

DEPARTMENT OF ENVIRONMENTAL SCIENCE

**BIR TIKENDRAJIT UNIVERSITY**

Syllabus for M.Sc. Environmental Science

- M.Sc. programme in Environmental Science is of 2 years duration i.e. first and second years
- Each year will have 10 theory papers carrying 100 marks and 4 practical papers carrying 75 marks each
- The pass mark for each paper is 40% (i.e. 30 + 10 respectively for annual exam and internal assessment)

Details of various courses are given as follows:

Course code	Course Title	Marks		
		Internal Assessment	Annual Exam	Total
<b>FIRST YEAR</b>				
EVS-101	Environmental Biology	25	75	100
EVS-102	Environmental Chemistry	25	75	100
<b>EVS-103-P</b>	<b>Practical -1 (EVS-101 &amp; EVS-102)</b>	-	<b>75</b>	<b>75</b>
EVS-104	Environmental Earth Science	25	75	100
EVS-105	Statistical Methods & Computer Application	25	75	100
EVS-106-O1	One from the list*	-	75	75
<b>EVS-107-P</b>	<b>Practical -2 (EVS-104 &amp; EVS-105)</b>	-	<b>75</b>	<b>75</b>
EVS-108	Air and Noise Pollution	25	75	100
EVS-109	Soil and Water pollution	25	75	75
<b>EVS-110-P</b>	<b>Practical -3 (EVS-108 &amp; EVS-109)</b>	-	<b>75</b>	<b>75</b>
EVS-111	Ecotoxicology	25	75	100

EVS-112	Remote Sensing and GIS	25	75	100
EVS-113-O2	One from the list*	-	75	75
EVS-114-P	Practical -4 (EVS-111 & EVS-112)	-	75	75
*Please refer page no. 10				

### **ENV-101: Environmental Biology**

**Unit-I:** Introduction to Ecology and Environment: Concept and scope of ecology; organism and environment; ecological factors and variables. Subdivisions of ecology. Concept of species; Key stone and Flagship species. Laws of limiting factors; Laws of tolerance. Concept of habitat, niches and guilds.

**Unit-II:** Population characteristics and dynamics: natality, mortality, patterns of dispersion, reproduction (r- & k- selection), concept of carrying capacity and intrinsic rate of increase, population regulation (density dependent and independent mechanisms), fluctuations, cycles and chaos.

**Unit-III:** Community characteristics and dynamics: diversity, structure, dominance, stratification, periodicity. Ecological succession, types and models of succession. Concept of Climax community. Community interdependence: types of interactions in ecosystems.

**Unit-IV:** Ecosystem structure and functions: components and processes; food chain and trophic levels. Concept of productivity: measurement and patterns of primary productivity. Ecological energetics: energy flow and Ecological efficiency; Ecological pyramids. Biogeochemical cycles. Ecosystem gradient and Ecotone. Major Ecosystems of the world - forest, grassland, desert, freshwater and marine ecosystem.

### **ENV-102: Environmental Chemistry**

**Unit- I:** Environmental Chemistry: Concept and scope; Chemical Kinetics: Simple reaction mechanisms; Order and molecularity of chemical reactions; Acid base reactions, common ion effect, catalysis; adsorption; buffer solutions, solubility and solubility product-hydrolysis, oxidation and reduction, chemical equilibrium; chemical speciation, concept of green chemistry.

**Unit-II:** Atmospheric Chemistry: Chemical composition of the atmosphere; Photochemical reactions in the atmosphere - formation of smog, PAN, acid rain, oxygen and ozone chemistry; atmospheric aerosol chemistry, Greenhouse gases (GHGs); Gasoline and additives, antiknock

compounds, lubricants and greases, biogas; Polycyclic aromatic hydrocarbons, Polychlorinated Biphenyls, phenols, chlorofluorocarbons.

**Unit-III:** Water Chemistry: Physical and chemical properties of fresh and marine water; Chemical species in water; Chemistry of cleaning agents: Chemistry of Soap and detergents, Bleaching agents; Chemistry of colloids; Pesticides, classification, formulations; chemical fertilizers.

