# B.Sc Programme

# in

## ECOLOGY AND ENVIRONMENTAL SCIENCE

# (PASS)

# ASSAM UNIVERSITY, SILCHAR

# DISCIPLINE SPECIFIC CORE (DSC) COURSE

## DISCIPLINE SPECIFIC CORE (DSC) 1: ENVIRONMENT AND SOCIETY

**Theory (60 Lectures :Credit=04:Marks=50)**

Unit 1: **Basic concept and significant environmental issues** (12 lectures)

Meaning and scope of Ecology and Environmental Science, Multidisciplinary nature of Environmental Science, Approaches to study Ecology and Environmental Science, Man-Environment Relationship, Need for environmental awareness.

Significant global environmental issues such as acid rain, climate change, and resource depletion; interface between environment and society.

Unit 2: **Development-environment conflict** (12 lectures)

Developmental issues and related impacts such as ecological degradation; environmental pollution; development-induced displacement, resettlement, and rehabilitation: problems, concerns, and compensative mechanisms;

Unit 3: **Urbanization and environment** (12 lectures)

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;

Unit 4: **Regulatory framework** (8 lectures)

Brief account of Forest Conservation Act 1980,1988; Forest Dwellers Act 2008; Land Acquisition Act 1894, 2007, 2011, 2012;

Unit 5**: Community participation** (16 lectures)

State, corporate, civil society, community, and individual-level initiatives to ensure sustainable development; case studies of environmental movements (Appiko Movement, Chipko Movement, Narmada Bachao Andolan); role played by NGOs; environmental education and awareness.

**Practicals: (60 Practical Classes :Credit=02:Marks=30)**

1. Study biotic (eg. bacteria and fungi) and abiotic (eg. pH and organic carbon) factors of soil environment

2. Preparation of a chart of biodegradable and non biodegradable pollutants generated in your locality

3. Study of factors responsible for ecological degradation and air pollution in your locality

4. Study of a representative type of ecosystem.

5. Study of different control measures for air pollution and noise pollution

**Suggested Readings**

1. Chokkan, K.B., Pandya, H. & Raghunathan, H. (eds). 2004. Understanding Environment. Sagar Publication India Pvt. Ltd., New Delhi.

2. Elliot, D. 2003. Energy, Society and Environment, Technology for a Sustainable Future. Routledge Press.

3. Guha, R. 1989. Ecological change and peasant resistance in the Himalaya. Unquiet Woods, Oxford University Press, Delhi.

4. Leopold, A. 1949. The Land Ethic. pp. 201-214. Chicago, USA.

5. National Research Council (NRC). 1996. Linking Science and Technology to Society's Environmental Goals. National Academy Press.

6. Pandit, M.K. 2013. Chipko: Failure of a Successful Conservation Movement. In: Sodhi, N.S., Gibson, L. & Raven, P.H. Conservation Biology: Voices from the Tropics. pp. 126-127. WileyBlackwellOxford, UK.

**DISCIPLINE SPECIFIC CORE (DSC) 2: HUMAN-WILDLIFE CONFLICT AND MANAGEMENT**

**Theory (60 Lectures :Credit=04:Marks=50)**

Unit 1: **Introduction to wildlife management** (10 lectures)

Need of environmental management; philosophy of wildlife management; human wildlife conflicts role of government, wildlife biologists and social scientists,

Unit 2: **Concept of wildlife management** (10 lectures)

Understanding wildlife management, Bishnoi community; conservation and policies regarding protected areas in 21st century; Values of wildlife management

Unit 3: **Wildlife conservation** (12 lectures)

Types of protected areas (Wildlife Sanctuaries, National Parks, Biosphere Reserves); IUCN categories of protected areas, Natural World Heritage sites; concept of core and buffer area in a protected range, introduction of Tiger task force, Status of current protected areas in India.

Unit 4: **Socio-economic and legal basis of conflicts** (12 lectures)

Impact of conflict on humans and wildlife, impact of habitat fragmentation, social inequality in terms of forest conservation:, forest produce as a need vs. forest exploitation, introduction to tribal rights in India, importance of forest produce to tribal populations, Scheduled tribes and other traditional Forest dwellers (Recognition of forest right) Act, 2006.

Unit 5: **Human wildlife coexistence** (16 lectures)

Symbiotic relationship between tribals and forest, forest and development, focus on the inclusive growth of tribes: community participation in forest management, sacred groves forests, ecological-economic welfare and development: wildlife corridors .

