatic processes, internal Energy, entropy, enthalpy and Gibbs free energy
13	Riversible, irreversible processes, different types of systems,
14-15	Carnot's Engine, Carnot cycle and efficiency related problems
16	Clasius-Clapeyron Equation- Importance
17	Different types of Lapserates
18	**Mid-term Examination**
19	Fluid properties basics, ideal fluid, actual fluid, pressure in fluids
20-21	D' Alamberts paradox, Hydrostatic equation
22	Laplaces Equation
23	Langrangian Method of Fluid Flows
24	Eulerian Method of fluid flows
25	Steam and Streak lines, Blatons equation
26-27	Rotation, Circulation, Divergence and Vorticity
28-29	Equation of continuity and mass conservation, Coriolis force

30-31 Bernoulli's theorem and applications

32-33 Stocks theorem, Kelvins theorem, Helmoltz theorem

34 Barotropic, baroclinic fluids properties

35 Circulation and Bjerkens circulation theorems and interpretations-Air flow over mountain barriers

36 Final Theory Examination

Practical

Computation of atmospheric pressure, correction of elevation, equations of motion and continuity and their applications- Problems on gas laws- Problems on laws of thermodynamics

Practical Schedule

1 Numerical problems based on gas laws: Boyle's law

2 Numerical problems based on gas laws: Charles law

3 Numerical problems based on gas laws: Gaylusacs law

4 Numerical problems based on gas laws: Ideal Gas law

5 Numerical problems based on gas laws: Avogadro Law

6 Numerical problems based on gas laws: Combined Gas Law

7 Repetition of numerical problem based on gas laws

8 Problems based on different types of lapse rates

9 Numerical problems based on pressure in fluids (P=Rho*R*T)

10 Numerical problems based on pressure in fluids (P=Rho*g*h)

11 Problems related with the Volume flow rate of fluids-Class1

12 Problems related with the Volume flow rate of fluids-Class2

13 Numerical problems based on Bernoulli’s theorems

14 Problems on different types of temperature conversions-I

15 Problems on different types of temperature conversions-II

16 Numerical problems based on Carnot Engine-1

17 Numerical problems based on efficiency of Carnot Engine-2

18 Final Practical Examination

Suggested Readings

Batchelor, C.K. and Batchelor, G.K., 2000. *An introduction to fluid dynamics*. Cambridge university press

Pedlosky, J., 2013. *Geophysical fluid dynamics*. Springer Science & Business Media.

Tritton, D.J., 1988. Physical fluid mechanics. Clarendon.

Yuan, S.W., 1970. *Foundations of fluid mechanics* (No. BOOK). Prentice-Hall.

EARS 1202 Physical Meteorology 2(2+0)

Theory

Thermal structure of the atmosphere and its composition. Radiation: basic Laws - Rayleigh and Mie scattering, multiple scattering, radiation from the sun, solar constant, effect of clouds, surface and planetary albedo. Emission and absorption of terrestrial radiation, radiation windows, radiative transfer, Greenhouse effect, net radiation budget; Thermodynamics of dry and moist air: specific gas constant, Adiabatic and isentropic processes, entropy and enthalpy, Moisture variables, virtual temperature; Clausius –Clapeyron equation, adiabatic process of moist air; thermodynamic diagrams: Hydrostatic equilibrium: Hydrostatic equation, variation of pressure with height, geopotential, standard atmosphere, altimetry. Vertical stability of the atmosphere: Dry and moist air parcel and slice methods. Tropical convection. Atmospheric optics - visibility -optical phenomenon -rainbows, haloes, corona, glory, mirage.

Lecture Schedule- Theory

1-2 Thermal Structure of atmosphere, Troposphere, stratosphere

3-4 Thermal Structure of atmosphere:- Mesosphere, Thermosphere, Exosphere

5 Composition of atmosphere

6-8	Radiation, solar constant, basic points, laws of radiation: Planks Law, Wien's displacement law, Stefan-Boltzman law, Kirchoff law.
9-10	Basics of scattering, different types of scattering, Mie and Rayleigh scattering, Raman scattering
11	Albedo, Properties of albedo
12	Terrestrial radiation- basics, Emmission and absorption
13-14	Green house effect, radiation windows
15-17	Green house effect, Net radiation/solar energy budget
18	**Mid Term Examination**
19	Thermodynamics of dry and moist air: Adiabatic and isentropic processes
20	Enthalpy and entropy, specific gas constant
21-22	Adiabatic process of moist air: Moist adiabatic lapse rate
23-24	Moisture variables: Vapour pressure, saturation vapourpressure,mixing ratio, saturation mixing ratio, specific humidity, relative humidity
25	Virtual temperature, Clausius-Clapeyron Equation
26	Thermodynamic diagrams:Basic concepts, different types of lines
27	Thermodynamic diagrams: Emagram, Tephigram
28	Thermodynamic diagrams: Skew-T / Log-P diagram, Stuv Diagram
29-30	Hydrostatic Equilibrium and Equation
31-32	Stability of atmosphere, convective properties
33-34	Atmospheric optics: Basics, visibility

35 Optical phenomena: Rainbows, Halos, corona,glory and mirage etc

36 **Final Theory examination**

Suggested Readings

Andrews, D.G., *An introduction atmospheric physics/by David G. Andrews* (No. 551.51 A5.).

Ayres, F., 1981. Differential Equations In SI Metric Units, 1St Ed.. New York: McGraw- Hill.

Grewal, B., Grewal, J. and Dhanoa, J., 2015. Higher Engineering Mathematics. New Delhi: Khana Publishers

Haltiner, G.J. and Martin, F.L., 1957. *Dynamic and physical meteorology*. McGraw-Hill Book Company.

Hess, S.L., 1979. *Introduction to theoretical meteorology* :No. 551.5 HES.

Iribarne, J.V. and Cho, H.R., 1980. Atmospheric physics. *Nature*, *284*(5751), pp.88-88.

Johnson, J.C., 1955. Physical meteorology. *American Journal of Physics*, *23*(1), pp.75-76.

Mason, B.J., 1975. *Clouds, rain and rainmaking*. Cambridge University Press.

Retallack, B.J., 1973. *Physical Meteorology*. Secretariat of the World Meteorological Oranization.

Spiegel, M.R. ,1974. Theory and problems of Fourier analysis : with applications to boundary value problems. New York, N.Y.: Mcgraw-Hill.

Wallace, J.M. and Peter Victor Hobbs (2011). *Atmospheric science : an introductory survey*. Amsterdam: Elsevier Acad. Press.

EARS 1203 Physical Oceanography 3(2+1)

Theory

General introduction, dimension of the oceans, geographical features - Physical properties of sea water, distribution of temperature, salinity, and density in space and time, PSU and TOES-10, acoustical and optical characteristics of seawater – SOFAR channel and shadow zone – color of the sea. Oceanographic Instruments: Temperature measurements; Protected and unprotected reversing thermometers, XBT, Sea Gliders, ROV, CTD. Current measurements: Lagrangian and Eulerian methods with examples, Aanderra current meter, ADCP, Position fixing at sea – GPS. Measurements– Waves and Tides. Heat budget of ocean: insolation – long wave radiation – effect of clouds – sensible and latent heat transfer, Bowen's ratio – ocean heat transport – spatiotemporal variability of heat budget terms and net heat balance. Water masses: formation classification and identification of water masses – T-S diagram – merits and demerits, characteristics of important water masses in the oceans, water masses in the Indian Ocean. Circulation: wind driven and thermohaline circulation, characteristics of the global conveyor belt circulation and its causes – Circulation in Arabian Sea and Bay of Bengal – Major currents in Indian Ocean – Upwelling and sinking with special reference to the Indian ocean – mixed layer variability – ocean eddies and winter cooling.

Lecture Schedule- Theory

1-2 General introduction

3 Dimension of the oceans

4 Geographical features

5-6 Physical properties of seawater

7 Acoustical and optical characteristics of seawater

8 SONAR and SOFAR channel and shadow zone – color of the sea

9-10 Heat Budget of the Oceans

11-12 Formation and classification of water masses

13-15 Water masses of the ocean with special reference to Indian Ocean

16-17 Causes of currents in the oceans

18 **Mid-Term Examination**

19-20 Circulation: wind driven and thermohaline circulation

21-22 Major currents in the Indian Ocean during different seasons

23-24 Dynamics of coastal upwelling

25-26 Upwelling along the west coast of India

27 Upwelling and biological productivity

28 Breakers in the oceans

29 Sea floor dimensions

30-31 Tides

32 General aspects of ocean waves, their generation and propagation

33 Storm surges and tsunami

34-35 Ocean Instruments- CTD, Tide Gauge, ADCP, Current Meter

36 **Final Examination**

Practical

Observations on sea surface temperature, Data analysis on sea level rise graphical representations, Temperature Salinity (T-S) diagram, Isotherms and isobars over sea surface, analysis using sample data, Oceanic heat budget components like Latent heat flux, sensible heat flux etc sample data analysis and interpretations, Visit any institute dealing with physical Oceanography like NPOL and NIO Kochi, Ship observations

Lecture Schedule- Practical

1-2 Analysis on sea surface temperature and Local Temperature Anomaly (LTA)

3-4 Study of vertical section of Temperature and analysis on Thermo-cline Depth

5-6 Study of vertical section of Salinity and analysis on halo-cline Depth

7-8 Study of vertical section of Potential Density and analysis on pycno-cline Depth

9-10 Analysis on Mixed Layer Variability

11-12 Analysis on zonal and meridional components of wind

13-14 Analysis on Ekman Transport along the west coast of India

15-16 Analysis on Oceanic Heat Budget

17 Visit any Oceanography Institute in India

18 **Final Practical Examination**

Suggested Readings

Hersey, J.B., 1961. Physical Oceanography. Albert Defant. Pergamon, New York, 1961. vol. 1, 729 pp.; vol. 2, 598 pp.

Murty, A. S. N., 2010. Physical Oceanography, A.P.H. Pub.

Neumann, G. and Pierson Jr, W.J., 1966. Principles of physical oceanography.

Pickard, G.L. and Emery, W.J., 1961. *Descriptive physical oceanography: an introduction*. Oxford: Butterworth.

Siedler, G., Gould, J. and Church, J.A., 2001. *Ocean circulation and climate: observing and modelling the global ocean*. Elsevier.

Steele, J.H., Thorpe, S.A. and Turekian, K.K. eds., 2009. *Elements of physical oceanography: a derivative of the encyclopedia of ocean sciences*. Academic Press.

Stewart, R.H., 2008. *Introduction to physical oceanography* (pp. 1-342). College Station: Texas A & M University.

Sverdrup, H.U., Johnson, M.W. and Fleming, R.H., 1942. *The Oceans: Their physics, chemistry, and general biology* (Vol. 7). New York: Prentice-Hall.

Talley, L.D., 2011. *Descriptive physical oceanography: an introduction*. Academic press.

Wiegel, R.L., 2013. *Oceanographical engineering*. Courier Corporation.

EARS 2204 Global Physical Climatology 3(2+1)

Theory

Global climates- Classification of climates - genetic and empirical classifications, Koppen and Thornthwaite's schemes - other classifications - homoclimates - climatic types and climatic zones. Global distribution - seasonal variation - precipitation zones. Climatology of air masses - origin, movement and modification of air masses - fronts and convergence zones. Radiation climatology of the earth’s atmosphere, geographical and seasonal distribution of incoming solar radiation, outgoing radiation, net radiation, terrestrial heat balance. Geographical and seasonal distributions of temperature, pressure, wind, evaporation, humidity, fog, clouds and thunderstorms. - weather associated with frontal zones - extra tropical cyclones - their origin, structure development and dissipation. Introduction to paleoclimatology - fossil studies - dendroclimatology.- pollen grains –theories of climatic changes - overview of the climatic history of the earth. Man’s impact on climate, potential consequences. Fundamentals of climate dynamics- Equation of motion in different coordinate systems: Cartesian, spherical and polar, isobaric, natural and sigma co-ordinate

system, frame of reference, momentum equation in rotating frame of reference, gravitational force, geopotential, geopotential height, effective gravity, pressure gradient force, Coriolis force, centrifugal force, scale analysis of dynamical equation, geostrophic approximation, Rossby Number, hydrostatic equation. Classification of flows, geostrophic wind, inertial wind, cyclostrophic wind, gradient winds; Thermal wind, backing and veering, barotropic and baroclinic atmospheres, Equation of continuity in cartesian and isobaric coordinate systems, its applications. Divergence, vorticity and circulation; relative, planetary and absolute vorticity, vorticity equation in cartesian and isobaric coordinate system, potential vorticity conservation, application to air flow over mountain barriers, absolute and relative circulation, Stoke's theorem, Kelvin's theorem, barotropic and baroclinic fluids, Bjerknes circulation theorem and its interpretation. Internal, potential and kinetic energy, mechanical and thermal forms of energy in the atmosphere, atmospheric energy equation, available potential energy. Kinematics of pressure field, pressure tendency equation, Bjerknes-Holmboe theory of the motion of pressure systems, isallobars and isallobaric wind.

Lecture Schedule

1	Climate - definition and introduction
2-3	Climate Classifications – Genetic and Empirical Classifications
4-5	Climate Classifications – Koppen and Thornthwaite's' schemes
6-7	Homoclimates - climatic types and climatic zones
8-9	Introduction to Air masses – origin, movement and other properties
10	Energy Budget of Earth , Insolation and OLR properties
11-13	Distribution of Atmospheric parameters over world
14	Frontal Systems introduction
15	Frontal system- formation of extra tropical cyclones
16	Basic understanding of paleoclimatology and dendroclimatology
17	Introduction of Climatic History of Earth and Man's impact on climate
18	**Mid-Term Examination**

19-20	Equation of Motion in Cartesian and other Coordinate systems
21	Definition of Momentum equation, gravitational force,
22	Definition of geopotential, geopotential height
23	Definition of Pressure gradient force, Centrifugal force, Coriolis force
24	Scale analysis of equation of motion
25	Definition of Geostrophic wind, Rossby number, Inertial wind, cyclostrophic wind
26	Definition of Gradient wind, Thermal wind, Veering and backing
27	Introduction to Barotropic and baroclinic atmosphere
28-30	Continuity Equation in cartesian and other coordinates systems
31	Definition of vorticity, divergence and circulations
32-34	Different types of circulation theorems
35	Energy in the atmosphere and other concepts

36 Final Theory examination

Practical

Computation of incoming and outgoing radiation, preparation of maps showing temperature, rainfall and pressure distributions. Climatic classification of locations, analysis of climate variability. Computation of thermodynamic parameters (LCL, CCL, LFC, LNB, Tc) from t-phi gram. Computation of mixing ratio, relative humidity and precipitable water from t-phi gram. Computation of potential temperature, equivalent potential temperature and wet bulb temperature using t-phi gram. Discussion on thermodynamic structure and stability condition of the atmosphere using plotted t-phi gram. Computation of geopotential thickness. Computations of vorticity and divergence using (a) Bellamy's Grid Method and (b) Curvature Method. Computation of divergence, vorticity and circulation. Computation of vertical velocity

Practical

1	Introduction to weather maps
2	Plotting on Weather maps details - I

3 Plotting on Weather maps details – II

4 Introduction to Te-Phi digram (Tephigram)

5 Tephigram Analysis – I (LCL calculation)

6 Tephigram Analysis – II (CCL calculation)

7 Tephigram Analysis – III (LFC calculation)

8 Tephigram Analysis – IV (LNB calculation)

9 Tephigram Analysis – V(TC calculation)

10 Computation of mixing ratio from Te-phi diagram

11 Computation of relative humidity from Te-phi diagram

12 Computation of precipitable water from Te-phi diagram

13 Computation of wet-bulb temperature from Te-phi gram

14 Computation of potential temperature, and equivalent potential temperature from Te-phi diagram

15 Computation of equivalent potential temperature from Te-phi diagram

16 Discussion on stability of atmosphere based on Te-phi diagram

17 Repetition of combined Practical and other experiments

18 Final Practical Examination

Suggested Readings

Critchfield, H.J., 1974. *General climatology* (No. 551.59 C75 1974).

Griffiths, J.F. and Driscoll, D.M., 1982. *Survey of climatology*. Merrill Publishing Company.

Hess, S.L., 1979. *Introduction to theoretical meteorology* (No. 551.5 HES). Holton, J.R., 1979. *Introduction to Dynamic Meteorology (Volume 23)*.

Landsberg, H.E., 1972. World survey of climatology

Lockwood, J.G., 1974. *World climatology: an environmental approach*. E. Arnold.

Sellers, W.D., 1965. *Physical climatology* (No. 551.6 S467). University of Chicago Press

Trewartha, G.T., 1954. *An introduction to climate* (No. QC981 T65 1954).

EARS 2205 Geomatics 3(1+2)

Theory

Remote sensing - classification based on source: Active and passive remote sensing; Aerial and space remote sensing; Interaction of electromagnetic radiation with atmosphere and earth surface; Aerial photographs – types; Photo interpretation - Satellite remote sensing - platforms and sensors; Satellite systems. Indian Remote Sensing Programme; Visual and digital image processing; Application of satellite based remote sensing techniques in forestry - vegetation mapping using satellite imagery-NDVI; Forest cover monitoring and damage assessment; Microwave remote sensing. Introduction to GIS. Differences between GIS and conventional cartography. Spatial and non-spatial data- Integration of attribute data with spatial data.

Spatial data Raster and Vector data-Thematic over lays in GIS- topology building and calculation of area and length etc. Application of GIS in forestry – using imageries and integration with GIS data. Maps-its projection-Toposheet and Map reading. Global Positioning System (GPS) applications in resource inventory, Global Navigation Satellite System, Galileo, GLONASS, QZSS, Compass, IRNSS etc., GAGAN.

