ASSAM UNIVERSITY, SILCHAR

SYLLABUS
FOR

B.Sc Programme in Ecology and Environmental Science (HONOURS)

Choice Based Credit System (CBCS)

2017

CORE COURSE 1: EARTH AND EARTH SURFACE PROCESSES

Theory (60 Lectures)

Unit 1: History of Earth (10 lectures)

Formation of the Earth: formation and composition of core, mantle, crust, atmosphere and hydrosphere; chemical composition of Earth; geological time scale and major changes on the Earth's surface; Holocene and the emergence of humans,

Unit 2: Earth system processes (10 lectures)

Movement of lithosphere plates; mantle convection and plate tectonics, major plates and hot spots, plate boundaries; sea floor spread; earthquakes; volcanic activities; orogeny; isostasy; gravitational and magnetic fields of the earth; origin of the main geomagnetic field; continental drift, Pangaea and present-day continents,

Unit 3: Minerals and rocks (15 lectures)

Minerals and important rock forming minerals; rock cycle: lithification and metamorphism; Three rock laws; rock structure, igneous, sedimentary and metamorphic rocks; weathering: physical, biogeochemical processes; erosion: physical processes of erosion, factors affecting erosion;

Unit 4: Earth surface processes (15 lectures)

Atmosphere: Composition of atmosphere, physical and optical properties, circulation; interfaces: atmosphere–ocean interface, atmosphere–land interface, ocean–land interface, rivers and geomorphology; types of glaciers, glacier dynamics,

Unit 5: Importance of being a mountain (10 lectures)

Formation of Peninsular Indian mountain systems - Western and Eastern Ghats, Vindhyas, Aravallis, etc. Formation of the Himalaya; development of glaciers, perennial river systems, formation of Indo-Gangetic Plains,

Practicals: EARTH AND EARTH SURFACE PROCESSESS

1. Study of Topographic map
2. Preparation of profile / section and determination of slopes of different directions.
3. Study of Model for continental drift
4. Identification of rocks and minerals.
5. Study and interpretation of Geological time scale.
6. Study of landscapes of urban, semi-urban and rural areas.

Suggested Readings

1. Bridge, J., & Demicco, R. 2008. Earth Surface Processes, Landforms and Sediment deposits. Cambridge University Press.

2. Duff, P. M. D., & Duff, D. (Eds.). 1993. Holmes' Principles of Physical Geology. Taylor & Francis.

3. Gupta, A. K., Anderson, D. M., & Overpeck, J. T. 2003. Abrupt changes in the Asian southwest monsoon during the Holocene and their links to the North Atlantic Ocean. Nature 421: 354-357.

4. Gupta, A. K., Anderson, D. M., Pandey, D. N., & Singhvi, A. K. 2006. Adaptation and human migration, and evidence of agriculture coincident with changes in the Indian summer monsoon during the Holocene. Current Science 90: 1082-1090.

5. Keller, E.A. 2011. Introduction to Environmental Geology (5^{th} edition). Pearson Prentice Hall.

6. Krishnan, M. S. 1982. Geology of India and Burma. CBS Publishers & Distributors.

7. Leeder, M., Arlucea, M.P. 2005. Physical Processes in Earth and Environmental Sciences. Blackwell Publishing.

8. Pelletier, J. D. 2008. Quantitative Modeling of Earth Surface Processes (Vol. 304). Cambridge: Cambridge University Press. Chicago.

CORE COURSE 2: PHYSICS AND CHEMISTRY OF ENVIRONMENT

Theory (60 Lectures)

Unit 1: Fundamentals of environmental physics (16 lectures)

Basic concepts of light and matter; quantum mechanics (relation between energy, wavelength and frequency), black body radiation, spectroscopic concepts: Introduction to the concept of absorption and transmission of light, Beer–Lambert law. Basic concepts of pressure, force, work and energy; types of forces and their relation (pressure gradient, viscous, Coriolis, gravitational, centripetal, and centrifugal force); concept of heat transfer, conduction, convection; concept of temperature, laws of thermodynamics;

Unit 2: Fundamentals of environmental chemistry (16 lectures)

Atomic structure, electronic configuration, periodic properties of elements (ionization potential, electron affinity and electronegativity), types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds); mole concept, molarity and normality, quantitative volumetric analysis. types of chemical reactions; acids, bases and salts, solubility products; solutes and solvents; redox reactions, concepts of pH and pE,

Unit 3: Atmospheric chemistry (10 lectures)

Composition of atmosphere; photochemical reactions in atmosphere; smog formation, types of smog (sulphur smog and photochemical smog), aerosols; chemistry of acid rain, reactions of NO2 and SO2; free radicals and ozone layer depletion, role of CFCs in ozone depletion.

Unit 4: Water chemistry (10 lectures)

Chemical and physical properties of water; alkalinity and acidity of water, hardness of water, calculation of total hardness; solubility of metals, complex formation and chelation; colloidal particles; heavy metals in water.

