Indicative Syllabus of Environmental Engineering

1. ENVIRONMENT AND SOCIETY

Significant global environmental issues such as acid rain, climate change, and resource depletion; historical developments in cultural, social and economic issues related to land, forest, and water management in a global context; interface between environment and society.

Development-environment conflict: Developmental issues and related impacts such as ecological degradation; environmental pollution; development-induced displacement, resettlement, and rehabilitation: problems, concerns, and compensative mechanisms; discussion on Project Affected People (PAPs).

Urbanization and environment: Production and consumption oriented approaches to environmental issues in Indian as well as global context; impact of industry and technology on environment; urban sprawl, traffic congestion and social-economic problems; conflict between economic and environmental interests.

Regulatory frameworks: Environment Protection Act 1986, Amendments, Notifications, The Forest (Conservation) Act, 1980, The Wildlife Protection Act 1972, Rules 1973 and Amendment 1991, The Wild Life (Protection) Amendment Act, 2006, The Indian Forest Act, 1927, National Forest Policy, 1988 and State Forest Policies, Forest Dwellers Act 2008, PESA, 1996, National Green Tribunal (NGT), The Water (Prevention and Control of Pollution) Act 1974; The Forests (Conservation) Act 1980; The Air (Prevention and Control of Pollution) Act 1981; Noise Pollution (Regulation and Control) Rules 2000, Land Acquisition Act 1894, 2007, 2011, 2012; Land Acquisition Rehabilitation and Resettlement Act 2013, The Biological Diversity Act 2002; scheme and labelling of environment friendly products, Ecomarks, etc.

International laws and policy: Stockholm Conference 1972; United Nations Conference on Environment and Development 1992; Rio de Janeiro (Rio Declaration, Agenda 21); Montreal Protocol 1987; Kyoto Protocol 1997; Copenhagen and Paris summits; Ramsar convention.

2. SYSTEMATICS AND BIOGEOGRAPHY

Definition of systematics; taxonomic identification; keys; field inventory; herbarium; museum; botanical gardens; taxonomic literature; nomenclature; evidence from anatomy, palynology, ultrastructure, cytology, phyto-chemistry, numerical and molecular methods; taxonomy databases. Concept of taxa (species, genus, family, order, class, phylum,

kingdom); concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); categories and taxonomic hierarchy. Nomenclature and systems of classification. Principles and rules (International Code of Botanical and Zoological Nomenclature); ranks and names; types and typification; author citation; valid publication; rejection of names; principle of priority and its limitations; names of hybrids; classification systems of Bentham and Hooker; Angiosperm Phylogeny Group (APG III) classification.

3. BIODIVERSITY AND CONSERVATION

Levels of organization in living world from genes to ecosystems; tree of life; history of character transformation; organic evolution through geographic time scale; species concept – what's in a name? how many species are there on earth?; concept and types of speciation. Spatial patterns: latitudinal and elevational trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns; importance of biodiversity patterns in conservation. Biodiversity estimation and Sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity, biomass estimation; community diversity estimation: alpha, beta and gamma diversity; molecular techniques: RAPD, RFLP, AFLP; NCBI database, BLAST analyses.: Importance of biodiversity and Economic values – medicinal plants, drugs, fisheries and livelihoods; ecological services – primary productivity, role in hydrological cycle, biogeochemical cycling; ecosystem services – purification of water and air, nutrient cycling, climate control, pest control, pollination, and formation and protection of soil; social, aesthetic, consumptive, and ethical values of biodiversity. Threats to biodiversity , Conservation of biodiversity : In-situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries); Ex-situ conservation (botanical gardens, zoological gardens, gene banks, seed and seedling banks, pollen culture, tissue culture and DNA banks), role of local communities and traditional knowledge in conservation; biodiversity hotspots; IUCN Red List categorization – guidelines, practice and application; Red Data book; ecological restoration; afforestation; social forestry; agro forestry; joint forest management; role of remote sensing in management of natural resources. Biodiversity in India as a mega diversity nation; phytogeographic and zoogeographic zones of the country; forest types and forest cover in India; fish and fisheries of India; impact of hydropower development on biological diversity; status of protected areas and biosphere reserves in the country; National Biodiversity Action Plan.