**Practicals: (60 Practical Classes :Credit=02:Marks=30)**

1. To study animal diversity of a disturbed site.

2. Identification of important food plants of mammals in a given area.

3. Study of methods of animal diversity measurement.

4. Study of strategy for preventing and managing human-wildlife conflicts.

5. Project on human-wildlife conflicts.

6. Field trip to protected areas (Reserve forest/ Wildlife sanctuary -optional).

**Suggested Readings**


1. Conover, M. 2001. Resolving Human Wildlife Conflicts, CRC Press.

2. Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for

effectively resolving human–wildlife conflict. Animal Conservation 13: 458-466.

3. Messmer, T. A. 2000. The emergence of human–wildlife conflict management: Turning

challenges into opportunities. International Biodeterioration & Biodegradation 45: 97-102.

4. Paty, C. 2007. Forest Government and Tribe. Concept Publishing Company.

5. Treves, A. & Karanth, K. U. 2003. Human-carnivore conflict and perspectives on carnivore

management worldwide. Conservation Biology 17: 1491-1499.

6. Woodroffe, R. 2005. People and Wildlife: Conflict and Coexistence. Cambridge.

7. Woodroffe, R., Thirgood, S., & Rabinowitz, A. 2005. People and Wildlife, Conflict or Coexistence? (No. 9). Cambridge University Press.

**DISCIPLINE SPECIFIC CORE (DSC) 3: GENDER AND ENVIRONMENT**

**Theory (60 Lectures :Credit=04:Marks=50)**

Unit 1: **Gender and society** (12 lectures)

The socially constructed 'gender' concept; gender existence in society; gender: matriarchy and patriarchy as means of social exclusion (case studies in an Indian context); gender equity issues in rural and urban settings.

Unit 2: **Gender and the environment** (14 lectures)

Relevance of the concept in an environmental context; gendered division of roles in cultural, social and economic perspective; gender inequalities.

Unit 3: **Gender, resources and the environment** (12 lectures)

Knowledge about the environment among men and women; differential dependencies on environmental resources; implications of gendered responses to environmental degradation.

Unit 4**: Gender and environmental management** (12 lectures)

Women's participation in environmental movements and conservation; historical and contemporary case studies; role of women in environmental education, awareness and sustainable development.

Unit 5: **Strategies for change** (10 lectures)

Need for gender equity; Instruments for change: education, media, action groups, policy and management; equity in resource availability and consumption for a sustainable future.

**Practicals: (60 Practical Classes :Credit=02:Marks=30)**

1. Survey on percentage composition of women in commercial establishments and their awareness about environmental pollution.

2. Percentage composition of women in administrative posts/ teaching posts/ private organization and their perception about environmental pollution and its remediation.

3. Perception of urban women home makers about environmental pollution and its remediation

4. Analyze the state of gender equality and women empowerment in environment-related sectors (tutorial based)

5. Women as small scale entrepreneur using local natural resources ( tutorial based).

**Suggested Readings**

1. Agarwal, B. 1992. The Gender and Environment Debate: Lessons from India. Feminist Studies (Minnesota).

2. Agarwal, B. 1997. Gender, Environment and Poverty Interlinks: Regional Variations and

Temporal Shifts in Rural India: 1971-1991. World Development 25: 1-42.

3. Agarwal, B. 2001. Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework. World Development 29: 1623-1648.

4. Jackson, C. 1993. Doing what comes naturally? Women and environment in development World Development 21: 1947-63.

5. Krishna, S. 2004. Livelihood and Gender. New Delhi, Sage.

6. Leach, M. 2007. Earth Mother myths and other ecofeminist fables: How a strategic notion rose and fell. Development and Change 38: 67-85.

7. Miller, B. 1993. Sex and Gender Hierarchies. Cambridge University Press

8. Stein, R. (ed.). 2004. New Perspectives on Environmental Justice: Gender, Sexuality, and Activism. Rutgers University Press.

9. Steingraber, S. 1998. Living Downstream: A Scientist's Personal Investigation of Cancer and the Environment. New York: Vintage Books.

10. Zwarteveen, M.Z. 1995. Linking women to the main canal: Gender and irrigation management. Gatekeeper Series 54, IIED.