Lecture Schedule- Theory

1-2 Remote sensing - classification based on source: Active and passive remote sensing; Aerial and space remote sensing

3 Interaction of electromagnetic radiation with atmosphere and earth surface

4 Aerial photographs – types; Photo interpretation

5 Satellite remote sensing - platforms and sensors

6 Indian Remote Sensing Programme

7 Visual and digital image processing

8 Application of satellite based remote sensing techniques in forestry - vegetation mapping using satellite imagery-NDVI

9 **Mid-Term Examination**

10 Forest cover monitoring and damage assessment

11 Microwave remote sensing

12 Introduction to GIS. Differences between GIS and conventional cartography

13 Spatial and non-spatial data- Integration of attribute data with spatial data. Spatial data - Raster and Vector data

14 Thematic overlays in GIS- topology building and calculation of area and length etc

15 Application of GIS in forestry – using imageries and integration with GIS data, Maps- its projection-Toposheet and Map reading

16 Global Positioning System (GPS) applications in resource inventory

17 Global Navigation Satellite System, Galileo, GLONASS, QZSS, Compass, IRNSS etc.

18 **Final Examination**

Practical

Introduction to GIS tools: Introduction to ArcMap and ArcCatalog - Visualization of Geographic Datasets - Viewing properties - Basic ArcMap features (zoom – in, zoom out, pan etc.) - Symbology view and change. Maps and Projections: Introduction to coordinate systems - Defining geographic coordinate system - Projection to another - Importing coordinate systems - Projection of a text file. Database Management: Data organization in catalog - Importing data into a Shape file, MDB and GDB, Arc Coverage file - Creating layers - Creating topology. Satellite data management and preprocessing, Creating Digitization and Generation: Creating and editing annotations - Editing shared features and topologies - Understanding generation of features - Digitisation of Point line polygon from Toposheet– Exercises. Queries: Attribute data handling - Various types of queries and their executions (select by feature, location)

Queries attribute data, combine spatial and attribute query - Raster query. Relief representation techniques: Representation of Cartographic data Relief representation techniques Basic Concept of cartography, Categories of maps, Study and interpretation: SOI toposheet, cadastral and thematic maps, Numbering, scales, grid reference, signs and symbols, color system, cartographic design issues, map lettering, map compilation, Generalization, dot, isopleth and choropleth mapping, multivariate and dynamic mapping, map production, methods of map composing and printing Visualization of geospatial data: Design aspects, Multiscale and geometric aspects scale, dissemination of (visualized) geospatial data, data products, use and users of products, Various issues in map visualization

Lecture Schedule- Practical

1-3 Introduction to GIS tools

4-6 Introduction to ArcMap and ArcCatalog

7-9 Visualization of Geographic Datasets - Viewing properties - Basic ArcMap features (zoom – in, zoom out, pan etc.) - Symbology view and change

10-12 Maps and Projections: Introduction to coordinate systems - Defining geographic coordinate system - Projection to another - Importing coordinate systems - Projection of a text file

13-15 Database Management: Data organization in catalog

16-17 Importing data into a Shape file, MDB and GDB, Arc Coverage file

18-19 Creating layers - Creating topology. Creating Digitization and Generation: Creating and editing annotations

20-21 Editing shared features and topologies - Understanding generation of features

22-23 Digitisation of Point line polygon from Toposheet– Exercises

24-25 Queries: Attribute data handling - Various types of queries and their executions (select by feature, location) Queries attribute data, combine spatial and attribute query-Raster

query.

26-27 Relief representation techniques: Representation of Cartographic data Relief representation techniques

28-29 Basic Concept of cartography, Categories of maps, Study and interpretation

30-32 SOI toposheet, cadastral and thematic maps, Numbering, scales, grid reference, signs and symbols, color system, cartographic design issues, map lettering, map compilation, Generalization, dot, isopleth and choropleth mapping, multivariate and dynamic mapping, map production, methods of map composing and printing Visualization of geospatial data

33-34 Design aspects, Multi scale and geometric aspects scale, dissemination of (visualized) geospatial data, data products, use and users of products

35 Various issues in map visualization

36 Final Practical Examination

Suggested readings

Campbell, J.B. 2002. *Introduction to Remote Sensing*-Third edition. Taylor and Francis, London.

Environment System Research Institute, 1999. GIS for Everyone. Redlands, CA:ESRI

Jackson, M.J. 1992. Integrated Geographical Information Systems. *International Journal of Remote Sensing*, 13(6-7): 1343-1351p

Joseph, G. 2005. *Fundamentals of Remote Sensing*-Second edition. Universities Press

Lillesand, T.M. and Kiefer,W.R. 1994.*Remote sensing and Image Interpretation*, Fourth edition. John Wiley & Sons, Inc., USA.

Obi Reddy, G.P. and Sarkar, D. 2012. *RS and GIS in Digital Terrain Analysis and Soil Landscape Modelling*. NBSS & LUP, Nagpur.

EARS 2206 Air-Sea Interaction 2(1+1)

Theory

The ocean is a fundamental component and driver of the global climate system. The course stresses the importance of recognizing ocean-atmosphere links: the ocean in the climate system; physical interactions between the ocean and atmosphere. Atmospheric

turbulence: Introduction - atmospheric surface layer - general characteristics of turbulence - turbulent fluxes of momentum, water vapour and heat – turbulence spectrum - fundamental hypothesis and theories of turbulence – turbulent. kinetic energy (TKE) - Richardson number – Reynolds equations – Reynolds stress and friction velocity - K theory and eddy viscosity - mixing length theory Small scale interaction: Similarity theory for a neutral atmosphere - surface roughness logarithmic wind profile – MoninObukhov similarity theory - similarity functions - bulk-aerodynamic formulation of fluxes – bulk exchange coefficients - methods of flux measurements - air-sea gas exchange Large scale interaction: Ocean-atmosphere system - shortwave solar radiation – long- wave terrestrial radiation – radiation balance - latent and sensible heat fluxes – global and regional ocean heat budget - flux measurements using satellites – estimation of heat transport – evaporation and precipitation - freshwater budget – wind stress over the ocean – the ocean and its circulation –wind driven circulations – thermohaline circulation of the ocean – biogeochemical interactions of the atmosphere and ocean the ocean and natural climate variability – the ocean under future greenhouse states. Air-sea interaction and climate: ocean and climate – interannual variations in heat transport – long term trends – large-scale anomalies: ENSO, North Atlantic Oscillation (NAO), Indian Dipole mode (IOD), Pacific Decadal Oscillation (PDO) – sea spray and climate

Lecture Schedule- Theory

1-2 The ocean is a fundamental component and driver of the global climate system

3 The importance of recognizing ocean-atmosphere links

4 Physical interactions between the ocean and atmosphere

5 Atmospheric turbulence: Introduction

6 Atmospheric surface layer

7 General characteristics of turbulence

8-9 Turbulent fluxes of momentum, water vapour and heat – turbulence spectrum

10 Fundamental hypothesis and theories of turbulence

11-12 Turbulent kinetic energy and Richardson number

13-14 Reynolds equations – Reynolds stress and friction velocity

15 K theory and eddy viscosity

16 Mixing length theory

17 Small scale interaction: Similarity theory for a neutral atmosphere

18 **Mid-Term Examination**

19 Surface roughness and logarithmic wind profile

20 Monin-Obukhov similarity theory

21 Bulk aerodynamic formulation of fluxes

22 Methods of flux measurements

23 Air-sea gas exchange

24 Shortwave solar radiation and longwave terrestrial radiation

25 Radiation balance

26 Latent and sensible heat fluxes

27 Global and regional ocean heat budget

28 Wind stress over the ocean

29 Wind driven and thermo-haline circulation of the ocean

30 Biogeochemical interactions of the atmosphere and ocean

31 The ocean and natural climate variability

32 Ocean under future greenhouse states

33 El-Nino Southern Oscillation (ENSO)

34 North Atlantic Oscillation (NAO)

35 Indian Ocean Dipole mode (IOD) and Pacific Decadal Oscillation (PDO)

36 Final Examination

Practical

Calculation of Southern Oscillation Index (SOI), Calculation of North Atlantic Oscillation Index, Calculation of North Atlantic Oscillation Index, Calculation of Dipole Mode Index (DMI), An observation on meso-scale eddies in Arabian Sea, Contribution of remote forcing to the upper ocean circulation pattern over northern Indian Ocean, Evidence of propagation of Kelvin and Rossby waves in the north Indian Ocean, Study of the Oceanic Heat Budget components over major oceans

Lecture Schedule- Practical

1-3 Calculation of Southern Oscillation Index (SOI)

4-5 Calculation of North Atlantic Oscillation Index

6-7 Calculation of Dipole Mode Index (DMI)

8-10 An observation on meso-scale eddies in Arabian Sea

11-13 Contribution of remote forcing to the upper ocean circulation pattern over northern Indian Ocean

14-15 Evidence of propagation of Kelvin and Rossby waves in the northern Indian Ocean

16-17 Study of the Oceanic Heat Budget components

18 Final Practical Examination

Suggested Readings

Bigg, G.R., 2004. The oceans and climate. Cambridge University Press, Academic Publishers

Geernaert, G. L. Kluwer, 1999. Air-Sea Exchange: Physics, Chemistry and Dynamics

Academic Publishers,.

Grant R. Bigg, 1996. The Oceans and Climate, Cambridge University Press.

Ian S. F. Jones and Y. Toba, 2009. Wind Stress over the Oceans, Cambridge University Press,

Kraus E. B. and Businger J. A., 1994. Atmosphere-Ocean Interaction, Oxford University Press

Marshall, J., and Plumb, R.A., 2009. Atmosphere, Ocean and Climate Dynamics.
Stull, Kluwer, R. B, 1988. Introduction to Boundary Layer Meteorology

Yoshiaki Toba, 2003. Ocean-Atmosphere Interactions. Terra Scientific Publishing Company

EARS 3107 Remote Sensing and its Application in Climate Science 3(2+1)

Theory

Introduction to Remote Sensing - Basic concepts – principles of aerial photography - electromagnetic radiation – solar and terrestrial radiation - atmospheric effects – absorption, transmission and scattering – spectral response of earth's surface features- atmospheric windows – concept of signature Physical basis of remote sensing - Remote sensing of the environment with Electromagnetic energy - Atmospheric transmission, atmospheric window regions and absorption bands. Remote sensing of atmospheric variables: Schwarzchild's Equation and its solution, Vertical sounding, Limb sounding, No emission equation, Detection of Aerosols. Kepler's laws of universal planetary motion, Meteorological satellites and their orbital characteristics, Geostationary, Sun-synchronous, Polar and special purpose orbits. Different meteorological satellite systems- INSAT series, Meteosat series, NOAA series, TRMM and SSMI series, QUICKSCAT etc - MEGHA TROPIQUES satellite, SARAL, Global weather satellite system. Remote sensing platforms – satellite orbits - near polar, geostationary and sun-synchronous satellites – swath – spatial, temporal, spectral and radiometric resolution – LANDSAT, SPOT, IRS, INSAT, SEASAT, ERS, JERS, MOS, RADARSAT - sensors – active and passive sensors – sensor calibration-visible, thermal and microwave sensors and their applications. Introduction-Why satellites are needed for ocean observation, Types of satellites, satellites orbits, Requirement of global coverage and technology involved, Satellite revisit time, Radar altimeter sensors and methods, Ocean colour sensors, Microwave radiometers, scatterometer, SAR, Along Track Scanning Radiometer. Satellite capabilities-Global scale coverage – eg: El Nino, monsoon, Climate change, Indian

Ocean dipole, Different types of satellite products available for ocean monitoring- SeaWiFS, MODIS, OCM-1,2, SARAL-Altika, TOPEX-Poseidon, OCTS, MERIS, AMSR, SeaWinds. Application of AVHRR, Altimeters, SAR for studying mesoscale variabilities in the Ocean, Synergistic use of different sensors for studying coastal upwelling mesoscale features, Sea ice monitoring using Scatterometer, SAR and Altimeter, Sea level studies using satellite Altimeter. Main requirement for operational oceanography- sea surface topography. Remote sensing techniques for sea level, sea surface temperature, and wind stress - ocean waves-near shore environments and processes.-Ocean Color. Applications of remotes sensing in collecting atmospheric temperature data and for the CO_2 measurements.

Theory Lecture Schedule

1	Introduction to Remote Sensing - Basic concepts
2	Basic Principles of aerial photography
3-4	Electromagnetic radiation – solar and terrestrial radiation -
5	Atmospheric effects – absorption, transmission and scattering
6	Spectral response of earth's surface features- atmospheric windows
7	Concept of signature Physical basis of remote sensing
8	Remote sensing of the environment with Electromagnetic energy
9	Atmospheric transmission, atmospheric window regions and absorption bands.
10-11	Remote sensing of atmospheric variables: Schwarzchild’s Equation and its solution,
12	Vertical sounding, Limb sounding, No emission equation and detection of Aerosols
13	Kepler's laws of universal planetary motion,
14	Meteorological satellites and their orbital characteristics, Geostationary, Sun-synchronous,Polar and special purpose orbits.
15-17	Study on different meteorological satellite systems- (INSAT series, Meteosat series,NOAAseries, TRMM and SSMI series, QUICKSCAT, MEGHA TROPIQUES satellite, SARAL, Global weather satellite system)

18 Midterm Examination

19-20 Remote sensing platforms ,satellite orbits - near polar, geostationary and sun-synchronous,satellites,swath,spatial, temporal, spectral and radiometric resolution

21-22 Informations about LANDSAT, SPOT, IRS, INSAT, SEASAT, ERS, JERS, MOS, RADARSAT

23 Sensors – active and passive sensors – sensor calibration-visible, thermal and microwave sensors and their applications.

24 Introduction-Why satellites are needed for ocean observation,

25 Types of satellites, satellites orbits, Requirement of global coverage and technology involved, Satellite revisit time,

26 Satellite Sensors- Radar altimeter sensors and methods, Ocean colour sensors, Microwave radiometers, scatterometer, SAR, Along Track Scanning Radiometer.

27 Satellite capabilities-Global scale coverage – eg: El Nino, monsoon, Climate change, Indian Ocean dipole,

28-29 Different types of satellite products available for ocean monitoring- SeaWiFS, MODIS, OCM-1,2, SARAL-Altika, TOPEX-Poseidon, OCTS, MERIS, AMSR, SeaWinds.

30-31 Application of AVHRR, Altimeters, SAR for studying mesoscale variabilities in the Ocean.

32 Synergistic use of different sensors for studying coastal upwelling mesoscale features, Sea ice monitoring using Scatterometer, SAR and Altimeter, Sea level studies using satellite Altimeter.

33 Main requirement for operational oceanography- sea surface topography.

34 Remote sensing techniques for sea level, sea surface temperature, and wind stress - ocean waves-near shore environments and processes.-

35 Ocean Color. Applications of remotes sensing in collecting atmospheric temperature data and for the CO2measurements.

36 Final Theory examination

Practical

Operation of Weather balloons and data processing, basics of validating satellite data with field observations. Data preprocessing using GIS software like QGIS, ODV

Practical Schedule

1-2 Raster data-Sources of Remotely sensed sata

3-4 Remote sensing data-Data acquisition

5-8 Remote sensing data processing

9-12 Weather data Sources -weather data acquisition-WorldClim data-CMIP-6 data

13-17 Introduction to weather balloons and data analysis using ODV and QGIS - Qweather

18 Practical Examination

Suggested Readings

Allan, Thomas D., 1983. Satellite microwave remote sensing. John Wiley & Sons

Barrett, E., 2019. Climatology from satellites. Routledge.

Curran, P., 1982. The use of satellite data in rainfall monitoring. EC Barrett and WM Martin, Academic Press, London, 1981. No. of pages: 340. Price:£ 27.80. International Journal of Climatology, 2, pp.198-198.

Deepak, A. ed., 2012. Remote sensing of atmospheres and oceans. Elsevier.

Houghton, J.T., Houghton, J.T., Taylor, F.W. and Rodgers, C.D., 1986. Remote sounding of atmospheres (Vol. 5). CUP Archive.

Ikeda, M., 1995. Oceanographic applications of remote sensing. CRC press.

Kidder, S.Q., KIDDER, R.M. and Haar, T.H.V., 1995. Satellite meteorology: an introduction. Gulf Professional Publishing.

Lathram, E.H., 1986. Introduction to satellite oceanography: GA Maul: MartinusNijhoff Publishers, Dordrecht, 1985. x+ 606 pp.

Offiler, D., 1985. Satellite Oceanography. By IS Robinson. Ellis Horwood, Chichester (John Wiley), 1985. Pp, 455.£ 42.50. Quarterly Journal of the Royal Meteorological Society, 111, pp.1139-1140.

Robinson, I.S., 2004. Measuring the oceans from space: the principles and methods of satellite oceanography. Springer Science & Business Media.

Williams, P.D.L., 1986. Methods of Satellite Oceanography. Robert H. Stewart 360 pages. 18× 26 cm, 16 colour plates, over 500 references. University of California Press, Berkeley and London.

EARS 3108 Climate Dynamics 3(2+1)

Theory

Basic equations and fundamental forces: Pressure, gravity, centripetal and Coroli's forces, continuity equation in Cartesian and isobaric coordinates. Momentum equation Cartesian and spherical coordinates; scale analysis, inertial flow, geostrophic and gradient winds, thermal wind. Divergence and vertical motion Rossby, Richardson, Reynolds and Froude numbers. Circulation, vorticity and divergence; Bjerknese circulation theorem and applications, vorticity and divergence equations, scale analysis, potential vorticity, stream function and velocity potential. Atmospheric turbulence: Mixing length theory, planetary boundary layer equations, surface layer, Ekman layer, eddy transport of heat, moisture and momentum, Richardson criterion; Linear Perturbation Theory: Internal and external gravity waves, inertia waves, gravity waves, Rossby waves, wave motion in the tropics, barotropic and baroclinic instabilities. Atmospheric Energetics: Kinetic, potential and internal energies – conversion of potential and internal energies into kinetic energy, available potential energy.

Theory Lecture Schedule

1-2	Basics of fundamental forces: Pressure, gravity,centripetal and Corioli's forces
3-5	Continuity Equation in Cartesian and isobaric coordinate Systems
6-7	Momentum equation Cartesian and spherical coordinates
8	Definition of scale analysis

9-10	Inertial flow, gradient wind, geostrophic wind, thermal wind
11	Divergence, vertical motion,
12-13	Rossby number, Richardson number, Reynolds number, Froude number
14-15	Circulation, vorticity and divergence
16-17	Bjerknes Circulation theorem, scale analysis
18	**Midterm Examination**
19	potential vorticity, stream function and velocity potential
20-21	Atmospheric turbulence:Mixing length theory, planetary boundary layer equations
22-24	Surface layer, Ekman layer, eddy transport of heat in ocean
25-26	Moisture and momentum transfer in ocean
27-28	Richardson Criterion, Linear Perturbation Theory
29	Internal and external gravity waves and inertial waves in the ocean
30-31	Rossby waves and wave motion in Tropics
32-33	Barotropic and baroclinic instabilities in the atmosphere
34-35	Atmospheric Energetics: Kinetic, potential and internal energies, energy conversions
36	**Final Theory Examination**

Practical

Climate modelling exercises using IPCC Climate model outputs, Exercises on different atmospheric and oceanic phenomenon like ElSO, IOD, Etc on Grads, Exercises on Low Level Jet stream Dynamics during monsoon, Model outputs analysis for wind, rainfall, temperature etc using grads, Exercises on IPCC CMIP-5 and CMIP -6 model outputs in different scenarios.

Practical Schedules

1-2	Introduction to Grads- Basics and commands
3-4	Hands on Exercise of Grads on computer systems

5-7 Different climate model output analysis using Grads

8 Grads analysis on sea surface temperature temperature- ENSO event

9 Grads analysis on sea surface temperature temperature- IOD event

10-11 Wind Speed analysis on Grads during South-West and North-East monsoon months

12 Rainfall analysis on Grads during South-West monsoon months

13 Rainfall analysis on Grads during North-East monsoon months

14-15 Air temperature analysis on Grads for different months in a year

16-17 Grads exercise for IPCC-CMIP-5,6 model output scenarios

18 Final Practical Examinations

Suggested Readings

Atmospheriques, R., RS Scorer, 1997. Dynamics of Meteorology and Climate. John Wiley and Sons, 686 Ž.

Gill, A.E., 2016. Atmosphere-Ocean Dynamics. Elsevier.

Hartmann, D.L., 2015. Global physical climatology (Vol. 103). Newnes.

McGuffie, K. and Henderson-Sellers, A., 2014. The climate modelling primer. John Wiley & Sons.

Peixoto, J.P. and Oort, A.H., 1992. Physics of climate.