**Unit-IV:** Geochemistry: Chemical composition of earth, earth's crust- hydrosphere, atmosphere, biosphere, Geochemical classification of elements, Chemistry of trace elements (Pb, Cr, As, Hg and Cd etc.), Trace elements and health; Rare earth elements (REE); Radioactivity-decay of parents and growth of daughter nuclides, radioactive dating.

### **EVS-103-P: PRACTICAL**

1. Methods of vegetation sampling and analysis using various ecological methods.
  2. Quantitative community characteristics.
  3. Estimation of productivity of Terrestrial ecosystem (Determination of LAI & LMA).
  4. Estimation of productivity of aquatic ecosystem (Pond productivity by plankton study).
  5. Study the life forms of vegetation by physiognomic method.
  6. Determination of Diversity Index & Biotic Indices.
  7. Identification of Common Soil Micro-Flora.
1. Estimation of physico-chemical and biological parameters of soil and water
  2. Measurement of air pollutants – particulates, gaseous pollutants
  3. Volumetric, Turbidimetric, Potentiometric, Colorimetric experiments estimation of water samples
  4. Estimation of alkali metals in water samples by flame-photometry
  5. Determination of ions using UV-VIS Spectrophotometers
  6. Advanced methods of water analysis-AAS, GC, HPLC etc.

### **ENV-C104: Environmental Earth Science**

**Unit-I:** Origin and evolution of the earth; Plate tectonics – sea floor spreading and continental drift, mountain building; Weathering of rocks - physical, chemical and biological; Mass-wasting; Erosion, Transportation and deposition of earth's materials by running water, wind

and glaciers; Development of landforms; Earthquakes, Volcanoes and Tsunamis - Environmental changes.

**Unit-II:** Rocks and Minerals- types and formation of rocks; Minerals- formation and classification; Mineral deposits; Soil - formation, composition, and classification; Soil profile; Soil erosion; Important minerals of India, ores, Exploration of mineral from the sea; Environmental consequences of exploitation of mineral resources, conservation of mineral resources; Glaciers- physical and chemical aspects, mass balance, Glaciers as index of climate change.

**Unit-III:** Atmosphere-origin, composition and structure; insolation and heat budget; temperature and pressure distribution, humidity and wind; Atmospheric thermodynamics – equation of state of dry and moist air; Hydrostatic balance and atmospheric Equilibrium-stability, instability, temperature lapse rate and inversion; Scales in meteorology; planetary boundary layer – variation of air temperature; Diffusion and Turbulence, Mixing length.

**Unit-IV:** General circulation air pressure and wind systems; Atmospheric disturbances- cyclones, anticyclones and tropical disturbances; El-Nino, La-Nina, ENSO; Climatology: Elements of weather systems and Climate; Climatic controls; Climatic variability and Climate Change; Climatic Classifications-types and distribution; Weather forecasting and analysis; Air masses –definition, source, modification and classification; Front- characteristics and classification; Monsoons-origin, concept and distribution, Monsoon of Indian Sub-continent.

### **ENV-105: Remote Sensing and GIS**

**Unit-I:** Introduction to Remote Sensing (RS): definition and scope; Physics of RS and Electromagnetic Radiation (EMR); Interaction with matter and spectral regions; Spectral characteristics of surface features (rocks, soils, vegetation, water); Types of Remote Sensing; Remote sensing regions and bands; Platforms and Sensors; Resolutions; Types of RS data; Aerial photography; stereoscopy; orthophotographs; stereoscopic parallax; relief displacement; Indian and foreign RS Satellites; Image Interpretation and Analysis - elements of visual interpretation, Digital Image Processing (DIP), Classification accuracy assessment; Available software and Tools, Application of RS in environmental science.

