UNIVERSITY OF DELHI

MASTER OF SCIENCE/ MASTER OF ARTS IN ENVIRONMENTAL STUDIES

(M.Sc./M.A. in Environmental Studies)

(Effective from academic Year 2018 – 2019)

PROGRAMME BROCHURE

M.A./M.Sc. Environmental Studies Revised Syllabus as approved by Academic Council on xxx, 2018 and Executive Council on xxx, 2018

CONTENTS

I. About the Department

The history of the Department of Environmental Studies (DES) goes back to 1972 when its earlier avatar – the Department of Environmental Biology (DEB) was established, but became operational only in 1990 imparting education at post-graduate level in the area of environmental biology. Later, the School of Environmental Studies (SES) was founded in the year 2000 which functioned till 2009 with an interdisciplinary focus offering M.A., M.Sc. and Ph.D. degrees. In a major academic restructuring exercise, the University of Delhi, while maintaining the interdisciplinary nature of the School and its academic programmes, merged DEB and SES into the present Department of Environmental Studies in 2010.

The restructuring effort in 2009-10 aimed at achieving a critical mass in terms of faculty strength which was dispersed in various teaching and research units of the university engaged in the environmental studies. The University decided to relocate the faculty members of different units, namely Centre for Environmental Management of Degraded Ecosystems (CEMDE), Centre for Interdisciplinary Studies of Mountain & Hill Environment (CISMHE), DEB and SES to the newly established DES. The formulation reflected the synthetic nature of the 'Environment' drawing strengths from these multiple units in terms of the programme and the faculty.

Today, the Department of Environmental Studies draws one of the highest number of applicants to its post-graduate programme and has the highest rejection rate of applicants as per available seats and the second highest in the University after Plant Molecular Biology. The Department has more number of research publications in top quality journals such as Nature, Science, PNAS than any other Department in the Faculty of Science

The courses offered by the Department include the following (admissions made only through all India entrance examination):

M.Sc. Environmental Studies/ M.A. Environmental Studies

The Department offers two post-graduate courses in Environmental Studies, namely M.A. in Environmental Studies and M.Sc. in Environmental Studies. A prospective student to the Programme must have an undergraduate degree with 55% marks from University of Delhi or any other university/institution. The applicant must fulfill other conditions of eligibility and must have studied at least one of these subjects (Physics/Chemistry/Biology/Maths/Geography/ Economics) at 10+2 level.

The admissions to 54 seats (23 for M.A. and 31 for M.Sc. stream) are made through an All India level entrance test conducted by the Department in May-June every year.

Graduate Attributes

The graduate attributes of our students shall be aligned with those of our University in terms of touching "the life of every student through inculcating virtues of empathy, ethics, efficiency, respect for diversity, prudence and creativity with compassion". We wish to achieve this through rigorous

teaching and research effort, which remains the basic tenet of our teaching-learning philosophy. The following are the University's graduate attributes which we emphasize.

- In depth Domain Knowledge
- Interdisciplinary Perspective
- Competence for Research and Innovation
- Analytical Competence
- Critical Thinking
- Problem Solving Competence
- Decision Making
- Information Technology Skills
- Ability to Work Independently
- Capacity for Creativity
- Contribute to Societal Well-being & Sustainability

Process of Course development involving various stakeholders at different stages

1. Appointment of syllabus revision committee comprising 5 faculty members from the Department of Environmental Studies.
2. Draft revised syllabus circulated among all the Department faculty members including the guest faculty.
3. Draft revised syllabus sent to more than 10 external experts including alumni and international reviewers.
4. Incorporation of suggestions/ changes in the draft revised syllabus.
5. Draft revised syllabus sent to the Department course committee which included guest faculty.
6. Draft revised syllabus submitted to the Faculty of Science for consideration &approval.
7. Revised syllabus sent for statutory approvals in the University.

II. Introduction to CBCS (Choice Based Credit System)

Scope

The CBCS provides an opportunity for the students to choose courses from the prescribed courses comprising core, elective/minor or skill-based courses. The courses can be evaluated following the grading system, which is considered to be better than the conventional marks system. Grading system provides uniformity in the evaluation and computation of the Cumulative Grade Point Average (CGPA) based on student's performance in examinations which enables the student to move across institutions of higher learning. The uniformity in evaluation system also enable the potential employers in assessing the performance of the candidates.

