

**SYLLABUS  
(Credit based)**

**FOR**

**M.Sc. Programme**

**In**

**Environment Management**

**AT**

**FOREST RESEARCH INSTITUTE**

**DEEMED UNIVERSITY**

**DEHRADUN- 248006**

**Forest Research Institute (Deemed) university  
M.Sc. Environment Management**

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**Programme objectives:** The programme aims to provide opportunities to the students to make themselves aware about the problems related to environmental concerns and its management. The programme is designed to provide a holistic and integrated approach of learning comprising of classroom lectures, classroom assignments, practical sessions, interactive seminars, field visits, industrial visits, term papers, divisional attachments and master's thesis writing. The course builds and facilitates understanding of the dynamics of environment especially in the context of ecology, forestry, and climate change. Different types of processes, models, plans and techniques related to environmental processes are described and discussed through class room interaction as well as exposures visits to different ecosystems and institutional/industrial arrangements. The students are expected to get enough exposure for practical solutions to various ecological and environmental problems in the context of today's world.

**Programme structure:** The programme consists of courses and other requirements worth a total of 89 credits. One credit is equivalent to one hour of teaching (lecture or tutorial) or two hours of practical work/field work per week. Each semester will consist of 18 to 20 weeks of academic work equivalent to 90 actual teaching days. The programme structure and respective credits are given below as:

<b>Programme Structure</b>		<b>Credits</b>
Core courses	:	53
Foundation courses	:	5
Elective courses	:	5
Synopsis	:	1
Master's thesis	:	17
Master thesis seminar	:	2
Term paper I	:	2
Term paper II	:	2
Study tour	:	2
Total	:	89

**Allotment of credits to different courses**

**FIRST SEMESTER**

Course Code	Course	Credit	
		Theory	Practical
<b>Foundation Course</b>			
<b>ERG 101</b>	Remote Sensing and Geographical Information System	1	1
<b>Core Course</b>			
<b>EFE 111</b>	Fundamentals of Ecology	3	1
<b>EEA 112</b>	Ecosystem Analysis	3	1
<b>EPB 113</b>	Environment Physics and Biogeochemistry	3	1
<b>ECE 114</b>	Conservation Ecology	3	1
<b>EIA 115</b>	Environment Impact Assessment	3	1
<b>ERE 116</b>	Restoration Ecology	3	1
<b>ETP 117</b>	Term Paper I	2	-
<b>Total credits in first semester</b>		<b><math>19^a + 7^b + 2^c = 28</math></b>	

**SECOND SEMESTER**

Course Code	Course	Credit	
		Theory	Practical
<b>Foundation Course</b>			
<b>ESC 201</b>	Environment Statistics and Computer Application	2	1
<b>Core Course</b>			
<b>EFM 211</b>	Forestry for Sustainable Management	3	1
<b>EEM 212</b>	Environment Microbiology	3	1
<b>EGF 213</b>	Global Climate Change and Forest	3	1
<b>EDM 214</b>	Disaster Management	3	1
<b>FFE 214</b>	Forest Economics	2	1
<b>ETM 215</b>	Term Paper II	2	-
<b>Total credits in second semester</b>		<b><math>16^a + 6^b + 2^c = 24</math></b>	

### THIRD SEMESTER

Course Code	Course	Credit	
		Theory	Practical
<b>Core Course</b>			
EPS 311	Environment Policy, Law and Sociology	3	1
EPM 312	Environment Pollution Management	3	1
EFC 313	Forest Certification	2	-
EST 314	Study Tour	2	-
<b>Elective course 5 Credits</b>			
ENM 321	Natural Resource Conservation and Management	4	1
EBM 322	Bio Diversity Monitoring and Management	4	1
EBC 323	Bio Statistics and Computer Application	4	1
ESM 324	Solid Waste Management	4	1
EPC 325	Forest, Society and Climate Change	4	1
ERG 326	Remote sensing and Geographic Information System- Advance and Application in Environment Management	4	1
EIA 328	Environment Impact Assessment	4	1
PTN 330	Plant Taxonomy	2	3
<b>Total credits in first semester</b>		<b>8<sup>a</sup> +2<sup>b</sup> +5<sup>c</sup> +2<sup>d</sup> =17</b>	

### FOURTH – SEMESTER

Code	Particulars	Credit
ESY 441	Synopsis	1
EMT 442	Master's thesis	17
ETS 443	Master thesis seminar	2
<b>Total</b>		<b>20</b>

*a- Theory, b- Practical, c- Term paper, d-Study tour, e- Elective paper. One lecture credit comprises of one hour teaching of the course in a week, while one practical credit comprises of two hours of practical/assignment work in a week*

#### Descriptions of Course Code

The courses of M. Sc. programme are divided into four series:

- ❖ 100-series courses pertain to first semester
- ❖ 200-series courses pertain to second semester
- ❖ 300-series courses pertain to third semester
- ❖ 400-series courses pertain to fourth semester
- ❖ Credit for Synopsis, Master's thesis and Master thesis seminar is designated by code no. 441, 442 and 443 respectively

Course code is formulated as:

- First alphabet shows programme
- Second and third alphabet shows course name
- First digit shows semester number
- Second digit shows course type (0= foundation, 1= core, 2= elective)
- Last digit shows course number

## 1<sup>st</sup> SEMESTER

### FOUNDATION COURSE

#### **ERG 101     REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEMS**

**LEARNING OBJECTIVES:** To develop understanding about the scope and application of remote sensing and Geographic Information Systems in Environmental science

#### **MODULE I INTRODUCTION**

- Remote Sensing: History of Remote Sensing, Aerial Remote Sensing, Satellite Remote Sensing, Space programme development in different countries
- Limitations of Remote Sensing; Resolution- Definition and types; Remote sensing data types, cost and sources

#### **MODULE II AERIAL REMOTE SENSING**

- Aerial Remote Sensing/ (Air Borne RS):Aerial Photography; Principle of Remote Sensing; Characteristic of Electromagnetic spectrum and spectral range; Sensors; Agency involved for aerial photography; Cameras used ; Types of Aerial Photography depending on: i) Orientation of optical axis, ii) Angle of coverage; Sources of energy; Measurement on Aerial photographs: Scale determination and Height measurement. Limitations

#### **MODULE III BASIC OF MAPS**

- Introduction, Classification, Concept of scale, Fundamentals of Cartography, Numbering of topographical maps, Map Projection, Datum and Spheroid. Preparation of Thematic maps using aerial photographs: Elements of Photo Interpretation; Stereoscopes- Types & Functions; Area Calculation by: i) Dot grid, ii) Square grid, iii) Planimeter