**Unit-II:** Geographical Information System (GIS): Basic principles, Raster and vector data, Map projection, Topology, Overlay analysis, Data structure and Digital cartography, Development of GIS database for decision making, Basic GIS operations; Global Positioning System (GPS): Basic principles and concept, Applications forest and environmental studies;

Available software and Tools; Applications of GIS and GPS in addressing environmental issues, monitoring and management.

### **EVS-107-P: PRACTICAL**

1. Study and Preparation of Geological Maps and determination of Fault line
2. Geological Surveying and preparation of survey maps
3. Determination of meteorological parameters-Atmospheric pressure, Relative Humidity, wind speed, wind direction, and analysis of meteorological data.
4. Determination of Rainfall using rain gauges, mass curve and hyetograph analysis
5. Identification of common Rocks and Minerals and their properties
1. Experiments related to measurements on aerial photograph, use of simple instruments like stereoscope, stereo-meter, digital planimeter
2. Interpretation of aerial photographs for preparation of land use and vegetation maps
3. Digital Interpretation of satellite imagery for environmental mapping and pollution monitoring
4. Identification, delineation and mapping of environmental hazards on satellite imagery
5. Digital analysis of satellite data and their interpretation
6. Digital Map Preparation (slope, slope aspect, LULC etc)
7. GIS and GPS applications in environmental survey and monitoring
8. Basic GIS operations (database preparation, overlay etc)

### **EVS-108: Air and Noise Pollution**

**Unit-I:** Atmosphere-origin, composition and structure; Air Pollution, types of sources, primary and secondary pollutants; Particulate matter, types, prevention and control; Gaseous pollutants, Oxides of nitrogen, Hydrogen sulphide, CO, PAH, health effects, Control and removal; Odour pollution, sources, effects, control measures.

**Unit-II:** Impact of air pollution on local and global scale; Acid rain; Global warming, ozone depletion, Photochemistry of atmosphere; Sinks of atmospheric gases; Problems of fly ash; Indoor air pollution; Air sampling and monitoring technologies, Air pollution control devices; Air quality standards.

**Unit-III:** Meteorological aspects of air pollution, dispersion, temperature lapse rate and inversion; stack plumes, Gaussian Plume model; Fugitive emissions, sources, prevention and

control; Case studies of air pollution disaster, Bhopal Gas Tragedy, London Smog, Donora Smog. Case studies of air pollution from industries, thermal power plants, Cement industries.

**Unit-IV:** Noise Pollution: Basic properties of sound waves – plane and spherical waves, Sources of noise pollution, measurement of noise, noise exposure levels and noise standards; Noise Indices, Noise sampling methods; Effects of noise pollution on human health and environment; Noise Zones and categories; Noise control and abatement measures.

### **ENV-109: Soil and Water Pollution**

**Unit I:** Definition of soil; Soil composition; Soil forming rocks and minerals, Factors of soil formation; Soil forming processes- Profile development; Soil physical, Chemical and Biological properties and their significance; Soil sampling and monitoring

**Unit-II:** Soil Pollution: Sources and causes; pollutant and contaminant; Impacts Inorganic and Organic pollutant; Soil pollution from chemical residues on soil (pesticides, fertilizers, heavy metals, Industrial effluents, Sewage); Soil salinity and alkalinity, trace elements and radionuclide; soil erosion and land degradation; Reclamation and remediation of contaminated soil.

**Unit III:** Physicochemical properties of fresh and marine water, Major water quality (physico-chemical and bacteriological) parameters and their applications; Water quality objectives and water uses; Sampling and monitoring; Water quality standards, indicators and indices; Water pollution– Concepts and types; Contaminant behaviour in water environment-heavy metals, trace elements, radionuclide water chemistry; Eutrophication; Marine pollution.

**Unit-IV:** Physical, chemical and biological processes necessary for designing drinking water and wastewater treatment (coagulation, flocculation, sedimentation, chemical precipitation, porous media filtration, disinfection, ion exchange, adsorption, membrane processes and other advanced treatment processes); Major contaminant groups and natural pathways for their removal from water.