Definitions

1. 'Academic Programme' means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/ Centre

2. Course' means a segment of a subject that is part of an Academic Programme
3. 'Programme Structure' means a list of courses (Core, Elective, Open Elective) that makes up an Academic Programme, specifying the syllabus, Credits, hours of teaching, evaluation and examination schemes, minimum number of credits required for successful completion of the programme etc. prepared in conformity to University Rules, eligibility criteria for admission
4. 'Core Course' means a course that a student admitted to a particular programme must successfully complete to receive the degree and which cannot be substituted by any other course
5. 'Elective Course' means an optional course to be selected by a student out of such courses offered in the same or any other Department/Centre
6. 'Open Elective' means an elective course which is available to students of all programmes, including students of same Department. Students of other Department will opt these courses subject to fulfilling eligibility criteria as laid down by the Department offering the course.
7. 'Credit' means the value assigned to a course which indicates the level of instruction; One-hour lecture per week equals 1 Credit, 2 hours practical class per week equals 1 credit. Credit for a practical could be proposed as part of a course or as a separate practical course
8. 'SGPA' means Semester Grade Point Average calculated for individual semester.
9. CGPA' is Cumulative Grade Points Average calculated for all courses completed by the students at any point of time. CGPA is calculated each year for both the semesters clubbed together.
10. 'Grand CGPA' is calculated in the last year of the course by clubbing together of CGPA of two years, i.e., four semesters. Grand CGPA is being given in Transcript form. To benefit the student a formula for conversation of Grand CGPA into %age marks is given in the Transcript.

Programme Specific Objectives (PsOs)

The Master's course (M.Sc./M.A.) in Environmental Studies was instituted as an Innovative Programme of the University Grant Commission. The programme aims to train students with the objective of teaching-learning and research to promote the idea of sustainability. This objective shall beachieved through developing a foundation on ecological,social, economic, legal and ethical dimensions of the environmental studies on a robust interdisciplinary foundation.

Programme Outcomes (POs)

After completion of the Master's degree (M.Sc./M.A.), the students would be empowered with multi-disciplinary tools to:

- transform into original researchers and undertake cutting-edge research and teaching for an in-depth understanding of the complex environmental issues;
- predict the environmental change and provide scientifically sound and socially acceptable solutions;
- develop as sustainability managers to guide manufacturing industries, non-government organizations (national and international), policy-making bodies; and

- act as a catalysts to bridge the gap between science and society in achieving ecosystem restoration, conservation and management of biodiversity including well-being of the society at large.

Course Outcomes (COs)

M.A. Semesters III and IV M.Sc./M.A. Semesters I and II

COs of the Course on "Introduction to Environmental Sciences" (Paper 1):

M.A. Semesters III and IV

M.A. Semesters III and IV

CO1: Develop foundation on principles of Environmental Science and concept of structure and function of different compartments of the Environment.

CO2: Gain scientific perspective of the issues confronting our present day environment.

CO3: Enable to analyze the national and global environmental issues relating to atmosphere, water, soil and land use, biodiversity, and natural resources (global warming, climate change, mineral extraction and energy resources, environmental impact assessment and environmental audit).

COs of the Course on "Social Perspectives on Environment" (Paper 2):

CO1: Develop understanding between social thoughts and environmental issues in traditional and modern societies.

CO2: Gain insights into historical and contemporary perspectives on environmental issues, specifically energy, transport and resource consumption.

CO3: Analyze critical issues in environmental studies in an Indian and global perspective.

CO4: Enable to understand environmental politics in contemporary India, and issues in global environmentalism.

COs of the Course on "Environment, Development and Sustainability" (Paper 3)

CO1: Demonstrate the human dimension of development and environment.

CO2: Gain insights on management of natural resources.

CO3: Train in tools and methodologies of ecological and environmental economics.

COs of the Course on "Methodologies for Environmental Studies" (Paper 4)

CO1: Equip with various methods used in the collection and analyses of data for Environmental Studies.

CO2: Train on the theory and practice of biostatistical tools for analyzing the data and deriving meaningful conclusions.

CO3: Investigate the potential of simulation models to understand the complexity of environmental processes and enables to use environmental modeling, remote sensing and GIS in environmental studies.

COs of the Course on "Environmental Risk and Impact Assessment" (Paper 5)

CO1: Lay foundation on the concept and components of environmental impact assessment.
CO2: Enable to practice EIA that examines the environmental consequences of development actions, in advance.
CO3: Investigate the agenda of all environmental agencies as a result of introduction of legislations in various countries.
CO4: Develop skill to evaluate the issues and problems in environmental assessment from the perspective of process and methods, and the goals of EIA.