#### **MODULE IV SATELLITE REMOTE SENSING (SPACE BORNE)**

- Types of Remote Sensing based on: Source of Energy; Platform. Types of Satellite: LANDSAT, IRS, SPOT, IKONOS, QUICKBIRD,RADAR, LIDAR, SRTM, NOAA. Types of Sensors and their - MSS, TM, LISS-I, II, III, IV, PAN, Characteristics AVHRR, WIFS, A WIFs. Multispectral Scanners: Whiskbroom and Pushbroom scanners

## **MODULE V PREPARATION OF VEGETATION/FOREST COVER MAP USING SATELLITE DATA**

- Visual Interpretation; Basic principle of Image interpretation; Elements of Image interpretation; Digital Interpretation; Supervised, Unsupervised and Hybrid approach if interpretation

## **MODULE VI MICROWAVE REMOTE SENSING**

- Types, Platform and Utility; Radar Microwave Remote Sensing; Lidar Sensing and applications

## **MODULE VII GIS AND GPS**

- Geographic Information System (GIS): Definitions and objectives, Principle of GIS, Basic requirements of GIS, Components of GIS, Data Structure, Data Types, Data models, Topology, Applications in Forestry and Environment
- Global Positioning System (GPS): Definitions, Types of GPS, Principle of GPS, Functions, GPS Segments, Applications in Forestry, Limitations

## **PRACTICAL**

- Digital Image Processing of satellite data
  - Geo-referencing of Toposheet
  - Geometric rectification of satellite data
  - Sub-setting of satellite data
  - Classification and Area computation
  - Digitisation of Polygon and line in vector format
  - Computation of Area, length and perimeter
  - Use of GPS in forest survey
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## CORE COURSES

EFE 111

### FUNDAMENTALS OF ECOLOGY

**LEARNING OBJECTIVES:** To provide knowledge about population and community ecology, dynamics and sampling procedure for vegetation analysis

#### **MODULE I INTRODUCTION**

- Definition of Ecology, Evolutionary/ Historical background
- Natural ecosystems, Concept of species (niche, species interaction- mutualism, commensalism, competition, ammensalism, character displacement) and individual, Concept of carrying capacity

#### **MODULE II AUTECOLOGY**

- Introduction to Autecology; Population definition & characteristics (population size, density dispersion, age structure, natality, mortality etc)
- Population parameters- growth, fluctuation, regulation and dynamics, r and k selection, species interaction and intra and inter specific competition, evolutionary consequences of competition, allelopathy, biotic potential

#### **MODULE III SYNECOLOGY**

- Introduction to Synecology; Community dynamics, concept, structure and composition.
- Community characteristics (analytical characters-quantitative and qualitative, synthetic characters), dominance and diversity (alpha, beta, gamma), community coefficients, cluster analysis, association analysis, gradient analysis (ecotone, habitat and niche).
- Vegetation mapping, Community classification concept (individualistic and vegetational continuum concept).

#### **MODULE IV ECOSYSTEM**

- Ecosystem components and structure; Abiotic and biotic factors, trophic relation, functional aspect of ecosystem.
- Ecological succession (definition and causes), types of succession, process of succession, succession models, concept of climax

## **MODULE V VEGETATION SAMPLING**

- Vegetation sampling; Purpose of studying plant communities, sampling units (point frame transect and quadrat), size and shape of sampling unit (species area curve, running mean method), methods of sampling (line transect, quadrat and point centered quarter method).

## **PRACTICAL**

- Ecological sampling of an area (line transect, quadrat and point centered quarter method).
  - Phyto-sociological analysis
  - Species-Area Curve
  - Measurement of tree height and diameter
  - Determination of homogeneity and heterogeneity of the system using Raunkier's frequency class
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EEA 112

## **ECOSYSTEM ANALYSIS**

**LEARNING OBJECTIVES:** To impart knowledge of ecosystem, biomes and functional aspects of ecosystem

## **MODULE I MAJOR ECOSYSTEM**

- Ecosystem concepts, evaluation of ecosystem past and present, major ecosystems of India and world (terrestrial, aquatic, marine), influence of climatic factors on major ecosystems of the world
- Major biomes of India and world, biogeographic regions of India and world, agro-ecological and floristic zones, forest types of India

## **MODULE II RESOURCE DEPLETION**

- Natural resources (definition and types), Natural resources degradation (types and causes), loss of biodiversity, land degradation, deforestation, ecological and social impact of resource depletion

### **MODULE III FUNCTIONAL ASPECTS OF ECOSYSTEM**

- Functional aspect of ecosystem analysis; Energy flow (food chain, food web, ecological pyramid), energy resources and use efficiency, ecological energetic and energy models.
- Biomass production (gross and net), biomass estimation methods.
- Litter production and decomposition in different ecosystem.
- Biogeochemical cycles (nutrient cycle: carbon, nitrogen, sulphur, phosphorus, hydrological cycle); Cybernetics and homeostasis

### **PRACTICAL**

- Collection of litter, soil and plant samples
  - Nutrient analysis
  - Vegetation analysis
  - Calculation of the species diversity, similarity index, concentration of dominance, richness Index and evenness
  - Measurement of biomass and productivity
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### **EPB 113 ENVIRONMENTAL PHYSICS AND BIOGEOCHEMISTRY**

**LEARNING OBJECTIVES:** To develop understanding of students about structure and chemical composition of the atmosphere, hydrosphere and lithosphere and physico- chemical properties and nutrient dynamics of soil

### **MODULE I ATMOSPHERE**

- Structure of the atmosphere, radiation budgets, general circulation in the atmosphere, prevailing and adiabatic lapse rates, air masses and fronts, vertical profiles of major and trace gases
- Cloud formation and precipitation, cloud classification, condensation nuclei, global patterns of pressures and winds, monsoon systems.
- Chemical composition and processes in the atmosphere, atmospheric photochemistry, reactions of nitrogen, oxygen, ozone, chlorides. Transport and deposition processes of dust and aerosols in the atmosphere.

## **MODULE II HYDROSPHERE**

- Chemistry of hydrosphere: properties of water(surface and ground water), physical chemistry of sea water, characteristics of natural water, complexation in natural water and waste water, aquatic chemical reactions. Ground water recharge, aquifers

## **MODULE III LITHOSPHERE**

- Landform and their development; structure and tectonics, weathering, erosion, classification
- Structural classification of minerals and their properties; major rock forming and ore minerals
- Geochemical classification and distribution of elements in the earth, properties of soil parent materials and their relation to soil and vegetation

## **MODULE IV SOIL SCIENCE**

- Definition of soil, soil types, factors of soil formation, weathering of rocks and minerals and processes of soil formation
- Soil profile. Soil colloids, Soil physico-chemical properties, soil water, types of soil water, its retention, movement, availability and measurement of soil water, soil organic matter and its role in soil fertility.
- Causes, kinds, extents of soil degradation & pollution and measures for their prevention and amelioration.
- Plant nutrition; essential nutrients and their forms in the soil and their role in plant growth, factors and forms of erosion.

