Course Code: ES 547

Course Title: Agro-Forestry and Forest Management

L2 T0 P0 CR2

Course Outcomes

CO1. Ability to demonstrate understanding of the role and importance of forest and agroforestry in livelihood development

CO2. Ability to comprehend the species composition and its functional response with respect to the prevailing micro- and macro environmental conditions.

CO3. Ability to critically examine the participation and role of community for the management and conservation of forest with due awareness of deforestation in large scale. **Course Content**

- Agroforestry and socioeconomic aspects.
- Microclimate of forest ecosystem, tree physiology, growth, forestation for waste land recovery, deforestation and its impact on environment, agri, horti, silvicultural ecosystem.
- Principles of forest management, rotation, kinds of rotation, community and joint forest management, traditional forest management.

Textbooks

- Singh M. P. and Tewari D.N., Agro-forestry and Waste Land, Anmol Publication, 1996
- Dwivedi A.P., Agro-forestry - Principles and Practices Oxford and IHB, 1992

Suggested readings

- Gadgil, M. and Guha, R., The use and abuse of Nature, Oxford University Press, 2002.
- Singh, P.et al (eds.), Agro-forestry Systems for Sustainable Land Use, Science Publisher, 2000.
- Wojtkowski, P. A., Theory and Practices of Agro-forestry Design, Science Publisher, 2004.
- Wojtkowski, P.A., Agrocological Perspectives in Agronomy, Forestry and Agro-forestry, Science Publisher, 2004.

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Course Code: ES 550

Course Title: Project

L0 T0 P14 CR14

Course Outcomes

CO1. Ability to identify the gap based to a survey of the relevant literature.

CO2. Ability to undertake field and laboratory experiments in a systematic way.

CO3. Ability to work independently on a scientific question and arrive at a conclusion.

CO4. Ability to communicate the work undertaken effectively.

Course Content

Each student is required to work for at least one semester on a research project assigned by a teacher. The projects are offered afresh every year. The project report is required to be submitted before the end semester examination of the IV semester. The evaluation includes a viva-voce examination by the students' advisory committee

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Controller of Examinations
Tezpur University
Tezpur, Assam

Course Code: ES 552

Course Title: Statistical Methods and Environmental Application

L2 T0 P1 CR3

Course Outcomes

CO1. Ability to demonstrate sound understanding on descriptive and analytical statistics **CO2.**

Ability to suitably apply useful statistical software (R, SPSS, Minitab, etc.).

CO3. Ability to perform vital statistical estimation and interpret the underlying relationships among target variables.

CO4. Ability to apply the knowledge on probability and other forms of distributions (Normal, Poisson etc.) for data analysis.

Course Content

- Introduction to statistics, Sampling, Data collection and recording
- Linear Programming, Graphical and Simplex methods, Measures of central tendency, dispersion,
- Moments, Skewness and Kurtosis, Probability, Conditional probability, Bayes' theorem
- Random variable – two dimensional random variables – standard probability distributions Binomial Poisson and normal distributions - moment generating function
- Sampling distributions – confidence interval estimation of population parameters – testing of Hypotheses – Large sample tests for mean and proportion – t-test, F-test and Chi-square test – Curve fitting-method of least squares
- Regression and correlation – rank correlation – multiple and partial correlation – analysis of variance-one way and two way classifications – experimental design – Latin square design
- Time series analysis
- Difference among means: F-test: 1 way ANOVA; F-test: 2 ways ANOVA. Computer applications in environmental modeling. Computer-based modeling: Linear, regression, validation and forecasting. Computer-based modeling for population and population studies.
- Application in environmental research
- Practical on every topic using Excel, SPSS and STATISTICA

Textbooks

Bowker and Liberman, Engineering Statistics, Prentice-Hall, 1972.

- Venkatraman, M.K., Numerical Methods in Science and Engineering, National Publisher Company, 1999

Suggested readings

- Berthouex, P.U., Statistics for Environmental Engineers , Lewis Publ., 1994
- Wayne R., Ott Environmental Statistics and Data Analysis, CRC Press. (1995)
- Spiegel M. R., and Stephens L.J. Schaum's outline of theory and problems of Statistics. McGraw Hill, Singapore, 1999.

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Course Code: ES 554

Course Title: Earth Processes and Natural Hazards

L3 T0 P0 CR3

Course Outcomes

CO1. Understand the geophysical processes as the drivers of different types of hazards.

CO2. Appreciate how human activities interface with the geophysical processes in causing and/or accentuating natural hazard.

CO3. Learn the mitigation approaches, their choices and alternatives.

CO4. Develop foundations for hazard, risk and vulnerability assessment

Course Content

Origin of earth, evolution earth's mantle and crust, continental drift, plate tectonics, sea floor spreading, seismic waves, plate boundaries;

- Exogenetic processes and landforms - denudation, fluvial, aeolian and glacial landforms; Runoff process- generation, component, catchment process;
- Rocks – types, formation, minerals, rock cycle. Chemical and mineralogical composition of the earth, abundance of elements, geochemical classification of elements, major and trace elements and their partitioning during mineral formation. Biogeochemical Cycles
- Natural hazards- definitions and associated concepts; River flooding- river system, causes and accentuating factors of flooding, effects of flooding, response to flood hazards; Earthquake - worlds earthquake zones, seismic study of Indo-Burma region, hazards associated with earthquakes, response to earthquake hazards; Drought- cause and impact, mitigation and adaptation; Cyclones- cause, frequency and trajectory of tropical cyclone over BB and Arabian Sea, impact of cyclone, mitigation and adaptation. Landslides Common causes of landslides, slope failure, slope stability, prevention and correction methods **Textbooks**
- Bell F.G., Geological Hazards: Their Assessment, Avoidance & Mitigation, Taylor and Francis, 2003.
- Don L. Anderson, Theory of the Earth. Blackwell Scientific Publications, 1989.

Suggested readings

- Smith K.and Ward R., Floods: Physical Process and Human Impacts, John Wiley and Sons, 1998
- Kale V.S., Flood studies in India, Geological Society of India, 1998
- Krauskopf K.B. and Bird D.K., Introduction to Geochemistry. McGraw-Hill, 1994.
- Bell F.G., Environmental Geology - Principles and Practice, Blackwell Science, 1998.