COs of the Course on "Environmental Pollution and Health" (Paper 6)

CO1: Examine the critical linkage between environmental pollution and human health.
CO2: Develop understanding on the mode of various diseases as triggered by the spread of contaminants in soil, water and air.
CO3: Analyze different types of pollution and the guidelines for their control in the context of public health.

COs of the Course on "Urban Ecosystems" (Paper 7)

CO1: Demonstrate emerging importance of the urban setting as the locus of environmental conflict and governance in India, across a range of urban clusters including metros, cities and towns.
CO2: Explores the importance for policy, community mobilization, law and governance.
CO3: Insight into some key challenges facing urban sustainability in the 21st century.

COs of the Course on "Natural Resources: Their Conservation and Management" (Paper 8)

CO1: Develop an objective view of the nature of Earth's resources, particularly the non-renewable resources.
CO2: Explain how and where the Earth's resources are generated, how they are extracted and used, and how these activities impact Earth's environment.
CO3: Develop perspectives on sustainability by looking into different ways of conservation of the natural resources and their management.

Course Outcomes (COs) – M.Sc. Semesters III and IV

COs of the Course on "Atmosphere and Global Climate Change" –M.Sc. (Paper 9)

CO1: Gain knowledge on the development of the Earth's atmosphere, its dynamic nature and variability in turns of the global energy balance.

CO2: Develop understanding on the elements of the climate and climate change, and human impacts on climate initiative policies.
CO3: Train on different methods to understand the functioning of atmospheric processes

COs of the Course on "Natural & Managed Ecosystem" –M.Sc. (Paper 10)

CO1: Analyze the role of Ecological principles to manage ecosystems.
CO2: Demonstrate distinction between natural and managed ecosystems.
CO3: Empowers on tools and techniques used to analyze the status of ecosystems.
CO4: Develop skills to manage ecosystems for sustainable development.

COs of the Course on "Biodiversity and Conservation Biology" –M.Sc. (Paper 11)

CO1: Demonstrate importance of diversity at different levels of biological organization.
CO2: Lay foundation on basic concept of ecological and biological processes that ensures long-term stability of ecosystems.
CO3: Train on the methods for measurement of species diversity and molecular diversity.
CO4: Analyze the values of biodiversity and scientific approaches for conservation that can lead to sustainable development.

COs of the Course on "Soil Biology" –M.Sc. (Paper 12)

CO1: Gain knowledge on fundamental principles of soil science, the processes of soil developmentand the criteria of soil classifications and mapping.
CO2: Analyze the importance of applied soil science in the practice of composting, and the fight against pollution or erosion of soils.
CO3: Demonstrate the types of organismic interactions in soil, and problems and solutions to d different soil related challenges.
CO4: Train on methods to analyze soil physical, chemical and biological characteristics.

COs of the Course on "Ecotoxicology and Environmental Health" –M.Sc. (Paper 13)

CO1: Lay foundation for in-depth understanding on the sources, origins and effects of various toxic materials and heavy metals that adversely affect environmental health.
CO2: Develop perspective on the movement of toxicants in different components of environment, in different levels of biological organization and in trophic transfer across the food chain.
CO3: Demonstrates the relationship between types of contaminants and effect on human health.
CO4: Trains on the methods used to assess the ecotoxicological impact and human health issues due to increase in the levels of contaminants in environment.

COs of the Course on "Environmental Chemistry" –M.Sc. (Paper 15)

CO1: Develop understanding on the chemistry of the lithosphere, hydrosphere and atmosphere.
CO2: Gain understanding on the chemistry of various anthropogenic pollutants and basic analytical techniques.

CO3: Trains on chemical analysis of water and waste water, and the scientific principle of tools and techniques used for chemical analysis.

COs of the Course on "Environmental Hazards" –M.Sc. (Paper 16)

CO1: Gain insights into various environmental hazards, their causes, nature, preparedness and assessment of loss.
CO2: Empower to develop model hazards and learn methods of disaster management.
CO3: Trains on preparation of hazard zonation map of India for landslides, earthquakes, floods; methods to estimate earthquake-loss using remote sensing and GIS, and prepare master plan for any environmental hazard mitigation.