**DISCIPLINE SPECIFIC CORE (DSC) 4: GREEN TECHNOLOGIES**

**Theory (60 Lectures :Credit=04:Marks=50)**

Unit 1**: Green technologies** (6 lectures)

Successful green technologies: wind turbines, solar panels; 3 R's of green technology: recycle, renew and reduce; paradigm shift from 'cradle to cradle' to 'cradle to grave'.

Unit 2: **Green infrastructure, planning and economy** (16 lectures)

Green buildings; need and relevance of green buildings over conventional buildings, LEED certified building; Eco-mark certification, establishment of Eco-mark in India, its importance and implementation; Green planning: role of governmental bodies, land use planning, concept of green cities, waste reduction and recycling in cities, role of informal sector in waste management, public transportation for sustainable development, green belts.

Unit 3: **Applications of green technologies** (16 lectures)

Carbon capture and storage (CCS) technologies, 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). Pollution reduction and removal (Flue Gas Desulfurization (FGD) methods, catalytic or thermal destruction of NOX,

Unit 4**: Green chemistry** (10 lectures)

Introduction to green chemistry; principles and recognition of green criteria in chemistry; biodegradable and bio-accumulative products in environment; green nanotechnology; reagents, reactions and technologies that should be and realistically could be replaced by green alternatives; photodegradable plastic bags.

Unit 5**: Green future** (12 lectures)

Agenda of green development; reduction of ecological footprint; role of green technologies towards a sustainable future; major challenges and their resolution for implementation of green technologies; green practices to conserve natural resources (organic agriculture, agro-forestry, reducing paper usage and consumption, etc.); emphasis on waste reduction instead of recycling, role of advancement in science in developing environmental friendly technologies.

**Practicals: (60 Practical Classes :Credit=02:Marks=30)**

Renewable Energy Technologies

1. Study of solar water heater, solar dryers, solar PV cell solar cooker, solar cells

2. Biogas production by anaerobic digestion.

3. Fuels: Knowledge about Density, Viscosity, Flash-point, Fire-point, Pour-point, ASTM distillation of liquid fuels.

4.: Study of Programmable batteries

**Suggested Readings**

1. Anastas, P.T. & Warner, J.C. 1998. Green Chemistry: Theory & Practice. Oxford University Press.

2. Arceivala, S.L. 2014. Green Technologies: For a Better Future. Mc-Graw Hill Publications.

3. Baker, S. 2006. Sustainable Development. Routledge Press.

4. Hrubovcak, J., Vasavada, U. & Aldy, J. E. 1999. Green technologies for a more sustainable agriculture (No. 33721). United States Department of Agriculture, Economic Research Service.

5. Thangavel, P. & Sridevi, G. 2015. Environmental Sustainability: Role of Green Technologies. Springer Publications.

6. Woolley, T. & Kimmins, S. 2002. Green Building Handbook (Volume 1 and 2). Spon Press.

# SKILL ENHANCEMENT COURSE (SEC)

**SKILL ENHANCEMENT COURSE 1 Bamboo Cultivation, Utilization and Management**

**Theory (60 Lectures : Credit=04:Marks=50)**

**Unit I: Diversity, Distribution and Growth behaviour :** Origin, diversity and distribution of bamboo with special reference to Northeast India, Rhizome types, Clump and culm character, Culm sheath, Culm emergence, Culm elongation, Shoot mortality, Branching habit, Culm production. **(Lectures: 12),**

**Unit II: Bamboo and Rural Socio-economy**: Traditional and commercial utilization of bamboos, utilization of bamboo resources for: traditional and value added craft, incense stick and paper industry. **(Lectures: 12)**

**Unit III**: **Propagation and Nursery Management**: Rhizome, culm and branch cutting, culm cutting and layering. Concept of tissue culture, Infrastructure facilities, Concept of green house, net house, polyhouse and their utility. Nursery bed preparation, seedling nursing, techniques of nursery management, seedling nursing and management, Vegetative Propagation Centre. **(Lectures: 12)**

**Unit IV: Bamboo as food:** Bamboo shoots and human health, Indigenous and oriental recepies, Nutritional properties of bamboo shoot, Processing technology for storage of fresh bamboo shoots, Preservation techniques, Traditional and laboratory fermentation techniques of bamboo shoots. **(Lectures: 12)**

**Unit V: Silvicultural management:** Plantation raising and silvicultural management, harvesting strategies of forest and village bamboos, Nutrient and fertilizer management in bamboos, Flowering periodicity and management strategies adopted before and after gregarious flowering, Insect pests and diseases of bamboo and their control.. **(Lectures: 12)**

**Suggested readings:**


Banik, R.L. (1995) *A Manual for Vegetative Propagation of Bamboos*. INBAR.