4. HUMAN-WILDLIFE CONFLICT AND MANAGEMENT

Need of environmental management; wildlife conservation: moral obligation? philosophy of wildlife management; why is it necessary to worry about human wildlife conflicts? What is the role of government, wildlife biologists and social scientists, concept of deep and shallow ecology. Evolution of the concept of wildlife management, Wildlife conservation laws in India. Types of protected areas (Wildlife Sanctuaries, National Parks, Biosphere Reserves, Sanctuaries, etc); IUCN categories of protected areas, Natural World Heritage sites; concept of core and buffer area in a protected range, brief introduction to Wildlife Protection Act of 1972, Forest act 1927, Environmental Protection Act 1986, and Forest conservation Act 1920; introduction of Tiger task force, Status of current protected areas in India. Concepts of development and encroachment, who is the intruders: human or animal? Impact of conflict on humans and wildlife, impact of habitat fragmentation, social inequality in terms of forest conservation: luxury hotels within protected areas vs. displacement of native tribes, forest produce as a need vs. forest exploitation, introduction to tribal rights in India, demographic profile of tribes in India, importance of forest produce to tribal populations, Scheduled tribes and other traditional Forest dwellers (Recognition of forest right) Act, 2006.

5. ATMOSPHERE AND GLOBAL CLIMATE CHANGE

Evolution and development of Earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the Earth, the only biosphere. Global energy balance, Earth's energy balance; energy transfers in atmosphere; Earth's radiation budget; greenhouse gases (GHGs); greenhouse effect; global conveyor belt.

Atmospheric circulation, Movement of air masses; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; El Nino and La Nina; tropical cyclone; Indian monsoon and its development, changing monsoon in Holocene in the Indian subcontinent, its impact on agriculture and Indus valley civilization; effect of urbanization on micro climate; Asian brown clouds. Meteorology and atmospheric stability, Meteorological parameters (temperature, relative humidity, wind speed and direction, precipitation); atmospheric stability and mixing heights; temperature inversion; plume behaviour; Gaussian plume model. Atmospheric chemistry , Chemistry of atmospheric particles and gases; smog – types and processes; photochemical processes; ions and radicals in atmosphere; acid-base reactions in atmosphere; atmospheric water; role of hydroxyl and hydroperoxyl radicals in atmosphere.

Global warming and climate change , Earth's climate through ages; trends of global warming and climate change; drivers of global warming and the potential of different greenhouse gases (GHGs) causing the climate change; atmospheric windows; impact of climate change on atmosphere, weather patterns, sea level rise, agricultural productivity and biological responses - range shift of species, CO2 fertilization and agriculture; impact on economy and spread of human diseases. Ozone layer or ozone shield; importance of ozone layer; ozone layer depletion and causes; Chapman cycle; process of spring time ozone depletion over Antarctica; ozone depleting substances (ODS); effects of ozone depletion; mitigation measures and international protocols. Climate change and policy, International agreements; Montreal protocol 1987; Kyoto protocol 1997; Convention on Climate Change; carbon credit and carbon trading; clean development mechanism.

6. LAND AND SOIL CONSERVATION AND MANAGEMENT

Land as a resource, soil health; ecological and economic importance of soil; types and causes of soil degradation; impact of soil loss and soil degradation on agriculture and food security; need for soil conservation and restoration of soil fertility. Fundamentals of soil science and Soil formation; classification of soil; soil architecture; physical properties of soil; soil texture; soil water holding capacity; soil temperature; soil colloids; soil acidity and alkalinity; soil salinity and sodicity; soil organic matter; micronutrients of soil; nitrogen, sulphur, potassium and phosphorus economy of soil; soil biodiversity; soil taxonomy maps. Soil degradation: Soil resistance and resilience; nature and types of soil erosion; non-erosive and erosive soil degradation; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, industrial and urban development, toxic organic chemicals, and organic contaminants in soils; fertilizers and fertilizer management; recycling of soil nutrients.

Landuse changes and land degradation: Biological and physical phenomena in land degradation; visual indicators of land degradation; drivers of land degradation - deforestation, desertification; habitat loss, loss of biodiversity; land salinization; human population pressure, poverty, socio-economic and institutional factors; drivers of land use and land cover change in major geographic zones and biodiverse regions with particular reference to the Himalayas and the Western Ghats or Biodiversity hotspot areas of the North-east.

Controlling land degradation, Sustainable land use planning; role of databases and data analysis in landuse planning control and management; land tenure and land policy; legal,

institutional and sociological factors; participatory land degradation assessment; integrating land degradation assessment into conservation.