COs of the Course on "Hydrology and Water Resources" –M.Sc. (Paper 17)

CO1: Develop an in-depth understanding on the hydrologic cycle and various characteristics of surface and groundwater resources including different techniques of water management.
CO2: Enable to estimate physico-chemical properties of water and evaluate hydrologic parameters; catchment delineation and water balance.
CO3: Trains on basic analytical methods to quantify water quality, analyze hydrographs anddetermine hydrological parameters.

COs of the Course on "Environmental Geology" –M.Sc. (Paper 18)

CO1: Lay foundation on basic geologic knowledge to maximize the utilization of all natural resources and minimize their degradation.
CO2: Empower with geological methods to minimize the destructive potential of natural processes and to sustain a healthy biosphere on earth.
CO3: Train on methods to identify common minerals & major rock types in hand specimens and under petrological microscope, and tools to analyze geomorphological basis of land use and interpret plate tectonics and hazard zonation maps.

COs of the Course on "Systems Analysis and Modelling" –M.Sc. (Paper 19)

CO1: Develop the concept of systems and sub-systems, and modelling and simulations as well as computational techniques.
CO2: Learn to model various environmental systems, particularly those dealing with ecology and ecosystems and study of environmental pollution in modelling air and water quality.
CO3: Empower with major approaches towards natural resource issues and enables to think creatively about conflict and concord in general, with special emphasis on the roles of ideas and institutions in environmental politics.
CO4: Trains on the computational techniques and simulation models to analyze environmental processes.

Course Outcomes (COs) – M.A. Semesters III and IV

COs of the Course on "Environmental and Resource Economics" –MA (Paper 9)

CO1: Empower with the integrated use of economics & ecology in decision making & law making processes.
CO2: Acquire ideas and tools developed in other branches of economics to make significant contribution to valuation techniques, design of policy instruments for pollution control and management of commons.
CO3: Enables to use the cost-benefit analysis and valuation techniques for environmental economics.

COs of the Course on "Indian and International Environmental Law" –M.A. (Paper 11)

CO1: Develop insights into the role of environmental laws for planetary housekeeping, protecting the planet and its people from activities that upset the earth and its life-sustaining capacities.
CO2: Enable to apply a range of regulatory instruments to preserve and protect the environment.
CO3: Demonstrate the strengths and weaknesses in law and its enforcement for developing strategies to overcome the same.

COs of the Course on "Environmental History and Environmentalism" –MA (Paper 13)

CO1: Develop a comprehensive historical perspective on the interactions between human societies in relationship to ecosystems in ancient to modern societies.
CO2: Gain knowledge on the present day environmental dilemmas, and the conflicts and choices that have their roots in the past.
CO3: Examine the ways in which environmental changes, often the result of human actions, have caused historical trends in human societies.
CO4: Enables with the ideology of environmentalism and environmental history, modern environmental movements, the Gaia theory.

COs of the Course on "Environmental Policies and Politics" –M.A. (Paper 14)

CO1: Gain insights into the politics of environmental issues at the national and international levels.
CO2: Debate on environmental policies and regulations and environmental movements in India.

COs of the Course on "Environmental Communications and Education" –M.A. (Paper 15)

CO1: Empowers with the methods of communication to the masses and consumers for environmental issues.
CO2: Develop global perspective on the scenario of environmental education and communication at the national and international levels.
CO3: Lay foundation of environmental communication, education and interpretations to achieve the goal of sustainable development, protection of environment, and conservation of biodiversity and ecosystems.

COs of the Course on "Technology, Environment and Society" –M.A. (Paper 16)

CO1: Develop evolutionary perspective on the relationship between and evolution of technology and environment.
CO2: Develop in-depth understanding on the role and contribution of different types of economic and social mechanisms in the contemporary societies shaping the structure and function environment.
CO3: Demonstrate the technological changes in the direction of sustainable development, which will help to achieve ecological and social justice.

COs of the Course on "Natural Resource Conflicts and Choices" –MA (Paper 17)

CO1: Analyze contemporary conflicts, struggles and policy choices around natural resources.
CO2: Develop critical thinking on who controls the environment and how, and who degrades nature and why.
CO3: Develop perspective on major approaches towards natural resource issues and enable to think creatively about conflict and concord in general, with special emphasis on the roles of ideas and institutions in environmental politics.
CO4: Learn skills to analyze case studies on big dams and endangered fauna, industrial pollution and global warming, the role of gender and empire.

COs of the Course on "Global Environmental Issues" –M.A. (Paper 19)

CO1: Develop perspective on important environmental issues that have become a matter of global policy making, international negotiations and trade disputes.
CO2: Develop critical thinking on the links between environment, property regimes, trade and information economies.