### **EVS-110-P: PRACTICAL**

1. Study on different Sampling techniques and instruments used in air pollution measurement
2. Measurement of Particulates – SPM, fine particulates in air (PM<sub>10</sub> & PM<sub>2.5</sub>)
3. Measurement of emission of trace gases (CH<sub>4</sub>, CO<sub>2</sub>, CO, N<sub>2</sub>O) from soil and wetland
4. Determination of ambient concentrations of SO<sub>x</sub>, NO<sub>x</sub>, O<sub>3</sub> and NH<sub>3</sub>

5. Measurement of airborne fungal spore and pollen grains.
6. Characterization and estimation of heavy metals in air.
7. Measurement of related meteorological parameters for air quality study
8. Measurement of indoor and outdoor noises.
9. Estimation of Noise Indices and Equivalent Noise levels ( $L_{10}$ ,  $L_{50}$ ,  $L_{90}$  etc.)
10. Estimation of day-night noise levels, background noise and other noise parameters
11. Noise mapping
12. Basic methods of soil and water sampling
13. Determination of basic soil physical parameters (Soil moisture, Soil texture, soil composition, bulk density, porosity, WHC, Particle size of soil by hydrometer method etc.)
14. 3. Determination of Organic Carbon, Nitrogen, Phosphorous, Potassium in Soil
15. 4. Determination of Soil pH, EC, CEC. pH, EC, Temperature,
16. Determination soil respiration and soil microbes, isolation and identification of soil microbes
17. Determination of Basic Water Physical parameters (Colour, Temperature, Suspended Solids, etc.)
18. Determination of Basic Water Chemical parameters (pH, TDS, DO, Hardness, Alkalinity, Salinity, Acidity, BOD, COD), Alkali metals in water samples.
19. Determination of Bacteriological parameters of water (MPN, Coliform test)
20. Determination of ions using advanced methods UV-Spectrophotometers, Ion-chromatography, AAS, GC, etc.

### **EVS-111: Ecotoxicology**

**Unit I:** Toxicology: basic principles of toxicology and Ecotoxicology; toxicants; degradable and non-degradable toxic substances. Major classes of Environmental Pollutants. Acute and chronic toxicity; dose response curve; concepts of  $LD_{50}$  and  $LC_{50}$ ; frequency response and cumulative response; Influence of ecological factors on effect of toxicity.

**Unit II:** Routes of entry of toxicants (water, land and atmosphere); Long-range movement and global transport of pollutants. Fate of Toxicants in Ecosystems and Environment: Biotransformation, Bioaccumulation & Bio-magnification.

**Unit III:** Fate and transport of toxicants in the biological system; routes of entry, toxicological interactions; detoxification in the human body - detoxification mechanisms, organs of detoxification.

**Unit IV:** Environmental Health: basic principle of environmental health; Occupational health hazards and its impacts. Epidemiology - water, soil, air and food borne diseases; Food additives and their prevention.

### **EVS-112: Remote Sensing and GIS**

**Unit-I:** Introduction to Remote Sensing (RS): definition and scope; Physics of RS and Electromagnetic Radiation (EMR); Interaction with matter and spectral regions; Spectral characteristics of surface features (rocks, soils, vegetation, water); Types of Remote Sensing; Remote sensing regions and bands; Platforms and Sensors; Resolutions; Types of RS data; Aerial photography; stereoscopy; orthophotographs; stereoscopic parallax; relief displacement; Indian and foreign RS Satellites; Image Interpretation and Analysis - elements of visual interpretation, Digital Image Processing (DIP), Classification accuracy assessment; Available software and Tools, Application of RS in environmental science.

**Unit-II:** Geographical Information System (GIS): Basic principles, Raster and vector data, Map projection, Topology, Overlay analysis, Data structure and Digital cartography, Development of GIS database for decision making, Basic GIS operations; Global Positioning System (GPS): Basic principles and concept, Applications forest and environmental studies; Available software and Tools; Applications of GIS and GPS in addressing environmental issues, monitoring and management.