Banik, R.L. (2000) *Silviculture and Field-Guide to Priority Bamboos of Bangladesh and South Asia*. Government of the people's republic of Bangladesh, Bangladesh Forest research Institute, Chittagong.

Banik, R.L. (2010) Biology and silviculture of Muli Bamboo (*Melocanna baccifera*).National Mission on Bamboo Applications, New Delhi.

Barooah, C.and Bortakur, S.K. (2003) *Diversity and Distribution of Bamboos in Assam.* Bishen Singh Mahendra Pal Singh.

Bedell, P.E. (1997) *Taxonomy of Bamboos.*APC Publications Pvt.Ltd.

FAO (2010) *Global Forest Resources Assessment, 2010.* Food and Agricultural Organisation.

FSI (2011) *India State of Forest Report*. Forest Survey of India, Dehradun.

Liese, W. And Kohl, M. (2015). **Bamboo**: The Plant and its Uses (Tropical Forestry). Springer International Publishing.

NMBA (2004) *The Bamboo Book*. National Mission on Bamboo Applications. Department of Science and Technology, New Delhi.

Negi, S.S. (2009) *Bamboos of India.* Bishen Singh Mahendra Pal Singh.

Seethalakshmi, K.K. and Muktesh Kumar, M.S. (1998) *Bamboos of India: A compendium.* Kerala Forest Research Institute &INBAR.

Tewari, D.N. (1992) *A Monograph on Bamboo*. International Book Distributors.

**SKILL ENHANCEMENT COURSE 2: REMOTE SENSING, GEOGRAPHIC INFORMATION SYSTEM & MODELLING**

**Theory (60 Lectures :Credit=04:Marks=50)**

Unit 1: **Remote Sensing: definitions and principles**; electromagnetic (EME) spectrum; interaction of EMR with Earth's surface; spectral signature; satellites and sensors; aerial photography and image interpretation. **(Lectures: 12)**

Unit 2: **Geographical Information Systems**: definitions and components; spatial and non-spatial data; raster and vector data. **(Lectures: 12)**

Unit 3: **Database generation; database management system**; land use/ land cover mapping; overview of GIS software packages; GPS survey, data import, processing, and mapping. **(Lectures: 12)**

Unit 4: **Applications of remote sensing** : Application of and case studies of remote sensing and GIS in geosciences, water resource management, land use planning, forest resources, agriculture, marine and atmospheric studies. **(Lectures: 12)**

Unit 5: **Basic elements of statistical analyses**: sampling; types of distribution – normal, binomial, poisson; measurements of central tendency and dispersion; skewness; kurtosis; hypothesis testing; parametric and non-parametric tests; correlation and regression; curve fitting; analysis of variance; ordination. **(Lectures: 12)**

**Suggested Readings**


1. Zar, J.H. 2010. Biostatistical Analysis (5thedition). Prentice Hall Publications.
2. Edmondson, A. & Druce, D.1996.Advanced Biology Statistics. Oxford University Press.
3. Demers, M.N. 2005. Fundamentals of Geographic Information System. Wiley & Sons.
4. Richards, J. A. & Jia, X. 1999. Remote Sensing and Digital Image Processing. Springer.
5. Sabins, F. F. 1996. Remote Sensing: Principles an Interpretation. W. H. Freeman.

**SKILL ENHANCEMENT COURSE 3: ENVIRONMENTAL IMPACT AND RISK ASSESSMENT**

**Theory (60 Lectures :Credit=04:Marks=50)**

Unit 1: **Environmental impact assessment (EIA):** definitions, introduction and concepts; rationale and historical development of EIA; scope and methodologies of EIA; **(Lectures: 12)**

Unit 2: **EIA - project components**: Role of project proponents, project developers and consultants; Terms of Reference; impact identification and prediction; baseline data collection; Environmental Impact Statement (EIS), Environmental Management Plan (EMP) **(Lectures: 12)**