Trenberth, K.E. ed., 1992. Climate system modeling. Cambridge University Press.

Washington, W.M. and Parkinson, C., 2005. Introduction to three-dimensional climate modeling. University science books.

EARS 3209 Ocean and Atmosphere Modelling 3(2+1)

Theory

Historical Background of atmospheric and ocean models; primitive equations and their simplification. Hierarchy of numerical models: Filtering problem, barotropic model; equivalent barotropic model; two level Baroclinic model; general circulation

model. Finite difference Techniques: Taylor's expansion; forward, backward and central schemes; nonlinear instability and aliasing; Arakawa grids. Time integration schemes: Explicit and implicit schemes; semi-implicit schemes; initial conditions; surface and lateral boundary conditions. Galerkin methods: spectral method; finite element method; spectral model. Parameterization of physical processes in the atmosphere: Basic concepts of parameterization-boundary layer, cumulus convection, radiation and land surface processes Ocean modelling: Hierarchy of ocean models; reduced gravity model; linear continuously stratified model; shallow water model; global ocean model; physical processes and parameterization schemes; Parameterization of physical processes in the ocean: Basic concepts of parameterization-mixing processes, air-sea fluxes, tide and waves. Coupling- Hierarchy of coupled models; coupling strategies; spin-up problems.

Lecture Schedule- Theory

1-2 Historical Background of atmospheric and ocean models

3 Primitive equations and their simplification

4 Hierarchy of numerical models: Filtering problem

5-6 Barotropic model; equivalent barotropic model

7 Two level baroclinic model

8 General circulation model

9-10 Finite difference Techniques

11-12 Taylor's expansion; forward, backward and central schemes

13 Nonlinear instability and aliasing

14 Arakawa grids

15-17 Time integration schemes: Explicit and implicit schemes; semi-implicit schemes; initial conditions; surface and lateral boundary conditions

18 **Mid-Term Examination**

19-21 Galerkin methods: spectral method; finite element method; spectral model

22 Parameterization of physical processes in the atmosphere

23 Basic concepts of parameterization-boundary layer

24 Cumulus convection, radiation and land surface processes

25-26 Ocean modelling: Hierarchy of ocean models

27 Reduced gravity model

28 Linear continuously stratified model

29 Shallow water model

30-31 Global ocean model: physical processes and parameterization schemes

32 Parameterization of physical processes in the ocean

33 Basic concepts of parameterization-mixing processes, air-sea fluxes, tide and waves.

34-35 Coupling-Hierarchy of coupled models; coupling strategies; spin-up problems.

36 **Final Examination**

Practical

Climate modelling exercises, Exercises on different atmospheric and oceanic phenomenon like El Nino, Lanina, IOD, Etc on Grads, Exercises on Low Level Jet stream at 850 hPa and Tropical Easterly Jet stream at 150 hPa using grads, Exercises on different model outputs and NCEP/, ECMWF, NOAA Outputs using grads, Exercises on IPCC CMIP-5 and CMIP -6 model outputs in different scenarios.

Lecture Schedule- Practical

1-2 Introduction to Grads- Basics and commands

3-4 Hands on Exercise of Grads on computer systems

5-7 Different climate model output analysis using Grads

8 Grads analysis on sea surface temperature temperature-ENSO event

9 Grads analysis on sea surface temperature temperature-IOD event

10-11 Wind Speed analysis on Grads during South-West and North-East monsoon months

12 Rainfall analysis on Grads during South-West monsoon months

13 Rainfall analysis on Grads during North-East monsoon months

14-15 Air temperature analysis on Grads for different months in a year

16-17 Grads exercise for IPCC-CMIP-5,6 model output scenarios

18 **Final Practical Examination**

Suggested Readings

Asnani, G.C., 2005. *Tropical meteorology*. GC Asnani

Daley, R., 1993. *Atmospheric data analysis* (No. 2). Cambridge university press.

Haltiner, G.J. and Williams, R.T., Numerical Weather Prediction and Dynamic Meteorology.1980.

Hess, S.L., 1979. *Introduction to theoretical meteorology* (No. 551.5 HES).

Holton, J.R., 1973. An introduction to dynamic meteorology. *American Journal of Physics*, *41*(5), pp.752-754. .

Krishnamurti, T.N. and Bounoua, L., 1995. *An introduction to numerical weather prediction techniques*. CRC press.

Krishnamurti, T.N., 1986. *Workbook on numerical weather prediction for the tropics for the training of class I and class II meteorological personnel* (No. 669). World Meteorological Organization.

McGuffie, K. and Henderson-Sellers, A., 2014. *The climate modelling primer*. John Wiley & Sons.

Treenberth, K., 1994. Climate System Modelling.

Trenberth, K.E. ed., 1992. *Climate system modeling*. Cambridge University Press.

Washington, W.M. and Parkinson, C.L., 2005. An Introduction to Three-Dimensional Climate Modelling, Univ. *Science Books. Baker, DG, Ruschy, DL, Skaggs, RH, & Wall, DB (1992). Air Temperature and Radiation Depressions Associated with a Snow Cover. Journal of Applied Meteorology*, *31*(3), pp.247-254.

EARS 3210 Climate Change and Polar Science 3(2+1)

Theory

Polar Regions as an indicator of climate change, CO_2 Emissions, Human Emissions of CO_2. Carbon Cycling: Some Examples, the Physical Carbon Pump, the Biological Carbon Pump, the Marine Carbon Cycle, and the Terrestrial Carbon Cycle Global Ocean Circulation: Introduction and Overview; El Niño and the Southern Oscillation; El Niño and its Effects; Indian Ocean Dipole; Upwelling and Climate. Outlook for the Future: IPCC projections; Computer Modeling.

Overview of Polar Geology & Geography and Climate;; Physical characteristics; weather and climate, ice coring in Antarctica for paleo-environment studies, logistics operational aspects of Antarctic Science, opportunities, Governance and protection of Antarctic environment, International linkages. Ice characteristics and physical oceanography of polar seas; Sea ice: types, physical and mechanical properties, heat flux, temporal and spatial distribution, melting and freezing processes, forecasting models, and remote sensing of ice/snow covered surfaces. Microbial geochemistry of ice. Currents and water masses, deep and bottom water formation, fronts and eddies, polynya processes, and underwater acoustics. Arctic; Operational aspects of Arctic meteorology, including polar lows, boundary layer and marginal ice zone influences. Polar oceanography: Sea ice amount, seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions. Currents and water masses, deep and bottom water formation, fronts and eddies. Indian Polar

programme - History and status.

Lecture Schedule- Theory

1 Polar Regions as an indicator of climate change, CO_2 Emissions

2 Human Emissions of CO_2

3 Carbon Cycling

4-6 Physical Carbon Pump, Biological Carbon Pump, Marine Carbon Cycle and the Terrestrial Carbon Cycle

7-8 Global Ocean Circulation: Introduction and Overview

9 El Niño and the Southern Oscillation; El Niño and its Effects

10 Indian Ocean Dipole

11 Upwelling and Climate

12-13 Outlook for the Future: IPCC projections

14 Computer Modeling.

15 Overview of Polar Geology & Geography and Climate

16 Physical characteristics; weather and climate

17 Ice coring in Antarctica for paleo-environment studies

18 **Mid-Term Examination**

19 Logistics operational aspects of Antarctic Science, opportunities

20 Governance and protection of Antarctic environment, International linkages

21 Ice characteristics and physical oceanography of polar seas

22 Sea ice: types, physical and mechanical properties

23-24 Heat flux, temporal and spatial distribution

25 Melting and freezing processes, forecasting models

26 Remote sensing of ice/snow covered surfaces

27 Microbial geochemistry of ice

28-29 Currents and water masses, deep and bottom water formation, fronts and eddies, polynya processes, and underwater acoustics

30-32 Operational aspects of Arctic meteorology, including polar lows, boundary layer and marginal ice zone influences

33-34 Polar oceanography: Sea ice amount, seasonal distribution, melting and freezing processes, physical and mechanical properties, drift and predictions

35 Indian Polar programme - History and status

36 **Final Examination**

Practical

Hydrography and circulation in Antarctic and Arctic oceans, Study on the variability of Arctic sea-ice thickness from satellite derived sea-ice freeboard obtained from ICESAT, Satellite-based Applications on Climate Change in Antarctic and Arctic regions

Lecture Schedule- Practical

1-4 Hydrography and circulation in Antarctic oceans

5-8 Hydrography and circulation in Arctic oceans

9-13 Study on the variability of Arctic sea-ice thickness from satellite derived sea-ice freeboard obtained from ICESAT

14-15 Satellite-based Applications on Climate Change in Antarctic regions

16-17 Satellite-based Applications on Climate Change in Arctic regions

18 **Final Practical Examination**

Suggested Reading

Green, J., 2005. *Mediterranean Sea*. Gareth Stevens Publishing LLLP. Harries, J.E., 1990. Earthwatch: the climate from space.

Hartmann, D.L., 1994. *Global Physical Climatology (International geophysics; v. 56)*. Academic Press.

Johannessen, O.M., Muench, R.D. and Overland, J.E., 1994. The polar oceans and their role in shaping the global environment. *Washington DC American Geophysical Union Geophysical Monograph Series*, *85*.

Kaiser, B., Allen, B. and Zicus, S., 2010. *Polar science and global climate: An international resource for education and outreach*. Pearson Education Limited.

Kininmonth, W., 2004. *Climate change: a natural hazard*. multi-science publishing.

Kump, L.R., Kasting, J.F. and Crane, R.G., 2004. *The earth system* (Vol. 432). Upper Saddle River, NJ: Pearson Prentice Hall.

Leppäranta, M. ed., 1998. *Physics of ice-covered seas: lecture notes from a summer school in Savonlinna, Finland, 6-17 June 1994* (Vol. 1). Department of Geophysics, University of Helsinki

Leppäranta, M., 2011. *The drift of sea ice*. Springer Science & Business Media.

Lizotte, M.P. and Arrigo, K.R., 1998. *Antarctic sea ice: biological processes, interactions and variability* (Vol. 2). American Geophysical Union.

McGuffie, K. and Henderson-Sellers, A., 2014. *The climate modelling primer*. John Wiley & Sons.

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Pittock, A.B., 2013. *Climate change: the science, impacts and solutions*. Routledge.

Ruth, M. ed., 2009. *Distributional impacts of climate change and disasters: Concepts and cases*. Edward Elgar Publishing.

Siegfried, W.R., Condy, P.R. and Laws, R.M. eds., 2013. *Antarctic nutrient cycles and food webs*. Springer Science & Business Media.

Smith Jr, W.O. and Barber, D. eds., 2007. *Polynyas: windows to the world*. Elsevier.
Smith Jr, W.O. ed., 2013. *Polar Oceanography: Chemistry, biology, and geology*. Elsevier.

Turnell, Lance. *Glacier hazards*. Longman Publishing Group, 1984. Untersteiner, N. ed., 2013. *The geophysics of sea ice*. Springer.

DEPARTMENT OF SUPPORTIVE AND ALLIED SUBJECTS

SAAS 1101 Mathematics 2(1+1)

Theory

Periodic functions, Dirichlet's theorem, Euler's formula, expansion of odd and even functions, Half range series, Fourier integrals- sine and cosine transformations, Fourier transforms of derivatives of functions, Parseval's identity, Harmonic analysis, use of Fourier transformations to solve boundary value problems, Application to heat conduction, Application to wave equations. Partial differential equations, Introduction, parabolic, elliptic and hyperbolic differential equations, formation of partial differential equations, methods of separation of variables, equation of vibrating string, one dimensional wave equation, one dimensional heat flow, 2-D heat flow, Laplace equation. Complex variables, continuity and differentially analytic and conjugate functions, Cauchy-Riemann equations, Line integrals of complex functions, Cauchy's integral theorem, Taylor and Laurent series, residue theorem, Singular points, conformal mapping, linear conformal transformations, Linear algebra.

Practical

Functions of a complex variable, Harmonic functions, Cauchy-Reimann equations, Conformal Transformations, Complex integration, Taylor's and Laurent's series, Singular points and Residue theorem, Fourier Sine and cosine integrals, Parseval's identity for Fourier Transform, Formation of Partial differential equations, Solution of Partial differential equations using method of separation of variables.

Suggested Readings

Ayres, F., 1981. Differential Equations In SI Metric Units, 1St Ed.. New York: McGraw- Hill.

Churchill, R.V. and Brown, J.W., 1987. Fourier series and boundary value problems. New York: Mcgraw-Hill.

Creighton Buck, R 2003. Advanced calculus. Long Grove, Il: Waveland Press.

Grewal, B., Grewal, J. and Dhanoa, J., 2015. Higher Engineering Mathematics. New Delhi: Khana Publishers

Scarborough, J.B., 1990. Numerical Mathematical Analysis. New Delhi: Oxford AndIbh Publishing Co. Pvt. Ltd.

Spiegel, M.R. ,1974. Theory and problems of Fourier analysis : with applications to

boundary value problems. New York, N.Y.: Mcgraw-Hill.

Spiegel, M.R. and Lipschutz, S., 1974. Schaum's outline of theory and problems of complex variables. New York: Mcgraw-Hill.

Stanton, R.G., 1967. Numerical methods for science and engineering. New Delhi: Prentice-Hall.

SAAS 1102 Introduction to Forestry 3(2+1)

Theory

A Brief History of Forestry and Natural Resource Management -Forests; definitions, role, benefits; direct and indirect. -Agricultural lands and forests- systems; differences in nutrient cycling, diversity etc. Forest resources -Forest Products-Wildlife Habitat Relationships-Ecosystem Services-Forest Recreation - Forest ecology-Forest hydrology-Forest soil-Forest Dynamics-Gap dynamics-Forest Succession-Closed canopy-open forest-edge effect and forest degradation. Classification of forests- Forest types. Functional classification of forests-Protection forestry-Commercial forestry-Social forestry -Farm forestry-Extension forestry- Agroforestry-Mixed forestry-Plantation forestry-Reforestation of degraded forests-Recreational forestry.

Global warming; forestry options for mitigation and adaptation- carbon sequestration. Introduction to world forests- Geographical distribution of forests and their classification- Factors influencing world distribution of forests. Forest Mensuration-Forest survey-Forest regeneration-Forestry-Related Data. Forest utilization-Forest based Industries. Forestry and Natural Resource Management -State Forest management-Participatory Forest Management-Joint Forest Management. National and international organizations in Forestry-Forestry Education, Research and Research Institutions

Lecture Schedule-Theory

1. Forests – Definition – Forestry Science- History
2. Branches of Forestry- Scope and importance of Forestry
3. Forests-Role-Benefits-direct and indirect
4. Natural Resource Management-Agricultural lands and Forestlands-Nutrient cycling
5. Forest resources-forest products-NTFP
6. Wildlife habitat Relationships-Ecosystem Services
7. Forest ecology
8. Forest succession

9. Bio diversity
10. Forest hydrology-Forest soil
11. Forest dynamics-Gap dynamics and forest succession
12. Forest degradation-Closed-Open canopy-Edge effect
13. Forest classification-Forest types
14. Forest functional classification-Forest classification by origin-Classification by ownership and management
15. Commercial forestry-Social forestry
16. Farm forestry-Extension forestry
17. Agroforestry- Mixed forestry-Plantation
18. **Mid-term examination**
19. Global warming; forestry options for mitigation and adaptation
20. Carbon sequestration
21. Climate change-UNFCCC
22. Carbon credit-REDD-REDD+
23. Introduction to world forest
24. Geographical distribution of forests and their classification
25. Factors influencing world distribution of forest
26. Forest Mensuration
27. Forest Mensuration
28. Forest survey
29. Forest inventory-enumeration
30. Forest regeneration
31. Forest utilization-Forest based industries
32. State Forest management
33. Participatory Forest Management-Joint Forest Management
34. National and international organizations in Forestry-Forestry Education, Research and Research Institutions
35. National and international organizations in Forestry-Forestry Education, Research and Research Institutions
36. **Final theory examination**

Practical

Visit to forest areas and study the forest types, and understanding the different types of forests, functioning of the forests, quantification of nutrient cycling, and forest inventories and enumeration techniques, estimation of the carbon sequestration ability of the different types of forests.

Practical Schedule

1-10 Forest enumeration techniques-IVI-Estimation of carbon storage ability

11-17 Visit to forest area and study the forest types, and understanding the different types of forests, functioning of the forests-nutrient cycling

18 Practical Examination

Suggested readings

Beazley, M. (1981). The International Book of Forest. Mitchell Beazly Publishers, London.

Grebner, D.L., Bettinger, P and Siry, J.P. (2012). Introduction to Forestry and Natural Resources. Academic Press. 508p (Google eBook).

Khanna, L.S. (1989). Principles and Practice of Silviculture. Khanna Bandhu, New Delhi, 473p.

Mather, A.S. (1990). Global forest resources. Belhaven, London.

Persson, R. (1992). World forest resources. Periodical experts, New Delhi. Westoby, J. (1991). Introduction to World Forestry. Wiley, 240p.

SAAS 1103 Introduction to Agriculture 3(2+1)

Theory

Agriculture as an art, science and business of crop production -Branches of agriculture. History of agricultural development – Ancient India, Agriculture in civilization era-Chronology of agricultural technology development in India- Green revolution. Origin and Diffusion of crops. Subsistence, sustainable and commercial agriculture.Factors affecting crop production. Agricultural seasons in India and Kerala. Rain-fed and irrigated agriculture. Classification of crops. Cropping system and pattern. Tillage – Definition – objectives – types of tillage - modern concepts of tillage.Inter cultivation - Thinning - Gap filling and other intercultural operation. Planting geometry and its effect on growth and yield. Method of sowing- Role of manures and fertilizers in crop production- classification of fertilizers- Methods of fertilizer application. Irrigation - methods - Modern techniques of irrigation. Weeds- Introduction- harmful and beneficial effects ofweeds- Classification of

weeds- Weed controls methods- Principles- Mechanical/cultural method-Biological control methods-Chemical control method. Cropping system in Kerala and India. Farming system approach- Integrated Farming System-introduction- objectives-benefits- resource/nutrient flow in low land and upland.

Lecture Schedule-Theory

1-2. Agriculture – Definition – Branches of agriculture- Scope and importance of Agriculture

3-4. History of agricultural development – Ancient India, Agriculture in civilization era-Chronology of agricultural technology development in India

5. Green revolution.

6. Origin and Diffusion of crops.

7. Subsistence, sustainable and commercial agriculture.

8. Factors affecting crop production.

9. Agricultural seasons in India and Kerala.

10. Rain-fed and irrigated agriculture.

11-12. Classification of crops.

13-14. Cropping system and pattern.

15-16. Tillage – Definition – objectives – types of tillage - modern concepts of tillage.

17.Inter cultivation - Thinning - Gap filling and other intercultural operation.

18. Mid-term examination

19. Planting geometry and its effect on growth and yield.

20. Method of sowing

21-22. Role of manures and fertilizers in crop production

23-24. Classification of fertilizers- Methods of fertilizer application.

25-26. Irrigation - methods - Modern techniques of irrigation.

27. Weeds- Introduction- harmful and beneficial effects of weeds- Classification of weeds- 24.

28-30. Weed controls methods- Principles- Mechanical/cultural method-Biological control methods- Chemical control method.