Unit 5: Soil chemistry (8 lectures)

Soil composition; relation between organic carbon and organic matter, inorganic and organic components in soil; soil humus; cation and anion exchange reactions in soil; nitrogen, phosphorus and potassium in soil; phenolic compounds in soil.

Practicals:

1. Analysis of sample spectrophotometrically.
2. Determination of the strength of an acid.
3. Determination of carbonate, hydroxide and total alkalinity of a given water sample.
4. Determination of pH of various water samples.
5. Determination of temporary, permanent and total hardness of water.
6. To measure soil temperature , soil pH and water holding capacity and moisture percentage of soil.

Suggested Readings

1. Beard, J.M. 2013. Environmental Chemistry in Society (2ndedition). CRC Press.

2. Boeker, E. & Grondelle, R. 2011. Environmental Physics: Sustainable Energy and Climate Change. Wiley.

3. Connell, D.W. 2005. Basic Concepts of Environmental Chemistry (2ndedition). CRC Press.

4. Forinash, K. 2010. Foundation of Environmental Physics. Island Press.

5. Girard, J. 2013. Principles of Environmental Chemistry (3rd

edition). Jones & Bartlett.

6. Harnung, S.E. & Johnson, M.S. 2012. Chemistry and the Environment. Cambridge University Press.

7. Hites, R.A. 2012. Elements of Environmental Chemistry (2nd

edition). Wiley & Sons.

8. Manhan, S. E. 2000. Fundamentals of Environmental Chemistry. CRC Press.

9. Pani, B. 2007. Textbook of Environmental Chemistry. IK international Publishing House.

GENERAL ELECTIVE 1: ENVIRONMENT AND SOCIETY

Theory (60 Lectures)

Unit 1: Issues in environmentalism (12 lectures)

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:

1. Study of different components of environment
2. Prepare a chart of biodegradable and non biodegradable pollutants generated in your locality
3. Study of factors responsible for ecological degradation and air pollution
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. Wiley-Blackwell, Oxford, UK.

CORE COURSE 3: WATER AND WATER RESOURCES

Theory (60 Lectures)

(4 lectures)

Unit 1: Physico-chemical parameters of water (12 lectures)

Sources and types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapo-transpiration; 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,

Unit 2: Surface and subsurface water (12 lectures)

Introduction to surface and ground 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; importance of watershed and watershed management; rain water harvesting in urban settings.

Unit 3: Water resource in India (16 lectures)

Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; Definition of a wetland; types of wetlands (fresh water and marine); ecological significance of wetlands; threats to wetlands, Ramsar Convention, 1971; major wetlands of N E India.

Unit 4: Marine resource management (6 lectures)

Marine resources; commercial use of marine resources; threats to marine ecosystems and resources; marine ecosystem and resource management (planning approachs, construction techniques and monitoring of coastal zones), EEZ.

Unit 5: Water resources conflicts and major laws and treaties (14 lectures)

Water resources and sharing problems, Multi-purpose river valley projects in India and their environmental and social impacts; case studies of dams- Narmada and Tehri dam – social and ecological losses versus economic benefits; International conflicts on water sharing between India and her neighbours; National water policy; water pollution (control and prevention) Act 1972; National River linking plan.

Practicals: WATER & WATER RESOURCES

1. To determine pH of water of different water bodies (Pond, River, Lakes & Ground water)
2. To determine the transparency of water of Pond ecosystem by Secchi disc.
3. Study of common plants, insects, birds following basic principles of identification.
4. Visit to an area to document environmental assets: river/ forest/ flora/fauna, etc.
5. Visit to a local polluted site-Urban/Rural/Industrial/Agricultural.
6. Study of simple ecosystems-pond, river etc. and submit a report

Suggested Readings

1. Bansil, P.C. 2004. Water Management in India. Concept Publishing Company, India.

2. Brebbia, C.A. 2013. Water Resources Management VII. WIT Press.

3. CEA. 2011. Water Resources and Power Maps of India. Central Board of Irrigation & Power.

4. Grumbine, R.E. & Pandit, M.K. 2013. Threats from India's Himalaya dams. Science 339: 36-37.

5. Loucks, D.P., Stedinger, J.R. & Haith, D. A. 1981. Water Resource Systems Planning and Analysis. Englewood Cliffs, NJ, Prentice Hall.

6. Mays, L.W. 2006. Water Resources Sustainability. The McGraw-Hill Publications.

7. Schward& Zhang, 2003. Fundamentals of Groundwater. John Willey and Sons.

8. Souvorov, A.V. 1999. Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource Management. Elsevier Publications.

9. Vickers, A. 2001. Handbook of Water Use and Conservation. WaterPlow Press.

CORE COURSE 4: LAND AND SOIL CONSERVATION AND MANAGEMENT

Theory (60 Lectures)

Unit 1: Fundamentals of soil science (15 lectures)

Land as a resource, soil health; 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; soil formation; classification of soil; physical properties of soil; soil texture; soil water holding capacity; soil organic matter; micronutrients of soil; nitrogen, sulphur, potassium and phosphorus economy of soil

Unit 2: Soil degradation - causes (10 lectures)

types of soil erosion; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, industrial and urban development, toxic contaminants in soils; organic and inorganic.