Course Code: ES 555

Course Title: Environmental Chemistry and Toxicology

L2 T0 P1 CR3

Course Outcomes

CO1. Ability to demonstrate sound understanding of the concept of Environmental Chemistry and Environmental Toxicology

CO2. Ability to Summarize the most relevant terms, principles, and methods in environmental toxicology

CO3. Ability to recognize the importance of environmental changes and understand various aspects of air, soil and water chemistry

Course Content

- Introduction concept and scope of environmental chemistry and green chemistry; Stoichiometry; Chemical Thermodynamics - Gibb's energy ,chemical potential, Gibb's phase equilibria , equilibrium of chemical reactions;
- Chemical Kinetics: Simple reaction mechanisms, order and molecularity of chemical reactions, First, second and zero order reactions, Catalysis, Adsorption;
- Chemistry of the atmosphere – gases and particles, atmospheric reactions, Chemistry of Photooxidants, Chemistry of atmospheric precipitation
- Chemical species in water; The carbonate system, organic matter and humic matter in water , acid base reactions, pH and pOH, ionic product of water, common ion effect, buffer solutions solubility of gases in water, solubility and solubility product, hydrolysis, chemical equilibrium, oxidation and reduction, radionuclides,
- Environmental Toxicology: Introduction to Environmental Toxicology, Concepts of Toxicology, Dose-Response Relationships, Absorption of Toxicants, , Toxic substances in the environment, Biochemical impacts of toxic substances, their sources and entry roots, Pesticide Residues, Eco-system influence on the fate and transport of toxicants; Transport of toxicants by air and water; Transport through food chain - bio-transformation and biomagnification.

Textbooks

- De A.K., Environmental Chemistry, Wiley Eastern Limited, 1990
- Manahan S.E., Fundamental of Environmental Chemistry, Lewis, 2001

Suggested readings

- Ibanez, J.B., Hernandez-esparza, M.H., Doris Serrano Arthuro Fregoso-Infante ,C., Singh, M.M. (2007). Environmental Chemistry Fundamentals, Springer.

- Fifield, F.W. and P.J.Haines (Eds), P.J. (1998). Environmental Analytical Chemistry, Blackwell.
- Keith, L.H.(edtr).(1988). Principles of Environmental Sampling, American Chemical Society.
- Clesceri, L.S.(1998). Standard Methods for Examination of Water and Waste Water, American Public Health Association, 28th Edition.
- Lodge, J.P. Jr. (edtr). (1988). Methods of Air Sampling and Analysis, Lewis.
- Neil, P.O. (1994). Environmental Chemistry, Champman & Hall.
- Shaw I.C. and Chadwick J., Principles of Environmental Toxicology, Taylor& Francis ltd, 2008
- Gupta P.K., Methods in Environmental Analysis- Water, Soil and Air, Agrobios, 2000 Connell D.W., Basic Concept of Environmental Chemistry, Lewis, 1997

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Course Code: ES 556

Course Title: Solid Waste Management and Technology

L2 T0 P1 CR3

Course Outcomes

CO1. Ability to demonstrate sound understanding of the waste generation process and characteristics of different types of solid wastes.

CO2. Ability to address the waste management processes through cradle-to-grave perspectives.

CO3. Ability to assess the underlying science behind the waste driven pollution.

CO4. Ability to apply recycling vis-à-vis resource recovery technologies for useful conversion of specific waste type to eco-friendly products.

Course Content

- Municipal Solid waste –Definitions, sources, generation, segregation, classification and physico-chemical characterization; principles of solid waste management
- Hazardous wastes: definition, source, effects and management;
- Biomedical wastes: definition, source, effects and management; E-waste generation & management; Eco friendly disposal methods of solid wastes.
- Flyash: definition, source, effects and management
- Waste treatment technologies for resource and energy recovery - basic principles; techniques of resource & energy recovery; composting, vermicomposting, microbial decay, anaerobic digestion, incineration, pyrolysis.; landfill engineering and leachate management; mining of old landfills; advances in waste recycling and recovery technologies to deliver added-value products.

  Interface of waste and resource management and engineering in the context of sustainable waste management in global cities and developing countries; life cycle analysis. **Textbooks**

- White P.R. et al, Integrated Solid Waste Management, Lewis Publisher, 1989.
- Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Urban Development, Govt. of India, New Delhi, 2000

Suggested readings

 David L.H.F. and Liptak D. G., Hazardous waste and solid waste, Lewis Publisher, 2000

Oberoi N.K, Environmental Management, (2nd Edition) Excel Books, New Delhi, 2003. ***

Course Code: ES 557

Course Title: Climatology and Meteorology

L2 T0 P0 CR2

Course Outcomes

CO1. Ability to demonstrate sound understanding of the atmosphere and climate as integral part of the physical environment.

CO2. Ability to appreciate the interaction between earth and atmosphere system, particularly the microclimate

CO3. Ability to integrate and use meteorological knowledge in the matrices of environmental research

Course Content

- The earth and the atmosphere system, Overview of the structure and composition of the atmosphere; Energy for the earth-atmosphere- sun relation, rotation revolution and variation of energy received, radiation and atmospheric interaction.
- Meteorology fundamentals-, temperature; pressure, pressure belts, wind and atmospheric circulation; atmospheric moisture- , condensation, formation of precipitation, dew, fog and clouds; atmospheric stability (-lapse rate, adiabatic process, mixing height.)
- Micrometeorology- introduction to ABL, microclimate of vegetated surface, urban microclimate- factors that modifies meteorological process in urban area, modified process and observed results, UHI, thermal comfort.
- Weather system- Tropical system- equatorial trough, ITCZ, jet streams, vortices; monsoon, El-Nino
- Climate- elements of climate, climate control; classification of climate, degree days, thermal comfort.
- Climate of India; spatial and temporal patterns of climatic parameters- temperature, rainfall and its variability in India with special reference to N.E.