31. Cropping system in Kerala and India.

32. Farming system approach

33-35. Integrated Farming System-introduction- objectives-benefits- resource/nutrient flow in low land and upland.

36.Final theory examination

Practical

Major crops of India & Kerala- Collection of data on area, distribution and productivity- Identification of field crops- Cereals, millets, pulses, tuber crops, sugar crops,

fodder crops and fibre crops- Identification of green manure and green leaf crops- Identification of tillage implement – primary and secondary tillage implement- Preparation of seed bed- the planting of crops- Seed treatment- different pre-sowing seed treatment method- Calculation of seed rate and plant population - Different irrigation systems- surface- subsurface and micro irrigation methods- Identification of manures and fertilizers- Calculation of fertilizer requirements for different crops- Identification of weeds- grasses, broad leaves, and sedges- Problems on WCE and WI- Herbicide calculation- Method of herbicide application- Soil sample collection using soil auger and spade- Determination of soil moisture content by thermo-gravimetric method- Preparation of weed herbarium

Practical Schedule

1. Major crops of India and Kerala- collection of data on area, distribution and productivity
2. Identification of field crops- Cereals, millets, pulses, tuber crops, sugar crops,

fodder crops and fibre crops

3. Identification of green manure and green leaf crops
4. Identification of tillage implement – primary and secondary tillage implement
5. Preparation of seed bed- the planting of crops
6. Seed treatment- different pre-sowing seed treatment methods- mid-storage treatment
7. Calculation of seed rate and plant population
8. Different irrigation systems- surface- subsurface and micro irrigation methods
9. Identification of manures and fertilizers
10. Calculation of fertilizer requirements for different crops
11. Identification of weeds- grasses, broad leaves, and sedges
12. Problems on WCE and WI
13. Herbicide calculation
14. Method of herbicide application
15. Soil sample collection using soil auger and spade
16. Determination of soil moisture content by thermo-gravimetric method
17. Preparation of weed herbarium
18. **Practical exam**

Suggested Readings

Ahmed, I. (ed.) 1985. *Technology and Rural Women: Conceptual and Empirical Issues*, ILO, London

Ahmed, S. 2004. *Gender Issues in Agricultural and Rural Livelihoods*-Vol. I M.S. Swaminathan Research Foundation, Chennai and Kerala Agricultural University, Thrissur.

Commonwealth Secretariat.1996. *Women and Natural Resource Management: A Manual for the Asian Region*. Gender and Youth Affairs Division, London.

Cox, G.W and Atkins, M.D. 1979. *Agricultural Ecology : An Analysis of World Food Production Systems*. W.H. Freeman and Company, San Francisco.

FAO [Food and Agriculture Organization of the United Nations]. 2001. Field Level Handbook, SEAGA Socio–Economic and Gender Analysis Programme. FAO, Rome (Available: http://www.fao.org/sd/seaga/downloads/En/fieldEn.pdf).

Grigg, D.B. 1974. *The Agricultural Systems of the World: An Evolutionary Approach.*

Harlan, J.R. 1992. *Crops and Man.* American Society of Agronomy& Crop Science Society of America, Madison, WI.

Husain, M. 1996. *Systematic Agricultural Geography*. Rawat Publications, Jaipur

Janick, J., Schery, R.W., Woods, F.W., and Ruttan, V.W. 1974. *Plant Science: An Introduction to World Crops*. W.H. Freeman and Company, San Francisco.

Noor Mohammed.1992. Origin, diffusion and development of agriculture. In: Noor Mohammed (ed.), *New Dimensions in agricultural geography: Vol.1.Historical Dimensions of agriculture.* Concept publishing Co., New Delhi. pp29-75.

Pandey, H. 2002. *Women in Agriculture*. National Research Centre for Women in Agriculture (ICAR), Bhubanewar.

Purseglove, J.W. 1974. *Tropical Crops: Dicotyledons*. The English Language Book Society and Longman, London

SAAS 1104 Introduction to Statistics 2(1+1)

Theory

Elementary statistical concepts, collection, classification and tabulation of statistical data, Formation of frequency distribution. Diagrammatical and Graphical representation of statistical data. Measures of central tendency – Arithmetic mean; its calculation – properties, Geometric mean and Harmonic mean, Median and mode – its calculation on grouped and ungrouped data – properties. Measures of Dispersion– range – Quartile Deviation – Mean Deviation – Standard deviation – Variance – Coefficient of variation (CV). Skewness – Measures of Skewness – Moments – Kurtosis. Scatter diagram – Correlation – properties – Correlation coefficient – measures of correlation: Karl

Pearson's correlation coefficient, Spearman's rank correlation and Kendall's coefficient of concordance. Regression – Assumptions – Regression coefficient – properties of regression coefficient – uses of regression. Elementary ideas of probability – Conditional probability – Addition and multiplication theorems on probability. Probability distributions – Discrete probability distributions: Bernoulli, Binomial and Poisson – Continuous probability distribution: Normal distribution and Standard normal distribution (SND). Basic sampling concepts – sampling units – sampling frame – Sampling Vs Complete enumeration – parameter and statistic – Standard error. Probabilistic sampling methods: Simple random sampling, Stratified random sampling and its various allocation. Systematic sampling, Cluster sampling and multistage sampling – Non-probabilistic samplings. Tests of statistical hypothesis – Type 1 and type 2 error – critical region – level of significance
– degrees of freedom – large sample test (SND / Z – test). Small sample test (t–tests), one sample t-test – two sample t-tests, Paired t-test, test of significance of correlation coefficient. F- Test, Chi-square test assumptions, application and its limitations. Important terms and definitions of design of experiments – Basic principles of experimental designs – Randomization, Replication and Local control. Analysis of variance (ANOVA) – assumptions – construction of ANOVA table – interpretation based on ANOVA table. Post-hoc analysis – Critical Difference (CD) and Duncan's Multiple Range Test (DMRT).

Lecture schedule

1. Elementary statistical concepts – functions of statistics – collection, classification and tabulation of statistical data.
2. Formation of frequency distribution
3. Diagrammatical representation of statistical data
4. Graphical representation of statistical data
5. Measures of central tendency-requisites for an ideal measures of central tendency-arithmetic mean – its calculation-properties-weighted arithmetic mean.
6. Median and other measures of location –their calculation – merits and demerits – comparison of different averages
7. Measures of dispersion-range-mean deviation-quartile deviation-their calculation
8. Variance and standard deviation-comparisons among different measures of dispersion and their applications to specific situations – relative measures of dispersion –coefficient of variation measures of skewness and kurtosis
9. Presentation of bi-variate data – scatter diagram – measures of association – production moment correlation coefficient-rank correlation
10. Linear regression – its application in forestry-interpretation of regression coefficient-correlation vs. regression
11. Elementary ideas on probability-addition and multiplication theorems on

probability.

12. Binomial theorem on probability-binomial and poisson distributions.
13. Normal distribution-properties-its importance in statistic-normal probability integral
14. Basic concepts on sampling-sampling unit, sampling frame, sample size-sampling Vs. complete enumeration, parameter and statistic, sampling distribution of statistic & standard error
15. Sampling methods, simple random sampling and stratified random sampling
16. Tests of statistical hypotheses-critical region large sample test-transformation of the correlation coefficient

17-18. Small sample test-tests for equality of mean and variances t and F tests-Applications and assumptions-test of significance of correlation coefficient.

19-20. Chi-square test-assumption and limitation-application of chi-square test.

21. Important terms and definitions-need for designing an experiment. Basic principles of Experimental design-replication, randomization and local control.
22. Practical considerations infield experiments cropping with soil heterogeneity-size And shape of plots and blocks-boarder effect-uniformity trials and their uses.
23. Analysis of variance-assumptions-construction of ANOVA table conclusions based on ANVOA
24. Comparisons based on means-critical difference.

Practical

Formation of frequency distribution- Diagrammatic and Graphical representation of statistical data- Computation of different measures of central tendency- Computation of various measures of dispersions- Calculations of coefficient of skewness and kurtosis- Computation of Pearson's correlation coefficient, Spearman's rank correlation and Kendall's coefficient of concordance- Fitting of linear regression models for prediction- Simple problems on probability- Fitting of binomial and Poisson distributions- Fitting of normal distribution- Simple random sampling with replacement and without replacement- Stratified random sampling – sample size, mean and variance under Equal, Proportional and Neyman's allocation-Systematic sampling- Large sample tests- Small sample tests-F-test and Paired t-test- Chi-square test, test of goodness of fit – test of independence of attributes in a contingency table.

Practical Schedule

1. Formation of frequency distribution, Diagrammatic and graphic representation
2. Calculation of different measures of central tendency
3. Computation of various measures of dispersion-calculation of coefficient of variation coefficients of skewness and kurtosis.
4. Computation of product moment correlation coefficient-rank correlation coefficient and coefficient of concordance

5. Fitting of linear regression models for prediction

6. Simple problems on probability-fitting of binomial distribution

7. Fitting of poisson distribution, problems on normal distribution

8. Selection of simple random sample-estimation of parameters – sample size determination

9. Selection of stratified random sample equal, proportion land Neyman's allocation in stratified sampling

10. Large sample test

11. Small sample tests t and F tests

12. Chi-Square test, test of goodness of fit – test of independence of attributes in a contingency table – computation of mean – squares contingency

13. Analysis of variance-construction of ANOVA table og one-way classified data

14. Analysis of variance-construction of ANOVA tables of two-way classified data

15. Lay out and analysis of CRD, Lay out and analysis og RBD

16. Analysis of data from 2n factorial experiments in RBD. Formation of Yate's table-calculation of main effects and interaction effects

17. Layout and analysis of split-plot design

18. Final practical examination

Suggested Readings

Das, M. N. and Giri, N. C. 1986. *Design and analysis of experiments*. Wiley Eastern Ltd. New Delhi.

Gomez, K. A. and Gomez, A. A. 1984. *Statistical Procedures for Agricultural Research*. John Wiley and sons, New York, 680p.

Goon, A. M., Gupta, M. K., and Dasgupta, B. 1983. *Fundamentals of Statistics. Vol.1*. The world press Pvt. Ltd., Calcutta.

Gupta, S. C. 2004. *Fundamentals of Statistics.*Himalaya publishing house Pvt. Ltd.

Panse, V. G. and Sukhatme, P. V. 1967. *Statistical methods for Agricultural workers*. Indian Council of Agricultural Research, New Delhi, India.

SAAS 1105 Introductory Animal Husbandry 2(1+1)

Theory

Introduction to Physiology of Farm Animals- Introduction to Animal Nutrition- Nutrient requirements of farm animals for various stages of production, feed formulation, unconventional feed resources, ration balancing; Shelter management,

Feedingmanagement, disease surveillance and management, Significance of Poultry Production- poultry meat production, egg production, breeding strategies, thermo-regulatory mechanisms, hatchery and incubation, backyard poultry. Basics in animal reproduction- Reproductive endocrinology, Estrous cycle, oocyte production, spermatogenesis, fertilization, conception, calving/lambing/kidding, reproductive diseases and management, seasonal influences on reproduction; Impact of heat stress on growth, milk and meat production, reproduction and immune responses in livestock; Adaptation of livestock to heat stress- Different thermo- regulatory mechanisms - morphological, behavioural, physiological, neuro-endocrine, metabolic, cellular and molecular mechanisms, Breed (exotic and indigenous) differences in livestock adaptation; Impact of climate change on feed and fodder resources for livestock, Significance of unconventional feed/fodder resources for livestock during scarcity period, Significance of optimum nutrition to counter heat stress in livestock, Significance of studying the concept of multiple stresses in livestock particularly from extensive system of rearing Global warming: Role of livestock- Significance enteric methane emission from climate change perspectives, livestock manure as sources of methane and nitrous oxide Different Amelioration strategies to counter heat stress impact in livestock production Mitigation strategies to reduce enteric methane emission in ruminants Various adaptation strategies to sustain livestock production in the changing climate scenario.

Theory Topic

1 Introduction to Physiology of Farm Animals

2 Introduction to Animal Nutrition

Nutrient requirements of farm animals for various stages of growth, feed formulation, unconventional feed resources, ration balancing

3 Shelter management, Feeding management, disease surveillance and management

4-6 Significance of Poultry Production
poultry meat production, egg production, breeding strategies, thermo-regulatory mechanisms, hatchery and incubation, backyard poultry.

7-8 Basics in animal reproduction
Estrous cycle, oocyte production, spermatogenesis, fertilization, conception, calving/lambing/kidding, reproductive diseases and management, seasonal influences on reproduction

9 **Midterm Examination**

10 Impact of heat stress on growth, milk and meat production, reproduction and immune responses in livestock

11-12 Adaptation of livestock to heat stress
Different thermo- regulatory mechanisms - morphological, behavioural, physiological, neuro-endocrine, metabolic, cellular and molecular mechanisms

13 Breed differences in livestock adaptation

Impact of climate change on feed and fodder resources for livestock

14 Significance of unconventional feed/fodder resources for livestock during scarcity period.
Significance of optimum nutrition to counter heat stress in livestock.

15 Significance of studying the concept of multiple stresses in livestock particularly from extensive system of rearing.

16 Global warming: Role of livestock- Significance enteric methane emission from climate change perspectives- livestock manure as sources of methane and nitrous oxide

17 Different Amelioration strategies to counter heat stress impact in livestock production -- Mitigation strategies to reduce enteric methane emission in ruminants.
Various adaptation strategies to sustain livestock production in the changing climate scenario.

18 **Final Theory Examination**

Practical

Recording of behavioural, physiological responses and sweating rate measurement in livestock, Applications of infrared thermal imager & rumen boluses in assessing thermos-tolerance in livestock, Measurement of various growth variables in livestock-body weight, body condition score, allometric measurements, Different thermal indices and heat load index for assessing heat stress, Different methane estimation techniques in livestock- IVGPT, SF6, respiratory chamber, Micrometeorological mass difference technique, bLS dispersion technique, Greenfeed technique, Visit to slaughter house for studying different body parts in livestock, Visit to centre for climate resilient animal

adaptation studies at NIANP Bangalore (or) any other climatological centre dealing with livestock.

	Topic
1-2	Recording of behavioural, physiological responses and sweating rate measurement in livestock
3-4	Applications of infrared thermal imager & rumen boluses in assessing thermo-tolerance in livestock
5	Measurement of various growth variables in livestock- body weight, body condition score, allometric measurements
6-7	Different thermal indices and heat load index for assessing heat stress
8-10	Different methane estimation techniques in livestock- IVGPT, SF6, respiratory chamber, Micrometeorological mass difference technique, bLS dispersion technique, Greenfeed technique
11-13	Visit to slaughter house for studying different body parts in livestock
14-17	Visit to centre for climate resilient animal adaptation studies at NIANP Bangalore (or) any other climatological centre dealing with livestock
18	**Practical Examination**

Suggested Readings

Anjali, A and Upadhyay, R (2013). Heat Stress and Animal Productivity, Springer-Verlag GMbH Publisher, India, pp 1-188, ISBN No. 978-81-322-0878-5.

McDonald, P., 2002. *Animal nutrition*. Pearson education.

Sejian, V., Bhatta, R., Gaughan, J., Malik, P.K., Naqvi, S.M.K., Lal, R (2017). Sheep production adapting to climate change. Springer-Verlag GMbH Publisher, Singapore, pp 1-441, ISBN No. 978-981-10-4713-8.

Sejian, V., Gaughan, J.B., Baumgard, L and Prasad, C.S (2015). Climate Change impact on Livestock: Adaptation and Mitigation. Springer-Verlag GMbH Publisher, New Delhi,, India pp1-532, ISBN No. 978-81-322-2264-4.

Sejian, V., Naqvi, S.M.K.,Ezeji, T., Lakritz, J and Lal, R (2012). Environmental stress and amelioration in livestock production. Springer-Verlag GMbH Publisher, Berlin Heidelberg, Germany pp1-569, ISBN No. 978-3-642-29204-0.

Senger, P.L., 1997. *Pathways to pregnancy and parturition*. Current Conceptions, Inc., 1615 NE Eastgate Blvd.

SAAS 1106 Comprehension and communication skills in English 1 (0+1*)

Theory

Lectures – preparation, objective/s, concepts, contents, sequence, formal proof, inter-relationships, logic, conclusions, time management, using audiovisual aids. Giving a talk - body language, extempore and prepared talks. Preparing for interviews, CV/bio data. Vocabulary - word power, pronunciations, guessing the meaning of words from the context and body language and using a dictionary. Review of basic grammar. Punctuation marks - comma, colon, semicolon, full stop, inverted comma. Avoiding repetitious statements, double positives, double negatives, circular arguments. Dealing with questions - avoiding circumvention and circular arguments, answering after breaking down long questions into parts.

SAAS 1107 NCC/NSS/Physical Education and Yoga Practice 1 (0+1*)

Definition, aims and objectives of Physical Education. Modern concept of health, physical fitness and wellness. Hypo kinetic/ life style diseases and its management. First aid.

Athletics

Conditioning (warming up- jogging- free hand exercises- short sprints), Types of running, Start and finish, Types of jumps (long, triple, high jump, pole vault), Types of throws (shot put, discus throw, javelin throw, hammer throw), Team events (4x100 relay, 4x400m relay), Combined events (decathlon, heptathlon)

Games: Basketball: Hold, Passing – chest pass, bounce pass, baseball pass, overhead pass, Dribbling – high dribble, low dribble, zigzag dribble, figure of eight, Shooting- lay-ups, free throw and jump shot, Moves- two man, three man weave, four man and five man running pass, Tactics- Offence, defense, pivot and screening

Volleyball: Hold, passing (over head- under arm), Lift – Vertical lift, arch lift, short lift, Service – Simple service, tennis service, Smash and block

Football: Passing and stopping, instep-inside-back pass- wall pass weaving – dribbling and long pass, Trapping - Foot trapping- chest-thigh and head

Shuttle Badminton &Table Tennis: Grip – forehand and backhand, Service – long service and short service, Lob – underhand and overhead, Overhead strokes – drop shot and smash, Tactics: Singles and doubles

Yoga and Meditation*Pranayama, Asanas, Suryanamaskar*

Health Related Physical Fitness Test: mile run Abdominal sit-ups Sit and reach Modified pull ups BMI

SAAS 1208 Vector calculus 3(2+1)

Theory

Lines and planes in space, Cylinders and Quadric surfaces, Cylindrical and spherical coordinates, vector valued functions and space curves, Arc length and Unit tangent vector, Curvature, torsion and TNB frame, Functions of several variables, Limits and continuity, Partial derivatives, Differentiability linearization and differentials, Chain rule, Partial derivatives with constrained variables, Directional derivatives, gradient vectors and tangent planes, Extreme value and saddle points, Lagrange multipliers Taylor's formula, double integrals, Double integrals in polar form, Triple integrals in Rectangular coordinates, Triple integrals in cylindrical and spherical coordinates, substitution in multiple integrals, Line integrals, Vector fields, Work circulation and flux, Path independence, potential functions and conservative fields, Green's theorem in the plane surface and surface integrals, Parametrized surfaces, Stoke's theorem(statement only), Divergence theorem and unified theory(no proof)

Practical

Vector valued functions, Motion along a curve, Directional derivatives and gradients., Vector fields, Line integrals, Conservative vector fields, Green's theorem,

Stoke'stheorem, Surface integrals, Application of surface integrals, Flux, Divergence theorem.