Unit 3: Landuse changes and land degradation (15 lectures)

Land resources: types and evaluation; biological and physical phenomena in land degradation; visual indicators of land degradation; drivers of land degradation - deforestation, desertification; habitat loss, loss of biodiversity; range land degradation; land salinization; human population pressure, poverty, socio-economic and institutional factors;

Unit 4: Costs of land degradation (15 lectures)

Economic valuation of land degradation; onsite and offsite costs of land degradation; loss of ecosystem services; effects on farming communities; effects on food security; effects on nutrient cycles; future effects of soil degradation;

Unit 5: Controlling land degradation (5 lectures)

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.

Practicals:

1. To determine the colour of soil samples by Munsell-soil colour chart.
2. To determine the p^H of soil sampler by p^H meter.
3. To determine the texture of soil sampler by sieving method.
4. To determine the moisture content of soil sampler by oven drying method.
5. To study the profile of a soil in the field.
6. Project on soil degradation due to bricks mining.

Suggested Readings

1. Brady, N.C. & Well, R.R. 2007.The Nature and Properties of Soils (13Th edition), Pearson Education Inc.

2. Gadgil, M. 1993. Biodiversity and India's degraded lands. Ambio 22: 167-172.

3. Johnson, D.L. 2006. Land Degradation (2nd

edition). Rowman& Littlefield Publishers.

4. Marsh, W. M. &Dozier,J. 1983. Landscape Planning: Environmental Applications. John Wiley and Sons.

5. Oldeman, L. R. 1994. The global extent of soil degradation. Soil resilience and sustainable land use, 9. (http://library.wur.nl/isric/fulltext/isricu_i26803_001.pdf).

6. Pandit, M.K. et. al. 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. Biodiversity Conservation 16: 153-163.

7. Pandit, M.K. &Kumar, V. 2013. Land use and conservation challenges in Himalaya: Past, present and future. In: Sodhi, N.S., Gibson, L. & Raven, P.H. Conservation Biology: Voices from the Tropics. pp. 123-133. Wiley-Blackwell, Oxford, UK(file:///Users/mkpandit/Downloads/Raven%20et%20al.%202013.%20CB%20Voices%20from%20Tropics%20(2).pdf) .

8. Peterson, G. D., Cumming, G. S. & Carpenter, S. R. 2003. Scenario planning: a tool for conservation in an uncertain world. Conservation Biology 17: 358-366.

9. Scherr, S. J. 1999. Soil degradation: A threat to developing-country food security by 2020? (Vol. 27). International Food Policy Research Institute.

GENERAL ELECTIVE 2: HUMAN-WILDLIFE CONFLICT AND MANAGEMENT

Theory (60 Lectures)

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:

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 Co-existence? (No. 9). Cambridge University Press.

CORE COURSE 5: ECOLOGY AND ECOSYSTEMS

Theory (60 Lectures)

Unit 1: Ecology of individuals (16 lectures)

Basic concepts and definitions: ecology, landscape, habitat, ecozones, biosphere, ecosystems, ecosystem stability, resistance and resilience; autecology; synecology; major terrestrial biomes; ecological amplitude; Liebig's Law of the Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; ecological niche;

Unit 2: Ecology of populations (12 lectures)

Concept of population and meta-population; r- and K-selection; characteristics of population: density, dispersion, natality, mortality, life tables, survivorship curves, age structure; population growth: geometric, exponential, logistic, density-dependent; limits to population growth;

Unit 3: Ecology of communities (10 lectures)

community structure and organization: keystone species, ecotone and edge effect; species interactions: positive and negative ecological succession and climax community.

Unit 4: Ecosystem ecology (12 lectures)

Types of ecosystem: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands; ecosystem structure and function; abiotic and biotic components of ecosystem; food chain, food web; ecological efficiencies; ecological pyramids: pyramids of number, biomass, and energy.

Unit 5: Biogeochemical cycles and nutrient cycling (10 lectures)

Carbon cycle; nitrogen cycle; phosphorus cycle; sulphur cycle; hydrological cycle; nutrient cycle models; ecosystem input of nutrients; biotic accumulation; ecosystem losses; nutrient supply and uptake;

Practicals:

1. To study the allelopathic influence of one plant species.

2. To prepare a checklist of invasive species.

3. To estimate the productivity of a pond ecosystem using Light and Dark Bottle method.

4. To study the plankton communities in a fresh water ecosystem.

5. To study the distribution of road side species and investigate the changes in species richness.

6. Field report: Visit to a forest/ river/ wetland ecosystem.

Suggested Readings

1. Groom. B. & Jenkins. M. 2000.Global Biodiversity: Earth's Living Resources in the 21stCentury. World Conservation Press, Cambridge, UK.

2. Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2002. The Ecology of Plants. Sinauer associates incorporated.

3. Loreau, M. & Inchausti, P. 2002. Biodiversity and Ecosystem functioning: Synthesis and Perspectives. Oxford University Press, Oxford, UK.

4. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders.