Unit 3: **Rapid EIA**; Strategic Environmental Assessment; Social Impact Assessment; CostBenefit analysis; Life cycle assessment; environmental appraisal; environmental management - principles, problems and strategies; environmental planning; environmental audit; introduction to ISO and ISO 14000; sustainable development. **(Lectures: 12)**

Unit 4: **EIA regulations in India**; status of EIA in India; current issues in EIA; case study of hydropower projects/ thermal projects. **(Lectures: 12)**

Unit 5**: Risk assessment**: introduction and scope; project planning; exposure assessment; toxicity assessment; hazard identification and assessment; risk characterization; risk communication; environmental monitoring; community involvement; legal and regulatory framework; human and ecological risk assessment. **(Lectures: 12)**

**Suggested Readings**

1. Barrow, C.J. 2000. Social Impact Assessment: An Introduction. Oxford University Press.

2. Glasson, J., Therivel, R., Chadwick, A. 1994. Introduction to Environmental Impact Assessment. London, Research Press, UK.

3. Judith, P. 1999. Handbook of Environmental Impact Assessment. Blackwell Science. 4. Marriott, B. 1997. Environmental Impact Assessment: A Practical Guide. McGraw-Hill, NewYork, USA

**SKILL ENHANCEMENT COURSE 4** : **ECOSYSTEM ANALYSIS & BIODIVERSITY CONSERVATION**

**Theory (60 Lectures : Credit=04:Marks=50)**

**UnitI- Ecosystem: Concept of ecosystem**, components of ecosystem; Major ecosystem types: terrestrial ecosystem (grassland ecosystem; forest ecosystem; desert ecosystem; agro-ecosystem; mangrove ecosystem) and aquatic ecosystem (pond ecosystems; estuarine ecosystem, marine ecosystem). Biomes: Concept and definition of major biomes – Tundra, Tropical, Temperate Grassland, Desert biome**. (12 Lectures )**

**Unit II : Energy flow in ecosystem**: food chain, food-web, and ecological pyramids (pyramid of number, biomass and energy) Biogeochemical cycles – patterns and basic types; carbon cycle, oxygen cycle, nitrogen cycle and phosphorous cycle.

Concept of primary and secondary Productivity, methods of measuring productivity in terrestrial and aquatic ecosystem (harvest method, gas exchange method, radioisotope method, leaf area index method, chlorophyll method) **( 12 Lectures )**

**Unit III-Community Ecology**: Concept of community – definition, Community structure – horizontal and vertical stratification. Community Characteristics: Analytical Characters of a community – qualitative (physiognomy, phenology, stratification, life form) and quantitative (frequency, density, abundance, cover and basal area). Methods of studying communities: quadrate method and its types, transect method and its types, point method and its types. **(12 Lectures )**

**Unit IV- Ecological Succession**: Definition; basic types, Processes and stages of succession in different habitat (hydrosere, xerosere), microbial succession; Concept of Climax; **(12 Lectures )**

Unit V : **Conservation of biodiversity:** Importance of biodiversity: economic values, ecosystem services and ethical values . 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. India as a mega diversity nation; phytogeographic and zoogeographic zones of the country; National Biodiversity Action Plan. **( 12 Lectures )**

**Suggested Readings**

1. Gaston, K J. & Spicer, J.I. 1998. Biodiversity: An Introduction. Blackwell Science, London, UK.

2. Krishnamurthy, K.V. 2004. An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.

3. Pandit, M.K. & Grumbine R.E. 2012. Ongoing and proposed hydropower development in the Himalaya and its impact on terrestrial biodiversity. Conservation Biology 26:1061-1071.

4. Primack, R.B. 2002. Essentials of Conservation Biology (3rd edition). Sinauer Associates, Sunderland, USA.

5. Singh, J. S. & Singh, S. P. 1987. Forest vegetation of the Himalaya. The Botanical Review 53: 80-192.

6. Singh, J. S., Singh, S.P. & Gupta, S. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.

7. Sodhi, N.S. & Ehrlich, P.R. (Eds). 2010. Conservation Biology for All. Oxford University Press.

8. Sodhi, N.S., Gibson, L. & Raven, P.H. 2013. Conservation Biology: Voices from the Tropics. Wiley-Blackwell, Oxford, UK.