Textbooks

- Ahrensand R C. D., Hensen. Meteorology Today: An Introduction to weather climate and the Environment. 10th Edition. Brookes/ Cole Cengage Learning Learning, 2013
- Oliver J.E. and. Hidore J.J., Climatology: An atmospheric science, Second Edition, Pearson Education, 2003

Suggested readings

- Wang B., The Asian Monsoon. Springer Praxis Publishing, 2006
- Thornthwaite C. W., An Approach toward a Rational Classification of climate. Geographical Review, 38(1), 59-94, 1948

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Course Code: ES 558

Course Title: Environmental Biology

L2 T0 P1 CR3

Course Outcomes

CO1. Ability to demonstrate comprehensive understanding of the pollution damage to flora and fauna.

CO2. Ability to recognize and describe how both plants and animals respond to pollutants and tolerance mechanism.

CO3. Ability to realize the usefulness of flora and fauna for pollution control mechanism

Course Content:

- Major environmental pollutants and their impact on plant and animal systems
- Damage of cell ultrastructure due to atmospheric pollutant, mode of action Visible symptoms of air pollution damage in plants, chlorosis and necrosis
- Transmission of pollutants in plants
- Response of animals to environmental pollutant
- Potential hazards of nitrates, chlorine, arsenic and polycyclic organic hydrocarbons in human health.
- Biological monitoring, bio indicators and control of environmental pollution
- Xenobiotics and microbial transformation of pollutants in the soil
- Biodiversity and its conservation:- Definition, hotspots of biodiversity, strategies for biodiversity conservation, protected areas, gene pool

  Impact of radiation on biological system
- Fermentation technology and biofertilizer technology Soil microorganisms and their functions.
- Physical techniques used in biology.

Practical: Experimental observation on effect of acid rain on plants; effect of water pollution in flora and fauna, effect of air pollution in flora and fauna, study on bioremediation. Study of some soil microorganisms through collection of sample.

Textbooks

- Bell J.N.B., Air Pollution and Plant Life, 2nd Edition, John Wiley and Sons, 2002

- Ming-Ho Yo., Environmental Toxology-Biological and Health Effects of Pollutant, Third Edition, CRC Press, 2011.

.

Suggested readings

- Krishnamurthy, K.V., An Advanced Text Bookon Biodiversity- Principle and Practices, Oxford & IBH Publishing, 2004.
- Bertold, Hock and Erich, F. F. Elstner. (eds), Plant Toxicology, Fourth Editon, CRC Press, 2004
- Mari S. Golub (Ed), Metals, Fertility and Reproductive Toxicity, CRC Press, 2005.
- Stanley, E.Manahan, Environmental Chemistry,Eightedition,CRC Press, 2004.
- Saradhi P.P., Biophysical processes in living systems, Oxford & IBH Publishing, 2008.
- Prosser C. Ladd., (editor). Comparative Animal Physiology, fourth edition, Wiley-Liss, New York, 1991.

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Course Code: ES 559

Course Title: Environmental Physics

L3 T0 P0 CR3

Course Outcomes

CO1. Ability to demonstrate understanding of the inherent forces and flows responsible for various naturally occurring events.

CO2. Ability to apply the theory to quantify the fluxes across the interfaces.

CO3. Ability to solve simple transport problems in natural environment

Course Content

- Basic Mathematics: Elementary Vector Operations; Taylor Series; Exact Differential; Partial Differential Equations; Gauss's theorem; Stoke's theorem; Potential Function; Solid angle.
- Properties of Gases and Liquids: Physical properties of gases such as density, heat capacity, and molecular diffusivity, exchanges between organisms or land surfaces and their environment; Evaporation of water from soils, plants, and animals, surface water bodies; Cloud Physics.
- Transport of Heat, Mass and Momentum: Transport of heat, mass, and momentum in the atmosphere across different interface such as soil, vegetation, water. Mass transfer by Gases, water vapour and particles. Mass diffusion, Mass exchange between air, plants and animals. Properties of turbulence, Roughness parameters, Aerodynamic resistance, Bowen ratio, flux gradients, wind speed gradients. Turbulent transfer, profiles and fluxes across vegetation canopies. General equation for transport within a gas. Verticle fluxes, Eddy Covariance. Conduction, Convection and Advection in gases, liquids and solids. Diffusion coefficients for momentum, heat, water vapor, and other gases and dependence on temperature. Transient heat balance. Sensible heat flux, latent heat flux.

- Radiation Environment: Properties of Electromagnetic radiation, Principles of radiation absorption and emission, Concepts of BlackBody, Wein's law, Kirchoff's law, Planck's law, Stefan-Boltzman's law; Radiative exchange between layers and surfaces, radiative resistance; Cosine law, Spectral reflectivity and absorptivity, Beer's law, Kubelka-Munk Equations. Irradiance and radiance. Principle of scattering and absorption of shortwave and long wave radiation, Aerosol Optical depth, Single scattering Albedo, Radiation balance, concept of radiative forcing.

Textbooks

- Monteith J. and Unsworth, M., Principles of Environmental Physics: Plants, Animals, and the Atmosphere, 4e, Academic Press, 2013.
- Campbell G.S., Norman, J.M., An Introduction to Environmental Biophysics, 2e, SpringerVerlag, New York, 1997.

Suggested readings

- Petty, G.W., A First Course in Atmospheric Radiation, second ed. Sundog Publishing, 2006.
- Foken, T. Micrometeorology. Springer-Verlag, Berlin, Heidelberg, 2008.

  Jacobson, Mark Z., Fundamentals of Atmospheric Modelling, Cambridge University Press, 2005.

- Iqbal M., Introduction to solar Radiation, Academic press, 1983.

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Course Code: ES 560

Course Title: GIS-Remote Sensing and Application

L1 T0 P1 CR2

Course Outcomes

CO1. Building the foundation for understanding Remote Sensing and Geographic Information System (RS-GIS) as a powerful tool for geospatial analysis

CO2. Learn about data and sources (RS based and other sources, field data) and GIS software.

CO3. Develop capability to handle at least one GIS software with understanding.