## **PRACTICAL**

- Monitoring of micro-meteorological parameters, maximum and minimum temperature, relative humidity, wind speed and wind direction, solar radiation, preparation of wind rose diagram
  - Determination of soil moisture, bulk density, porosity, colour, pH, N, P, K and organic carbon
  - Physical and chemical properties of minerals and different diagnostic characters of rocks
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**LEARNING OBJECTIVES:** To acquaint students about conservation of biological resources, natural selection, ecosystem fragmentation, energy sources and environmental laws

### **MODULE I INTRODUCTION**

- Definition of conservation, postulates of conservation biology. The origin and evolution of living organisms, the invasion of unoccupied ecological niches, Adaptive radiation, genetic plasticity a factor in evolution
- Natural selection; self-replicating molecular assemblages, limiting factors and tolerance curves, rules of inheritance for life on earth, Mendelian genetics, nature versus nurture, selfish genes, population genetics, maintenance of variability, genetics and ecology of extinction

### **MODULE II ECOSYSTEM INSTABILITY**

- Species of biological importance: Native, Non-native, indicator, endemic, threatened, umbrella, flagship, keystone, and charismatic species.
- Ecosystem fragmentation and edge effects, concept of keystone species, effects of species deletions and additions and invasive species on the maintenance of biological diversity, stability and complexity in relation to development
- Red and green data books, genetic resources, world conservation strategy

### **MODULE III INVENTORIZATION AND MONITORING**

- Survey, monitoring and sampling populations for biological conservation, collection and analysis of inventory data, criteria on choice of species for conservation

### **MODULE IV CONSERVATION OF RESOURCES**

- Energy sources: Conservation and management of non-renewable fossil fuel resources, strategies for management of non renewable reusable mineral and metal resources. Forest and water resources and their conservation and management
- Conservation of biological resources: *in-situ* and *ex-situ* conservation strategies, captive breeding, botanical and zoological gardens; design and management of protected area for wildlife conservation. Cultural significance of natural protection

## **PRACTICAL**

- Measurement of leaf area and leaf area index (LAI)
  - Estimation of moisture contents of leaves and soil
  - Estimation of chlorophyll content (from grass and tree leaves)
  - Measurement of root-shoot ratio
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## **EIA 115      ENVIRONMENTAL IMPACT ASSESSMENT**

**LEARNING OBJECTIVES:** Students will be able to explore the features, auditing and monitoring of EIA reports, public participation in Environmental decision making and quality checks in EIA

### **MODULE I INTRODUCTION AND BACKGROUND**

- Origin of EIA and historical perspective, scope and purpose of EIA; Key merits of environmental assessment in regulating the state of environment
- Global experience in EIA; Comparative review of EIA systems in different countries and regions

### **MODULE II ENVIRONMENTAL LEGISLATIONS AND REGULATIONS**

- Salient features of EIA legislation and other statutory obligations
- Environmental decision making in India: Environmental clearance procedures and national requirements.

### **MODULE III ASSESSMENT FRAMEWORK**

- Flow charts showing key steps; Methodological approaches and tools for key stages in the process: Screening (classification of developments and stage to determine the level of EIA, exclusion and inclusion lists of projects, different approaches to screening) Scoping (scoping steps, guidance and tools, and stakeholder involvement), Impact prediction and evaluation (approach for baseline development and methods of impact identification-checklists, Matrices, Networks)

### **MODULE IV METHODS AND TOOLS FOR EIA**

- Introduction to various impact assessment methods: checklist, matrices, networks, indices and weight scaling techniques and their scope and limitations
- Prediction and assessment of impact on the land, air, water, noise, biological and socioeconomic environments

- Mitigation: definitions and hierarchy of measures including avoidance, reduction, rectification and compensation enhancement approaches, principles and concepts of offsets, type of offsets

#### **MODULE V PUBLIC PARTICIPATION IN ENVIRONMENTAL DECISION MAKING**

- Regulatory requirements, procedures, advantages and disadvantages of public participation
- Environmental Impact Assessment Reporting: Guidelines for developing formats for preparing and reviewing EIA reports and Environmental Management Plans, Case studies

#### **MODULE VI ENVIRONMENTAL AUDITING AND MONITORING**

- Concepts, objectives and usefulness of monitoring relevant to impact mitigation, Types (Impact/effect monitoring, Baseline monitoring, Compliance monitoring; Mitigation monitoring), Ex ante and Post ante EIAs
- Accreditation of EIA consultants: Obligatory requirement in India, introduction to national accreditation scheme

#### **MODULE VII ISO STANDARDS**

- ISO 9001, historical background, benefits and clause analysis.
- EMS and its benefits, formulating environment policy exercise, preparation ground for development EMS-Initial environmental review and exercise of identification of environmental aspects,
- Clause analysis of ISO 14001, explanation of PDCA cycle
- Training need identification, communication, audit process, preparation audit investigation-interview techniques and nonconformities, closing meeting and follow up. Attributes of an auditor and psychology of auditing audit reporting, certification process and certification bodies, legislation pertaining to ISO 14001 documentation-preparation of L/R, emergency preparedness and response
- Comparison of ISO 9001 and ISO 14001, comparison of ISO 14001 and OHSAS-18001.

## **PRACTICAL**

### **Case studies on:**

- EIA of development projects
  - EIA of restored mine lands
  - EIA of hydroelectric plant
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**ERE 116**

## **RESTORATION ECOLOGY**

**LEARNING OBJECTIVES:** To impart knowledge about restoration of degraded land, public participation in conservation and restoration and concept of sustainable development

### **MODULE I INTRODUCTION**

- Definition, aims and objectives of restoration, principles, concepts and strategies (long term vs. short term), physical, chemical and biological restoration, role of ecological principles in restoration, holistic approach in restoration

### **MODULE II RESTORATION OF NATURAL AND DEGRADED RESOURCES**

- Restoration of degraded lands/waste lands, range land, forest, river corridor, water resources, mine spoils and wet lands
- Methods of soil and water conservation for reclamation of degraded land. The concept of sustainable development, Environmental degradation and conservation issues, Global change and sustainable issues

### **MODULE III MICROBIAL MANAGEMENT**

- Microbial management and biofertilizers for restoring soil fertility. Biotechnology for restoration of degraded land

### **MODULE IV PUBLIC PARTICIPATION IN RESTORATION**

- Role of public participation, government agencies and NGOs in conservation and restoration, environmental education and its role in conservation and restoration

## **PRACTICAL**

- Cover, Basal area
- Soil binding capacity
- Charting and Mapping of Vegetation,
- Root Density
- Fertility Rejuvenation Index,

- Infiltration rate
  - Field visit to restoration sites
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**ETM 117**

**Term paper I**

**Learning objectives**

The objective of the term paper is to develop the skill of research writing. In this course generally students have to review literature in their field of interest related to environment. They have to prepare a project report on a particular topic under the supervision of faculty and submit it to the university.