Ambasht, R.S. Ambasht, N.K., 2011. A Textbook of Plant Ecology (15th edition)CBS Publishers

9. Bharucha, E.,2005. Text Book of Environmental studies University Press (India) Pvt. Ltd, Hyderabad.

10 Kormondy, E.J., 2000. Concepts of Ecology. Fourth Edition. Prentice Hall of India, New Delhi.

11. Misra, K.C., 1992. Manual of Plant Ecology. Oxford and IBH Publishing Co., New Delhi.

12. Rana, S.V.S. ,2013. Essentials of Ecology and Environmental Science. Prentice Hall of India, New Delhi

13. Sharma, P.D., 2011. Ecology and Environment. Rastogi Publications, Meerut.

# DISCIPLINE SPECIFIC ELECTIVE (DSE)

**( Students will take any two as offered by the college)**

## DISCIPLINE SPECIFIC ELECTIVE 1: ENERGY AND ENVIRONMENT

**Theory (60 Lectures :Credit=04:Marks=50)**

Unit 1: **Energy resources** (10 lectures)

Global energy resources; renewable and non-renewable resources: distribution and availability; past, present, and future technologies for capturing and integrating these resources into our energy infrastructure; energy-use scenarios in rural and urban setups; energy conservation.

Unit 2: **Energy demand** (10 lectures)

Global energy demand: current perspective; energy demand and use in domestic, industrial, agriculture and transportation sector; generation and utilization in rural and urban environments; changes in demand in major world economies; energy subsidies and environmental costs.

Unit 3: **Energy, environment and society** (14 lectures)

Nature, scope and analysis of local and global impacts of energy use on the environment; fossil fuel burning and related issues of air pollution, greenhouse effect, global warming and, urban heat island effect; nuclear energy and related issues such as radioactive waste, spent fuel; social inequalities related to energy production, distribution, and use.

Unit 4: **Energy, ecology and the environment** (10 lectures)

Energy production as driver of environmental change; energy production, transformation and utilization associated environmental impacts (Chernobyl and Fukushima nuclear accidents, construction of dams, environmental pollution); energy over-consumption and its impact on the environment, economy, and global change.

Unit 5: **Our energy future** (16 lectures)

Current and future energy use patterns in the world and in India; alternative sources as green energy (biofuels, wind energy, solar energy, geothermal energy; ocean energy; nuclear energy); need for energy efficiency; energy conservation and sustainability; action strategies for sustainable energy mix and management from a future perspective.

**Practicals: (60 Practical Classes :Credit=02:Marks=30)**

1. Demonstration of photovoltaics and solar energy.
2. Biofuel energy resource (Hydrocarbon, Alcohol and Oil) from microorganisms and higher plants.
3. Types of oil and gas and its characterization (Tutorial based)
4. Renewable energy from biomass and wastes

**Suggested Readings**

1. McKibben, B. 2012. Global Warming's Terrifying New Math, Rolling Stone Magazine.

2. Craig. J.R., Vaughan, D.J., Skinner. B.J. 1996. Resources of the Earth: Origin, use, and environmental impact (2nd edition). Prentice Hall, New Jersey.

3. Elliott, D. 1997. Sustainable Technology. Energy, Society and Environment (Chapter 3). New York, Routledge Press.

4. Rowlands, I.H. 2009. Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies in Debora L. Van Nijnatten and Robert Boardman (eds), Canadian Environmental Policy and Politics: Prospects for Leadership and Innovation, Third Edition. Oxford University Press, pp. 167-82.

5. Oliver, J. 2013. Dispelling the Myths about Canada's Energy Future, Policy: Canadian Politics and Public Policy, June-July.

6. Mallon, K. 2006. Myths, Pitfalls and Oversights, Renewable Energy Policy and Politics: A Handbook for Decision-Making. EarthScan.

**DISCIPLINE SPECIFIC ELECTIVE 2: ENVIRONMENTAL ECONOMICS**

**Theory (60 Lectures :Credit=04:Marks=50)**

Unit1: **Introduction to microeconomics** (15 lectures)

Definition and scope of environmental economics; environmental economics versus traditional economics; brief introduction to major components of economy: consumer, firm and their interaction in the market, producer and consumer surplus, market failure, law of demand and supply, tangible and non tangible goods;

Unit 2: **Environmental economics** (15 lectures)

Main characteristics of environmental goods; marginal analysis; markets and market failure; social benefit, costs and welfare functions; meaning and types of environmental values; measures of economic values; tangible and intangible benefits; Pareto principle or criterion; Hardin's Thesis of 'The Tragedy of Commons';