7. ENVIRONMENTAL POLLUTION AND HUMAN HEALTH

Definition of pollution; pollutants; classification of pollutants. Air pollution - Ambient air quality: monitoring and standards (National Ambient Air Quality Standards of India); air quality index; sources and types of pollutants (primary and secondary); smog (case study); effects of different pollutants on human health (NOx, SOx, PM, CO, CO2, hydrocarbons and VOCs) and control measures; indoor air pollution: sources and effects on human health.

Water pollution - Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; eutrophication; COD, BOD, DO; effect of water contaminants on human health (nitrate, fluoride, arsenic, chlorine, cadmium, mercury, pesticides); water borne diseases; concept and working of effluent treatment plants (ETPs).

Soil pollution - Causes of soil pollution and degradation; effect of soil pollution on environment, vegetation and other life forms; control strategies.

Noise pollution – sources; frequency, intensity and permissible ambient noise levels; effect on communication, impacts on life forms and humans - working efficiency, physical and mental health; control measures.

Radioactive and thermal pollution - sources of radioactive pollution; effect of radiation on human health (somatic and genetic effects); thermal pollution and its effects.

Chemistry of environmental pollutants - Solubility of pollutants (hydrophilic and lipophilic pollutants), transfer of pollutants within different mediums, role of chelating agents in transferring pollutants, concept of biotransformation and bioaccumulation, concept of radioactivity, radioactive decay and half-life of pollutants, organometallic compounds, acid mine drainage.

Pollution control - Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds, fluidized bed reactors, membrane bioreactor neutralization, ETP sludge management; digesters, up flow anaerobic sludge blanket reactor, fixed film reactors, sequencing batch reactors, hybrid reactors, bio scrubbers, bio trickling filters; regulatory framework for pollution monitoring and control; case study: Ganga Action Plan; Yamuna Action Plan; implementation of CNG in NCT of Delhi.

8. NATURAL RESOURCE MANAGEMENT AND SUSTAINABILITY

Resource and reserves; classification of natural resources; renewable and non-renewable resources; resource degradation; resource conservation; resource availability and factors influencing its availability; land resources; water resources; fisheries and other marine resources; energy resources; mineral resources; human impact on natural resources; ecological, social and economic dimension of resource management.

Natural resources and conservation - Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry; water resources: supply, renewal, and use of water resources, freshwater shortages, strategies of water conservation; soil resources: importance of soil, soil conservation strategies; food resources: world food problem, techniques to increase world food production, green revolution.

Non-renewable energy resources - Oil: formation, exploration, extraction and processing, oil shale, tar sands; natural gas: exploration, liquefied petroleum gas, liquefied natural gas; coal: reserves, classification, formation, extraction, processing, coal gasification; environmental impacts of non renewable energy consumption; impact of energy consumption on global economy; application of green technology; future energy options and challenges

Renewable energy resources - Energy efficiency; life cycle cost; cogeneration; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, JNN solar mission; hydropower: technology, potential, operational costs, benefits of hydropower development; nuclear power: nuclear fission, fusion, reactors, pros and cons of nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel.

Resource management - Approaches in resource management: ecological approach; economic approach; ethnological approach; implications of the approaches; integrated resource management strategies; concept of sustainability science: different approach towards sustainable development and its different constituents; sustainability of society, resources and framework; sustainable energy strategy; principles of energy conservation; Indian renewable energy programme.

9. SOLID WASTE MANAGEMENT

Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste. Effect of solid waste disposal on environment - Impact of solid waste on environment, human and plant health; effect of solid waste and industrial effluent discharge on water quality and aquatic life; mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution. Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; drawbacks in waste management techniques.

Waste- to- energy (WTE) - Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification.

Integrated waste management - Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.

Policies for solid waste management - Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989; Bio-Medical Waste (Management and Handling) Rules 1998; Ecofriendly or green products.

10. WATER AND WATER RESOURCES

Hydrological cycle; precipitation, runoff, infiltration, evaporation, evapotranspiration; classification of water resources (oceans, rivers, lakes and wetlands).

Properties of water : Physical: temperature, colour, odour, total dissolved solids and total suspended solids; Chemical: major inorganic and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity, electrical conductivity, sodium adsorption ratio; Biological: phytoplankton, phytobenthos, zooplankton, macro-invertebrates and microbes.