Suggested Readings

Davis, H.F. and Arthur David Snider (1988). *Introduction to vector analysis*. Dubuque, Iowa: Brown.

Finney, R.L., Weir, M.D., Giordano, F.R. and Thomas, G.B., 2003. *Thomas' calculus*. Boston, Mass. ; London: Addison-Wesley.

Kreyszig, E 2006. *Advanced engineering mathematics*. New York: John Wiley & Sons.

SAAS 1209 Fundamentals of Computer Science 2(1+1)

Theory

Introduction to Computers- Anatomy of Computers, Input and Output devices, Units of Memory, Hardware, Software and Classification of Computers. Personal computers, Booting of computer, Warm and cold Booting. Computer Viruses, Worms and Vaccines: Operating System – DOS and WINDOWS. Disk operating System(DOS), Some Fundamental DOS Commands, FORMAT, DIR, COPY, PATH, LABEL, VOL ,MD,CD,DEL and TREE .Rules for naming files in DOS and Type of files. WINDOWS: GUI, Desktop and its elements, WINDOWS Explorer.MS-OFFICE – MSWORD: Word Processing and Units of Document, Features of Word Processing Packages, MS EXCEL: Electronic spread sheets, Concepts, packages, Use of Data, Analysis Tools, Creating Graphs. MS Power point: Features of power point Package. MS Access: Concepts of Database, Units of Database, Creating Database. Introduction to Programming – C Constants, Variables and Data Types: - Character Set, C Tokens, Keywords and Identifiers, Constants, Variables, Data types Operators and Expressions: - Decision making And Branching :- if statement, if-else statement, switch statement, The ?: Operator, The goto statement. Decision making and Looping: - while, do and for statements, break, continue.

Lecture Schedule- Theory

1. Introduction to Computers: Generations and classification
2. Anatomy of Computers: Internal architecture with diagram
3. Input and Output devices: Keyboard, mouse, printers monitors etc
4. Units of Memory, Hardware
5. Software and Classification of Computers. Personal computers,
6. Booting of computer, Warm and cold Booting. Computer Viruses, Worms and

Vaccines

7. Operating System – DOS and WINDOWS. Disk operating System(DOS), Some Fundamental DOS Commands, FORMAT, DIR,COPY,PATH,LABEL,VOL ,MD,CD,DEL and TREE

8. Rules for naming files in DOS and Type of files. WINDOWS: GUI, Desktop and its elements, WINDOWS Explorer, MS-OFFICE – MSWORD: Word Processing and Units of Document, Features of Word Processing Packages, MS EXCEL: Electronic spread sheets, Concepts, packages

9. Mid Term Exam

10. Use of Data, Analysis Tools,. Creating Graphs

11. MS Power point: Features of power point Package. MS Access: Concepts of Database, Units of Database, Units of Database, Creating Database, Structured Query Language

12. Introduction to Programming – C Constants ,Variables and Data Types : - Character Set, C Tokens

13. Keywords and Identifiers, Constants, Variables, Data types Operators and Expressions

14. The? Operator, The goto statement.

15. Decision making and Looping

16. while, do while and for statements

17. break, continue. Arrays

18. Final theory exam

Practical

Internal architecture of computer, Fundamental DOS commands, Experiments on MS-WORD,MS EXCEL - creating graphs, Creating ,spreadsheets-, Power point packages, MS-ACCESS- Creation of databases, Managing data in a relational database management system (RDBMS), stream processing in a relational data stream management system (RDSMS) - data query, data manipulation (insert, update and delete), data definition (schema creation and modification), and data access control, C Programs on Decision Making and Branching, C Programs on Ternary Operator, Goto Statement, Decision making and looping-for, while, do while statements

Practical Schedule

1. Internal architecture of computer working model explanation

2. Fundamental DOS commands to handle files remove,copy rename

3. Experiments on MS-WORD,
4. MS EXCEL
5. creating graphs
6. Power point packages, MS-ACCESS- Creation of databases
7. RDBMS,DDL,DML and DCL
8. Data query, data manipulation
9. Data definition, Data access control
10. C Programs on Decision Making and Branching
11. Ternary Operator
12. Goto Statement
13. Decision making
14. looping
15. for looping
16. while looping
17. do while, break and continue
18. **Practical Exam**

Suggested Readings

Balagurusamy, E 2019. *Programming in ANSI C*. Chennai: Mcgraw Hill Education (India) Private Limited.

Norton, P.,2007. *Introduction to computers*. New Delhi: Tata Mcgraw Hill.

Rajaraman V and NeeharikaAdabala., 2015. *Fundamentals of computers*. Delhi: Phi Learning Private Learning.

Schildt, H. (2008). *C: the complete reference*. Berkeley, Calif.: Osborne, Mcgraw-Hill,

SAAS 1210 Introduction to Soil Science 2(1+1)

Theory

Soil-Pedological and edaphological concepts -origin of the earth - earth's crust - composition. Rocks and minerals. Weathering - soil formation - factors and processes components of soils -soil profile. Soil physical properties - soil texture - textural classes. Soil structure Classification - soil aggregates – significance. Soil consistency - soil crusting. Bulk density and particle density of soils and porosity - their significance and manipulation. Soil compaction - soil colour. Elementary knowledge of soil classification. Soils of India – characterization of soils of Kerala. Soil water - retention and potentials - soil moisture constants - movement of soil water– infiltration – percolation – permeability – drainage - methods of determination of soil moisture. Thermal properties of soils - soil temperature - soil air - gaseous exchange influence of soil temperature and air on plant growth. Soil colloids- Adsorption of ions - ion exchange - CEC and AEC - factors influencing ion exchange and its significance. Concept of pH - soil acidity - brief overview of saline, sodic and calcareous soils. Soil organic matter – composition – decomposability – humus - fractionation of organic matter. Carbon cycle - C: N ratio. Soil biology – biomass - soil organisms and their beneficial and harmful roles.

Lecture Schedule -Theory

1.Soil definition - soil as a three-dimensional natural body - pedological and edaphological concepts- Origin of the earth - theories - Planetisimal and Nebular hypothesis -Spheres of earth-interior of the earth- earth's crust -composition

2.Rocks- definition –formation- classification- igneous, sedimentary and metamorphic rocks and their characteristics

3.Minerals - definition, formation, occurrence, classification of important soil-forming primary minerals, silicate and non-silicate minerals, Ferro and non-Ferro magnesium minerals

4. Formation of secondary minerals- clay minerals and amorphous minerals

5. Weathering – physical chemical and biological weathering

6. Factors of soil formation - active and passive soil forming factors- Soil-forming process- fundamental and specific soil-forming process

7. Soil profile description – master horizons-transitional horizons- pedon and polypedon

8.Soil physical property- Soil structure -Classification - soil aggregates – significance.

9. Mid-term examination

10. Soil consistency - soil crusting- soil compaction - Bulk density and particle density of soils and porosity - their significance and manipulation- Soil color Munsell color chart- factors affecting soil color

11. Elementary knowledge of soil classification- soil taxonomy- description of soil orders-Soils of India - geological formations – characterization of soils of Kerala

12. Soil water – importance- retention of water by soil –factors affecting soil water and soil water potentials and its components- Soil moisture constants – maximum water holding capacity, field capacity, permanent wilting point, hygroscopic coefficient , and moisture equivalent

13. Movement of soil water– infiltration – percolation – permeability – drainage- Methods of determination of soil moisture- Tensiometer, gypsum block method, neutron moisture meter, and pressure plate apparatus.

14. Thermal properties of soils - soil temperature –sources of soil heat- loss of soil heat- factors influencing soil temperature- influence of soil temperature and air on plant growth- management of soil temperature- Soil air –composition of soil air-factors affecting the composition of soil air- gaseous exchange between soil and atmosphere- the importance of soil aeration

15. Soil colloids -Adsorption of ions - ion exchange - CEC and AEC - factors influencing ion exchange and its significance.

16. Concept of pH - soil acidity- Types and source of soil acidity- management of acid soil-Brief overview of saline, sodic and calcareous soils- reclamation of problem soil

17. Soil organic matter – composition – decomposability – humus - fractionation of organic matter- Carbon cycle - C: N ratio and their significance- Soil biology – biomass - soil organisms and their beneficial and harmful roles.

18. Final theory exam

Practical

Identification of rocks and minerals -Hypothetical soil profile and examination of the soil profile- Collection and preparation of soil samples using the soil auger and spade- Determination of soil moisture by thermogravimetric method- Determination of particle density - Determination of bulk density - Problems on particle density and bulk density- Soil moisture determination by different methods- Tensiometer, gypsum block method, neutron moisture meter, and pressure plate apparatus- Determination of Soil moisture constants - Field capacity and PWP- Determination of water holding capacity by percolation method- Problems on soil moisture content- Determination of organic carbon

by *Walkley-Black* chromic acid wet oxidation *method*- Determination of soil pH and electrical conductivity of soil- Determination of total N by Permanganate method using Kelplus Nitrogen Distillation unit- Estimation of available P in soil by Bray No.1 method using spectrophotometer- Estimation of available K in soil by Neutral normal ammonium acetate method using flame photometer.

Practical Schedule

1. Hypothetical soil profile and examination of the soil profile
2. Collection and preparation of soil samples using the soil auger and spade
3. Determination of soil moisture by thermogravimetric method
4. Determination of particle density
5. Determination of bulk density
6. Problems on particle density and bulk density
7. Soil moisture determination by different methods- Tensiometer, gypsum block method, neutron moisture meter, and pressure plate apparatus
8. Determination of Soil moisture constants - Field capacity and PWP
9. Determination of water holding capacity by percolation method
10. Problems on soil moisture content
11. Determination of organic carbon by *Walkley-Black* chromic acid wet oxidation *method*
12. Determination of soil pH and electrical conductivity of soil
13. Determination of total N by Permanganate method using Kelplus Nitrogen Distillation unit
14. Estimation of available P in soil by Bray No.1 method using spectrophotometer
15. Estimation of available K in soil by Neutral normal ammonium acetate method using flame photometer

16-17. Identification of rocks and minerals

18. Final practical

Suggested Readings

Biswas, T.D. and Mukherjee, S.K. 1987. *Text Book of Soil Science*. Tata McGraw Hill Publishing Co., New Delhi

Brady, N.C. 1990. *Nature and Properties of Soils*. 10th Edn, Macmillian Publishing Co. Inc., New York

Das.D.K, 1997. *Introductory Soil Science*. Kalyani Publishers, New Delhi.

Foth, H.D. and Turk, L. M. 1972. *Fundamental of Soil Science*. 5th Edn. Wiley Eastern Pvt. Ltd., New Delhi

Gupta, P.K. 2007. Soil, Plant, Water and Fertilizer Analysis. Published by AGROBIOS (India), Jodpur

ISSS, 2002. *Fundamentals of Soil Science*. Published by Indian Society of Soil Science, IARI, New Delhi

Jaiswal, P.C. 2006. Soil, *Plant and Water Analysis.* 2nd Edn. Kalyani Publishers, ludhiyana Samuel L.Tisdale, Werner.L. Nelson, James D.Beaton and John L. Havlin. 1995. Soil Fertility and Fertilisers. 5th Edn. Macmillan publishing company, USA.

SAAS 1211 Economic & Entrepreneurship Development 2(2+0)

Economics- Meaning, definition, Divisions of economics -Importance of economics Basic concepts - Goods, service, utility, value, price, wealth, welfare- Wants- Meaning, characteristics, classifications of wants, importance. Theory of consumption- Law of diminishing marginal utility, meaning, definition, assumption, illustration, limitations, law of equi-marginal utility. Consumer surplus- Meaning, definition, importance. Demand- Meaning, definition, kinds of demand, demand schedule, demand curve, law of Demand, extension and contraction vs increase and decrease in demand. Elasticity of demand and its types , factors influencing elasticity of demand, importance of elasticity of demand. Supply meaning, supply function-Law of supply- factors influencing supply–Production- Meaning, factors of production- land, labour, capital, and organization

Production Economics: concepts, Three production relationships, returns to scale. *Cost:* Cost concepts- fixed cost, variable cost. Market : definition and types of market, basic features of perfectly competitive and imperfect markets. Welfare economics- meaning and basic concepts.

Principles and functions of management-SWOT Analysis- Supply chain management-Project planning- project cycle- business plan and proposal writing. Characteristics of entrepreneurs, Entrepreneurship Development -fundamentals.

Lecture Schedule - Theory

1. Economics- meaning, definition, divisions of economics –the importance of economics

2-4. Basic concepts - Goods, service, utility, value, price, wealth, welfare -wants- Meaning, characteristics, classifications and importance.

5-7. Theory of consumption- Law of diminishing marginal utility, meaning, definition, assumption, illustration, limitations, law of equi-marginal utility.

8. Consumer surplus- Meaning, definition, importance.

9-11. Demand- Meaning, definition, kinds of demand, demand schedule, demand curve

12-13. Law of Demand, extension and contraction vs increase and decrease in demand.

14-15. Elasticity of demand and its types, factors influencing the elasticity of demand, importance of elasticity of demand.

16-17. Supply meaning, supply function-Law of supply- factors influencing supply

18. Mid-term examination

19-21. Production- Meaning, factors of production- land, labour, capital, and organization

22-23. Production Economics: concepts, three production relationships, returns to scale.

24-25. Cost: Cost concepts- fixed cost, variable cost.

26-28. Market: definition and types of market, basic features of perfectly competitive and imperfect markets.

29.30. Welfare economics- meaning and basic concepts

31-33. Principles and functions of management-SWOT Analysis- Supply chain management

34. Project planning- project cycle- the business plan and proposal writing.

35. Characteristics of entrepreneurs, Entrepreneurship Development -fundamentals.

36. Final examination

Suggested readings

Ahuja. 2006. Modern Micro Economics S. Chand, New Delhi

Bhaskaran, S. 2014. Entrepreneurship Development and Management .Aman Publishing House, New Delhi

Dewett, K.K., Verma. (2005). Elementary Economic Theory, S. Chand, New Delhi. H. L.

Khanka, S.S. 2012. Entrepreneurial Development .S. Chand and Company Pvt. Ltd

Marriott S. and C. Glackin. 2012. Entrepreneurship and Small Business Management. Prentice Hall.

Philp Kotler and K. L. Keller. 2020. Marketing Management. 15 th Edition. Pearson

Poornima M. Charntimath. 2019. Entrepreneurship Development and Small Business Enterprise. Pearson.

Reddy, S.S., RaghuRam, P., NeelakantaSastry, T.V., Bhavani, D.I. (2009). Agricultural Economics. Oxford and IBH Publishers, New Delhi.

Sonu et al. 2013. Foundation course in Business Entrepreneurship and Management. Pearson.

SAAS 1212 Communication Skills and Personality Development 1(0+1*)

Practical

Review of communication skills, Functional grammar; Parts of speech, Tenses, Active-passive voice, speaking skills: Public speaking, Presentation skills, Mock Interview session, Writing skills: Academic Writing, Report writing, Preparation of CV/ Resume, Covering letter, Developing a pleasing personality, Confidence building activities, Etiquettes and Manners, Positive attitude.

SAAS 1213 Physical Education and Yoga Practice II 1(0+1*)

Practical

Definition and Meaning of Physical Fitness - Values of Physical Fitness - Components of Health Related Physical Fitness and Athletic related Physical Fitness – Health benefits of Physical Activity, Hypokinetic/ lifestyle diseases and its management. First Aid - Treatment - Laceration – Blisters – Contusion - Strain – Sprain – Fracture – Dislocation and Cramps – Bandages – Types of Bandages – trapping and supports. Concept of Yogic Practices-Kinds of Yogic Practices: Asana, Pranayama, Kriya, Bandha, Murda, Dhyana. Asana: Definition, Scope and Limitation of Asanas – Classification of Asanas – Meditative Asanas – Relaxative Asanas-Cultural Asanas – Step by Step Performance of Asanas - Safety Measures and Precautions. Pranayama: Meaning – different Phases in Pranayama Practice: Puraka (Inhalation), Kumbhaka (Retention) and Recaka (Exhalation) – Breathing Ratio in Pranayama Practice – Application of Bandhas in Pranayama – Safety Measures and Precautions. Meaning and Concepts of Meditation. Practical (Optional: Any two will offer according to the infrastructure facilities available) Track & Field, Games (Basketball, Volleyball, Football, Shuttle Badminton, Cricket), Health Related Physical Fitness Test.

SAAS 2114 Application of Computer Programming in Climate Science 2(1+1)

Theory

Introduction to Python Programming – History, Features, Basic syntax and Data Types, Operator. Conditional Statement – if, -else, Nested if- else. Looping –For, While, Nested loops. Control statements-Break, Continue and Pass. String Manipulation – Accessing Strings, Basic Operations, slices, Function and Methods. Lists- Introduction, Accessing list, Operations, Working with lists, Tuple, Dictionary Function and Methods. R programming – Overview of R, R data types and objects, reading and writing data, Control structures, functions. OOPs concept– Class and object, Attributes, Inheritance, Abstraction, Polymorphism, Overloading, Overriding and Data hiding. Database – Introduction, Concepts. Modules-Importing module, Math module, Packages. Visualization Techniques – Data visualization and analysis (R Programming),

Lecture Schedule-Theory

1. Introduction to Python Programming – History and development, Why Python?
2. Features, Basic syntax and Data Types, identifiers, Reserved words and Operators
3. Conditional Statement – if, -else, Nested if- else
4. Looping –For, While, Nested loops with examples
5. Control Statements-Break, Continue and Pass
6. String Manipulation, Accessing Strings, Basic Operations: Assign string to a variable, multiline strings, string length, check string
7. slices, Function and Methods: slice from the start, slice to the end, negative indexing, upper case, lower case, remove white space, replace string, split string, string concatenation
8. Lists- Introduction, Accessinglist, listsize, append method Operations, Working with lists, Tuple, Dictionary
9. Final theory exam
10. Function and Methods, R programming – Overview of R, Features of R, Comments,R data types and objects, lists, factors, data frames, reading and writing data scanmethod
11. Control structures, if condition , if-else condition ,for, nestedloop,

whileloop,repeat and break statement, return and next statement functions

12. Variables ,Loop functions, debugging tools
13. OOPs concept– Class and object, Attributes, Abstraction, Polymorphism, Overloading, Overriding and Data hiding
14. Database – Introduction, Concepts
15. Modules-Importing module, Math module, Packages
16. Visualization Techniquesin R
17. R programming R Line graphs,Bar charts, pie charts
18. Final Theory Exam

Practical

Basic programs on Python , Python programs on conditional statements, Looping- for ,while, do while statement, Programs on control statements, Break, Continue, Pass, Python string Handling Slices, Functions and methods, List manipulation,. Programming concepts in R ,R programs on control structures, Functions, Looping and methods, Simulation handling, Programs on OOP concepts, Inheritance, function overloading, overriding, R programming R Line graphs,Bar charts, pie charts

Practical Schedule

1. Basic programs on Python,
2. Python programs on conditional statements
3. Looping- for , while, do while statement
4. Programs on control statements
5. Break, Continue
6. Pass, Python string Handling Slices
7. Functions and methods
8. List manipulation
9. Exercises using of Pycharm
10. Programming concepts in R
11. R programs on control structures
12. Functions

13. Programs on OOP concepts
14. Visualization techniques in R
15. Bar chart, Pie chart
16. Line chart, column chart
17. Regression, correlation
18. **Practical Exam**

Suggested Readings

Balmain, D. 2008. *Ferret*. Sebastopol, Ca: O'reilly Media.