III. M.Sc./ M.A. in Environmental Studies Course Structure &Details

Programme Structure

M.Sc. Environmental Studies

TOTAL CREDITS	92	Number of core papers	8
Practicals/Field Study	10	Number electives	6
Number of open elective	1	Dissertation	1

Semester	Core Courses			Electives			Open Elective*			Total Credits
	No. of papers	Credits	Total	No. of papers	Credits	Total	No. of papers	Credits	Total	
I	4T +2P/FS/Tu	16T+4P	20	0	0	0	0	0	0	20
II	4T+2P/FS/Tu	16T+4P	20	0	0	0	0	0	0	20
III	0	0	0	4T+4P	16T+8P	24	1	4	4	28
IV	1D (2T+2P)	8T+4P	12	2T+2P	8T+4P	12	0	0	0	24
Total	10		52	6		36	1		4	92

M.A. Environmental Studies

TOTAL CREDITS	92	Number of core papers	8
Practicals/Field Study	10	Number elective papers	6
Number of open elective	1	Dissertation	1

Semester	Core Courses			Electives			Open Elective*			Total Credits
	No. of papers	Credits	Total	No. of papers	Credits	Total	No. of papers	Credits	Total	
I	4T +2P/FS/Tu	16T+4P	20	0	0	0	0	0	0	20
II	4T+2P/FS/Tu	16T+4P	20	0	0	0	0	0	0	20
III	0	0	0	4T+4Tu	16T+8Tu	24	1	4	4	28
IV	1D (2T+2P)	8T+4P	12	2T+2Tu	8T+4Tu	12	0	0	0	24
Total	10		52	6		36	1		4	92

FS = Field Study; P = Practical;Tu= Tutorial; and D = Dissertation (includes practical/lab/field work and thesis writing).

Note:

- The first 2 semesters (Semester I and II) shall have a common curriculum for both streams – M.Sc. and M.A. These two semesters shall comprise 8Core Papers/Courses.
- Dissertation, equal to two core papers/courses (8 credits) shall be offered in Semester IV and will include submission of a thesis (based on primary research work in lab/field) followed by a *viva voce* examination.
- Each student shall be required to earn 92 credits to earn M.Sc./M.A. Environment Degree which shall include minimum 4 credits of Open Elective Course offered by this or any other Department.

***Open Elective**

- Enrollment to Open Elective shall be as per norms laid down by the Faculty of Science.
- The Open Elective (Paper 21) offered by the Department of Environmental Studies shall be open to students from the Departments of Faculty of Science, Faculty of Social Sciences, Faculty of Mathematical Sciences, Faculty of Interdisciplinary & Applied Sciences and those students who meet the eligibility requirements for admission to M.Sc./M.A. Environmental Studies.

IV. M.Sc./M.A. in Environment Studies
Semester-wise Course Structure

Year 1 (Common for both M.Sc. and M.A.)		**Year 2 Elective Courses**	
Semester 1	**Semester 2**	**Semesters 3 & 4 (Any 6 papers from the basket of the following 12 Papers (Papers9-20)**	
Core Courses	**Core Courses**	**M.Sc. Stream**	**M.A. Stream**
Paper 1: Introduction to the Environment Studies	Paper 5: Environment Impact & Risk Assessment	Paper 9: Atmosphere and Global Climate Change	Paper 9: Environment and Resource Economics
Paper 2: Social Perspectives of the Environment	Paper 6: Pollution and Health	Paper 10: Natural and Managed Ecosystems	Paper 10: Social Theory, Sociology of Development and the Environment
Paper 3: Environment, Development & Sustainability	Paper 7: Urban Ecosystems	Paper 11: Biodiversity and Conservation Biology	Paper 11: India and International Environmental Law
Paper 4: Methodologies for Environmental Studies	Paper 8: Natural Resources: Conservation & Management	Paper 12: Soil Biology	Paper 12: Environmental Ethics and Philosophy
		Paper 13: Eco-toxicology and Environmental Health	Paper 13: Environmental History and Environmentalism
		Paper 14: Environmental Biotechnology	Paper 14: Environmental Policies and Politics
		Paper 15: Environmental Chemistry	Paper 15: Environmental Communication and Education
		Paper 16: Environmental Hazards	Paper 16: Technology, Environment and Society
		Paper 17: Hydrology and Water Resources	Paper 17: Natural Resource Conflicts and Choices
		Paper 18: Environmental Geology	Paper 18: Gender and the Environment
		Paper 19: System Analysis and Modeling	Paper 19: Global Environmental Issues
		Paper 20: Environmental Engineering	Paper 20: Culture and the Environment
		Open Elective Course (Semester III)	
		Paper 21: Environmental Studies: Toward a Sustainable Future	

Selection of Elective Courses

The Department offers a basket of 12 Elective Papers offered over II, III and IV semesters. These Elective Papers shall be offered in Semester III& IV. The students can choose 6 elective papersfrom among Papers 9-20 over semesters III& IV.