### **EVS-114-P: PRACTICAL**

1. Estimation of heavy metals.
2. Analyses of biochemical and molecular responses in living organisms to contaminants.
3. Determination of fate of toxicants in living organisms or environment.
4. Effect of contaminants on genetic structure of a plant population.
5. Extraction and separation of organic compounds from biological materials.
6. Experiments related to dose-response relationship for different contaminants.
7. Evaluation of antimicrobial chemical agents and bioassays - determination of MIC, Determination of IC<sub>50</sub>.



8. Potable water quality assessment.
9. Effect of nanoparticles on the environment.
1. Experiments related to measurements on aerial photograph, use of simple instruments like stereoscope, stereo-meter, digital planimeter
2. Interpretation of aerial photographs for preparation of land use and vegetation maps
3. Digital Interpretation of satellite imagery for environmental mapping and pollution monitoring
4. Identification, delineation and mapping of environmental hazards on satellite imagery
5. Digital analysis of satellite data and their interpretation
6. Digital Map Preparation (slope, slope aspect, LULC etc)
7. GIS and GPS applications in environmental survey and monitoring
8. Basic GIS operations (database preparation, overlay etc)

**\*ONE FROM THE LIST -- EVS-106-O1 AND EVS-113-O2**

<b>SPECIALISATION</b>	
<b>Group A Environmental Planning and Management (EPM)</b>	<b>Group B Natural Resource Management (NRM)</b>
ENV-GA1: Environmental Planning	ENV-GB1: Natural Resources Management
ENV-GA2: Environmental Impact Assessment	ENV-GB2: Conservation Biology
ENV-GA3: Environmental Management	ENV-GB3: Wildlife Management
ENV-GA4: Environmental Education	ENV-GB4: Global Environmental & Climate change
ENV-GA5: Environmental Awareness	ENV-GB5: Watershed Management
ENV-GA6: Environmental Laws	ENV-GB6: Sustainable Development

**ENV-GA1: Environmental Planning**

**Unit-I:** Environmental planning- Concept, history and elements of environmental planning; Development of habitat patterns, settlement structure; Resource analysis for various ecosystems and development imperatives (land, geology, soil, climate, water, vegetation); Causative factors for environmental degradation; Environmental Zones and regulating mechanisms for development.

**Unit-II:** Rural and Urban planning; Settlement planning; micro planning; landuse/land cover pattern; Green Technology- Green building concept, Urbanisation - traffic, housing, urban climatology, heat islands, urban acoustics; Use of alternative technology in design of human settlements.

**Unit-III:** Environmental auditing; Role in Environmental planning and sustainable development; Life Cycle Assessment (LCA) in Environmental Planning; Application of Energy code, energy auditing. Eco-restoration of degraded environments. CDM for Environment Planning.

**Unit-IV:** Emerging and Future Trends; Recent and contemporary contributions to the changing paradigms; Planning for future and in future- vision development, strategies, implementation

of planning policies and regulations, development plans. Role of EIA in Environmental Planning. Global environmental movements, India's environmental programmes.

### **ENV-GA2: Environmental Impact Assessment**

**Unit-I:** Concept of environmental Impact Assessment (EIA); Nexus between development and environment; Origin and development of concept of EIA; Fundamental Approach to Environmental Impact Assessment; Practices and guidelines for EIA in India, EIA to sustainable development.

**Unit-II:** Environmental Impacts and their significance; Screening and Scoping process; Framework of Planning and Management of EIA studies; Description of Environmental setting; Environmental Indices and Indicator; Environmental Standards; Environmental Impact Assessment Methodologies of SIA and EIA, Role of GIS in EIA.

**Unit-III:** Framework for Prediction and Assessment of Air, Surface Water, Groundwater and Soil, Noise, Biological, Socio-economically and Cultural Environment-Base line study; Evaluation of impacts of proposed actions; Standards and guidelines; Prediction and determination of impact; Risk Prediction and Assessment; Mitigation measures for environmental impacts.