5. Pandit, M.K., White, S.M.& Pocock, M.J.O. 2014. The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis. New Phytologist203: 697-703.

6. Pimentel, D. (Ed.). 2011. Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species. CRC Press.

7. Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications.

8. Wilson, E. O. 1985. The Biological Diversity Crisis. BioScience 35: 700-706

CORE COURSE 6: ENVIRONMENTAL BIOTECHNOLOGY

Theory (60 Lectures)

Unit 1: The Structure and Function of DNA, RNA (8 lectures)

DNA: structural forms and their characteristics (B, A, C, D, T, Z); physical properties: UV absorption spectra,; biological significance of different forms;

RNA: structural forms and their characteristics (rRNA, mRNA, tRNA; SnRNA, Si RNA, miRNA, hnRNA);

Unit 2: The Structure and Function of Protein (7 lectures)

Protein: hierarchical structure (primary, secondary, tertiary, quaternary), types of amino acids;

Central dogma of biology; genetic material prokaryotes, viruses, eukaryotes and organelles;

Unit 3: Recombinant DNA Technology (15 lectures)

Recombinant DNA: origin and current status; steps of preparation; toolkit of enzymes for manipulation of DNA: restriction enzymes, DNA polymerases other DNA modifying enzymes genomic and cDNA libraries: uses; cloning and expression vectors (plasmids, bacteriophage, cosmids, BAC.

Unit 4: Ecological restoration and bioremediation (20 lectures)

Wastewater treatment: anaerobic, aerobic process, solid waste treatment: sources and management (composting, vermiculture and methane production, landfill. bioremediation technologies: composting, constructed wetlands, phytoremediation; heavy metals degradative pathways.

Unit 5: Ecologically safe products and processes (10 lectures)

PGPR bacteria: biofertilizers, microbial insecticides and pesticides, bio-control of plant pathogen, Integrated pest management; development of stress tolerant plants, biofuel; mining and metal biotechnology: microbial transformation, accumulation and concentration of metals, metal leaching, extraction

Practicals:

1. Isolation of DNA from plant sample
2. Isolation of DNA from Animal tissue
3. Isolation of DNA from Gram negative bacteria
4. Isolation of PGPR bacteria from soil
5. Restriction digestion of DNA

Suggested Readings

1. Evans, G.G. & Furlong, J. 2010. Environmental Biotechnology: Theory and Application (2ndedition). Wiley-Blackwell Publications.

2. Jordening, H.J. & Winter J. 2005. Environmental Biotechnology: Concepts and Applications. John Wiley& Sons.

3. Lodish, H.F., Baltimore, D., Berk, A. Zipursky, S.L. Matsudiara, P. & Darnell, J. 1995.

Molecular Cell Biology. W.H. Freeman.

4. Nelson, D.L. & Cox, M.M. 2013. Lehninger's Principles of Biochemistry. W.H. Freeman.

5. Rittman, B.E. & McCarty, P.L. 2001. Environmental Biotechnology. Principles and Applications. McGraw-Hill, New York.

6. Scagg, A.H. 2005. Environmental Biotechnology. Oxford University Press.

7. Snustad, D.P. & Simmons, M.J. 2011. Principles of Genetics (6th

edition). John Wiley& Sons.

8. Wainwright, M. 1999. An Introduction to Environmental Biotechnology. Springer.

CORE COURSE 7: ATMOSPHERE AND GLOBAL CLIMATE CHANGE

Theory (60 Lectures)

Unit 1: Global energy balance (8 lectures)

Evolution and development of Earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the Earth, the only biosphere; Milankovitch cycles. green house gases (GHGs); greenhouse effect;

Unit 2: Atmospheric circulation (20 lectures)

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, effect of urbanization on micro climate.

Meteorology and atmospheric stability: Meteorological parameters (temperature, relative humidity, wind speed and direction, precipitation); atmospheric stability and mixing heights; temperature inversion;

Unit 3: Global warming and climate change (12 lectures)

Trends of global warming and climate change; drivers of global warming and the potential of different green house gases (GHGs) causing the climate change; atmospheric windows; impact of climate change on atmosphere, weather patterns, sea level rise, agricultural productivity and biological responses

Unit 4: Ozone layer depletion (12 lectures)

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

Unit 5: Climate change and policy (8 lectures)

Environmental policy debate; International agreements; Montreal protocol 1987; Kyoto protocol 1997; Convention on Climate Change; carbon credit and carbon trading; clean development mechanism.

Practicals:

Comparative analysis of rainfall of past 30 years using data obtained from a meteorological station

1. Comparative analysis of maximum-minimum temperature of past 30 years using data obtained from a meteorological station
2. Study of heat-island effect
3. Study of ozone levels in different places using Schonbein filter paper
4. Filed visit to nearby meteorological station

Suggested Readings:

1. Barry, R. G. 2003. Atmosphere, Weather and Climate. Routledge Press, UK.

2. Gillespie, A. 2006. Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries with Policy and Science Considerations. Martinus Nijhoff Publishers.