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**2<sup>nd</sup> SEMESTER**  
**FOUNDATION COURSE**

**ESC 201     ENVIRONMENTAL STATISTICS AND COMPUTER APPLICATIONS**

**LEARNING OBJECTIVES:** To develop the understanding of application of statistics and computer softwares in diverse fields of life sciences

**MODULE I BASIC STATISTICS**

- Data collection, tabulation, Primary and secondary data, Scales of data (nominal, Ordinal, Interval, Ratio and Circular)
- Exploring data; Skewness and Kurtosis, Frequency distributions, Graphs (stem and leaf plots, bar diagrams, histograms, pie-charts)
- Measures of central tendency and dispersion. Correlation and Regression Estimation; Estimation of mean and variance, point and interval estimation. Estimation of important environmental parameters

**MODULE II PROBABILITY**

- Probability and Probability distributions; Basic concepts of probability. Binomial, Poisson and Normal distributions

**MODULE III TESTING HYPOTHESIS**

- Null and alternative hypotheses, types of errors in testing hypotheses, tests of significance: t, F, z,  $\chi^2$  and Analysis of variance

**MODULE IV SAMPLING**

- The need of sample surveys, advantages and disadvantages of sampling, simple, random sampling, stratified random sampling, systematic sampling.

**MODULE V COMPUTER APPLICATIONS**

- Windows OS, MS Word, Excel, Power point, Adobe Page Maker, Adobe Photoshop, Video editing, Graphics and designs.

**PRACTICAL**

- Practical problems using statistical software, problem solving and analysis using MS-Office, SPSS and STATISTICA
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## **CORE COURSE**

### **EFM 211    FORESTRY FOR SUSTAINABLE MANAGEMENT**

**LEARNING OBJECTIVES:** Students will be introduced to basic forestry including botany, biotechnology, silviculture, mensuration, protection and forest products.

#### **MODULE I INTRODUCTION**

- Overview of Forestry in India: History of management and development of management systems of forests in recent years.
- Evolution of forest policy: Benefits of forest and forestry resources. Champion and Seth classification of Indian Forests.

#### **MODULE II FOREST BOTANY**

- Importance of systematic botany in forestry: concept of genus, species, herbarium, arboretum, Bambusetum.
- Plant nomenclature, Bentham and Hooker system of classification, identification of Family, Genus and Species using Flora.

#### **MODULE III SILVICULTURE**

- Definition of silvics and silviculture, study of locality factors like climatic, edaphic etc
- Forest regeneration, natural and artificial regeneration of forests, (plantation forests) and mixed regeneration; methods of propagation, grafting techniques, site factors
- Nursery and planting techniques ó nursery beds, polybags and maintenance, water budgeting, grading and hardening of seedling, pruning and lopping. Macro and micro propagation.
- Silviculture systems: Definition, classification and brief study of the following systems: clear felling system, uniform system, group system, coppice & coppice with standard and reserve system, Rotation and its types

#### **MODULE IV FOREST MENSURATION**

- Measurement of tree ó methods of measuring ó diameter, girth height, crown and volume of trees, form ó factor, volume estimation of a tree, and a stand. Current and mean annual increment

## **MODULE V FOREST PROTECTION**

- Agencies causing forest damage viz. man, fire, cattle wildlife, insects and pathogens, nature of their damages, cause, prevention, remedial measures.
- General forest protection against fire, equipment and methods, controlled use of fire.

## **MODULE VI NON WOOD FOREST PRODUCTS**

- Definition, Importance, diversity/Types, their distribution, role in rural livelihood and industry, present and future scope of utilization

## **PRACTICAL**

- Seed viability and Quality Testing
  - Seed Preservation techniques
  - Nursery Techniques: Poly bag, Nursery raising, lifting, grading and packing of nursery, stock nursery layout; Mist chamber, Glass house
  - Net house, designing
  - Measurement of tree diameter, height and volume
  - Identification of plants using flora upto genus level
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**LEARNING OBJECTIVES:** To acquaint with various aspects of microbes in environment, Bacteriology of water and waste water treatment

### **MODULE I INTRODUCTION**

- Microbes and environment, classification and occurrences, distribution, diversity and ecological importance, characteristics of protists, prokaryotes and viruses
- Photoautotrophs, chemolithotrophs, organotrophs, parasites and symbionts
- Scope of environmental microbiology, Release of genetically engineered microbes and environmental risks

### **MODULE II SOIL AMELIORATION**

- Soil microorganisms and their interaction, soil borne diseases
- Water borne pathogens and water borne disease, microbial standards of water quality microbial toxins, air borne microbes, microbial dispersal through air and water estimation of microbial biomass
- Microbial treatment of soil pollution, pesticides and surfactants

### **MODULE III MICROBIAL MINING AND TREATMENT**

- Microbial mining and metal recovery, biological management of hazardous wastes and wasteland. Bacteriology of water, milk and air; Techniques of microbial culture; Downstream processing
- Biocontrol agents; Bio fertilizers

### **MODULE IV WATER AMELIORATION**

- Waste water treatment (sewage and industrial effluents), properties and step involved in aerobic and anaerobic treatments, specific biotechnological approaches (conventional and advanced treatment technology); methanogenesis, methanogenic, acetogenic and fermentative bacteria

### **PRACTICAL**

- Isolation of Rhizobium bacteria and their culture from root nodules
  - Gram staining of Rhizobium bacteria
  - Isolation, purification and maintenance of fungal culture: sub culturing, mineral oil preservation, lysolization
  - Effluent treatment using microbes
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## **EGF 213 GLOBAL CLIMATE CHANGES AND FOREST**

**Learning objectives:** To develop the understanding of Earth's Climate System, climate change Mitigation and International Cooperation: Agreements and Instruments such as Kyoto protocol, UNFCCC, IPCC, CDM projects

### **MODULE I INTRODUCTION**

- Earth's Climate System. The physical basis of climate change. Observation of changes in the climate system: Observations from cryosphere, ocean, atmosphere and surface. Past, Present and Future Climate. Information from Paleoclimate and Climate Models.
- The greenhouse effect and major greenhouse gases. Anthropogenic and natural radiative forcing. Clouds and Aerosols.
- Climate Change: Impacts Adaptation and Vulnerability