**Unit-IV:** Public participation in Environmental decision making; Evaluation of alternatives and Trade-off Analysis; Preparation of written documents (EIA/EIS report); Environmental Management/Monitoring Plan (EMP); Decision making and Environmental Clearance; Case studies (Power Plants, Industries, Transportation and Communication projects, Mining and Explorations, Infrastructure development projects etc.)

### **ENV-GA3: Environmental Management**

**Unit-I:** Concept: Basics of environment and its management, National and Global Perspectives, Environmental sampling and data analysis, Analytical methods for environmental monitoring, Management process and Organizational behaviour, Management Practice & the Environment toward a Sustainable Society.

**Unit II:** Environmental problem: Basics of water supply and treatment, Air pollution management, Wastewater management, Solid waste management and disposal. Urban Environmental Management, Environmental earth science and natural hazards management.

**Unit III:** Application: Remote sensing and GIS - Application in environmental management, Energy and environment, Environmental modelling, Environmental impact assessment & risk analysis, Environmental law and management.

**Unit-IV:** Environmental Management and Mitigation – Environmental Management System (EMS), Environmental Certification, Performance evaluation; ISO 14000 (series), Environmental Management Plan (EMP); Eco-mark & Eco-labelling; Environmental accounting and auditing; Green funding and taxes, Carbon – foot print, trading, credit and sequestration; Environmental Economics- law of diminishing return, valuation of environment.

#### **ENV-GA4: Environmental Education**

**Unit- I:** Man and environment: Human activities and its impacts- local, regional and global; Concepts of carrying capacity and global commons; Ecological security, Common property Resources (CPR), Environmental priorities in India and Environmental crisis.

**Unit-II:** Environmental education: Background and definition, Different approaches to EE, International norms guiding EE, Current scenario of EE in India and the world, Major challenges and the possible way-outs.

**Unit-III:** Public awareness about environment: Need of creating public awareness about environment Role of individuals, NGOs and mass media. People involved in prominent environmental issues.

**Unit-IV:** Environmental ethics – concept, Eco-philosophy: eco-centric and anthropocentric world views, Environmental ethics and sustainable development; Imbibing lessons from religions, cultures and human values, Relevance of Environmental ethics in the present day society,

#### **ENV- GA5: Environmental Awareness**

**Unit- I:** Man and environment: Human activities and its impacts- local, regional and global; short-term and long-term impacts on environment; Socio-economic and cultural dimensions of environment, Concepts of carrying capacity and global commons; Environmental priorities in India and Environmental crisis

**Unit-II:** Environmental Awareness: definitions and concepts, role of Government, NGOs and media, Biosphere and socioeconomic and cultural environment and their interactions; Environment awareness programme in Northeast India with special emphasis on Manipur.

**Unit-III:** Natural Resources and Conservation, Ecological security, Common property Resources (CPR), Environmental movements in India-Chipko, Appiko, Silent Valley, Tehri Dam, Narmada Dam.

**Unit-IV:** National and international organizations involved in environmental conservation and campaigns-Green Peace, WWF, WHO, IUCN, FAO, UNEP and UNESCO; Conventions and Summits on Environment; Carbon trading and sequestration, Clean Development Mechanism (CDM), Kyoto protocol.

### **ENV- GA6: Environmental Laws**

**Unit-I:** Environmental Laws and its evolution; Strategy and tools of environmental protection; Constitutional provisions for environmental protection in India (Article 48 & 51 A); Environmental laws in India and its salient features, Factories Act (1948), Insecticides Act (1968) with Amendments, Environmental Regulatory Authorities, National Green Tribunal (NGT).

**Unit-II:** The Water (Prevention and Control of Pollution) Act (1974) and amended in 1988; Air (Prevention and Control of Pollution) Act (1981) amended in 1987; Hazardous Waste (Solid and Biomedical waste) Management rules (1989); Noise pollution (Regulation and control) Rules (2000).