CO4. Obtain basic capability in skills and functional knowledge to carry out GIS (RS-GIS) based project

Course Content

Introduction to Remote sensing – principles, spectral reflectance of earth's surface features; Data products and data sources. Applications of Remote Sensing in environmental monitoring and assessment.

Introduction to GIS – principles, digital image processing- image rectification, enhancement and mosaicking elements of map- projection, scale, coordinate systems Image interpretation classification, ground truth data and training set manipulation, accuracy assessment; introduction GPS; NDVI, overlay analysis, model running. **Textbooks**

- Jense J. R., Remote Sensing of the Environment – An earth resource perspective. Pearson Education, 2009 .
- Lillesand T. M., Remote Sensing and Image Interpretation. John Wiley, 2004.

Suggested reading

- Burrough P.A. and McDonnell R.A., Principles of Geographical Information Systems. 2nd Edition, Oxford University Press, 2006.

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Course Code: ES 562

Course Title: Analytical Methods

L3 T0 P0 CR3

Course Outcomes

CO1. Ability to demonstrate sound understanding of analytical techniques applied in environmental analyses.

CO2. Ability to design of monitoring and analytical experiments and conclude the findings.

CO3. Ability to deal with QA/QC of analytical protocols.

Course Content

- Introduction: Interaction of electromagnetic radiation with matter, transition probability and selection rules
- Rotational and vibrational spectroscopy: Introduction, Infrared spectroscopy of diatomic molecules, FT-IR instrumentation
- Raman spectroscopy: Raman Effect, rotational and vibrational Raman spectroscopy;
- Electronic spectroscopy: Introduction, electronic spectroscopy, basic principle, electronic transitions in organic molecules, Franck-Condon, selection rules, Photoelectron spectroscopy, fluorescence and phosphorescence
- Separation Methods: Principle of chromatography, Classifications of chromatography, Techniques of planar and column chromatography, Gas chromatography, High-performance liquid chromatography
- X-ray methods: X-ray diffraction, X-ray fluorescence and X-ray absorption, and X-ray emission spectroscopy

  Optical Spectroscopy: Transmission electron microscopy (TEM), and Scanning electron microscopy
- Atomic absorption spectroscopy (AAS), Inductively coupled plasma mass spectroscopy (ICPMS), ICP-AES, ICP-OES

Textbooks

- Rouessac, Francis, and Annick Rouessac. Chemical analysis: modern instrumentation methods and techniques. John Wiley & Sons, 2013.
- Kemp W., Organic Spectroscopy, ELBS Macmillan, 1991.

Suggested readings

- Helfrick D. and W. D., Cooper Modern Electronic Instrumentation and Measurement Techniques, Prentice Hall of India, New Delhi, 1997.

- Sharma. B.K., Industrial Methods of Chemical Analysis, Krishna Prakashan, Meerut. Sareen K., Instrumental Methods of Environmental Analysis, DVS Publisher, 2001. Fifield F.W. (ed)., Environmental Analytical Chemistry, Blackwell, 1998.
- Dina T.V. (ed), Chemical Analysis of Polycyclic Aeromatic Compounds, Willey, 1998.
- Banwell C. N. and McCash E. M., Fundamentals of Molecular Spectroscopy 5th ed, McGraw-Hill, 2013.
- Hollas J. M., Modern Spectroscopy, 4th edition, John Wiley & Sons, Ltd., Chichester, 2004
- Williams D. H. and Fleming I., Spectroscopic methods in organic chemistry, Tata McGraw Hill. 1988.

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Course Code: ES 563

Course Title: Environmental Impact Assessment

L2 T0 P0 CR2

Course Outcomes

CO1. Ability to appreciate the philosophies and historical development of EIA in India and elsewhere.

CO2. Ability to demonstrate sound understanding of the EIA process and the methodologies to prepare an EIS.

CO3. Ability to critically examine development actions with the fundamentals understanding of EIA and sustainable development.

Course Content

- Definition of nature of environment, project , stages of project and impact
- Introduction and Principle – purpose of EIA, Sustainable development and EIA
- Origin and development of EIA
- The EIA Process – methodologies and practice
- Early stages - Screening, Scoping and consideration of alternatives
- Baseline studies
- Impact identification and prediction, evaluation, and mitigation – Environmental Management plan
- Public consultation and participation
- EIA presentation, The EIS, review and decision making
- Post decision making EIA – monitoring and Audit
- The Indian EIA regime – guidelines and notifications
- Environmental priorities in India and sustainable development.
- EIA case studies – River Valley Project, Township, Oil Refinery, Highway
- Development issues in the Northeast India

Textbooks

- Glasson, The rival and Chadwick, Introduction to Environmental Impact Assessment, Routledge, 2005
- Morgan R. K., Environmental Impact Assessment - A Methodological Approach, Springer 1998

Suggested readings

- Carter E.L., Environmental Impact Assessment, McGraw-Hill Education, 1996
- All guidelines and notifications of Government of India

Course Code: ES 564

Course Title: Agriculture & Environmental Sustainability

L2 T0 P0 v Course Outcomes

CO1. Ability to demonstrate sound understanding of the concepts of sustainability and agricultural systems.

CO2. Ability to identifying intricate relationships among crop growth and microclimatic conditions.

CO3. Ability to appreciate disease-pest cycle and epidemiology and apply in the field.

CO4. Ability to delve into the current agricultural perspectives and issues pertaining to North East India.