Teaching

The faculty of the Department is primarily responsible for organizing lecture work for M.Sc./M.A. in Environmental Studies. The instructions related to tutorials are provided by the respective registering units under the overall guidance of the Department. Faculty from some other Departments and constituent colleges are also associated with lecture and tutorial work in the Department.

There shall be 90 instructional days excluding examination in a semester.

Eligibility for the Admissions

M.A.: Any undergraduate (B.Sc./ B.A.Sc. (Hons.)/B.A. and B. Com Hons./Pass Course), (3 year course after 10+2) from University of Delhi or any other University whose Examination is recognized as equivalent fulfilling other conditions of eligibility, but having at least one of these subjects (Physics / Chemistry / Biology / Math / Geography / Economics) at 10+2 or undergraduate level.

OR

B.Tech./B.E. Degree from any University/Institution recognized by UGC/AICTEE.

M.Sc.: Any undergraduate B.Sc./B.A.Sc. (Hons.) /B.Sc. Programme/B.Sc. General (3 year Course after 10+2) from University of Delhi or any other University whose examination is recognized as equivalent fulfilling other conditions of eligibility, but having at least one of these subjects (Physics/ Chemistry/ Biology/ Maths) at 10+2 Level.

OR

B.Tech./B.E. Degree from any University/ Institution recognized by UGC/AICTEE) Structure of M.A./M.Sc. course in Environmental Studies.

Assessment of Students' Performance and Scheme of Examinations

1. English shall be the medium of instruction and examination.
2. Assessment of students' performance shall consist of:

(Point wise details of internal assessment and end semester examination, their weightage and scheme to be given)

(Assessment will be based on learning outcomes for the course)

Pass Percentage & Promotion Criteria

As per university norms & examination regulations.

Part I to Part II Progression

As per University Examination rules.

Conversion of Marks into Grades

As per University Examination rules.

Grade Points

As per University Examination rules.

CGPA Calculation

As per University Examination rules.

SGPA Calculation

Grand SGPA Calculation

Conversion of Grand CGPA into Marks

As notified by competent authority the formula for conversion of Grand CGPA into marks is: Final %age of marks = CGPA based on all four semesters × 9.5

Division of Degree into Classes

Post Graduate degree to be classified based on CGPA obtained into various classes as notified into Examination policy.

Attendance Requirement

The Department recommends 75% mandatory attendance as per University Ordinance VII Clause (7) recommended for M.A. Course (Social Work) (page 325 University Calendar Vol. 1) with usual discretion of the HoD to waive off 10% absence from class attendance under special circumstancesof a candidate.

Span Period

No student shall be admitted as a candidate for the examination for any of the Parts/Semesters after the lapse of four years from the date of admission to the Part-I/Semester-I of the M.Sc./M.A. in Environmental Studies.

Guidelines for the Award of Internal Assessment Marks M.Sc./M.A. in Environmental Studies (Semester Wise)

1. The internal assessment component for the Semesters I & II (courses common for M.A./M.Sc.) will be equal to 30% of the each course/paper. The final examination shall be equal to 70%.
2. The internal assessment/term papers for Semesters III & IV (M.A. Environmental Studies only) shall be equal to 30% and the final examination shall be equal to 70%.
3. For M.Sc. (Environmental Studies)semesters III & IV, the Practical component of each paper/course shall be equal to 30% and the final examination shall be equal to 70%.

Paper 1

INTRODUCTION TO ENVIRONMENTAL SCIENCES

Preamble: This paper introduces the students, coming from disparate backgrounds, to the basics of Environmental Science. Major themes and issues confronting our present day environment are introduced in this paper from a scientific perspective. Each theme in the paper is listed in separate paragraphs.

Introduction to the Environment. Acquisition, transformation and utilization of energy: the geochemical, biogeochemical and hydrological cycles. Concept of ecosystem.