Brown, M.C. 2001. *Python : the complete reference*. New York ; London: Osborne/Mcgraw-Hill

SAAS 2115 Plant Physiology 2(1+1)

Theory

Introduction, importance in agriculture. Seed physiology, seed structures, morphological, physiological and biochemical changes during seed development, physiological maturity – morphological and physiological changes associated with physiological maturity in crop, harvestable maturity, seed viability and vigour, factors affecting seed viability and vigour. Methods of testing seed viability and vigour, germination, utilization of seed reserves during seed germination, morphological, physiological and biochemical changes during seed germination, factors affecting seed germination. Growth and development, definition, determinate and indeterminate growth, monocarpic and polycarpic species with examples. Measurement of growth, growth analysis growth characteristics, definitions and mathematical formulae. Crop water relations, physiological importance of water to plants, water potential and its components, measurement of water status in plants. Transpiration, significance, transpiration in relation to crop productivity, water use efficiency, WUE in C3, C4 and CAM plants. Factors affecting WUE. Photosynthesis, Energy synthesis, significance of C3, C4 and CAM pathway, relationship of photosynthesis and crop productivity, photorespiration; Factors affecting photosynthesis and productivity, methods of measuring photosynthesis, photosynthetic efficiency. Translocation of assimilates,

phloem loading, apoplastic and symplastic transport of assimilates, source and sink concept, dry matter partitioning, harvest index of crops, respiration and its significance, brief account of growth respiration and maintenance respiration, alternate respiration salt respiration – wound respiration – measurement of respiration. Nutriophysiology – definition – classification of plant nutrients based on quantity, function and mobility – physiology of nutrient uptake – functions of plant nutrients – deficiency and toxicity symptoms of plant nutrients – foliar nutrition – hydroponics. Introduction of photoperiodism and vernalisation in relation to crop productivity – photoperiodism. Plant growth regulators – occurrence – biosynthesis – mode of action of auxins, gibberellins, cytokinins, ABA, Ethylen. Novel plant growth regulators, commercial application of plant growth regulators in agriculture. Senescence – physiological and biochemical changes and their significance. Post harvest physiology – seed dormancy definition – types of seed dormancy – advantages and disadvantages of seed dormancy – causes and remedial measures for breaking seed dormancy, optimum conditions of seed storage – factors influencing seed storage (ISTA standards). Fruit ripening - metamorphic changes – climateric and non-climeteric fruits – hormonal regulation of fruit ripening (ethrel, CCC, polaris, paclobuterazole).

Lecture Schedule -Theory

1. Introduction to plant physiology and its importance in agriculture
2. Seed physiology and structure of seeds-Morphological, physiological and biochemical changes during seed development
3. Physiological maturity – morphological and physiological changes in crops - harvestable maturity
4. Seed viability and vigour- factors affecting seed viability and vigour -Methods of testing seed viability and vigour
5. Germination-utilization of seed reserves during seed germination-Morphological, physiological and biochemical changes during seed germination- factors affecting seed germination

6Growth and development- definition-determinate and indeterminate growth-monocarpic and polycarpic species -Measurement of growth- growth analysis growth characteristics- definitions and mathematical formulae

7. Crop water relations- physiological importance of water to plants- water potential and its components- measurement of water status in plants

8. Transpiration- significance- transpiration in relation to crop productivity- water use efficiency, WUE in C3, C4 and CAM plants- Factors affecting WUE-Photosynthesis- light and dark reactions -Significance of C3, C4 and CAM pathway- relationship of photosynthesis and crop productivity- Photorespiration- Factors affecting photosynthesis and productivity- methods of measuring photosynthesis- photosynthetic efficiency

9. Mid-term examination

10. Translocation of assimilates, phloem loading, apoplastic and symplastic transport of assimilates- Source and sink concept- dry matter partitioning- harvest index of crops

11.Respiration and its significance- brief account of growth respiration and maintenance respiration- alternate respiration- salt respiration- wound respiration- measurement of respiration

12.Nutriophysiology – definition – classification of plant nutrients based on quantity, function and mobility – physiology of nutrient uptake -functions of plant nutrients – deficiency and toxicity symptoms of plant nutrients – foliar nutrition – hydroponics

13. Photoperiodism and vernalisation in relation to crop productivity

14.Plant growth regulators – occurrence – biosynthesis – mode of action of auxins, gibberellins, cytokinins, ABA, Ethylene-Novel plant growth regulators, commercial application of plant growth regulators in agriculture

15.Senescence – physiological and biochemical changes and their significance

16. Post-harvest physiology - optimum conditions of seed storage – factors influencing seed storage (ISTA standards)

17.Fruit ripening - metamorphic changes – climateric and non-climeteric fruits – hormonal regulation of fruit ripening (ethrel, CCC, polaris, paclobuterazole)

18. Final theory exam

Practical

Preparation of solutions; growth analysis; calculation of growth parameters; yield analysis, measurement of leaf area by various methods; methods of measuring water status in roots, stems and leaves; measurement of water potential by Chardakov's method; measurement of absorption spectrum of chloroplastic pigments; Chlorophyll fluorescence and its applications. Measuring photosynthetic rate using IRGA; measuring light intensity; leaf anatomy of C3 and C4 plants; stomatal frequency and index – respirometer – measurement of respirometer; measurement of transpiration rate;

imbibition of seed; optimum conditions for seed germination; breaking seed dormancy; (a) Chemical method (b) Mechanical method; seed viability and vigour tests; plant growth regulator – quantification and its effect on plant processes.

Practical Schedule

1. Preparation of standard solutions
2. Demonstration of diffusion, imbibition
3. Demonstration of osmosis
4. Demonstration of plasmolysis and deplasmolysis
5. Estimation of relative water content
6. Extraction of photosynthetic pigments
7. Estimation of chlorophyll and carotenoid pigments
8. Growth analysis- calculation of growth parameters - yield analysis
9. Measurement of leaf area by various methods
10. Measuring photosynthetic rate using IRGA
11. Leaf anatomy of C3 and C4 plants- stomatal frequency and index
12. Measurement of transpiration rate
13. Breaking seed dormancy- Chemical method - Mechanical method
14. Seed viability tests
15. Seed vigour test

16-17. Identification of deficiency and toxicity symptoms in various crops

18. Practical examination

Suggested Readings

Bidwil R.G.S I. *Plant Physiology* II End. Macmillan, Publishing Co., Inc. New York

Devlin R. M. and Witham F. H. 1983. *Plant Physiology* 4th Edn. CBS Publishers and Distributors, New Delhi

Devlin R.M. 1979. *Plant Physiolgoy II* End. Affiliated East West Press, New Delhi

Gupta .N.K and Sunita Gupta. 2002. *Plant Physiology*. Oxford & IBH Publishing Co.Pvt.Ltd.NewDelhi.

Malick, C.P. and Srivastava, A.K. 2000. *Textbook of Plant Physiology*. Kalyani publishers, New Delhi.

Milthrope, F.L. and Marby, J. 1979. *An introduction to Crop Physiology*, Cambridge University Press, London

Noggle, G.R. & Fritz G.J. 1992. *Introductory Plant Physiology II* End. Prentice Hill of India (P) Ltd., New Delhi

Salisburry, F. B. & Ross. C.W. *Plant Physiology*, CBS Publishers & Distributors, New Delhi

SAAS 2116 Soil and Water and Conservation 2(1+1)

Theory

Introduction to Soil and Water Conservation, Causes of soil erosion. Definition and agents of soil erosion, water erosion. Forms of water erosion. Gully classification and control measures. Soil loss estimation by Universal Soil Loss Equation. Soil loss measurement techniques. Watershed development-Concept of watershed-Watershed classification-Physiographic features-Prioritization- Principles of erosion control. Engineering measures of soil and water conservation - contouring, contour bund , graded bund and bench terracing Water harvesting and its techniques. Introduction to irrigation – terminologies – irrigation methods – micro irrigation –drip and sprinkler irrigation - fertigation. Introduction to irrigation pumps and their selection.

Lecture Schedule -Theory

1. Introduction to soil and water conservation- history of soil erosion- current global scenario in land use management- land degradation
2. Types and causes of soil erosion- Definition and agents of soil erosion, water erosion.
3. Water erosion – process and forms/types of water erosion
4. Gully classification and control measures
5. Factors affecting water erosion- losses due to water erosion
6. Wind erosion and its mechanisms- losses due to wind erosion
7. Soil loss estimation by Universal Soil Loss Equation
8. Soil loss measurement techniques
9. **Mid-term examination**
10. Watershed development-Concept, objective, and components of watershed-Watershed classification-Physiographic features-Prioritization- Principles of erosion control

11-12. Engineering measures of soil and water conservation - contouring, contour bund, graded

bund, and bench terracing

13. Water harvesting – concept and definition and importance of water harvesting – water harvesting techniques

14. Introduction to irrigation – water resources –soil water relationship - terminologies

15. Irrigation methods – surface and subsurface irrigation

16. `Irrigation methods -micro irrigation –drip and sprinkler irrigation - fertigation.

17. Introduction to irrigation pumps –types and their selection

18. **Final examination**

Practical

Calculation of erosion index and estimation of soil loss, measurement of soil loss, Preparation of contour maps, Estimation of runoff –problems, Water flow measuring devices, Design of contour bunds, graded bunds, Design of bench terracing system, Design of water harvesting ponds , Problems on irrigation efficiencies, Problems on drip and sprinkler irrigation systems, Irrigation pump selection – problems.

Practical Schedule

1. Calculation of erosion index and estimation of soil loss
2. Measurement of soil loss

3-4. Preparation of contour maps- direct and indirect methods

5-6. Estimation of runoff -Problems on runoff

7-9. Water flow measuring devices

10-11. Design of contour bunds and design of graded bunds

12. Design of bench terracing system

13. Design of water harvesting ponds

14. Irrigation efficiency and problems on irrigation efficiencies

15. Problems on drip and sprinkler irrigation systems

16-17. Irrigation pump selection - Problems

18. Practical examination

Suggested Readings

Kumar, S., Kumar, V. and Sahu, R.K.. 2016. Fundamentals of Agricultural Engineering, Kalyani Publishers, New Delhi.

Mal, B.C. 2014. Introduction to Soil and Water Conservation Engineering. Kalyani Publishers.

Michael, A.M. 2012. Irrigation: Theory and Practice. Vikas Publishing House New Delhi

Michael, A.M. and Ojha, T.P. 2014. Principles of Agricultural Engineering .Vol-II 5th Ed. Jain Brothers Publication, New Delhi.

Michael, A.M., Khepar, S.D. and Sondhi, S.K. 2008. Water Well and Pumps, 2nd Ed, Tata Mc-Graw Hill.

Samra, J.S., Sharda, V.N. and Sikka, A.K. 2002. Water Harvesting and Recycling: Indian Experiences. CSWCR&TI, Dehradun, Allied Printers, Dehradun

Schwab, G.O., Fangmeier, D.D., Elliot,W,J. and Frevert, R.K. 1993. Soil and Water Conservation Engineering. 4th Ed. John Wiley and Sons Inc. New York.

Singh, G., Venkataraman, C., Sastry, G. and Joshi, B.P. 1996. Manual of Soil and Water Conservation Practices. Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi.

Suresh, R. 2010. Principles of Micro-Irrigation Engineering. Standard Publishers, Distributors, New Delhi.

SAAS 2117 Crop Improvement for Climate Change 2(2+0)

Theory

Historical development, concept, and objectives of plant breeding; Modes of reproduction. Genetic consequences of self and cross pollinated crops; Methods of breeding in self and cross pollinated and asexually propagated crops: Introduction and acclimatization. Selection: mass selection, pure line selection. Hybridization: aims and objectives, types of hybridization. Methods of handling of segregating generations: pedigree method and bulk method, back cross method, heterosis breeding, synthetics and composites, recurrent selection, Methods of breeding for vegetatively propagated crops: clonal selection. Mutation breeding; Ploidy breeding. Molecular breeding – genetic engineering and marker aided selection (MAS). Effects of climate change on crop production. Crop improvement in the era of climate change: different types of abiotic stresses, characteristics of abiotic stresses, development of resistant varieties. Breeding for drought resistance, types of drought environment, drought escape, dehydration avoidance, dehydration tolerance, sources of drought resistance, water use efficiency. Breeding for submergence/flooding: effects of flooding, mechanism and source of

resistance, breeding strategy. Breeding for mineral stresses resistance (salinity, mineral deficiency and mineral toxicity): mechanisms and sources of resistance to mineral toxicity, sources of salinity resistance, problems in breeding for salinity. Breeding for resistance to heat and cold - heat stress resistance, sources, cold resistance, chilling tolerance, sources; freezing stress, freezing resistance, freezing tolerance sources.

Lecture Schedule-Theory

1. Historical development, concept, and objectives of plant breeding

2-3. Modes of reproduction- sexual, asexual, apomixes and their classification

4-5. Modes of pollination-genetic consequences- the difference between self and cross-pollinated crops

6. Introduction as a method of plant breeding

7. Components of variability- additive, and dominance- heritability and genetic advance

8-9. Selection: mass selection, pure line selection

10-11. Hybridization: aims and objectives, types of hybridization

12-13. Methods of handling segregating generations: pedigree method and bulk method

14. Heterosis – inbreeding depression-various theories of heterosis

15. Back cross method of breeding

16. Exploitation of hybrid vigour development of inbred lines- single cross and double cross hybrids

17. Synthetics and composites

18. Mid-term examination

19-20. Incompatibility and male sterility and their utilization in crop improvement

21. Concepts of population genetics and Hardy Weinberg law

22. Population improvement programs-recurrent selection

23. Methods of breeding for vegetatively propagated crops: clonal selection

24-25. Mutation breeding- mutation-mutagens-physical and chemical mutagens- advantages and disadvantages of mutation breeding - examples

26-27. Ploidy breeding- polyploidy types- origin and significance-polyploidy breeding-methods and examples

28-29. Molecular breeding – genetic engineering and marker-aided selection (MAS).

30. Effects of climate change on crop production.

31.Crop improvement in the era of climate change: different types of abiotic stresses- characteristics of abiotic stresses- development of resistant varieties.

32.Breeding for drought resistance; types of drought environment- drought escape, dehydration avoidance- dehydration tolerance- sources of drought resistance, and water use efficiency.

33.Breeding for submergence/flooding: effects of flooding, mechanism and source of resistance, breeding strategy.

34. Breeding for mineral stresses resistance (salinity, mineral deficiency, and mineral toxicity): mechanisms and sources of resistance to mineral toxicity, sources of salinity resistance, and problems in breeding for salinity.

35. Breeding for resistance to heat and cold - heat stress resistance, sources, cold resistance, chilling tolerance, sources; freezing stress, freezing resistance, freezing tolerance sources.

36. Final examination

Suggested readings

Ahmad, P., Wani, M.R., Azooz, M.M., Tran, L.S.P. (Eds.) 2016 , Improvement of Crops in the Era of Climatic Changes , Springer Book Achieves.

Allard, R.W. 1960. Principles of Plant Breeding. John Wiley & Sons INC. USA. Toppan Co. Ltd. Japan

Choudhari, T.C. 1982. Introduction to Plant Breeding. Oxford A& IBH Publishing Co., New Delhi

Dagar, J. C Arunachalam, A, and Singh, A. K. 2014 Climate Change and Crop Production, Delhi/ Ludhiana.

Elliot. 1958. Plant Breeding & Cytogenetics. Mc Grow Hill. New York

Hayward, M.D., Bosemark, N.O and Romagosa (eds) 1993 Plant breeding- principles and prospects Chapman and Hall, London

Kuckuck, H. Kobabe, G. and Wenzel, G. 1996 Fundamentals of Plant breeding Narosa Publishing House, Ludhiana.

Phundan Singh 1996 Essentials of plant breeding Kalyani Publishers. New Delhi/

Publishing Company Limited, New Delhi.

RajibRoychowdhury2014 . Crop Improvement in the Era of Climate Change, I.K. International Publishing, New Delhi, India

Sharma, J.R. 1989. Principles and Practice of Plant Breeding. Tata Mc Graw - Hill

Singh, B.D. 2001. Fundamentals of Genetics. Kalyani Publishers. New Delhi. Ludhiana

Singh, B.D. 2003. Plant Breeding Principles and Methods. Kalyani Publishers. New Delhi

SAAS 2118 Climate Smart Agriculture 2(2+0)

Theory

Definition and principles of climate smart agriculture- Need and importance of CSA- Key characteristics of CSA- Climate change impacts to crops and farmers: high temperature, erratic rainfall, sea level rise, drought and flood, salt intrusion, crop damage and failure- CSA approaches; Soil management-sustainable soil and land management- Prevention and mitigation of land degradation- Soil organic matter management for soil carbon sequestration- Efficient water use and management- Management of problematic soils and its management-Conservation agriculture- Biomass recycling and soil health; Soil organic matter, microbial activity, microbial biodiversity and resilience-Integrated farming and efficient use of fertilizers-Crop production management; System of Rice Intensification-Use of diverse and appropriate varieties-Crop diversification to reduce risk-Integrated Farming System- Organic farming for sustainable agriculture: Principles and practices-Participatory seed production and seed testing- Water management; Alternate wetting and drying technique for rice cultivation-water harvesting and saving techniques- micro irrigation methods-Agro forestry; The role SALT for soil conservation and crop production- Integrated pest, disease and weed management-Harvesting and post-harvest management; mechanized and timely harvest-quality improvement through drying – Post harvest management-Crop insurance-Gender and social inclusion; Gender gap in agriculture and its implications on the context of climate change-Inclusion of gender and other disadvantaged groups in agriculture development.

Lecture Schedule-Theory

1-2. Definition and principles of climate-smart agriculture- Need and importance of CSA- Key characteristics of CSA

3-4. Climate change impacts to crops and farmers: high temperature, erratic rainfall, sea level rise, drought and flood, salt intrusion, crop damage and failure

5. CSA approaches; Soil management-sustainable soil and land management-Prevention and mitigation of land degradation

6. Soil organic matter management for soil carbon sequestration

7-9. Management of problematic soils : Physical, Chemical and biological problem soil

10-12. Conservation agriculture- Biomass recycling and soil health; Soil organic matter,

microbial activity, microbial biodiversity and resilience

13-14. Integrated farming System: different IFS systems- achievement of CSA principles through IFS

15-16. Efficient use of fertilizers – Nitrogen fertilizer management- integrated nutrient management

17. Crop production management; System of Rice Intensification

18. Mid-term examination

19. Use of diverse and appropriate varieties-Crop diversification to reduce risk

20-22. Organic farming for sustainable agriculture: Principles and practices

23-24. Participatory seed production and seed testing

25. Water management; Alternate wetting and drying techniques for rice cultivation

26. Water management; water harvesting and saving techniques

27. Water management; micro irrigation methods

28. Agroforestry; The role of SALT for soil conservation and crop production

29. Integrated pest and disease management

30. Integrated weed management

31. Harvesting and post-harvest management; mechanized and timely harvest-quality improvement through drying

32-33. Crop insurance

34-35. Gender and social inclusion; Gender gap in agriculture and its implications on the context of climate change-Inclusion of gender and other disadvantaged groups in agriculture development

36. Final theory exam

Suggested Readings

Abrol, I.P., Gupta, R.K. and Malik, R.K. eds., 2005. *Conservation agriculture: status and prospects*. Centre for Advancement of Sustainable Agriculture. New Delhi

F.A.O., 2010. Climate-Smart Agriculture: Policies, Practices and Financing for Food Security, Adaptation and Mitigation. *Food and Agriculture Organization (FAO), Rome, Italy*.