### **MODULE II NATURAL AND MANAGED RESOURCES**

- Natural and managed resources and systems: Freshwater resources, Terrestrial and inland water systems, Coastal systems and low-lying areas, Ocean systems, Food security and food production system

### **MODULE III IMPACTS AND VULNERABILITY**

- Conceptual understanding of forest and Climate Change. Impact of CC on forest types and characteristics, Observed changes in earth's climate IPCC assessment reports.
- Carbon(C) cycle in the forest; carbon related definitions e.g. C-pool, C-stock, C-flux, C-sink, C-source, Sequestration/uptake.
- Measurement of Carbon in forested ecosystems, Eddy covariance. A broad view of assessment of C in Indian forests
- Vulnerability of terrestrial ecosystem to Climate Change. Observed and projected Changes in Forest Ecosystems: Phenology, Primary productivity, Biomass and Carbon stocks, Evapo-transpiration and Water use efficiency, Changes in species range abundance and extinction, Impacts on and Risk for forests.
- Impacts on key ecosystem services: Habitat for Biodiversity, timber production, biomass derived energy, pollination pest and diseases regulation, moderation of climate change variability and extremes

## **MODULE IV MITIGATION AND ADAPTATION**

- Adaptation to climate Change
- Autonomous Adaptation Phenological, Evolutionary and genetic, migration of species  
Human Assisted Adaptation: Protected Areas, landscape and watershed management, assisted migration and *ex-situ* conservation
- Forests as source or sink of carbon; Emissions from deforestation, forest degradation, landuse changes, REDD and REDD-plus; Role of forest in carbon management; Climate Change mitigation through forest management; mitigation potential of forest sector in India. Managing production forest for carbon and environmental values; forest conservation and mitigation.
- India specific impact of Climate Change on various sectors of economy. Climate Change Mitigation: Challenges and strategies. Mitigation in different sectors of economy (i)Energy Systems, (ii) Transport, (iii) Buildings, (iv) Industry, (v) Agriculture, Forestry and Other Land Use (AFOLU), (vi) Human Settlements, Infrastructure and Spatial Planning
- Domestic Climate Change mitigation and adaptation efforts in India; International Cooperation: Agreements and Instruments

## **MODULE V INTERNATIONAL CONVENTIONS**

- International Multilateral Environmental Agreements and Climate Change; the Rio Conventions and their Synergy; UNFCCC, its various, bodies and their functions
- Kyoto Protocol, its operationalization and implication for developed and developing Countries.
- The Clean Development Mechanism (CDM) and its operationalization; modalities and procedures; National Communication to the UNFCCC (NATCOM); Carbon Markets; Role of IPCC in global Climate Change policy perspective

## **PRACTICAL**

- Assignments
-

**LEARNING OBJECTIVES:** To familiarize the students with cause and effects of natural disaster, its forecasting and warning systems and programme planning for better management

**MODULE I NATURAL DISASTERS**

- Natural disasters, nature, causes and effects, cyclone, tornadoes, floods, earthquakes, avalanches, landslides, drought, diseases, and fire
- Forecasting and warning systems of disasters, measurements of responses of disasters, community reaction to disaster, coping mechanism, classes of victims

**MODULE II DISASTER MANAGEMENT**

- Disaster management, pre-disaster phase, actual disaster phase, post-disaster phase, disaster assistance, technological assistance, relief camps, organization, camp layout, fire fighting camping and tent pitching, rope, knots and their use, rescue, emergency rescue

**MODULE III DISASTER EDUCATION**

- Disaster education. Alternatives and new directions, conceptualizing disaster recovery, mitigation and preparedness, programme planning and management
- Case studies of disasters

**PRACTICAL**

- Assignments and field visits
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**LEARNING OBJECTIVES:** The course is designed to explain the role and application of economics in management of forest, wildlife and environment.

**MODULE I FUNDAMENTALS OF ECONOMICS**

- Micro and Macro Economics, utility and marginal analysis, demand and supply of forest products, Law of diminishing marginal utility, Market equilibrium, Production Possibility curve, Production theory as applied to forestry, Production function

- Role of markets, open market economy, different forms and types of market competitions, regulation, cases studies of forest products
- Costs and revenues, Opportunity Cost, Interest, Rent, Wages
- Investment criteria, Benefit cost analysis, Internal rate of return (IRR), Sensitivity analysis and their applications

### **MODULE II FOREST RESOURCE ECONOMICS**

- Goods and services from forests, measuring forest ecosystem values and benefits, Monetization of intangible services from forest
- Soil expectation value
- Total Economic Valuation, Models for direct and indirect benefit estimation market price method, productivity method, Travel Cost Method (TCM), Hedonic Pricing Method (HPM) and Contingent Valuation Method (CVM) and other cost based methods of economic valuation and their application
- Contribution of goods and services from forests to national GDP, Natural Resource Accounting
- Economics of air, water and energy resources
- Economics of carbon sequestration

### **MODULE III PROJECT FORMULATION, IMPLEMENTATION, MONITORING AND EVALUATION**

- Assignments and case studies to demonstrate the economic valuation of different components of environment
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**ETM 215**

**Term paper II**

**2 Credits**

#### **Learning objectives**

The objective of term paper is to make students to aware about, how to write a scientific research paper/technical report. It helps the student to develop ability to do logical arguments, and thought process and also helps students to learn to relate their thoughts in a concise manner. It will also develop the communication and report writing skills.

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## 3<sup>rd</sup> SEMESTER

### EPS 311 ENVIRONMENTAL POLICY LAW AND SOCIOLOGY

**LEARNING OBJECTIVES:** To impart the knowledge of environmental legislation and policies (national and international) and develop the understanding of environmental sociology and human rights in relation to environment

#### **MODULE I ENVIRONMENTAL POLICY AND LAW**

- Environmental Legislation for protection of species and natural resources
- Government policies for environmental conservation. Government Agencies responsible for environmental protection. Air and water (protection) Act
- International organizations pertaining to environment. International environmental legislations, protocols, treaties, conventions
- Public Interest litigations and their role in control of environmental pollution in India

#### **MODULE II ENVIRONMENTAL SOCIOLOGY**

- Interrelationship among Ecology, Environment and Society. Role of population growth, technology and urbanization on society. Sustainable development and resource conservation
- Importance of bio-diversity and peoples value for ecosystem. Environmental needs and social justice, participatory management of biological resources
- Environmental Movements in India with special reference to Chipko and NBA
- Human Rights in relation to environment. Role of NGOs in Environmental Protection