Unit 3: **Economic solutions to environmental problems** (15 lectures)

Social costs and benefits of environmental programmes: marginal social benefit of abatement, marginal social cost of abatement; pollution control: policies for controlling air and water pollution, disposal of toxic and hazardous waste- standards vs. emissions charges, environmental subsidies, modelling and emission charges; polluter pay principles;

Unit 4: **Natural resource economics** (5 lectures)

Economics of non-renewable resources; economics of fuels and minerals; Hotelling's rule and extensions; taxation; economics of renewable resources; economics of water use, management of fisheries and forests; introduction to natural resource accounting

Unit 5: **Tools for environmental economic policy** (10 lectures)

Growth and environment; environmental audit and accounting, Kuznets curve, environmental risk analysis, assessing benefits and cost for environmental decision making; cost benefit analysis and valuation: discounting, principles of Cost-Benefit Analysis, estimation of costs and benefits, techniques of valuation, adjusting and comparing environmental benefits and costs.

**Practicals: (60 Practical Classes :Credit=02:Marks=30)**

1. Report on the major components of economy in Barak Valley and their potential environmental implications (Tutorial-based on secondary data)

2. Use of fertilizers and pesticides in agricultural activities in Barak Valley (based on field visits / secondary data)

3. Report on development of fishery sector in Barak Valley and its environmental implications (based on field visits / secondary data)

4. Report on status of transport sector in Barak Valley and its environmental implications.

**Suggested Readings**


1. Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C.S., Jansson, B.O., Levin, S., Maler, K.G., Perrings, C., Pimentel, D. 1995. Economic growth, carrying capacity, and the environment. Ecological Economics 15: 91-95.
2. Hanley, N., Shogren, J. F., & White, B. 2007. Environmental Economics: In Theory and Practice. Palgrave Macmillan.
3. Kolstad, C.D. 2010. Environmental Economics. Oxford University Press.
4. Perman, R. 2003. Natural Resource and Environmental Economics. Pearson Education.
5. Singh, K. & Shishodia, A. 2007. Environmental Economics: Theory and Applications. Sage Publications.
6. Thomas, J.M. & Callan, S.J. 2007.Environmental Economics. Thomson Learning Inc.
7. Tietenberg, T. 2004. Environmental and Natural Resource Economics(6thEdition). Pearson Education Pvt. Ltd.
8. Tietenberg, T. H. & Lewis, L. 2010. Environmental Economics and Policy. Addison-Wesley.
9. Turner, R. K., Pearce, D., & Bateman, I. 1994. Environmental Economics: An Elementary Introduction. Harvester Wheatsheaf.

**DISCIPLINE SPECIFIC ELECTIVE 3: NATURAL HAZARDS AND DISASTER MANAGEMENT**

**Theory (60 Lectures :Credit=04:Marks=50)**

Unit 1: **Natural hazards** (16 lectures)

Natural hazards: hydrological, atmospheric & geological hazards; earthquake: seismic waves, epicenter; volcanoes, floods, landslides, drought and famine, tsunamis.

Unit 2: **Anthropogenic hazards** (16 lectures)

Impacts of anthropogenic activities such as rapid urbanization, injudicious ground water extraction, sand mining from river bank, deforestation, mangroves destruction; role of construction along river banks in elevating flood hazard; disturbing flood plains. deforestation and landslide hazards associated with it; large scale developmental projects, like dams and nuclear reactors in hazard prone zones.

Unit 3**: Risk and vulnerability assessment** (8 lectures)

Two components of risk: likelihood and consequences, qualitative likelihood measurement index; categories of consequences (direct losses, indirect losses, tangible losses, and intangible losses); application of geoinformatics in hazard, risk & vulnerability assessment.

Unit 4: **Mitigation and preparedness** (10 lectures)

Concept of mitigation; types of mitigation: structural and non-structural mitigation, use of technologies in mitigations such as barrier, deflection and retention systems; concept of preparedness; importance of planning, exercise, and training in preparedness; role of public, education and media in hazard preparedness.

Unit 5: **Disaster management in India** (10 lectures)

National Disaster Management Framework, national response mechanism, role of government bodies such as NDMC and IMD; role of armed forces and media in disaster management; role of space technology in disaster management;

**Practicals: (60 Practical Classes :Credit=02:Marks=30)**

1) Studies on any natural hazard that took place in recent past and its impact on landscape and population.