3. Hardy, J.T. 2003. Climate Change: Causes, Effects and Solutions. John Wiley & Sons.

4. Harvey, D. 2000. Climate and Global Climate Change. Prentice Hall.

5. Manahan, S.E. 2010. Environmental Chemistry. CRC Press, Taylor and Francis Group.

6. Maslin, M. 2014. Climate Change: A Very Short Introduction. Oxford Publications.

7. Mathez, E.A. 2009. Climate Change: The Science of Global Warming and our Energy Future. Columbia University Press.

8. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. &Sen, K. 2004. Climate Change and India. Universities Press, India.

9. Philander, S.G. 2012. Encyclopedia of Global Warming and Climate Change (2ndedition). Sage Publications.

SKILL ENHANCEMENT COURSE 1: REMOTE SENSING, GEOGRAPHIC INFORMATION SYSTEM & MODELLING

Theory (Lectures: 30)

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.

Unit 2: Geographical Information Systems: definitions and components; spatial and non-spatial data; raster and vector data.

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

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

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.

Practicals:

1. Introduction to Google Earth and Google maps
2. Introduction and use of hand-held GPS
3. Identification of land use-land cover categories in a satellite imagery
4. Visual Interpretation of Satellite Imagery
5. Introduction to basics of Remote Sensing and GIS software

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.

GENERAL ELECTIVE 3: GENDER AND ENVIRONMENT

Theory (60 Lectures)

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:

1. Survey on percentage composition of women in commercial establishments and their awareness about environmental pollution with special reference to noise 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. Survey on men and women's contribution in income generation in rural and urban areas by questionnaire method
5. Analyze the state of gender equality and women empowerment in environment-related sectors (tutorial based)
6. 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.

CORE COURSE 8: SYSTEMATICS AND BIOGEOGRAPHY

Theory (Lectures: 60)

Preamble: This course will discuss principles and applications of classical and modern day systematics to classification of living organisms, develop understanding of historical and contemporary patterns of distributions of organisms, and design effective conservation strategies using biogeographic theories in an era of global change and large scale human induced degradation.

Unit 1: Concept and systematics approaches (14 lectures)

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.

Unit 2: Numerical and molecular systematics (14 lectures)

Characters; variations; Operational Taxonomic Units; character weighting and coding; phenograms; cladograms; DNA barcoding; phylogenetic tree (rooted,unrooted, ultrametric trees); clades: monophyly, paraphyly, polyphyly; homology and analogy; parallelism and convergence.

Unit 3: Introduction to Biogeography (10 lectures)

Genes as unit of evolutionary change; mutation; genetic drift; gene flow; natural selection; geographic and ecological variation; biogeographical rules – Gloger's rule, Bergmann's rule, Allen's rule, Geist rule; biogeographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species.

Unit 4: Speciation and extinction (16 lectures)

Types and processes of speciation – allopatric, parapatric, sympatric; ecological diversification; adaptive radiation, convergent and parallel evolution; dispersal and immigration; means of dispersal and barriers to dispersal; extinction.

Unit 5: Conservation Biogeography (6 lectures)

Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning; approaches to landscape conservation with special reference to North east India.

Practicals:

1. Study of vegetative and floral characters of the following families (Description, V.S. flower, section of ovary, floral diagrams, floral formula) systematic position according to Bentham & Hooker system of Classification: Brassicaceae, Solanaceae, Poaceae.
2. Mounting of a properly dried and pressed specimen of any wild plant with herbarium label.
3. To prepare a checklist of birds in and around college campus.
4. Visit to a center of Botanical Survey of India.

Suggested Readings

1. Lomolino, M.V., Riddle, B.R., Whittaker, R.J. & Brown, J.H. 2010. Biogeography (4thedition). Sinauer Associates, Sunderland.

2. Mani, M.S. 1974. Ecology and Biogeography in India. Dr. W Junk Publishers., The Hague.

3. Singh, G. 2012. Plant Systematics: Theory and Practice (3rdedition). Oxford & IBH Pvt. Ltd., New Delhi.

4. Wheeler, Q.D. & Meier R. 2000. Species Concepts and Phylogenetic Theory: A Debate. Columbia University Press, New York.

5. Williams, D. M., Ebach, M.C. 2008. Foundations of Systematics and Biogeography. Springer.

6. Wilkins, J. S. 2009. Species: A History of the Idea (Vol. 1). University of California Press.

CORE COURSE 9: URBAN ECOSYSTEMS **Theory (60 Lectures)**

Unit 1: Concept of urbanization **(14 lectures)**

Introduction to urbanization; urban sprawl and associated environmental issues; concept of 'controlled nature'; scope, importance and threats to nature in the city; organization and planning of green spaces such as parks, gardens and public spaces; concept of green belts;

Unit 2: Environment in an urban setting **(10 lectures)**

Man as the driver of urban ecosystem; commodification of nature; metros, cities and towns as sources and sinks of resources; resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; increasing challenges posed by modernity for the environment; urban pollution (air, water, soil).