#### **PRACTICAL**

- Assignments
-

**LEARNING OBJECTIVES:** To acquaint the students with different types of pollution, their sources, causes and control measures

**MODULE I INTRODUCTION**

- Definition of pollution, Pollution of the biosphere causes and significance, classification of pollutants, National and International Environmental Standards

**MODULE II AIR POLLUTION**

- Types and major sources of air pollutants, dispersal and deposition, response of biotic and abiotic ecosystem components to pollutants, impact of air pollutants on human beings
- Ionizing radiation, acid rain- causes and consequences. Monitoring of gaseous pollutants and particulate matter
- Air pollution mitigation and control. Atmospheric composition, reactions in the lower and higher atmosphere, radioactivity in the atmosphere, air quality standards and criteria. Air pollution control equipment viz. settling chambers, inertial separators, cyclones, multiple cyclones, bughouse filters, scrubbers or wet collectors, electrostatic precipitators, advantages and disadvantages of control equipment
- Air pollution abatement technologies including vehicular emissions

**MODULE II WATER POLLUTION**

- Important pollutants, sources and transformation in nature, impact of heavy metals, halogens, radionuclides on aquatic flora and fauna, Monitoring water pollution, Ganga Action Plan
- Radioactive materials, thermal, reclamation of polluted water, ground water resource

**MODULE III SOIL POLLUTION**

- Soil pollutants their source and types, heavy metal toxicity in soil
- Impact of pesticides, industrial waste and fertilizers on soil physio chemical properties
- Chemistry of solid wastes and integrated solid waste management

## **MODULE IV NOISE POLLUTION**

- Basic properties of sound waves-plane and spherical wave, sound pressure and intensity levels, decibel, effect of meteorological parameters on sound propagation
- Measurement and analysis of sound. A weighted sound level; equivalent sound pressure level (Leq) Noise pollution level (NPL), sound exposure level (SEL), traffic noise index (TNI), day-night level, noise criteria curves; noise sources; machinery noise, pumps; compressors, building and construction equipment, domestic appliances, traffic- vehicular, train, aircraft, diesel generator sets
- Prediction of traffic noise-nomograph method. Noise control sound absorption coefficient (ast), sound absorbing materials, reverberation time, acoustic silencers, mufflers, barriers, vibration and impact isolation

## **PRACTICAL**

- Monitoring of dust fall, SPM, CO<sub>2</sub>, CO, O<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub> in ambient air
  - Determination of acidity and alkalinity, total dissolved solids and total suspended solids, dissolved oxygen, COD, BOD, turbidity, pH, conductivity of water
  - Noise monitoring at residential localities/ forest areas
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**EFC 313**

## **FOREST CERTIFICATION**

**LEARNING OBJECTIVES:** The objective of the course is to introduce concept and importance of forest certification and its programme in India.

## **MODULE I INTRODUCTION**

- Forest certification: concept, definition, origin, evolution, relevance and benefits, Emerging issues, trends and schemes, certification and labelling

## **MODULE II FOREST CERTIFICATION PROGRAMMES**

- Standards, certification process, accreditation, auditing, organizational process, national and international schemes, certificate processes at global level

## **MODULE III CERTIFICATION OF FOREST PRODUCTS**

- NTFPs and their role in forest management, certification of NTFPs, issues, merits and demerits of NTFPs certification, certification of wood based products

## **MODULE IV SUSTAINABILITY, CHALLENGES AND POTENTIAL OF FOREST CERTIFICATION**

- Framework for forest certification in India, Government policies and their objectives, Indian forest certification agencies, Standards of certification for sustainable utilization, and management of forest resources, progress of certification in India, stakeholder expectation and economics of forest certification
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**EST 314**

**STUDY TOUR**

**2 Credits**

### **Learning objectives**

A study tour is organised every year for the students of M.Sc. Environment Management to acquaint themselves with the knowledge in the relevant fields. The study tours are intended for giving actual field exposures to students. It helps in providing a real opportunity to students to visualize the professional efforts and measures taken by different industries, institution in tackling the problems of environment.

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## **ELECTIVE COURSE**

**ENM 321**

### **NATURAL RESOURCE CONSERVATION AND MANAGEMENT**

**LEARNING OBJECTIVES:** To introduce the challenges for society in conserving natural resources such as forest, mineral, wildlife, soil, water and their sustainable management

#### **MODULE I INTRODUCTION**

- Current issues, Public policy. Law and public involvement: Endangered Species Act, Clean Water Act, Renewable and Nonrenewable resources

#### **MODULE II FOREST RESOURCES**

- Distribution of forests, wood production, carbon sequestration, non-wood forest produce
- Cost associated with forest exploitation, cost of felling/removal and transportation of forest produce
- Energy cost for forest exploitation, environmental cost, loss of habitat, deforestation impact reforestation and processing cost, sustainable management

#### **MODULE III MINERAL RESOURCES**

- Distribution and management, economics of mineral resources, cost associated with mineral exploitation, economic cost, energy cost, environmental cost, steps in mineral exploitation, recycling as an alternative

#### **MODULE IV SOIL AND WATER RESOURCES**

- Soil structure and use, decomposition of parent rock, formation of humus and organic matter, soil properties, soil texture, soil erosion, water holding capacity, biological activity in soil, soil conservation practice, land capability classes, contour forming strip forming, terracing, Salt affected soils and their management, Acid soils and their management, Water resources, water management, wind erosion, use of wind breaks

#### **MODULE V WILDLIFE RESOURCES**

- Wildlife resources, restoration of wildlife, habitat management

#### **PRACTICAL**

- Characterization and categorization of threatened species and habitat for biodiversity conservation in peri-urban forest ecosystem
-

**LEARNING OBJECTIVES:** To impart the thorough knowledge of biodiversity, their conservation status, assessment and management strategies including preservation plots and action plans

### **MODULE I INTRODUCTION**

- Biodiversity Inventorization, monitoring and characterization, Documenting and mapping biological diversity, Conservation sites characterization, NDVI (Normalized Difference Vegetation Index), floristic diversity of India and adjacent region, endemism value, recent trends in allied subject: Bamboo, Rattans medicinal plants diversity)

### **MODULE II CONSERVATION STATUS ASSESSMENT**

- Loss of biodiversity, Threat and conservation value: categorization of threat-international norms and national perspective; prioritization of key areas of conservation
- Techniques and tools of Biodiversity Impact Assessment, Economic evaluation of benefits of biodiversity and genetic resources; Integrated aspects of using indigenous knowledge and grassroots innovations and management