Course Content

- Agroclimatic zones of India & N E India; heat unit concept; thermal time and thermal use efficiency; cardinal temperature; photoperiodism; thermoperiodism; phenology of crops; meteorological factors associated with pest and disease incidence (potato blight; apple scan; groundnut red hairy caterpillar; locust etc); growing seasons and botanical features of major crops (rice; wheat; maize; sugarcane; rapeseed & mustard and pulses).
- Micrometerology- microclimate and micrometereology of crops; day and night radiation, humidity, temperature, wind and CO2 profiles in crop canopies; different methods and modification of field microclimate; light interception of crop canopies as influenced by leaf area index; leaf arrangements and leaf transmissibility; extinction coefficient and radiation use efficiency.
- Evapotranspiration- concepts of water balance; evapotransipiration (ET): potential and actual ET, consumptive use and different approaches of ET determination; water use and water useefficiency; dry matter production and crop yield functions; irrigation scheduling based on ET.
- Agricultural pollution and sustainability - Agricultural pollutants and their remediation with special reference to agrochemical (pesticides and fertilizers) and heavy metals; Sustainable agriculture; soil erosion; desertification, watershed management and dryland agriculture.
- Special features of North East agriculture - Hill ecosystem; shifting cultivation in hill states and impact on environment; biomass burning and its impact.Interaction between agriculture and landscape degradation; Flood damage on ecosystem due to Brahmaputra flood and related environmental problems; vegetation recovery in degraded land and sandy areas caused by flood.

Textbooks

- Reddy T.Y. and Reddi G.H.S., Principles of Agronomy; Kalyani Publishers, 2010.
- Panda S.C., Agrometeorology and Contingent Crop Planning; Agrobios (India), 2010.
- Arakeri H.R. and Roy D.; Principles of Soil Conservation and Water Management; Oxford IBH Pub. Co. Pvt. Ltd.; 2000.

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Controller of Examinations
Tezpur University
Tezpur, Assam

Course Code: ES 565

Course Title: Environmental Pollution and Management

L2 T0 P1 CR3

Course Outcomes

CO1. Ability to identify and quantify the magnitude and intensity of Environmental pollution problems.

CO2. Ability to undertake environmental sampling and analysis with respect to air, water and noise pollution.

CO3. Ability to suggest the environmental control /management plan for environmental pollution problems.

Course Content

- Introduction- Definition, Great pollution disasters , Modern pollution issues, Role of individual in pollution prevention, Risk and benefits associated with pollution.
- Air pollution-Source and emission of air pollutant, Pollutant transport and properties of air pollutants, Health effects and source control, Trans boundary pollution, acid rain, Air Pollution Monitoring, air quality standards, Regulations and abatement of air pollutants.
- Water pollution-Introduction of water quality, Characteristics of water, Classification of pollutants, Concept of concentration , Water monitoring and water quality guidelines, Organic and Inorganic Pollutants, Cause and effect of water pollution , Counter measures of water pollution, Case study.
- Noise pollution-Sources and measurement indices of noise pollution, Effect of meteorological parameters on noise propagation, Noise exposure level and standards, Noise control and abatement measures, Impact of noise on human health, Mitigation of noise pollution, Case study.
- Managing the Oceans-Implications of uncontrolled exploitation of marine resources, Cause and impact of marine pollution, Strategies for sustainable harvesting of oceanic resources, Marine pollution control and remedial action.
- Managing air, water and land- Action on the atmosphere, Strategies to reduce pollution, climate change and its impact, Need for international action and changing attitudes to deal with cause and consequences of the damage to the atmosphere, Clean, safe water strategies; Managing the land-Wetland, Agriculture/industry/urbanization induced land pollution and its mitigation, Land reclamation measures, Land management through phytoremediation and bio-remediation; Biological mediated pollution control

Textbooks

- Manahan S.E., Environmental Chemistry, Lewis, 1994.
- Moore, James W. Inorganic contaminants of surface water: research and monitoring priorities. Springer Science & Business Media, 2012.

Suggested readings

- Bell, J.N.B., Air Pollution and Plant Life, 2nd Edition, John Wiley and Sons, 2002.
- Cheremisinoff, N. P., Bio-Technology for Waste and Wastewater Treatment William Andrew Publishing, 1996.
- Fellenberg, G., Chemistry of Pollution, John Wiley and Sons, 1999.
- El-Halwagi M.M., Pollution Prevention through Process Integration, AP. 1997

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Course Code: ES 566

Course Title: Soil Science
L2 T0 P1 CR3

Course Outcomes

CO1. Ability to demonstrate the understanding of the core principles of soil science.

CO2. Ability to describe the process of soil genesis and identify soil orders/groups based on their physico-chemical properties.

CO3. Ability to ascertain relationships between soil processes and relevant environmental consequences.

CO5. Ability to train farmers/growers to establish sound soil quality maintenance practices.

Course Content

- Soil Formation: Weathering-. and Soil formation - Profile development - Soil composition. Soil forming rocks and minerals - Classification
- Soil physics: Soil separates and particle size distribution - Soil texture and structure - Bulk density, particle density, pore space, soil air, soil temperature, soil water, soil consistence - Significance of physical properties to plant growth.
- Soil chemistry: Soil colloids - Inorganic colloids - Clay minerals - amorphous - Ion exchange reactions - Organic colloids -, Soil reaction- ph, Eh, CEC, base saturation –problem soils (acid, alkaline and sodic soils); Transportation of pollutants in soil system.

- Soil biology: Soil organic matter - Decomposition - Humus formation - Significance on soil fertility, nutrient availability. Soil microorganisms and their roles in soil quality.-C:N ratio.
- Soil and climate change: effects of global warming on soils and its management- Relative importance of soil and vegetation management in global warming.
- Practical: Study of physico-chemical properties of soil collected from different areas: Soil organic carbon, Water holding capacity, pH, Bulk density, soil respiration. Soil microbial biomass carbon estimation, soil nutrient analysis (N, P, K, Ca, Mg, etc); studies on various soil working and analytical equipment and tools. **Textbooks**

- Brady N.C., and R.R. Weil. 2010. Elements of the Nature and Properties of Soils, 3rd Ed. Prentice Hall.
- Stewart B.A., Advances in soil sciences, Lewis Publisher, 2000.
- Biswas T.D. and Mukherjee S.K., Textbook of Soil Sciences, Publisher: McGraw-Hill Inc., US, 2nd edition, 1995.

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Course Code: ES 567

Course Title: Environmental Plant Physiology and Biochemistry

L2 T0 P1 CR3

Course Outcomes

CO1. Ability to appreciate physiological and biochemical responses of plants to alterations of various environmental parameters.