Unit 3: Urban dwelling **(12 lectures)**

Housing scenario across a range of large-medium-small cities; poverty and slums in an urban context; Town planning Acts and their environmental aspects; energy consumption and waste disposal as well as accumulation; environmental costs of urban infrastructure.

Unit 4: Urban interface with the environment **(12 lectures)**

Management of urban environment; alternative resources; policy and management decisions; urban settings as loci of sustainability; challenges associated with sustainability and urban future.

Unit 5: Planning and environmental management **(12 lectures)**

Urban planning and its environmental aspects from historical and contemporary perspectives; benefits of environmental management; introduction to green buildings; urban governance; political complexity of applying ecological science to urban policy and planning, smart cities.

Practicals:

1) Measurement of density of population (this can be done in any three representative locations in any urban areas) and identifying the major issues faced by urban population.

2) Comparative study of the availability of resources in an urban area and a rural area.

3) Measurement of air, water and soil pollution in urban areas.

4) Assessment of green parameters in any building (like air circulation/light availability/environment friendly aspects etc.)

5) Measurement and quantification of green space in any office premise/ College premise/ total urban area

6) Visit to any nearby slum area and submitting a report on the same based on health and hygiene and also the environmental aspect.

Suggested Readings

1. D'Monte, Darryl. 1985. Industry versus Environment Temples or Tombs. Three Controversies, Delhi, CSE.

2. Ernstson, H. 2011. Re-translating nature in post-apartheid Cape Town: The material semiotics of people and plants at Bottom Road. In: Heeks, R., (Ed.) Conference on "Understanding Development through Actor-Network Theory", London School of Economics, 30 June, London.

3. Gaston, K.J. 2010. Urban Ecology. Cambridge University Press, New York.

4. Grimm, N. B., Faeth, S. H., et al. 2008. Global Change and the Ecology of Cities. Science 319: 756-760.

5. Hinchliffe, S. & Whatmore, S. 2006. Living cities: Towards a politics of conviviality. Science as Culture 15: 123–138.

6. McIntyre, N.E. 2000. Urban ecology as an interdisciplinary field: differences in the use of 'urban' between the social and natural sciences. Urban Ecosystems 4: 5-24.

7. Montgomery, M.R. 2009. Urban Transformation of the developing world. Science 319: 761-764.

8. Richter, M. & Weiland, U. (ed.). 2012. Applied Urban Ecology. Wiley-Blackwell, UK.

CORE COURSE 10: ENVIRONMENTAL LEGISLATION AND POLICY

Theory (60 lectures)

Unit 1: History of environmental legislation and policy (10 lectures)

Ancient period: Mauryan period, Medieval periodBritish India, Independent India: Van Mahotsava 1950, National Forest Policy 1952, Orissa River pollution and prevention Act 1953. Constitution of India: environment related areas. National green tribunal

Unit 2: Environmental legislation (5 lectures)

Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A (The protection and improvement of environment and safeguarding of forests and wildlife); Article 51 A (Fundamental duties).

Unit 3: Legislative Instruments (20 lectures)

The Wildlife (Protection) Act 1972; The Environment (Protection) Act 1986; The Biological Diversity Act 2002; scheme and labeling of environment friendly products, Ecomarks.

Unit 4: Case studies (5 lectures)

National Green Tribunal: Aditya N Prasad vs. Union of India & Others; Ganga Tanneries Case: M.C. Mehta vs. Union of India 1988; environmental education case: M.C. Mehta vs. Union of India, WP 860/1991.

Unit 5: International laws and policy (10 lectures)

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.

Practicals:

1. Survey of awareness level about the Indian Forest Act, 1927 / the Wildlife (Protection) Act, 1972 / the Biological Diversity Act, 2002 / The Schedule Tribes and other Traditional Dwellers (Recognition of Forests Rights) Act 2006, among officials of state forest department through Questionnaire / Interview Schedule
2. Report on pollution control measures adopted by Assam State Pollution Control Board office, Silchar, in the light of existing legal framework for prevention and control of pollution (actual visit or tutorial based)
3. Analysis of selected case studies on environmental litigation (could be tutorial-based)
4. To prepare Peoples Biodiversity Register of any locality

Suggested Readings

1. Abraham, C.M. 1999. Environmental Jurisprudence in India. Kluwer Law International.

2. Agarwal, V.K. 2005. Environmental Laws in India: Challenges for Enforcement. Bulletin of the National Institute of Ecology 15: 227-238.

3. Divan, S. & Rosencranz, A. 2001. Environmental Law and Policy in India. Oxford University Press.

4. Divan, S. & Rosencranz, A. 2002. Environmental Law and Policy in India: Cases, Materials and Statues (2ndedition). Oxford University Press.

5. Gupta, K.R. 2006. Environmental Legislation in India. Atlantic Publishers and Distributors.

6. Leelakrishnan, P. 2008. Environmental Law in India (3rdedition). LexisNexis India.

7. Naseem, M. 2011. Environmental Law in India Mohammad. Kluwer Law International.

8. Venkat, A. 2011. Environmental Law and Policy. PHI Learning Private Ltd.

SKILL ENHANCEMENT COURSE 2: ENVIRONMENTAL IMPACT AND RISK ASSESSMENT

Theory (30 Lectures)

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

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)

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

Unit 4: EIA regulations in India; status of EIA in India; current issues in EIA; case study of hydropower projects/ thermal projects.