### **MODULE III MANAGEMENT STRATEGIES**

- Development of conservatories and repositories, Protected areas, Regional and Global biodiversity Hotspots
- Base line study on Preservation plots, Corridors and migratory routes of flora and fauna
- Role of community in biodiversity management, man and animals conflict management
- National Biodiversity Strategy and Action Plan, National Biodiversity Authority, Wildlife Protection Act, International Conventions and initiatives-CBD, UNFCCC, CITES, WCS, GBIF, IUCN and important institutions
- Network on biodiversity information and management; Database development and information sharing through interdisciplinary cooperation and support

## **PRACTICAL**

- To make a single species inventory with enumeration with locational habitats
  - Study of the area of occupancy and extent of occurrence of species in naturalized colonized area with emphasis on habitat viability indices
  - Biodiversity impact assessment studies. Threat and conservation value assessment on the biodiversity of different ecosystem
- 

## **EBC 323      BIostatistics and Computer Application**

**LEARNING OBJECTIVES:** To teach students about the fundamentals and application of statistical methods comprising Multivariate Analysis, Time series analysis and Computer application in environmental sciences

### **MODULE I INTRODUCTION**

- Basic overview of Statistical Methods; Central Tendency and Dispersion, Probability and probability distributions, Correlation and Regression, Tests of significance

### **MODULE II SAMPLING TECHNIQUES**

- Advanced Sampling plans; Multistage Sampling, Double sampling, Controlled Selection, Adaptive cluster sampling; Dealing with non-response in sampling

### **MODULE III MULTIVARIATE ANALYSIS;**

- Multivariate Analysis of variance, Cluster Analysis, Principal Component Analysis, Factor Analysis, Multiple Regression Analysis, Correspondence Analysis, Discriminant Analysis
- Time series analysis and its applications in understanding environment; Introduction to Time Series. Component of Time Series (Random, Trend, Seasonal and Cyclic Fluctuations), Moving averages, Autocorrelations, ARIMA, Smoothing a time series Co-integration, forecasting using time series models. Time series in environmental studies

### **MODULE IV COMPUTER APPLICATION**

- Adobe Page Maker, Adobe Photoshop, MS Access, statistical softwares and application- SPSS, Statistica etc

## **PRACTICAL**

- Computational and analytical skills using statistical software and computer
- Assignments for individual students

**LEARNING OBJECTIVES:** To impart knowledge of issues, approaches, characteristics, control measures of solid wastes and technologies for management

**MODULE I SOLID WASTE MANAGEMENT**

- Introduction, Municipal Solid Waste Management in India: Issues and approaches, Engineering principles; Sources, nature and characteristics; quantitative and qualitative; Solid waste problems: Industrial, Mining, Agricultural and Domestic (urban) wastes, waste processing techniques, Hydrological aspects of solid waste. Regulatory aspects of Solid Waste Management

**MODULE II SOLID WASTE DISPOSAL**

- Sanitary landfill planning, site selection, design and operation, equipment, costs, Aerobic landfill stabilization. Biological oxidation. Composting, optimum conditions for composting, Biogas; Pyrolysis; Incineration: waste characterization, combustion calculation, unit operations, supply of air, products of combustion, furnace temperature, furnace calculation, storage of refuse, waste reduction and environmental control
- Industry specific solid waste management, Agriculture, Process Industry, Mineral and Metallurgical industry, Disposal of industrial and mill tailings, Resource and energy recovery: Recycling of solid waste, Integrated waste management
- Energy from the waste: important in national and international context

**PRACTICAL**

- Assignments
-

**LEARNING OBJECTIVES:** To impart knowledge of Climate Change issues at global and national level and connecting people on social and environmental concerns

**MODULE I SOCIAL DIMENSIONS ON CLIMATE CHANGE**

- Community social structure, status and role, norms and values, Concepts of equality, inequality, exclusion, poverty and deprivation, Social Stratification (class, status groups, gender, ethnicity and state, citizenship, democracy, civil society, ideology)
- Sociological issues related to climate change- Social causes, consequences, conflicts over resources etc
- People and forest interface in managing natural resource and Common property resources, gender perspective and priorities in relation to resource use and management, Gender impact analysis, Social drivers of Climate Change

**MODULE II CLIMATE CHANGE ISSUES AT GLOBAL AND NATIONAL LEVEL**

- Global environmental and social issues such as acid rain climate change disaster management, Global regional and local common resources
- Policies and initiatives related to global climate change, Montreal Protocol, UNFCCC, Kyoto Protocol, REDD +
- Regulations and policies for environment and social safeguards in selected national contexts

**MODULE III RESPONSE TO CLIMATE CHANGE**

- Mitigation and Adaptation
- Climate vulnerability exposure sensitivity and adaptive capacity of society
- Role of forests, Trees outside forests and agro forestry in climate change resilience and adaptation

**MODULE IV ASSESSING VULNERABILITY & ADAPTATION POTENTIAL**

- Participatory process, Stakeholders and SWOT Analysis
- Introduction of approaches for qualitative data collection and synthesis: Rapid Rural appraisal (RRA).
- Communicating and connecting to people on social and environmental concerns

- Data and Information: Data types population and sample, methods for collecting information; development of field survey questionnaire, data collection & processing, presentation and interpretation
- Spatial and non ó spatial data handling using Geographic Information Systems (GIS)  
Criteria for selecting study area Analysis and interpretation using GIS
- Data base creation tools for handing large data sets
- Analysis of trends and scenarios
- Methods for assessing climate change vulnerability and adaptation potential
- Scientific writing of result

### **MODULE V FIELD WORK**

- Data collection from field for opted problem
  - Data analysis, Report writing, presentation and communication of important finding
- 

## **ERG 326 REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM- ADVANCES AND APPLICATION IN ENVIRONMENTAL MANAGEMENT**

**LEARNING OBJECTIVES:** To impart advance knowledge of application of remote sensing and Geographic Information Systems in Environmental management

### **MODULE I ADVANCED DIGITAL IMAGE PROCESSING**

- Conversion of digital numbers to spectral radiances and top of atmosphere (TOP) reflectance; Concepts of atmosphere correction and radiometric normalization of multi-date satellite images; Spectral indices and their use in vegetation characterization; Multi-resolution and multi-sensor images fusions; Change detection techniques using temporal (multi-date) satellite images; Sub-pixel classification techniques; Principles of high resolution, microwave, thermal, hyper spectral and LIDAR data processing.