CO2. Ability to elucidate how plant biochemical parameters respond under changing environmental conditions

CO3. Has grown critical insight on the adaptive mechanisms of plants against stress

Course Content

- Plant growth and development in relation to environmental stress -water and temperature stress, drought stress and resistance
- Anaerobiosis in soils, the effect of anoxia on plant metabolism, plant adaptation, survival and growth in waterlogged soils.
- UV radiation and its effect on cellular processes and metabolism.
- Effect of air pollutants in light reactions in chloroplasts, photosynthesis, photorespiration and dark respiration, membrane transport
- Physiological and molecular aspects of plant tolerance to atmospheric pollutants
- Oxyradicals and scavenging systems, enzyme system associated with plant defense mechanisms, superoxidedismutase, role of stomata in plant defence system
- Bioconversion of pollutants- active vs. inactive process
- Enzymatic degradation by monooxygenase
- Role of cytochrome P 450 and its multiple forms.
- Metal toxicity: metal biomacromolecule interaction.

Textbooks

Fitter A.H. and Hay R.K.M., Environmental Physiology of Plants, Third edition, Academic Press,2001.

Park S. Nobel., Physicochemical & Environmental Plant Physiology (3rd Edition) Academic Press, 2005.

Suggested readings

- Lehninger, A, Biochemistry, Kalyani Publishers, 1993.

- Taiz, L.and Zeiger, E., Plant Physiology, Sinauer Associates, 1998.
- Pintan, Roberto., Varanini, Zeno. and Nannipieri, Paolo. (eds)., The RhizosphereBiochemistry and Organic Substances at the Soil Plant interface 2nd Edition, CRC Press, 2007
- Voet, D. and Voet, J., Biochemistry, John Wiley and Sons, 2004.
- Roger, R., Hand Book of Plant Ecophysiology Techniques, Kluwer, 2001.
- Levitt J., Responses of Plants to Environmental Stress, Volume-I, Second edition, Academic Press, New York,1972.

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Course Code: ES 568

Course Title: Hydrogeochemical Processes

L2 T0 P0 CR2

Course Outcomes

CO1. Ability to describe the major hydrogeochemical processes and parameters that control metal mobility in an aquatic system.

CO2. Ability to quantify mass balance relations and thermodynamic reactions.

CO3. Ability to explain the differences in water composition that are observed in the environment as a result of differences in soil, geology and climate.

Course Content

- Catchment hydrology-The global system, fluxes, reservoirs, and residence times;
- Evaporation, condensation, precipitation; Regional water balances and resources; Structure and properties of water ; Precipitation and Interception; Water and energy balance, Subsurface flow; Infiltration and soil moisture; Hydrographs.
- Groundwater transport - Water in natural formations (aquifer, aquitard, aquiclude etc); Hydraulic head; conductivity, permeability, storativity, and porosity; Darcy's law, advection, dispersion, adsorption and decay; Steady state groundwater flow & Flow nets; Forces on water in the unsaturated zone; Tracer techniques.
- Understanding of hydrogeochemical processes-Measurements and interpretation of water quality data; Identification of hydrogeochemical processes through Major ion chemistry, Graphical presentation, and Statistical analyses; Groundwater flow and transport models; Modeling runoff and PhreeqC, MINTEQ-A.

  Chemical Weathering- Clay mineralogy, Cation exchange and Carbonate mineral equilibrium; Silicate weathering, Carbonate weathering, Contaminant transport Adsorption processes; Hydrogeochemical processes and its role in contemporary environmental scenario.
- Arsenic and fluoride hydrogeochemistry; Remote sensing and hydrological networks; Desalination, Controlling demand and waste; Integrated water resources management;

  Case studies.

Textbooks

- Hornberger, G.M., Raffensberger, J.P., Wiberg, P.L., and Eshleman, K.N. (1998) Elements of physical hydrology. Johns Hopkins University Press, Baltimore, 302p.
- Fetter, C.W., Applied Hydrogeology 4rd ed. (2001). This text will be supplemented by material from Freeze, A. and Cherry, J., Groundwater, 1979.

Suggested readings:

- Chow, V.T., Maidment, D.R. and Mays, L.W., Applied Hydrology, Dingman, S.L., Physical Hydrology, 1998.
- Todd, D. K., and Larry W. M.. *Groundwater hydrology*. John Wiley & Sons, 2004.

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Course Code: ES 570

Course Title: Environmental Laws and Policies

L2 T0 P0 CR2

Course Outcomes

CO1. Ability to demonstrate understanding Environmental Laws and policies in India.

CO5. Ability to critically appreciate national and international laws and policies connected with India.

Course Content

- Definition, rationale, issues and problems, national and international efforts, international conventions, bilateral and multilateral conventions
- Fundamental norms, Constitution provisions in India. Division of legislative authority, The 42nd amendment act and inclusion of Art- 48A and Art- 51 A, Directive principles of state policiesEnvironmental protection and fundamental right – right to a wholesome environment, right to livelihood, right to equality.
- Laws for pollution control: The Water Act 1974 – Constitutional and legal framework, formation of pollution control boards, function and duties of the boards, scope of the act, judicial review under the act, The Air Act 1981- Legal framework and scope, Air pollution control areas, Air pollution standards. The Environment Protection Act' 1986 – Introduction, scope of the act, delegated legislations – pollution control, hazardous substance regulation, EIA, Coastal Regulations and Protection of special areas, The Ecomark Scheme, Violation and penalties under the act.
- Forest Laws and policies: The Forest Act 1927 – Scope of the act, different types of forests under the act, reserve forests – demarcations and declarations, rights of people and the forest act.The Forest (Conservation) Act 1980 – The background and imperatives, scope of the act. National Forest Policy. The Wildlife Protection Act 1972 – Constitutional framework, scope and implementation, wildlife advisory boards, inclusion of plant species as wildlife, violations of the act and actions.
- Laws for social justice: The Biodiversity Act 2002 – Scope and salient features; The Forest Dwellers Act 2006 – The rationale, definitions of various terms, provisions of the act, the rights conferred under the act to the forest dwellers, discussion.
- No-fault liability, Public liability Insurance Act 1991
- Case studies – Bhopal gas tragedy, Taj Trapezium Case, Poaching of Rhino, patents and geographical indicators, Issues of the Brahmaputra River **Textbooks:**

- Divan S. and Roseneranz A., Environmental Law and Policy in India: cases, materials and statues, Oxford University Press, 2002
- Singh G., Environmental Laws in India, McMillan Publisher, 2005

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Course Code: ES 571

Course Title: Climate Change and Its Impacts

L2 T0 P0 CR2

Course Outcomes

CO1. Ability to demonstrate understanding of the changing climate.