Atmosphere: structure and composition. Air pollutants and their emission sources. Aerosols and Smogs. Air quality standards. Tropospheric ozone. Air pollution in Indian cities.

Water: quantity and quality. Parameters and standards; Demands. Rain water chemistry. Surface and subsurface waters in India. Environmental hotspots related to water in India.

Soil and Land use: Climate and soil profile, Mineral matters in soil. Soil classification. Soil distribution in India. Land use in India. Impact of soil loss and land cover on biogeochemical cycles.

Biodiversity. Problems and issues in biodiversity.Biodiversity status and patterns and hotspots. Conservation and utilization of biodiversity.

Global warming and climate change. Recent records of climate change. Impact of climate change on Indian environment. Measures to cope with climate change.

Mineral and energy resources. Impact of mining and other human activities on the environment.

Environmental impact assessment and environmental audit: an introduction. Environmental policy matters and law.

Practical/Field Study: Combined based on Papers 1 & 4.

Suggested Readings

Anjaneyulu, Y. 2004. Introduction to Environmental Science. B. S. Publications.

Barrett, E.C. 2013. Introduction To Environmental Remote Sensing. Routledge.

Botkin, D.B. and Keller, E.A. 1995. Environmental Science Earth as a Living Planet, (9th Ed). Wileyplus.

Chiras, D.D. 2001. Environmental Science, 6Ed., Jones and Bartlett Publishers.

Cunningham, W. and Cunningham, M.A. 2010. Principles Of Environmental Science. McGraw-Hill Higher Education.

Cunningham, W.P., Saigo, B.W. and Cunningham, M.A. 2001. Environmental Science: A Global Concern (Vol. 412). Boston, MA: McGraw-Hill.

Glasson, J. and Therivel, R. 2013. Introduction To Environmental Impact Assessment. Routledge.

Masters, G.M. and Ela, W.P. 1991. Introduction To Environmental Engineering And Science (Vol. 3). Englewood Cliffs, NJ: Prentice Hall.

Turner, R.K., Pearce, D. and Bateman, I. 1994. Environmental Economics: An Elementary Introduction. Harvester Wheatsheaf.

Wright. R.T, and Nebel. B. J. 2004. Environmental Science, 8thEd. Prentice Hall India Ltd.

Paper 2

SOCIAL PERSPECTIVES ON ENVIRONMENT

Preamble: This paper aims at inculcating and developing a perspective and sensitivity towards environment and related issues. Paper stresses the fact that variability in inherent characteristic of nature and there has been multiplicity of human adaptations/negotiations. It also attempts to discuss the issue of predatory perspective vs harmonious perspective. Paper also focuses on social, economic, anthropological aspects of development and its politics.

Introduction to environmental thought. Traditions of thinking about environment from deep ecology to modernization, reflections on industrial societies and risk. Indian and global thinkers are discussed. Recent debates on concept of Anthropocene and Anthropocentricism are introduced.

Early issues in Indian environmentalism: land, forest and water. Looks at historical developments in natural resource use practice such as agriculture, forestry and water management and impacts of colonial intervention in India, both from the perspective of the state and of communities. Differences across various regions in India are explored.

Issues in global environmentalism. Highlights global inter-connectedness of environmental issues such as climate variability, loss of biodiversity, etc., by examining both the nature of the issues and instruments of international environmental negotiations.

Population and resources. Explores the historically evolving relationship between population pressures, resource consumption and sustainability. Tragedy of commons Indian and global debates are introduced.

Urbanization and environment. The process of urbanization is explored with respect of consumption of resources; environmental consequences of urban transformation, waste disposal and pollution.

Environment, technology and society. Examines the interface between specific technologies, including electrification, transport technologies, energy generation etc. and rural/urban environments. .

Risk and ecological modernization. The nature of environmental risk that emerges in the wake of modernity and the responses to the same in select national contexts are introduced.

Regulations and environment. Deals with law and policies to regulate environmental harm in select national contexts. health care and climate adaptation

Environmental politics in contemporary India. Introduces a range of policy initiatives and popular struggles around contemporary environmental issues such as, forests, wildlife, water, traditional knowledge and environmental resources and pollution.

Environmental governance and management. Deals with community resource management, given state and market failures. Traditional knowledge systems and resource management and sustainability.

Communicating environment. Introduces the media and educational dimensions of environmental awareness in contemporary societies.

Communicating environment. Introduces the media and educational dimensions of environmental awareness in contemporary societies.

Tutorials: Combined for Papers 2 & 3.