**Unit-III:** Wildlife Protection Act (1972) as amended in 1993; Forest Laws; Forest Conservation Act (1980); Indian Forest Act (1927) and amended in 1982; Forest Rights Act (2006); Environment (Protection) Act (1986); National Biodiversity Act (2002); National Biodiversity Strategy and Action Plan (2000).

**Unit-IV:** International Environmental Laws: Evolution and development; Significance of Stockholm Conference, Rio Conference; International laws to control Global warming, Ozone depletion, Acid rains, hazardous waste.

### **ENV-GB1: Natural Resources Management**

**Unit-I:** Introduction to Natural Resource: Concept of resource, classification of natural resources. Factors influencing resource availability, distribution and uses. Interrelationships among different types of natural resources. Ecological, social and economic dimension of resource management. Biodiversity- importance, values and threats. Conservation approaches.

**Unit-II: Forest resources:** Status, distribution and types of major forest. Use and over-exploitation, forest management. Strategies for conservation of forest. **Land resources:** Land

as a resource, land degradation, man induced landslides, soil erosion and desertification. Wetland ecology & management. **Water resources:** Water resources on earth; Use and over-utilization of surface and ground water; conflicts over water, dams-benefits and problems. Depletion of water resources. Management and conservation of water. **Energy resources:** Growing energy needs, renewable and non-renewable energy sources, use of alternate energy sources. **Food resources:** World food problems, changes caused by agriculture and over-grazing, effects of modern agriculture, fertilizer-pesticide problems, water logging, salinity. **Fish and other marine resources:** Production, status, dependence on fish resource, unsustainable harvesting, issues and challenges for resource supply, new prospects.

**Unit-III: Mineral resources:** Important minerals of India; types, uses and exploitation, environmental effects of extracting and using mineral resources. Resource Management Paradigms: Resource management the evolution and history of resource management paradigms. Resource conflicts: Resource extraction, access and control system. Approaches in Resource Management: Ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies. Poverty and implications in Resource Management in developing countries – Poverty in developing countries, causes and link with resources scarcity and poverty.

**Unit-IV: Management of Common International Resources:** Ocean, climate, International fisheries and management commissions; Antarctica: the evolution of an international resource management regime. Environmental education and awareness. Role of individuals in conservation of resources.

## **ENV-GB2: Conservation Biology**

**Unit-I:** Conservation Biology; Biodiversity - definition and elements of biodiversity, types, pattern and measurement of biodiversity, threats to biodiversity, and rarity and extinction process; Biodiversity and ecosystem services; Biogeographical classification of India.

**Unit-II:** History of Conservation movements: International and National. Methods of conservation - *In situ* (Biosphere reserves, National Parks, Sanctuaries, World heritage Sites and Ecologically Sensitive Areas) & *ex situ* (Botanical gardens, Zoological gardens, Gene banks, Pollen, seed and seedling banks, tissue culture and DNA banks) modes of conservation.

**Unit-III:** Biodiversity hotspots and their conservation; the Convention on Biological Diversity, 1992 -convention text, Cartagena Protocol, Nagoya protocol; the Biological Diversity Act,

2002 - National Biodiversity Authority and State Biodiversity Board. People's Biodiversity Register.

**Unit-IV:** Traditional Knowledge and Biodiversity Conservation: Sacred Groves; Biodiversity and ethno-botanical resources; Traditional Knowledge Digital Library (TKDL); Intellectual Property Rights and Bio-resource patenting; Conservation of biodiversity with reference to NE India.

### **ENV-GB3: Wildlife Management**

**Unit-I:** Wildlife management: definition, importance and concepts; Wildlife management in relation to allied subjects; Wildlife values and conflicts; History of wildlife conservation in India; Problem of wildlife protection in India; IUCN Red list category; rarity and extinction process; Important threatened/endemic plant and animal taxa of India.

**Unit-II:** Ecology of wildlife; Zoo-geographic regions; field observations and investigations, Census techniques; Wildlife management techniques: food production, water development, cover management, wetland improvement, fences and trenches, other habitat improvement measures, and predation management.