CO2. Ability to appreciate the ecosystem responses to climate change

CO3. Ability to critically examine the technological interventions for mitigating the climate change impacts.

Course Content

- Climate- past and present, dendroclimatology, tree rings and carbon isotope in the study of climatological changes
- Climate change- natural and anthropogenic causes
- Greenhouse gas emission from anthropogenic sources
- CO_2 -global carbon deposits, sinks and sources, carbon sequestration, carbon auditing
- Effect of elevated CO_2 on ecosystem growth and productivity
- Methane- sources and sinks, methane emission from wetlands
- Nitrous oxide- its chemistry, sources and sinks
- Nitrous oxide emission from agricultural soil
- Mitigation of GHGs in relation to climate change
- Climate change and impact on horticultural and plantation crops and impact on ecosystems and human health
- Future climate scenarios.

Textbooks

- Bengtsson F. O., Geosphere Biosphere Interaction and Climate, CambridgeUniversity Press, 2001
- Berdowski J., Guichert R. and Heil B., The Climate System, A.A. Blakema Publisher, 2000

Suggested readings

- Halmann, M.M. and Steinberg M., Greenhouse Gas Carbondioxide Mitigation, Lewis Publisher, 1999.
- Lal, R.et al (ed), Global Climate Change and Tropical Ecosystem, CRS Press, 2000.
- Faure, G. and Mensing, T.M., Isotopes : Principles and Applicatins, John Wily and Sons, 2004.
- Kendal, Mc. Guffie, Climate Modeling, Willey Inter Science, 2003.

Harrington , J., The Climate Diet-How you can cut carbon, cut costs and save the planet, Earthscan, 2008.

- Climate Change: The Scientific Basis, Contribution of Working group I to the third Assessment Report of Inter-Governmental Panel on Climate Change, 2001.
- Climate Change: Impact Adaptation and Vulnerability, Contribution of Working group II to the third Assessment Report of Inter-Governmental Panel on Climate Change, 2001.
- Climate Change: Mitigation, Contribution of Working group III to the third Assessment Report of Inter-Governmental Panel on Climate Change, 2001.
- Hardy J. T., Climate Change: Causes, effects and solutions, John Wiley and Sons, 2003.
- Horel J.and Geisler Jack., Global Environmental Change: An atmospheric perspective, John Wiley and Sons, 1997

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Course Code: ES 572

Course Title: Natural Resource and Biodiversity Conservation

L3 T0 P0 CR3

Course Outcomes

CO1. Understand systematically the natural resources and biodiversity and its vital role.

CO2. Sensitize the role and need of biodiversity conservation in the context of various developmental pathways of mankind.

CO3. Examined the policy framework within which the development processes are designed.

CO4. Estimate the significance of biodiversity of Northeast India.

Course Content

- Natural resource - introduction to earth's natural resources, types of natural resources and their classification, value of natural resources, extraction and uses of natural resourceslinkages and benefits. Potentiality of natural resources for economic and livelihood development.
  Conservation and management of natural resources- humans and conservation vice-versa, conservation and protection, sustainable use of natural resources. Natural resource management approaches: Community based natural resource management (CBNRM) and Integrated natural resource management (INRM).
- Biodiversity - understanding biodiversity, dimensions of biodiversity, taxonomic diversity, speciation and extinction of species, mass extinction events, measurement of biodiversity: diversity indices. Megadiverse countries, Ecoregions, Biodiversity hotspots. Importance of biodiversity, threats to biodiversity, causes and consequences of biodiversity loss, biodiversity and vulnerability to climate change, biodiversity and human health.
- Natural resources and biodiversity in India and Northeast India- biogeographic region of India, significance of NE India biodiversity, important forest resources and their diversity in NE India -medicinal plants, bamboo, orchids, palms, rattans, timbers, gymnosperm etc. Endemic and rare species biodiversity conservation with reference to NE India. Case studies.
- Conservation of biodiversity: in situ and ex situ, selection criteria for protection of species, IUCN conservation status, Red Data book, ethics in conservation of biodiversity. Biodiversity related national and international conventions and organizations.
- Management of biodiversity - Sacred groves, Community reserve forest, Reserve forests, National Parks, Wildlife Sanctuary, Biosphere Reserve, Private/corporate forest. Traditional ecological knowledge, CBD, Participatory Rural Appraisal (PRA), Constrains of conservation.

Textbooks

- Krishnamurthy K. V., Textbook of Biodiversity, CRC Press, 2003.

- Krishnamurthy K. V., An Advanced Textbook on Biodiversity: principles and Practice, Oxford & IBH Pub. Co. Pvt. Ltd., 2008.

Suggested readings:

- Anne, E. Magurran, Measuring Biological Diversity. Wiley-Blackwell, 2003.
- Anne, E. Magurran and Brian, J., Biological Diversity Frontiers in Measurement and Assessment. McGill (Eds.), Oxford University Press, 2010.
- Joshi, P. C. and Joshi, N., Biodiversity and conservation. A.P.H. Pub., 2004.
- Gabriel, M., Biodiversity and conservation. Science, University of Michigan, 2001.
- Pandey, B.N. (2012). Biodiversity Issues Threats and Conservation. Narendra Publishing, 2012.
- Navjot, S. Sodhi and Paul R., Conservation Biology for All. Ehrlich (Eds.) , Oxford University Press, 2010.
- Gary A. K., Conservation of Natural Resources. Prentice Hall College Div., 1991.
- Rai, G. D., Non-conventional energy sources. Khanna Publishers, New Delhi, 1997.
- Maiti Prabodh K. and Maiti Paulami., Biodiversity: Perception, Peril and Preservation, PHI, New Delhi, 2001.