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.

Practicals:

1) Environment Impact Assessment of any nearby industry, factory or similar area
2) Studies on biological and other waste disposal mechanism of any nearby health centre or hospital
3) To identify harmful wastes in any given water or soil sample
4) To visit any nearby market area and quantification of the daily waste generated from such areas.
5) Students may be asked to make some close ended questionnaire and interview local community (n=30) on various aspects of environmental risk and environmental impact and prepare a report based on it.

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, New York, USA

GENERAL ELECTIVE 4: GREEN TECHNOLOGIES

Theory (60 lectures)

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, construction of green buildings; associated costs and benefits; outlined examples of green 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. ; Introduction to UNEP's green economy initiative, inclusive economic growth of the society, REDD+ initiative, and cap and trade concept; green banking.

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; bio-degradable 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:

Renewable Energy Technologies
1. Survey work on performance of solar water heater, solar dryers, solar PV cell solar cooker, solar cells
2. Biogas production by anaerobic digestion and analysis.
3. Fuels: Density, Viscosity, Flash-point, Fire-point Pour-point, ASTM distillation of liquid fuels.
4. Storage: 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.

CORE COURSE 11: BIODIVERSITY AND CONSERVATION Theory (60 Lectures)

Unit 1: Biodiversity patterns (6 lectures)

Spatial patterns: latitudinal and elevational trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns; importance of biodiversity patterns in conservation.

Unit 2: Biodiversity estimation (10 lectures)

Sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, richness, density, frequency, abundance, evenness, diversity, community diversity estimation: alpha, beta and gamma diversity; NCBI database, BLAST analyses.

Unit 3: Importance of biodiversity (10 lectures)

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, social, aesthetic, consumptive, and ethical values of biodiversity.

Unit 4: Threats to biodiversity (10 lectures)

Natural and anthropogenic disturbances; habitat loss, habitat degradation, and habitat fragmentation; climate change; pollution; hunting; over-exploitation; deforestation; hydropower development; invasive species; land use changes; overgrazing; man wildlife conflicts; consequences of biodiversity loss; Intermediate Disturbance Hypothesis.

Unit 5: Conservation of biodiversity in India

(14 lectures)

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; ecological restoration; afforestation; social forestry; agro forestry; joint forest management;

Practicals:

1. Study of qualitative structure of plant community.
2. Study of animal diversity measurement .
3. To study the quantitative structure of plant community.
4. To study the methods of sampling of plant community.
5. To study the selected medicinal plants found in N.E. India
6. Field visit to protected areas (Reserve forest / Wildlife sanctuary etc.)

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 andPractices. 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 (3rdedition). 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.

CORE COURSE 12: ORGANISMAL AND EVOLUTIONARY BIOLOGY

Theory (60 Lectures)

Unit 1: History of life on Earth (10 lectures)

Evolutionary time scale; eras, periods and epoch; major events in the evolutionary time scale; origins of unicellular and multi cellular organisms; major groups of plants and animals; stages in primate evolution including Homo.

Unit 2: Introduction (10 lectures)

Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitness and natural selection; Mendelism; spontaneity of mutations; The Evolutionary Synthesis.

Unit 3: Evolution of unicellular life (12 lectures)

Origin of cells and unicellular evolution and basic biological molecules; abiotic synthesis of organic monomers and polymers; Oparin-Haldane hypothesis; study of Miller; the first cell; evolution of prokaryotes; origin of eukaryotic cells; evolution of unicellular eukaryotes; anaerobic metabolism, photosynthesis and aerobic metabolism.

Unit 4: Molecular evolution (12 lectures)

Neutral evolution; molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.

Unit 5: Fundamentals of population genetics (16 lectures)

Concepts of populations, gene pool, gene frequency; concepts and rate of change in gene frequency through natural selection, migration and genetic drift; adaptive radiation; isolating mechanisms; speciation (allopatric, sympatric, peripatric and parapatric); convergent evolution; sexual selection; co-evolution; Hardy-Weinberg Law.

Practicals:

1. Tutorial works are to be given to students based on theory paper

Suggested Readings

1. Futuyma, D.J. 2009. Evolution (2ndedition). Sinauer Associates.

2. Gillespie, J. H. 1991. The Causes of Molecular Evolution. Oxford University Press.

3. Graur, D. & Li, W.H. 1999. Fundamentals of Molecular Evolution (2ndedition). Sinauer Associates.

4. Kimura, M. 1984. The Neutral Theory of Molecular Evolution. Cambridge University Press.

5. Minkoff, E.C. 1983. Evolutionary Biology. Addison Wesley. Publishing Company.

6. Nei, M. & Kumar, S. 2000. Molecular Evolution and Phylogenetics. Oxford University Press.

7. Nei, M. 1975. Molecular Population Genetics and Evolution. North-Holland Publishing Company.

8. Nei, M. 1987. Molecular Evolutionary Genetics. Columbia university press.

9. Thorne, J. L., Kishino, H., & Painter, I. S. 1998. Estimating the rate of evolution of the rate of molecular evolution. Molecular Biology and Evolution 15: 1647-1657.