## **MODULE 2 TERRAIN ANALYSIS**

- Digital elevation model (DEM) and other terminologies like digital surface model (DSM) and digital terrain model (DTM); Sources of DEMs (e.g. topographic maps, aerial and satellite stereo photos/images, radar interferometer. LIDAR systems); Global and Indian DEMs available in public domain; Derivatives and applications of DEMs such as slope aspect and elevation, generation of shaded relief images and perspective views, topographic indices, watershed analysis, etc

## **MODULE III GEOSPATIAL ANALYSIS**

- Vector and raster-based analysis techniques; Multi-criteria analysis; Network analysis and its applications; Interpolation methods; Overview of internet GIS (or WebGIS) and geo-web services; Concepts of Mobile GIS, crowd sourcing and location-based services; Existing geo-web portals (e.g. BIS, Bhuvan, India WRIS, etc)

## **MODULE IV ENVIRONMENTAL APPLICATION AND CASE STUDIES**

- Utility of high data, microwave and hyper spectral remote sensing and LIDAR in forest cover type density mapping, monitoring and biodiversity characterization and conservation planning, estimation of forest growing stock, biomass and carbon pool, up scaling carbon and energy fluxes, forest infestation disease detection, etc., Species niche modeling; Assessment and modeling of forest hazards. INFFRAS; Inputs for solving forest litigation issues; Wildlife habitat suitability modeling and Protected Area management; Assessing LULC change and modeling future scenarios of LULC for EIA and EMP; National Forest Information System (NAFIS). Wildlife Information System (WILIS)

## **PRACTICAL**

- **Advanced image processing**-- Calculating spectral indices and using them for vegetation characterization, change detection using multi-date satellite images
- **Terrain analysis**-- Downloading different DEM products and their visual analysis, generation of slope (amount and aspect) map, shaded relief images and perspective views and watershed analysis including stream delineation, ordering and watershed delineation
- **Geospatial analysis**-- Vector and raster-based analysis techniques based on single and multiple layer operations, Interpolation of point data. Exploring geo-web portals (e.g. BIS, IBIN, Bhuvan, India WRIS, etc.). Data collection using Mobile GIS

- **Application and Case Studies-** Case studies demonstrating the potential of remote sensing and GIS techniques
  - **Short Group Project** – To be carried out by groups of students on different topics of their choice of two to three week duration
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## **EEI 327      ENVIRONMENTAL IMPACT ASSESSMENT**

**LEARNING OBJECTIVE:** To acquaint students about the importance of Strategic Environmental Assessment in cumulative, regional and landscape level impact assessment

### **MODULE I METHODS FOR EIA**

- Elaboration of steps in traditional EIA process

### **MODULE II STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)**

- The importance of SEA as a tool for assessing impacts of policy, plan and programmes. Relevance of SEA as a global tool for addressing cumulative, regional and landscape level impacts
- Examples of SEA and SEA like approaches from India; Key example of good SEAs from around the world. Introduction to tools and techniques

### **MODULE III ENVIRONMENTAL ECONOMICS**

- Introduction to some recent approaches of economic valuation of impacts and their application in impact assessment and presentation of case studies

### **MODULE IV ADVANCED LEARNING ON MITIGATION STEPS**

- Principles and concepts of offsets, type of offsets, examples of bio-banking and wetland banking and market based mitigation strategies
- Comparison of EIA approaches in other countries in South Asia
- Life Cycle Assessment Approach in Impact assessment
- Impact Assessment for addressing climate change

### **PRACTICAL**

Students will be exposed to practical aspects of the Environmental Impact Assessment through Self Learning Modules-

- Scoping for Hypothetical or real EIA study
- Scoping based on scenario projection through visuals (Some select films can be used)
- Review of EIA Reports and preparing comments for appraisal of project

- Development of Alternatives based on details available for project planning to ensure least impact option
  - EIA Report writing with case studies
  - Seminar on select topics ( eg: Merits of EIA using case study, shortfalls of EIA; What best practices would improve benefits of EIA for decision making)
  - Review and observations on Public Participation and Public Hearing
  - Conduct of environmental review for evaluating mitigation compliance
  - Essay on Road map for making EIA a tool for good governance
  - Review of decision support software for EIA
- 

**PTN 330**

**PLANT TAXONOMY**

**LEARNING OBJECTIVES:** The objective of the course is to impart knowledge about nomenclature and classification of genus, species and variety and to develop skills and abilities to identify plants in the field.

**Practical**

- Description of different types of stems; different types of leaves; flowers; inflorescences and different types of fruits.
- Floral parts, dissection and characteristics of one specimen each of ten families with identification, drawing of floral parts with floral formula and floral diagram of species with the help of local flora
- Field botanization, collection and making herbarium for identification of plant or tree species during various tours with the help of flora/
- Virtual Herbariums (Use of Digitalization Flora)

**Theory**

**MODULE I INTRODUCTON**

- Importance of plant taxonomy
- History of Plant Taxonomy in India
- Taxonomy in relation to: Anatomy, Chemotaxonomy, Numerical taxonomy, Cytotaxonomy, Molecular Taxonomy/ Phylogeny, Palynology, Ecology
- Phytogeography, GIS Tools use in Taxonomic explorations
- Plant conservatories ( Herbarium, Botanical Garden etc)
- Taxonomic Keys (Dichotomous & polyclave keys)
- History of the classification of Angiosperms, Classifications propose by Bentham and Hooker, Engler and Prantl, De candolle, Hutchinson, Takhtajan, Cronquist. Their

merits and demerits. APG classification (Angiosperm Phylogeny Group system of plant classification)

## **MODULE II BOTANICAL NOMENCLATURE**

- International code of Botanic Nomenclature (ICBN and ICN); principles; Rules and recommendations; priority; typification; Rules of effective and valid publications; retention and choice of names.

## **MODULE III DESCRIPTION OF IMPORTANT FAMILIES**

- Dendrology
- Description of families viz. Magnoliaceae, Dipterocarpaceae, Meliaceae, Sterculiaceae, Leguminosae, Rosaceae, Lythraceae, Myrtaceae, Rhizophoraceae, Rubiaceae, Lauraceae, Fagaceae, Verbenaceae, Euphorbiaceae, Coniferae, Poaceae (Bamboo)

## **MODULE IV ETHNOBOTANY**

- Ethnobotany and its importance.
  - Ethnobotany of important forest species
- 

### **4<sup>th</sup> SEMESTER**

**ESY 441**

**Synopsis**

**EMT 442**

**Master's thesis**

**12 Credits**

**LEARNING OBJECTIVES:** In final semester students have full six month to conduct their own experiment and conclude the findings as thesis reports. . Students work on research problem and hypothesis under the supervision of a concerned faculty. It equips the students to pursue the goal in academic area or R and D section. They learn methodology and techniques of research writing. This provides an opportunity to students about identifying problems such as challenges and opportunities and solving problems through research and experimentation

**EMT 443**

**Master thesis seminar**

**2 Credits**