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Course Code: ES 574

Course Title: Laboratory Safety

L2 T0 P0 CR2

Course Outcomes

CO1. Understand the general knowledge of good laboratory safety practices and the laboratory safety rules.

CO2. Evaluate Standard Operating Procedures (SOPs) and safety plans for handling dangerous samples, equipments and chemicals.

CO3. Ability to handle experimental data using statistical tools/methods **Course Content**

- Basic laboratory manners, Common-Sense Rules, Experimental Data Recording, Possible laboratory hazards, Safety, Security and Risk assessment, Handling dangerous equipments, Accidents and First-aid, Procedures after the first aid
- Handling of high pressured gas, Classification of hazardous chemicals, Chemical regulations, Development of instrument management system, Maintenance of instruments and Importance of instrument calibration, Quality control and Quality assurance

  Types of experimental waste, Classification of hazardous wastewater, Handling of unknown chemicals, Material Safety Data Sheet (MSDS), Pollutant Release and Transfer Register (PRTR)
- Statistical handling of experimental data, Measure of central tendency and symmetry, Hypothesis formulation and hypothesis testing, Check lists before producing data, Common statistical errors, Scientific Fraud and Ethics, Distributed materials and web sources, Reference management

Textbooks

- Jeffery, G.H., Bassett, J., Mendham, J., Denny, R.C. Textbook of quantitative chemical analysis, (John Wiley & Sons, 1998)
- KeithFurr, A. Handbook of Laboratory Safety, (CRC Press, 5th edition, 2000. **Suggested readings**

- Patnaik, P. Analytical Chemistry Handbook, McGraw-Hill, 2004. □ Cazes, J. Analytical instrumentation Handbook, CRC Press, 2005.
- Armour, M.A. Hazardous Laboratory Chemicals Disposal Guide, CRC Press, 3rd edition, 2003.

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Course Code: ES 575

Course Title: Atmospheric Chemistry

CR2 L2 T0 P0

Course Outcomes

CO1. Understand the physics and chemistry of atmosphere.

CO2. Understand the processes and mechanisms of change in the atmosphere.

CO3. Understand the Processes of transport and deposition.

CO4. Develop critical thinking in the matter of physicochemical changes in the atmosphere.

Course Content

- Introduction to the Atmosphere
- Genesis of the atmosphere
- Measures of atmospheric compositions – mixing ratio, number density, partial pressure
- Global circulation – atmospheric transport: Geotrophic flow, general circulation, vertical transport, atmospheric stability, Turbulence

Photochemistry and spectroscopy –Principle, fate of excited molecule

- Chemistry of aerosol
- Chemistry of trace gaseous – NO_x, SO_x, Ozone, Hydrocarbon, Chemistry of smog, Gas phase chemistry of NO_x,-O_3, VOC
- Chemistry of PoPs in the atmosphere and their fate
- Oxidising power of the troposphere - The Hydroxy radical and oxidants
- Stratospheric ozone chemistry
- Atmospheric chemistry of climate forcing gases and particles
- Basic atmospheric chemistry models

Textbooks

- Seinfeld, J. H., & Pandis, S. N., Atmospheric chemistry and physics: from air pollution to climate change. John Wiley & Sons, 2016.
- Jacob D. J, Introduction to Atmospheric Chemistry, Princeton, 2004 **Suggested Readings**

(Journals)

- Atmospheric Environment
- Chemical review
- Journal of Atmospheric chemistry and Physics
- Environmental Science and Technology

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Course Code: ES 576

Course Title: Environmental Systems Analysis

L3 T0 P0 CR3

Course Outcomes

CO1. Ability to demonstrate sound understanding of environmental systems analysis (ESA).

CO2. Ability to impart knowledge on ESA and its applications in interdisciplinary studies.

CO3. Ability to apply ESA tools in sustainable environmental management.

CO4. Ability to implement ESA tools in decision making processes.

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Course Content

- Introduction to Environmental Systems Analysis (ESA), identification and description of ESA, concepts and methods, particularly in the ecosystem services framework
- Environmental system boundaries and scale: environmental system boundaries – physical boundaries relating to interface between hydrosphere, lithosphere, biosphere and the atmosphere, closed system and open system, environmental system existence in spatial scales (microscopic and macroscopic), hierarchical organization – system, sub-system and system components (or system element)
  ESA tools: Life Cycle Assessment (LCA), Life Cycle Costing (LCC), Cost-Effectiveness Analysis (CEA), Material Input Per unit Service (MIPS), Material Flow Analysis (MFA), Risk Assessment (RA), Strategic Environmental Assessment (SEA), Environmental Impact Assessment (EIA), Environmental Management Systems (EMS), Energy Analysis (EA), Economic Valuation (EV), Carbon Footprint (CF), and Ecological Footprint (EF)
- ESA in decision-making: Analyzing decision problem (goals, decision or control variables), basic information on roles of environmental system models (structure, parameter, interconnections, computer simulation, testing, validity and sensitivity, solving the decision problems by scenario analysis, optimization and control, decision strategies, planning, etc.)
- ESA Methodologies: Data collection, data source and data management, data validation, data interpretation, statistical analysis (application software – R, SPSS, etc.)
- Application of ESA tools: Climate change, waste management, natural hazards, biodiversity conservation, agriculture, sustainable management of natural resources, best practice management, case-studies

Textbooks

- Charles Eccleston, J. Peyton Doub Y., Effective Environmental Assessments: How to Manage and Prepare NEPA EAs. CRC Press, 2001.

- Mike J. Barnsley, Environmental Modeling: A Practical Introduction, CRC Press, 2007

Suggested readings

- Anjaneyulu, Valli Manickam, Environmental Impact Assessment Methodologies, CRC Press, 2011.
- Walter J. Weber, Jr., Francis A. DiGiano, Process Dynamics in Environmental Systems, Wiley, 1996.
- Miguel F. Acevedo, Simulation of Ecological and Environmental Models, CRC Press, 2012.

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