Nagothu, U.S. ed., 2016. *Climate Change and Agricultural Development:* [MOU15] *Improving Resilience Through Climate Smart Agriculture, Agroecology and Conservation*. Routledge.

SAAS 2119 Forest Ecology and conservation biology 2(2+1)

Theory

Definition, History of ecology, Subdivisions, ecology and other subjects, fundamental ecological variables Ecosystems: Definition, Components, Structure and function, Size of Ecosystem, Classification of ecosystems Comparative Ecosystem Ecology.

Population Ecology Definition, Structure and Measures Population Growth, Population regulation Strategies of species survivability, Population Genetics, Human Population.

Community Ecology Concepts, Community gradients, Characters of community, Ecological Succession and climax Community, Organization Interactions between species Stress Ecology and Adaptation.

Applied Ecology -Estimating Abundance Species diversity measures, Museology Taxonomy and Biosystematics, Biomass productivity and estimation techniques.

Introduction to Conservation Biology- History, Concepts and Background Biogeography - Western Ghats.

Natural History- Natural History in India, Animal Behaviour, General Entomology, Ornithology, Mamma logy, Ichthyology, Herpetology- Basic understanding of common flora in Southern Western Ghats.

Biodiversity Concepts- Genetic diversity, species diversity, Eco-system diversity Global and Regional biodiversity Threats to Biological Diversity – Habitat Degradation, Fragmentation, Global Climate Change, over extraction, over abundance, alien and invasive species, diseases -Threatened species, IUCN, Red Data Book.

Conservation in Practice- Global Conservation initiatives – Biodiversity hot spots, Conservation in South and Southeast Asia, National Conservation Action Plan, Landscape-level Conservation Strategies – Protected Areas, Biosphere Reserves, Wildlife Sanctuaries, National Parks, Tiger Reserves and Reserve Forests- In situ and ex situ conservation- Restoration

Human Ecology- Environmental History and Conservation Movements -People and Nature: Ecosystem services- Indigenous communities and Ethno-biology -Human-wildlife Conflict

Practical

Study the world map of climatic regions and vegetation, Study the map of India showing climatic regions and vegetation, Phyto-sociological analysis. Vegetation

sampling - line transect method -quadrant method, species area curve- profile diagram, Field visits to study vegetation changes along environmental gradients, Field visits to study different ecosystem types, Biodiversity indices, MDS plots, Bray Curtis Similarity index and ANOSIM tests.

Suggested Readings

Ahmadullah, M and Nayar, M. P. 1987. Endemic plants of the Indian Region. Vol. I Botanical Survey of India.

Brewer, R. (1994), The Science of Ecology, Saunders College Publishing, New York.

Chapman, J. L. And Reiss, M. J. (19920, Ecology: Principles and Application, Cambridge University Press, Cambridge.

Groombridge, B. (ed) 1992. Global Biodiversity: Status of the Earth's Living Resources, Chapman and Hall, London

Heywood, V. H. (ed) 1995. Global Biodiversity Assessment (UNEP), Cambridge University Press, Cambridge

Hughes, J, D. 2001. An Environmental History of the World. Routledge, London. P264

Lewis, M. 2003. Inventing Global Ecology: Tracking the biodiversity ideal in India, Orient Longman. P369

Martin, G.J. 1995. Ethnobotany - A methods manual. Chapman & Hall. Madras. P 268

Maxted, N., B. V. Ford-Lloyd and J. G. Hawkes. 1997. Plant Genetic conservation-the in situ approach. Chapman & Hall, Madras.

Michael E. Soule and Bruce Wilcox, 1980. Conservation Biology: An Evolutionary Ecological Perspective.

Michael, P. 1990. Ecological methods for Laboratory and Field Investigations, Tata McGrew Hill Publishing Company Ltd, New Delhi.

Nair, S. C. Southern Western Ghats: A biodiversity conservation Plan, INTACH, New Delhi. P92.

Odum, E. P. 1971. Fundamentals of ecology

Sutherland, W. J. 2004. 1997. Ecological Census Techniques - A Handbook. Cambridge University Press. P336

Sutherland, W. J. 2004. The Conservation Handbook, Research, Management and

Policy, Blackwell Science ltd. P278.

SAAS 2120 Fundamentals of crop protection 3(2+1)

Theory

Insects - their general body structure; Importance of insects in agriculture; Insects diversity; Beneficial insects: Productive insects, parasitoids and predators. Concepts in population build-up of insects. General symptoms of pest attack; Principles and methods of insect-pests management; Integrated Pest Management concept; Bioecology and management of important pests of major crops and stored products. Plant Pathology- introduction, history and definitions; Plant pathogenic micro organisms and phanerogamic plant parasites; Survival and dispersal of plant pathogens; Epidemiology of crop diseases –role of weather parameters in disease development; Yield loss assessment and phytopathometry; Disease forecasting- disease modelling; Principles of crop disease management; Major diseases of important crops of Kerala- symptoms, etiology, environmental factors favoring disease development and integrated disease management.

Lecture Schedule-Theory

1-4. Insects - their general body structure- morphology and anatomy

5. Insect classification

6. Metamorphism

7-9. Importance of insects in agriculture-Insect diversity; beneficial insects- silk worm, honey bees, lac: Productive insects, parasitoids and predators.

10. Concepts in population build-up of insects

11. General symptoms of pest attacks

12. Types of damages caused by insects- direct, indirect, and other methods

13-14. Principles and methods of insect pest management-Integrated Pest Management (objectives, principles, and components)

15-17. Bio-ecology and management of important pests of major crops and stored products.

18. Mid-term examination

19. Plant Pathology- introduction, history, and definitions

20-21. Plant pathogenic microorganisms - general characteristics of fungi and fungal-like organisms, bacteria, virus, algae and flagellate protozoa causing plant diseases

22. Disease resistance and defense mechanisms in plants

23. Survival and dispersal of plant pathogens

24. Role of weather parameters in disease development- temperature, humidity, moisture, elevated CO2 etc.

25. Epidemiology of crop diseases

26. Yield loss assessment and phytopathometry

27. Disease forecasting- disease modeling

28-30. Principles of crop disease management- physical and legislative methods of plant disease management- Cultural methods of plant disease management- Biological methods of plant disease management- Chemical control of plant diseases- Use of resistant varieties in plant disease management- Integrated plant disease management

31-35. Major diseases of important crops of Kerala- symptoms, etiology, environmental factors favouring disease development, and integrated disease management.

36. Final examination

Practical

Familiarization with generalized insect's body structure and appendages; Identification of important insect-pests of major crops and stored-grains, and their symptoms of damage and management; acquaintance with useful insects: predators, parasitoids, honey bees and silkworms.

Acquaintance to plant pathology laboratory and plant protection equipments, Common symptoms of plant diseases; Isolation techniques of fungi and bacteria, preservation of diseased plant samples; Assessment of diseases, score chart, disease index; Plant protection chemicals; Study of symptoms, etiology and integrated disease management practices of crops like rice, vegetables (solanaceous vegetables, bhendi, crucifers, cucurbits etc.), banana, mango, pineapple, coconut, arecanut, tea, coffee, black pepper, ginger, nutmeg and rubber.

Practical Schedule

1-3. Familiarization with generalized insect's body structure and appendages- insect external morphology- head-antenna- thorax- abdomen- mouth parts- leg, wing, and abdomen structure and modifications

4-5. Insect's anatomy- digestive, respiratory, circulatory, excretory, reproductive, and nervous system

6-8. Identification of important insect pests of major crops and stored grains, and their symptoms of damage and management

9-10. Acquaintance with useful insects: predators, parasitoids, honey bees, and silkworms

11. Acquaintance to plant pathology laboratory and plant protection equipment

12. Common symptoms of plant diseases

13. Isolation techniques of fungi and bacteria

14. Preservation of diseased plant samples- Assessment of diseases, score chart, disease index

15. Plant protection chemicals- classification and mode of action

16-17. Study of symptoms, etiology, and integrated disease management practices of crops like rice, vegetables (solanaceous vegetables, bhendi, crucifers, cucurbits etc.), banana, mango, pineapple, coconut, arecanut, tea, coffee, black pepper, ginger, nutmeg and rubber

18. Practical examination

Suggested Reading

Agrios, GN. 2010. Plant Pathology. Acad. Press.

Atwal AS & Dhaliwal GS. 2002. Agricultural Pests of South-Asia and Their Management. Kalyani Publishers.

Dhaliwal GS & Arora R. 1996. Principles of Insect Pest Management. National Agriculture Technology Information Centre.

Dhaliwal GS, Singh R &Chhillar BS. 2006. Essentials of Agricultural Entomology. Kalyani Publishers.

Mehrotra RS & Aggarwal A. 2007. Plant Pathology. 7th Ed. Tata Mc Graw Hill Publ. Co. Ltd.

Singh H. 1984. House-hold and Kitchen Garden Pests - Principles and Practices. Kalyani Publishers.

Singh RS. 2008. Plant Diseases. 8th Ed. Oxford & IBH. Pub. Co.

Singh RS. 2013. Introduction to Principles of Plant Pathology. Oxford and IBH

Stakman EC &Harrar JG. 1957. Principles of Plant Pathology. Ronald Press, USA.

Tarr SAJ. 1964. The Principles of Plant Pathology. McMillan, London.

Vander Plank, JE. 1975. Principles of Plant Infection. Acad. Press.

SAAS 2221 Statistical methods and Experiment Design 3(2+1)

Theory

Introduction: Definition of Statistics - its uses and limitations, Functions of Statistics, Collection of statistical data. Frequency distributions-. Diagrammatic and graphical presentation of statistical data. Measures of central tendency:. Arithmetic mean, Median, Mode, Geometric mean and Harmonic mean. Comparisons of these averages and the selection of appropriate averages. Properties of Arithmetic mean. Weighted Arithmetic mean. Measures of Dispersion: definition.. Range, Quartile deviation, Mean deviation and Standard deviation. Relative measures of dispersion – Coefficient of variation. Skewness, Kurtosis and its measures. Correlation. scatter diagram. Correlation coefficient. Rank correlation coefficient.. Regression. Linear regression and its applications in agriculture, Interpretation of Regression coefficient. Correlation vs. Regression. Probability: Definition and concept of Probability, Addition, and Multiplication theorems on Probability (without proof). Binomial, Poisson and Normal Distributions. Introduction to Sampling- Sampling distributions and Standard error. Sample Surveys in Agriculture. Simple random sampling with and without replacement. Definition of Hypothesis - Tests of statistical hypothesis. Type I and II Errors. Steps involved in Testing of Hypothesis. Level of Significance and Degrees of freedom. Critical Region, Large Sample Tests – Z transformation of the Correlation Coefficient. Small sample tests- Tests for equality of means and variances – t and F tests. Paired t test. Tests of significance of correlation coefficient. Chi- square tests – Assumptions, limitations and applications. Contingency table – Yates' correction for continuity. Design of experiments. Need for designing experiments – Basic principles of experimentation. Practical considerations in field experimentation- Size and shape of plots and blocks, Border effects. Methods of analysis of data from designed experiments. Analysis of Variance, assumptions, Transformation of data, Post hoc tests. One, two and three way classifications. Completely Randomized Design: Layout and analysis, advantages and limitations. Randomized Block Design: Layout and analysis, advantages and limitations. Latin Square Design: Layout and analysis. Boxplots.

Lecture Shedule

1. Introduction: Definition of Statistics - its uses and limitations, Functions of Statistics, Collection of statistical data.

2-3. Frequency distributions-. Diagrammatic and graphical presentation of statistical data.

4. Measures of central tendency:. Arithmetic mean, Properties of Arithmetic mean. Weighted Arithmetic mean

5. Median, Mode, Geometric mean and Harmonic mean, Comparisons of these averages and the selection of appropriate averages.

6-7. Measures of Dispersion: definition.. Range, Quartile deviation, Mean deviation and Standard deviation. Relative measures of dispersion – Coefficient of variation.

8. Skewness, Kurtosis and its measures.

9.Correlation. scatter diagram. Correlation coefficient. Rank correlation coefficient..

10.Regression. Linear regression and its applications in agriculture, Interpretation of Regression coefficient. Correlation vs. Regression.

11-12. Probability: Definition and concept of Probability, Addition, and Multiplication theorems on Probability (without proof).

13. Binomial, Poisson distributions

14. Normal Distributions.

15. Introduction to Sampling- Sampling distributions and Standard error.

16. Sample Surveys in Agriculture. Simple random sampling with and without replacement. 17. Definition of Hypothesis - Tests of statistical hypothesis. Type I and II Errors. Steps involved in Testing of Hypothesis.Level of Significance and Degrees of freedom. Critical Region

18. Mid Term Examination

19.Large Sample Tests – Z transformation of the Correlation Coefficient

20-21.Small sample tests- Tests for equality of means and variances – t and F tests. Paired t test. Tests of significance of correlation coefficient.

22-23.Chi- square tests – Assumptions, limitations and applications. Contingency table – Yates' correction for continuity.

24.Design of experiments. Need for designing experiments – Basic principles of experimentation.

25-26. Practical considerations in field experimentation- Size and shape of plots and blocks, Border effects. Methods of analysis of data from designed experiments.

27. Analysis of Variance, assumptions,

28. Transformation of data

29.Post hoc tests.

30-31. One, two and three way classifications.

32. Completely Randomised Design: Layout and analysis, advantages and limitations.

33. Randomised Block Design: Layout and analysis, advantages and limitations.

34. Latin Square Design: Layout and analysis

35.Boxplots.

36 Final Examination

Practical

Calculation of various measures of central tendency, computation of various measures of dispersion viz. coefficients of variation, skewness and kurtosis, computation of product moment correlation coefficient and rank correlation, fitting of Linear regression models for prediction, simple problems on probability, fitting of binominal distribution, problems on Poisson distribution, applications of Normal distributions in agriculture, selection of simple random sample, estimation of parameters, sample size determination, large and small sample tests, tests on correlation coefficients, test for equality two small sample variances, F test, t test for equality of means with equal variance, means with unequal variances, Cochran and Cox tests, Paired t test, Chi-square tests of goodness of fit, Tests of independence of attributes in a contingency table, analysis of one way and two way classified data, layout and analysis CRD and RBD, layout and analysis LSD, transformations of data

Practical Schedule

1. Calculation of various measures of central tendency
2. Computation of various measures of dispersion viz. coefficients of variation
3. Skewness and kurtosis,
4. Computation of product moment correlation coefficient and rank correlation
5. Fitting of Linear regression models for prediction
6. Simple problems on probability
7. Fitting of binominal distribution
8. Problems on Poisson distribution
9. Applications of Normal distributions in agriculture
10. Selection of simple random sample, estimation of parameters, sample size determination,
11. Large sample tests
12. Small sample test – t, F, Cochran and Cox tests, Paired t test
13. Chi- square tests of goodness of fit, Tests of independence of attributes in a contingency table
14. Analysis of one way and two way classified data
15. Layout and analysis CRD
16. Layout and analysis RBD
17. Layout and analysis LSD
18. Transformations of data

Suggested Readings

Cochran,W.G.1989. Sampling Techniques , Oxford and IBH Publishing Co. [MOU14]
Cox, D.R. 1958. Planning of Experiments, Wiley, New York
Das, M.N. and Giri, V.V. 2011. Design and Analysis of Experiments, New Age International Publishers, Daryaganj- New Delhi-110 002

Federer, W.T. 1967. Experimental Design, Oxford and IBH Publishing Company, New Delhi.

Fisher, R.A. 1947. Design of Experiments, Oliver and Boyd, Edinburgh, London. 6. Gomez, K.A. and Gomez, A.A.1984. Statistical procedures for Agricultural Research . John Wiley and sons, Inc., New York.

Goon, A.M., Gupta, M.K. and Dasgupta, B. 1983. Fundamentals of Statistics. Vol. I. The World Press

Gupta, S.C. and Kapoor, V.K.1997. Fundamentals of Mathematical Statistic., Sulthan Chand Publications, New Delhi.

Learning Statistics: http://freestatistics.altervista.org/en/learning.php. Electronic Statistics : Text Book:

Panse, V.G. and Sukhatme, P.V. 1967. Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research , New Delhi

Rao, G.N. 2007. Statistics for Agricultural Sciences. BS publications, Hyderabad.

Sukhatme, P.V., Sukhatme, B.V., Sukhatme, S. and Asok, C. 1984. Sampling Theory of Surveys with Applications. Iowa State University Press and Indian Soc. of Agric. Stat., New Delhi

SAAS 2222 Biotechnology and Climate Change 3(2+1)

Theory

Principles and history of plant biotechnology and its scope. Introduction to plant tissue culture: history and scope. Nutritional requirements of in vitro cultures. Scope of plant tissue culture: Micropropagation; Production of virus free plants; Production of haploid plants; Overcoming incompatibility barriers; Protoplast isolation, culture and fusion; Somatic hybrids and cybrids; Production of secondary metabolites; Somaclonal variations; Germplasm conservation and exchange; Somatic embryogenesis and synthetic seed production. Factors influencing plant tissue culture and problems. Plant genetic engineering: introduction and history. Molecular tools: PCR , gel electrophoresis , blotting techniques. Isolation of DNA and RNA. General steps of transgenic production: gene isolation, restriction enzymes, rDNA, different vectors and gene cloning, direct and indirect gene transfer. Role of biotechnology for climate change mitigation: effect on greenhouse gas production. Agricultural biotechnology

and climate change: Productivity gains through biotechnology – GM crops for enhanced yield, biotic and abiotic stress resistance, crops adapted to environmental stress, energy efficient farming, carbon sequestration. Industrial biotechnology to mitigate greenhouse gas production. Biobasedproducts and bioenergy – biofuels, bioplastics production, pulp and paper production and bleaching, textile industry, chemicals industry, food industry, tanning and leather industry, dye industry. Biopharmaceuticals and climate change.