DISCIPLINE SPECIFIC ELECTIVE 1: ENERGY AND ENVIRONMENT

Theory (60 Lectures)

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:

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
5. Energy farms and energy plantations.

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)

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:

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.

CORE COURSE 13: ENVIRONMENTAL POLLUTION AND HUMAN HEALTH

Theory (60 Lectures)

Unit 1: Air pollution (14 lectures)

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.

Unit 2: Water pollution (12 lectures)

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).

Unit 3: Soil pollution (10 lectures)

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

Unit 4: Noise pollution (12 lectures)

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.

Unit 5: Radioactive and thermal pollution (12 lectures)

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

Practicals:

1. Study of suspended particulate matter deposition on plant leaves in polluted (roadside, near brick kilns, cement industry, etc.) and unpolluted sites
2. Microscopic study of leaf surface in leaf samples collected from polluted (roadside, near brick kilns, cement industry, etc.) and unpolluted sites
3. Measurement of suspended solids in water from polluted and unpolluted freshwater ecosystems
4. Measurement of road traffic noise by decibel meter
5. Survey of incidence of water-borne diseases among slum dwellers

Suggested Readings

1. Gurjar, B.R., Molina, L.T. & Ojha C.S.P. 2010. Air Pollution: Health and Environmental Impacts. CRC Press, Taylor & Francis.

2. Hester, R.E. & Harrison, R.M. 1998. Air Pollution and Health. The Royal Society of Chemistry, UK.

3. Park, K. 2015. Park's Textbook of Preventive and Social Medicine (23rdedition). Banarsidas Bhanot Publishers.

4. Pepper, I.L., Gerba, C.P. & Brusseau, M.L. 2006. Environmental and Pollution Science. Elsevier Academic Press.

5. Purohit, S.S. & Ranjan, R. 2007. Ecology, Environment & Pollution. Agrobios Publications.

6. Vesilind, P.J., Peirce, J.J., & Weiner R.F. 1990. Environmental Pollution and Control. Butterworth-Heinemann, USA.

CORE COURSE 14: NATURAL RESOURCE MANAGEMENT AND SUSTAINABILITY

Theory (60 Lectures)

Unit 1: Natural resources and conservation (12 lectures)

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;

Unit 2: Mineral resources (12 lectures)

Mineral resources and the rock cycle; identified resources; undiscovered resources; reserves; types of mining: surface, subsurface, open-pit, dredging, strip; reserve-to-production ratio; ocean mining for mineral resources; environmental effects of extracting and using mineral resources.

Unit 3: Non-renewable energy resources (12 lectures)

Oil: formation, exploration, extraction and processing; natural gas: exploration, coal: extraction, processing, environmental impacts of non renewable energy consumption;

Unit 4: Renewable energy resources (12 lectures)

Energy efficiency; solar energyhydropower, nuclear power, tidal energy, wave energy, ocean thermal energy conversion (OTEC); geothermal energy; energy from biomass; bio-diesel.

Unit 5: Resource management (12 lectures)

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;

Practicals:

1. Field visit to a nearby by forest to study the timber and non-timber forest resources.
2. Field visit to nearby wetland to study the wetland resources.
3. Visit to a nearby institute to study the utilization of solar energy resources
4. Visit to a nearby tea garden to study the management of tea plantation.
5. Field visit to a gas based power plant.

Suggested Readings

1. Craig, J.R., Vaughan. D.J. & Skinner. B.J. 1996. Resources of the Earth: Origin, Use, and Environmental Impacts (2ndedition). Prentice Hall, New Jersey.

2. Freeman, A.M. 2001. Measures of value and Resources: Resources for the Future. Washington DC.

3. Freeman, A.M. 2003. Millennium Ecosystem Assessment: Conceptual Framework. Island Press.

4. Ginley, D.S. & Cahen, D. 2011. Fundamentals of Materials for Energy and Environmental Sustainability. Cambridge University Press.

5. Klee, G.A. 1991. Conservation of Natural Resources. Prentice Hall Publication.

6. Miller, T.G. 2012. Environmental Science. Wadsworth Publishing Co.

7. Owen, O.S, Chiras, D.D, & Reganold, J.P. 1998. Natural Resource Conservation – Management for Sustainable Future (7thedition). Prentice Hall.

8. Ramade, F. 1984. Ecology of Natural Resources. John Wiley & Sons Ltd.

9. Tiwari, G.N. & Ghosal. M. K. 2005. Renewable Energy Resources: Basic Principles and Application. Narosa Publishing House.

DISCIPLINE SPECIFIC ELECTIVE 3: NATURAL HAZARDS AND DISASTER MANAGEMENT

Theory (60 Lectures)

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:

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)

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)

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

Practicals:

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 nonbiodegradable) 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.