**Unit-III:** Wild-life Legislation, Administration and Education; Indian Board for Wildlife; The Wildlife (Protection) Act, 1972; Protected areas network (PAN) – National parks and Sanctuary; Biosphere reserves; Botanical gardens; Zoological gardens. National conservation strategy with special reference to wildlife conservation; National Wildlife Action Plans; Project Tiger and Project Elephant.

**Unit-IV:** Role of conservation agencies; WWF, IUCN, CITES, WCU, UNESCO, TIES; Role of Indian NGOs for the conservation of wildlife. Conservation of Wildlife with reference to Northeast India.

### **ENV-GB4: Global Environmental and Climate change**

**Unit I:** Atmosphere – origin, composition, structure, insolation and heat budget; Basic atmospheric properties, Climatic classifications, Monsoon, El-nino, Southern Oscillation, cyclones, Milankovitch Cycle, Gia hypothesis.

**Unit II:** Global atmospheric temperature, Greenhouse gases – global and regional trend in GHGs emission, role of aerosol, ozone and trace gases; Global warming, Climate change, Climate variability in geological history, natural and human induced climate change.

**Unit III:** Impact of climate change on organisms, human, ecosystem, agriculture and food security; Sea level rise, Coral bleaching, Extinction risk of temperature sensitive species, melting of snow, ice and glaciers.

**Unit IV:** Policy response and mitigation strategies; UNFCCC, Kyoto Protocol – Carbon credit, Carbon trading, carbon sequestration, CDM; Clean energy options; CFCs – uses and trends; Reducing Carbon footprint.

### **ENV-GB5: Watershed Management**

**Unit-I:** Concept of watershed; Elements of watershed hydrology and watershed analysis; Factors affecting watershed; Watershed characteristics; Watershed Ecology; Management of water quality; Storm water and flood management; Drought management in watershed.

**Unit-II:** Introduction to the Concept of Watershed Management – Objective, Principle and Approaches; Introduction to Concept of Integrated and Sustainable Approach-Participatory Integrated Watershed Management (PIWM); Different stakeholders and their relative importance; Socio economic component of Watershed Management, Community participation, Private sector participation, Institutional issues, Socio-economy and Integrated development.

**Unit-III:** Watershed Monitoring and Risk assessment; Role of Indigenous and traditional knowledge (ITK) in watershed management; Participatory Rural Appraisal (PRA) Use of modern techniques in watershed management (applications of GIS and RS); Watershed modelling.

**Unit-IV:** Watershed management practices-natural resources management, agricultural and integrated farming, Soil erosion and Water conservation tools and techniques; Rain water harvesting and roof catchment system;); Watershed Management Policies; Role of Decision Support System in Watershed Management; Water legislation and implementations. Case studies.

### **ENV-GB6: Sustainable Development**

**Unit-I:** Definition and concepts of sustainable development, Concept of Sustainability Science, Emerging need for sustainability science, Historic perspectives – Gro Harlem Commission Report (1987) “Our Common Future”; Sustainability Indicators, The future and scope of sustainability Science.



**Unit-II:** Principles of Sustainable Development; Goals and Dimensions of Sustainable Development; Global Challenges of sustainable Development, Pathways to Sustainable Development; Limits to Growth, Carrying capacity.

**Unit-III:** Approaches to Sustainable Development, Natural Resource Management, Landscape Ecology; Watershed Management, Participation in Policy and Planning; Integrated Natural resource Management, Participatory NRM: Building new interface of NRM, Gender and NRM, Sustainability in NRM.

**Unit-IV:** Human society and sustainability; Unsustainable lifestyle; Eco-friendly lifestyle for sustainability, Global change and sustainability issues: Climate change, biological invasion, bio-diversity concerns; Ecology, Economics, Ethics, Education, Environmental Awareness and Moving towards Green Technology; Eco-philosophy: Eco-centric and anthropocentric world views.