Lecture Schedule-Theory

1. Principles and history of plant biotechnology and its scope

2. Introduction to plant tissue culture: history and scope

3. Nutritional requirements of in vitro cultures

4-5. Scope of plant tissue culture: Micro-propagation-Production of virus free plants-Production of haploid plants- overcoming incompatibility barriers

6-7. Protoplast isolation: culture and fusion- Somatic hybrids and cybrids

8-9. Production of secondary metabolites

10. Somaclonal variations

11-12. Germplasm conservation and exchange

13-14. Somatic embryogenesis and synthetic seed production

15. Factors influencing plant tissue culture and problems

16-17. Plant genetic engineering: introduction and history

18. Mid-term examination

19-20. Identification and Isolation of DNA and RNA

21-23. General steps of transgenic production: gene isolation, restriction enzymes, rDNA, different vectors and gene cloning, direct and indirect gene transfer

24-26. Molecular tools: PCR- gel electrophoresis- blotting techniques (southern, northern and western blotting)

27. Role of biotechnology for climate change mitigation: effect on greenhouse gas production.

28. Agricultural biotechnology and climate change: Productivity gains through biotechnology – GM crops for enhanced yield

29-30. Biotic and abiotic stress resistance, crops adapted to environmental stress, energy efficient farming, carbon sequestration

31-32. Industrial biotechnology to mitigate greenhouse gas production

33-34. Bio-based products and bioenergy – biofuels, bioplastics production, pulp and paper production and bleaching, textile industry, chemicals industry, food industry, tanning and leather industry, dye industry

35. Biopharmaceuticals and climate change

36. Final examination

Practical

Requirements for Plant Tissue Culture Laboratory; Preparation of stock solutions and tissue culture media; Surface sterilization techniques and inoculation of various explants; Aseptic manipulation of various explants; Callus induction and plant regeneration; Micro propagation of important crops; Anther, embryo and endosperm culture; Hardening / Acclimatization of regenerated plants; Somatic embryogenesis and synthetic seed production; Isolation of protoplast; Demonstration of culturing of protoplast.

Molecular Biology techniques: Isolation of DNA, RNA and proteins, Gel electrophoresis for separation of fragments of DNA and RNA , PAGE, SDSPAGE. Blotting techniques: Southern blotting, Northern blotting and Western blotting. In vitro amplification of gene by PCR, RTPCR, Demonstration of gene transfer techniques: direct methods, indirect methods.

Practical Schedule

1. Requirements for Plant Tissue Culture Laboratory

2. Preparation of stock solutions and tissue culture media

3. Surface sterilization techniques and inoculation of various explants

4-5. Aseptic manipulation of various explants; Callus induction and plant regeneration

5-6. Micro propagation of important crops; Anther, embryo and endosperm culture

7. Hardening / Acclimatization of regenerated plants

8. Somatic embryogenesis and synthetic seed production

9. Isolation of protoplast; Demonstration of culturing of protoplast

10-12. Molecular Biology techniques: Isolation of DNA, RNA and proteins, Gel electrophoresis for separation of fragments of DNA and RNA, PAGE, SDSPAGE

13-15. Blotting techniques: Southern blotting, Northern blotting and Western blotting

16. In vitro amplification of gene by PCR and RTPCR

17. Demonstration of gene transfer techniques: direct methods, indirect methods

18. Practical examination

Suggested Readings

Aswanikumar, S. Ojita, Yuan-YeuYau (Ed) 2018biofuels – Greenhouse Gas Mitigation And Global Warming, Springer India Pvt. Ltd.

Bhojwani, S.S. and Razdan, M.K., 1986. Plant tissue culture: theory and practice. Elsevier.

Chawla, H.S., 2003. *Introduction to Plant Biotechnology.* Oxford and IBH Publishing Co. Pvt. Ltd, New Delhi

Gupta, P.K., 1994. Elements of biotechnology. Rastogi Publications.

Lewin, B. 2007. Genes IX. Oxford University Press, Inc., New York. Singh, B.D. 1998. Biotechnology. Kalyani Publications, New Delhi.

Ram Lakhan Singh, SukantaMondal 2017 Biotechnology for Sustainable Agriculture: Emerging Approaches and Strategies**,** Woodhead Publishing,

Reinert, J. and Bajaj, Y.S. eds., 2013. Applied and fundamental aspects of plant cell, tissue, and organ culture. Springer Science & Business Media.

Rittmann, B.E. and McCarty, P.L., 2012. Environmental biotechnology: principles and applications. Tata McGraw-Hill Education.

Satya D, S., 2005. Essentials of Biotechnology for Students, Published by PeePee Publishers, New Delhi.

Singh, B.D. 1998. Biotechnology. Kalyani Publications, New Delhi

Watson, J.D., Hopkins, N.H., Roberts, J.W., Steitz, J.A. and Weiner, A.M., 1987. Molecular biology of the gene Benjamin. Cummings, Menlo Park.

SAAS 2223 Restoration Ecology 2 (1+1)

Theory

Ecosystem functions – Value of ecosystems – Ecosystem disturbances – fire -habitat fragmentation – felling – erosion- Mining – dams – pollution- overhunting-invasion of species –

vulnerability – restoration of species diversity- ecosystem resilience & stability-AssemblyRestoration of soil- Phytoremediation – Bioremediation- forest restoration – restoration of

critical habitat- translocation – reintroduction – Restoration of wetlands and aquatic ecosystems –Management of restoration projects – Monitoring – aftercare and assessment – Legal framework –integrated restoration efforts –Case studies –Decision making in ecological restoration.

Lecture Schedule-Theory

1-2 Ecosystem functions – Value of ecosystems-Eco system management-watershed

3-4 Ecosystem disturbances – fire -habitat fragmentation-Invasive alien species – vulnerability –eco system degradation

5-6 Forest degradation felling – erosion- Mining – dams – pollution- overhunting

6-8 Restoration of species diversity- ecosystem resilience & stability- Assembly

9 Mid-Term Examination

10-11Restoration of soil- Phytoremediation – Bioremediation- forest restoration

12-13 Restoration ofcritical habitat- translocation – reintroduction

14-15 Restoration of wetlands and aquaticecosystems –Management of restoration projects – Monitoring – aftercare and assessment

15-17 Legal framework –integrated restoration efforts –Case studies –Decision making in ecological restoration.

18 Final Theory Examination

Practical

Exposure to the degraded sites and assesses the ground conditions- Visit to fire porn areas, impact assessment and preparation of action plan- Fauna, flora, soil and water quality assessment of of degraded sites - Social, economic and environmental assessment of post restoration changes of degraded sites- Plan preparation for the management of restored area

1-4. Exposure to the degraded sites and assesses the ground conditions

5-8. Visit to fire prone areas and assesses the ground conditions

9-10. Impact assessment and preparation of action plan- Fauna, flora, soil and water quality assessment of degraded sites

11-14. Visit to restored areas-Social, economic and environmental assessment of post restoration changes of degraded sites

15-17. Plan preparation for the management of restored area

18 Practical Examination

Suggested readings

1) Andre F. Clewell and James Aronson. (2013). Ecological Restoration, Second Edition: Principles, Values, and Structure of an Emerging Profession. Island Press.
2) David J Tongway and John A Ludwig. (2010). Restoring Disturbed Landscapes: Putting Principles into Practice. Island Press.
3) Greipsson, S. (2011). Restoration Ecology. Jones & Bartlett Learning, LLC, Canada, 408p.

SAAS 3124 Introduction to Fisheries Oceanography 2(1+1)

Theory

Oceanographic factors in fisheries: Effects of physicochemical and biological oceanographic factors on adaptation, behaviour, abundance and production of aquatic organisms; Space and time scales in oceanographic analysis; Speed and magnitude of short-term changes in the ocean; Synoptic oceanographic analysis – currents, waves, tides, amplitudes, stratification, related chemical factors, upwelling and circulation patterns. Forecasting systems: Fisheries forecasts – interpretation and use of ocean thermal structure in fisheries; Fisheries forecasting system in India and other countries – remote sensing; Global Positioning System (GPS). Application of Remote Sensing in fisheries; Application of echo-sounders and SONAR. Coastal fishery: Coastal fishery and hydrography- introduction, scope and factors affecting; shoreline protection and influence of developmental activities on coastal hydrography. Climate and fisheries: Effect of marine meteorological factors on fish and fisheries. Influence of SST, precipitation, currents, weather systems, etc. on fish - El-Nino and La-nina – Possible effects of weather on long term changes in fish availability; Environmental factors influencing the seasonal variations in fish catches in the Arabian Sea and the Bay of Bengal.

Practical

Fish Biomass estimation using holistic and analytical approaches. Correlative and Mechanistic modelling of fish abundance and distribution with oceanographic variables such as water temperature, salinity, pH, nutrients, benthos, sediment characteristics etc.; Chlorophyll and Thermal fronts and Potential Fishing Zones; Oceanographic sampling

equipment and methods. Use of fish finding devices.

Suggested Readings

Cushing, D.H. (1982). *Climate and Fisheries: Academic Press*, London.

Grasshoff K, Ehrhardt M & Kremling V. 1983. *Methods of Seawater Analysis*. Verlag Chemie.

Kennish MJ. 1989. *Practical Handbook of Marine Science*. CRC Press.

Laevastu T & Hayes ML. 1981.*Fisheries Oceanography and Ecology*. Fishing News Books.

Lalli CM & Parsons TR. 1993.*Biological Oceanography: An Introduction*. Elsevier. Reddy MPM. 2007. *Ocean Environment and Fisheries.* Science Publication.

LeavastuTaivo (1993). *Mariene Climate, Weather and Fisheries; Fishing News.* (Books) Ltd., London.

LeavastuTaivo and IlmoHela (1970). *Fisheries Oceanography; Fishing News (Books)*

LeavastuTaivo and Murray L. Hayes (1981). *Fishery Oceanography and Ecology*: Fishing News (Books) Ltd., London.

Picard G.L. (1979). *Descriptive Physical Oceanography; Pergamon Press*, Oxford. Roll, H.U. (1965). *Physics of the Marine Atmosphere Academic Press*, Inc. New York.

SAAS 3125 Principles and Practice of Extension 2(1+1)

Theory

Concept, scope, principles, philosophy and objectives of extension education. Extension education: meaning, definition, nature, scope, objectives, principles, approaches and history. Types of education, formal, informal non-formal education. Elements of extension education, man himself man's environment and man's created devices. Rural Development: meaning, definition, objectives and genesis. Transfer of technology programmes like Lab to Land programme (LLP) National Demonstration (ND), Front Line Demonstration (FLD) KrishiVigyanKendras (KVK), Van VigyanKendras, Technology Assessment and Refinement Programme (TARP) of ICAR/ICFRE. Communication: meaning, definition, elements and selected models. Audio-visual aids: importance, classification and selection. Programme planning process – meaning, scope, principles and steps. Evaluation: meaning, importance and methods. Scope and importance of Participatory Rural Appraisal (PRA). Classification of

group- Rural social groups, primary and secondary groups, formal, informal group, temporary, permanent groups, references group.

Extension Teaching methods – Meaning, Definition, Functions and Classification. Individual contact methods – Farm and Home visit, Result Demonstration, Field trials – Meaning, Objectives, Steps, Merits and Demerits. Group contact methods – Group discussion, Method demonstration, Field Trips – Meaning, Objectives, Steps, Merits and Demerits. Small group discussion techniques – Lecture, Symposium, Panel, Debate, Forum, Buzz group, Workshop, Brain Storming, Seminar and Conference. Mass contact Methods – Campaign, Exhibition, KisanMela, Radio & Television – Meaning, Importance, Steps, Merits & Demerits. Factors influencing selection of Extension Teaching Methods and Combination (Media Mix) of Teaching methods. Innovative Information sources – Internet, Cyber Cafes, Video and Tele conferences, Kisan call centres, Consultancy clinics. Agricultural Journalism – Meaning, Scope and Importance, Sources of news, Types, Merits and Limitations. TOT through distance education mode. Diffusion and Adoption of Innovations – Meaning, Definition, Models of adoption Process, Innovation – Decision Process – Elements, Adopter categories and their characteristics, Factors influencing adoption process. Capacity building of Extension Personnel and Farmers – Meaning, Definition, Types of training, Training to farmers, farm women and Rural youth – FTC and KVK. Gender concerns and TOT approaches. Extension Programme Planning – Meaning, Definitions of Planning, programme, Project, Importance, Principles and Steps in Programme Development Process, Monitoring and Evaluation of Extension Programmes.

Lecture Schedule -Theory

1. Concept, scope, principles, philosophy and objectives of extension education

2. Extension education: meaning, definition, nature, scope, objectives, principles, approaches and history- Types of education: formal, informal non-formal education-Elements of extension education, man himself man’s environment and man’s created devices

3. Rural Development: meaning, definition, objectives and genesis

4. Transfer of technology programmes like Lab to Land programme (LLP) National Demonstration (ND), Front Line Demonstration (FLD) KrishiVigyanKendras (KVK), Van VigyanKendras, Technology Assessment and Refinement Programme (TARP) of ICAR/ICFRE

5. Communication: meaning, definition, elements and selected models- Audio-visual aids: importance, classification and selection

6. Programme planning process – meaning, scope, principles and steps- Evaluation: meaning, importance and methods

7. Scope and importance of Participatory Rural Appraisal (PRA)

8. Classification of group- Rural social groups, primary and secondary groups, formal, informal group, temporary, permanent groups, references group

9. Mid -term examination

10. Extension teaching methods – Meaning, Definition, Functions and Classification- Individual contact methods: Farm and Home visit, Result Demonstration, Field trials – Meaning, Objectives, Steps, Merits and Demerits- Group contact methods: Group discussion, Method demonstration, Field Trips – Meaning, Objectives, Steps, Merits and Demerits

11. Small group discussion techniques: lecture, symposium, panel, debate, forum, buzz group, workshop, brainstorming, seminar and conference- Mass contact Methods: campaign, exhibition, Kisanmela, radio & television – meaning, importance, steps, merits and demerits- Factors influencing the selection of extension teaching methods and combination (Media Mix) of teaching methods

12. Innovative information sources – internet, cyber cafes, video and teleconferences, Kisan call centres, consultancy clinics

13. Agricultural journalism – meaning, scope and importance, sources of news, types, merits and limitations- TOT through distance education mode

14. Diffusion and adoption of innovations – meaning, definition, models of the adoption process, innovation-decision process – elements, adopter categories and their characteristics, factors influencing the adoption process

15. Capacity building of extension personnel and farmers – meaning, definition, types of training, training to farmers, farm women and rural youth – FTC and KVK

16. Gender concerns and TOT approaches

17. Extension programme planning – meaning, definitions of planning, programme, project, importance, principles and steps in the programme development process, monitoring and evaluation of extension programmes

18. Final examination

Practical

Visits to study structure, functions, linkages and extension programmers of KVKs or ICAR institutes/voluntary organizations/Mahila Mandal/Village Panchayat/Van Panchayat/ State Forest Department (Social forestry wing). Group discussion at farm homesteads. Preparing individual and village level production plans. Preparation of charts, posters and flash cards. Participation in conducting exhibitions and method demonstrations/campaigns at the village level. Familiarization of the use of audio-visual aids. PRA exercises.

Simulated exercises on communication. Audio Visual aids – Meaning, Importance and Classification. Selection, Planning, Preparation, Evaluation and Presentation of visual aids. Planning & Preparation of visual aids – Charts, Posters, Over Head Projector, (OHP) Transparencies, Power Point Slides.

Practical Schedule

1-4. Visits to study structure, functions, linkages and extension programmers of KVKs or ICAR institutes/voluntary organizations/Mahila Mandal/Village Panchayat/Van Panchayat/ State Forest Department (Social forestry wing)

5-6. Group discussion at farm homesteads

7-8. Preparing individual and village-level production plans

9-11. Preparation of charts, posters and flash cards

12-13. Participation in conducting exhibitions and method demonstrations/campaigns at the village level

14. Familiarization of the use of audio-visual aids

15-17. PRA exercises-transect walk, seasonal calendar, Venn diagram, map etc.

18. Practical examination

Suggested Readings

Dahama, O.P. and Bhatnagar, O.P. (1980). Education and communication for development, Oxford & IBH Pub. Co., New Delhi.

Mishra, S.N. and Sharma, K. (1983). Problems and prospects of rural development in India. Uppal Publ. House, New Delhi.

Reddy, A.A. (1978). Extension education. Sree Laxmi Press, India.

Sandhu, A.S. (1993). Text book on agricultural communication: process and methods. Oxford & IBH Pub. Co., New Delhi.

Sandhu, A.S. (1994). Extension programme planning, Oxford & IBH Pub. Co., New Delhi. Supe, S.V. (1983). An introduction to extension education, Oxford & IBH Pub. Co., New Delhi. Waghmare, S.K. (1980). Teaching extension education, Prashant Publishers, India.

SAAS 4125 Educational Tour I 1(0+1)

Study tour of one week duration within Kerala, to familiarize the students with the climate change and environment related organizations and institutions within Kerala, including the Government and private organizations, such as IMD, CWRDM, Land use board, TBGRI, KFRI, DoECC, Institute for Climate Change Studies, KSDMA, TIES, CMFRI, KUFOS, CPCRI, CTCRI, KILA etc. To expose the students to various national / heritage monuments as part of national integration activity. (One week duration)

SAAS 4126 Educational Tour II 1(0+1)

To familiarize the students climate change and environment related organizations and institutions of different parts of India. To expose the students to various national /heritage monuments as part of national integration activity. (three weeks duration)

STUDENTS READY

CEWE 4101 Climate and Environmental Work Experience (CEWE) 20(0+20)

General orientation, Industrial Placement, Socio-economic survey & Village attachment, Attachment with Institutes/KVK/Industries/companies as internees Report Preparation, Presentation and Evaluation

Orientation

Conducting various exercises for exposing the students on the recent trends in the field of Climate change and Environmental Science, transactional analysis, personality development, soft skills etc. and to prepare students for the rigours of professional life after completing B.Sc.(CC & ES) programme.

Placement at Industrial/Local self-government organizations

Attachment with Climate Change and Environmental Science related industries. Works to be undertaken includes study the nature of industrial and business organization.

Socio Economic Surveys and Village Attachment:

Data collection, use of PRA techniques with respect to village profile including socio-

economic and cultural status, and the climate changes and environmental related challenges being faced by the villagers. Benchmark survey of the resources available in the village (cropping pattern, home steads, biodiversity etc.), Schedule development, tabulation, analysis and preparing plan of work. Understanding carbon footprint of the village and preparing a plan for making the village carbon neutral, through the participation of the villagers.

Attachment with KAU research stations/KVKs/ Institutes/ as internees

During this module the students are expected to learn about the functioning of these stations/KVKs/institutes and facilitate to address and mitigate the climate change related issues there

Report Writing and Presentation

Compilation of the work/experience detailing the objectives, places and persons visited, work done, experiences/skills gained and suggestions for improvement of training. Presentation of the report before faculty. The assessment will be based on Project Report evaluation and viva-voce.

CEWE 4102 Experiential Learning 10(0+10)

CEWE 4203 Project work 10 (0+10)

This course shall provide the B.Sc. (Hons) Climate Change and Environmental Science students an understanding of the principles and procedures of the experimental design, layout, analysis and interpretation of data and technical writing. Each student shall work on a specific research project to be identified with the help of the supervising teacher. They shall also prepare and present a proposed plan of work (PPW) specifying the objectives and procedures of the study and present the same before an audience consisting of faculty and students. The research work will be conducted leading to the preparation of a project report in the format and style of M.Sc. thesis. Evaluation will be done based on the quality of work, quality of report and its presentation before an audience consisting of faculty and students.

Every week the students should write a report of their activities and submit to the concerned field work supervisor on Mondays. The supervisor conducts individual and group conferences every week regularly. At the end of the semester Viva Voce is conducted by an external examiner and marks are awarded.