Surface and subsurface water: Surface and ground water pollution; water table; vertical distribution of water; formation and properties of aquifers; techniques for ground water recharge; river structure and patterns; watershed and drainage basins; importance of watershed and watershed management.

Wetlands and their management: types of wetlands (fresh water and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention, 1971; major wetlands of India.

Water resource in India: Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; role of State in water resources management.

Water resources conflicts: Water resources and sharing problems, Multipurpose river valley projects in India and their environmental and social impacts; case studies of dams– social and ecological losses versus economic benefits; International conflicts on water sharing between India and her neighbours; agreements to resolve these conflicts. Major laws and treaties, National Water Policy; Water Pollution (control and prevention) Act 1972; Indus Water Treaty; Ganges Water Ttreaty etc. and their implications

11. GREEN TECHNOLOGIES

Definition and concepts: green technology, green energy, green infrastructure, green economy, and, green chemistry; sustainable consumption of resources; individual and community level participation such as small-scale composting pits for biodegradable waste, energy conservation; encouraged use of public transport instead of private transport. Introduction to UNEP's green economy initiative, inclusive economic growth of the society, REDD+ initiative, and cap and trade concept; green banking. Green House Gas (GHG) emissions reduction: carbon capture and storage (CCS) technologies, purchase and use of carbon offsets, promotion and/or subsidy of alternative forms of transportation for employees, such as carpools, fuel efficient vehicles, and mass transit, methane emissions reduction and/or reuse).

12. ECOLOGY:

Scope of ecology in environmental management. Physical, chemical, environmental factors and their relation to organisms. Climatic Factors: Interaction of ecological factors - light - temperature. Precipitation - Humidity - Wind - Atmospheric gases - Fire factor.

Topographic (Physiographic) factors. Edaphic Factors (Soil Science) Composition of soil - formation of soil - Factors affecting soil formation - soil profile - Soil classification - Soil complex - components and properties - Soil erosion - soil conservation.

Structure and Function of Ecosystem - Energy flow - producers - herbivores - carnivores - decomposers - food webs - biogeochemical cycles - resource regeneration. Population ecology: Relation within species, population growth, population dynamics positive and negative growth, bio-potential, agricultural structure, equilibrium position, oscillation and

fluctuation. Major Ecosystems: Pond , Marine, Grassland, Forest, Desert and Cropland ecosystems - Productivity of different ecosystems. Ecosystem Modelling .

13. ENVIRONMENTAL CHEMISTRY:

Unique properties of water - characteristics of water, waste and soil - water pollution, oxygen demanding wastes - Significance of various parameters qualifying the quality of water and wastes.

Methods of analyses for important pollution parameters - various instrumental methods used in analysis.

Estimation and Significance of acidity - alkalinity - hardness- turbidity-suspended and dissolved solids- B.O.D. and C.O.D. and significance chlorides - fluorides - ammonia - nitrite - nitrate - total nitrogen - phosphates - sodium - potassium - calcium - magnesium - iron - manganese - heavy metals - pesticides - carbon monoxide - carbon dioxide - methane.

14. WATER TREATMENT PROCESSES:

General Standards for quality of water for different purposes - Water intake structures Water demand. Selection of treatment processes - Sequencing Treatment processes - Capacity of treatment plants. Design period - Design of treatment plants.

15. APPLICATION OF REMOTE SENSING &GIS IN NATURAL RESOURCE MANAGEMENT

LAND RESOURCES: Land evaluation and suitability studies by Remote Sensing and GIS. Techniques of Landuse/Landcover map preparation. Landuse/Landcover mapping and planning.

Municipal GIS: Landuse Statistics as a basis for Environmental Planning, Solid and Hazardous waste disposal site selection.

GEOSCIENCES: Role of Remote Sensing and GIS in geological studies and case studies. Ground Water exploration and targeting using RS &GIS, Application of RS in Environmental Geology.

OCEANOGRAPHIC APPLICATIONS: Ocean color, Sea Surface Temperature, Earth Radiation budget. NOAA AVHRR for SST.

BOTANY, ECOLOGY AND FORESTRY: Spectral response of vegetation and mapping, Ecosystem Analysis, Environmental impact analysis and monitoring, Ecosystem modelling, survey and mapping of forest cover, Forest change detection, Forest Damage assessment and Forests monitoring, Focus on Mangrove forests, Wetland mapping.