2) Recording of meteorological data (Maximum and minimum temperature, morning and afternoon humidity, sunshine hours, rainfall etc) of any area for the past 15 days (minimum three parameters are to be studied).

3) Risk assessment and vulnerability mapping of any natural disaster that occurred in the recent past.

4) Visit any nearby industrial area and assessment of hazard coming out from the industrial discharges.

5) To prepare a project report on any natural disaster that took place in the locality in the past and obtain people's perspective on the disaster.

**Suggested Readings**

1. Coppola D. P. 2007. Introduction to International Disaster Management. Butterworth Heinemann.

2. Cutter, S.L. 2012. Hazards Vulnerability and Environmental Justice. EarthScan, Routledge Press.

3. Keller, E. A. 1996. Introduction to Environmental Geology. Prentice Hall, Upper Saddle River, New Jersey.

4. Pine, J.C. 2009. Natural Hazards Analysis: Reducing the Impact of Disasters. CRC Press, Taylor and Francis Group.

5. Schneid, T.D. & Collins, L. 2001. Disaster Management and Preparedness. Lewis Publishers, New York, NY.

6. Smith, K. 2001. Environmental Hazards: Assessing Risk and Reducing Disaster. Routledge Press.

7. Wallace, J.M. & Hobbs, P.V. 1977. Atmospheric Science: An Introductory Survey. Academic Press, New York.

8. Wasson, R.J., Sundriyal, Y.P., Chaudhary, S., Jaiswal, M.K., Morthekai, P., Sati, S.P.&Juyal, N. 2013. A 1000-year history of large floods in the upper Ganga catchment, central Himalaya, India. Quaternary Science Reviews 77: 156–166

**DISCIPLINE SPECIFIC ELECTIVE 4: SOLID WASTE MANAGEMENT**

**Theory (60 Lectures :Credit=04:Marks=50)**

Unit 1: **Effect of solid waste disposal on environment** (10 lectures)

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.

Unit 2: **Solid waste Management** (16 lectures)

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

Unit 3: **Industrial waste management** (10 lectures)

Types of industrial waste: hazardous and non-hazardous; effect of industrial waste on air, water and soil; industrial waste management and its importance; stack emission control and emission monitoring; effluent treatment plant and sewage treatment plant.

Unit 4: **Resource Recovery** (12 lectures)

4R- reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment; waste- to- energy (WTE): refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification.

Unit 5: **Policies for solid waste management** (12 lectures)

Plastic Waste Management Rules 2016, e-waste (Management) Rules, 2016, Bio-Medical Waste Management Rules,2016, Construction and Demolition Waste Management Rules, 2016, Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016, Solid Waste Management Rules, 2016

**Practicals: (60 Practical Classes : Credit=02:Marks=30)**

1. Sampling of solid waste by quadrat method from different sites

2. Determination of pH, temperature and moisture content of a given sample of solid waste

3. Determination of different types of solid waste and their percentage composition in the municipal solid waste

4. A study on household waste generation in different areas of a city/town/locality by collecting and estimating daily waste (biodegradable and non biodegradable) or by questionnaire method.

5. Number of rag-pickers in urban areas and their contribution to solid waste management.

**Suggested Readings**


1. Asnani, P. U. 2006. Solid waste management. India Infrastructure Report 570.

2. Bagchi, A. 2004. Design of Landfills and Integrated Solid Waste Management. John Wiley & Sons.

3. Blackman, W.C. 2001. Basic Hazardous Waste Management. CRC Press.

4. McDougall, F. R., White, P. R., Franke, M., & Hindle, P. 2008. Integrated Solid Waste Management: A Life Cycle Inventory. John Wiley & Sons.

5. US EPA. 1999. Guide for Industrial Waste Management. Washington D.C.

6. White, P.R., Franke, M. &Hindle P. 1995. Integrated Solid waste Management: A Lifecycle Inventory. Blackie Academic & Professionals.

7. Zhu, D., Asnani, P.U., Zurbrugg, C., Anapolsky, S. & Mani, S. 2008. Improving Municipal Solid waste Management in India. The World Bank, Washington D.C.

8. CSE 2016 Not in my Backyard: Soild waste management in Indian Cities.Centre for Science and Environment, New Delhi