WATER RESOURCES: Watershed characteristics, watershed management and integrated approach for sustainable planning using RS &GIS.

16. AIR POLLUTION:

Classification and properties of air pollutants emission sources major emissions from Global sources importance of anthropogenic sources, behavior and fate of air pollutants? photochemical smog effects of air pollution on health, vegetation and materials damage in India, air pollution laws and standards. Global climatic and air pollution problems - greenhouse gases - acid rain - stratospheric ozone depletion.

Meteorological aspects of air pollution dispersions Temperature laps Rates and Stability wind velocity and turbulence, Plume behaviour dispersion of air pollutants solutions to the atmospheric dispersion equation the Gaussian Plume Model.

Air pollution sampling and measurement types of pollutant sampling and measurement Ambient air sampling collection of gaseous air pollutants collection of particulate pollutants stock sampling, analysis of air pollutants sulphur dioxide nitrogen dioxide, carbon monoxide, oxidants and ozone hydrocarbons particulate matter.

17. ENERGY:

1. ENERGY - theoretical treatment of energy - the first and second laws of thermodynamics - energy population and free energy - converting heat into work - reversible processes - converting heat to work - carnot efficiency - conversion of matter into more useful forms - storage, distribution and conversion of energy - synthetic chemical fuels - the electrochemical energy conversion - net energy - conservation of free energy the energy balance of the earth.

2. ENERGY RESOURCES:

1. Non renewable energy resources: Fossil fuels - origin and development of coal - coal - fired power plants - cleaner coal combusion - origin and reserves of petroleum and natural gas - composition and classification of petroleum - petroleum refining - environmental problems associated with petroleum.

2. Renewable energy resources: New developing renewable energy sources - nuclear fission reactors - fission power and the environment - solar energy - collection and storage -, present scenario in India, wind energy and management, tidal energy and management geothermal energy, bio-gas plants and energy, management.

18. ENVIRONMENTAL IMPACT ASSESSMENT:

Conceptual of Environmental Impact Assessment - frame work of environmental assessment - description of environmental setting - simple methods for impact identification - matrices, networks, and checklists - background information - interaction matrix methodologies - network methodologies - checklist methodologies.

Prediction and assessment of impact of air, water (surface and ground), biological, socio-economic environment - Basic information and issues - regulations - conceptual approach - identification of the types and quantities of pollutants - existing quality conditions - procurement of relevant quality standards and regulations - impact prediction - assessment of impact significance - identification and incorporation of mitigation measures.

Concepts of environmental audit - objectives of audit - Types of Audits - Features of Effective auditing - Programme Planning - Definition - Organisation of Auditing Programm - pre visit data collection Audit Protocol - Onsite Audit - Data Sampling - Inspections - Evaluation and presentation Exit Interview - Audit Report - Action Plan - Other types of Audits - Management of Audits - Waste Management Contractor Audits - Related Audits.

19. REMOTE SENSING:

A. Definition of a map, types of maps, map reading, map scale, map projections basics and fundamental concepts of Remote Sensing, physics of Remote Sensing , Effects of atmosphere, Spectral Reflectance of Earth Surface features in different wave regions of Electromagnetic spectrum, characteristics of space platforms, sensors.
B. Fundamentals of Satellite Image Interpretation, Techniques of Image interpretation, Techniques of digital data interpretation, Multi-spectral Data Analysis, overviews of Image processing methods for feature extraction.

20. GEOGRAPHIC INFORMATION SYSTEM (GIS):

Introduction, the essential elements of a GIS, GIS definition and terminology, GIS categories, Components of GIS Fundamental Operations of GIS, A theoretical framework for GIS. The Essential Elements of a GIS: An overview, Functional Elements, Data in a GIS, Data Structure Raster Data Structures, Vector Data Structures, Comparisons between Data Structures.

Data Acquisition and Data input: Introduction, Existing Data sets, Developing Own Data. Digitalization and Scanning. Preprocessing: Format Conversion, Data Reduction and Generalization, Error detection and Editing, Merging, Edge Matching, Rectification and Registration, Interpolation.

Data Management: Basic Principles of Data Management; Efficiency, Conventional Database Management systems, Spatial database Management Product Generation: Types of output products, hardware components. Integrated Analysis of Spectral and Attribute data.

Data Quality : Introduction, Components

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