Suggested Readings

Agarwal, B. 2010. Gender and Green Governance, Oxford University Press. (see chapter 2).

Benedict, Ruth, 2005. Patterns of Culture: Houghton Mifflin Harcourt, New York.

Chokkan, K.B., Pandya, H. and Raghunathan, H. (Eds). 2004. Understanding Environment. Sagar publication India Pvt. Ltd., New Delhi, London.

Elliot, S., 2011. Trans-disciplinary perspectives on environmental sustainability: a resource base and framework for IT-enabled business transformation. MisQuarterly, 35:197-236.

Gandhi, M.K. 1987. Hind Swaraj: Ahmedabad, Navjeevan Press,

Guha, R. 2006.How Much Should a Person Consume, University of California Press.

Harper, C., Harper, C.L. and Snowden, M. 2017. Environment And Society: Human Perspectives On Environmental Issues. Routledge.

Hobswan, E J., *Industry and Empire: From 1750 to present day*, Penguin, 1999.

Chandra, B. Colonialism, Stages of colonialism and Colonial State, *Journal of Contemporary Asia*, Vol-10 No.3, 2008, 272-85.

Hukkinen, J.I. 2012. Social networks and natural resource management: uncovering the social fabric of environmental governance. Journal of Integrative Environmental Sciences, 9:279-281.

Kumar, M. 2014. Adaptations to Climatic Variability: Irrigation, and Settlements patterns in Early Medieval Rajasthan, *The Medieval History Journal*, Vol. 17 No.1, 2014 pp.57-86.

Leach, M., Stirling, A.C. and Scoones, I. 2010. Dynamic Sustainabilities: Technology, Environment, Social Justice. Routledge.

McNiell, J.R.2002. Something New Under the Sun: An Environmental History of 20thCentury,Penguin Press, Allen Lane.

Rangarajan, M. and Sivaramakrishnan, K.2012. India's Environmental History (2 Vols.), Permanent Black.

Sharma, S. 2009.Why People protest: an analysis of ecological movements in the third World, Publication Division, Govt. of India, Delhi.

Singh, K. S.1992. Peoples of India, Vol-1, Anthropological Survey of India.

Strauss, L.C. 1995. Myth and meaning: Cracking the code of Culture: Schocken, New York.

Paper 3

ENVIRONMENT, DEVELOPMENT AND SUSTAINABILITY

Preamble: The paper deals with the human dimension of development and environment. It aims to provide adequate insight on management of natural resources by imparting training in tools and methodologies of ecological and environmental economics.

Concept of Sustainability, Sustainable Development and its different constituents.

Growth and Development, Technology, Affluence and the Environmental Kuznets' Curve.

Principles of Ecological and Environmental Economics, their scope and usefulness.

Basic Market process, Market Failure and Externality, case of environmental problems.

Solutions to Environmental Problems: Command and Control, Economic solutions.

Estimation of Environmental Costs and Benefits, Cost Benefit Analysis. Valuation of ecosystem services and impact of intervention (malign and benign). Best practices in ecosystem services and sustainability of society

Sustainability, issues of development and environmental protection and conflicts over resources discussed in context of Environmental Movements by taking up well known Indian and international case Studies . Inter-connection and linkages of environment destruction on a global scale. Select topics (Impacts of development and habitat destruction on pollution, biodiversity, human health, etc) taken up in seminar mode for internal assessment).

Tutorials: Combined for Papers 2 & 3

Suggested Readings

Baumol, W.J. and Oates, W.E. 1988. Theory of Environmental Policies, Cambridge University Press, Cambridge, UK.

Callan, S.J. and Thomas, J.M. 2013. Environmental Economics and management: Theory, Policy, and Applications. Cengage Learning.

Carson, Rachel. 2002. Silent Spring. Boston, Houghton Mifflin,

Freeman, A.M., Herriges, J.A. & Kling, C.L. 2001. The Measurement of Environmental and Resource Values. REF Press, Washington DC.

Freeman. A.M. 2003. Millennium Ecosystem Assessment: Conceptual framework. Island Press.

Hanley, N., Shogren, J.F. and White, B. 2002. Environmental Economics in Theory and Practice. Palgrave Macmillan.

Markandya, A. 2017. The Earthscan Reader in Environmental Economics. Routledge.

Tietenberg, T. 2003. Environmental and Natural Resource Economics. Pearson Education, New York.

Paper 4

METHODOLOGIES FOR ENVIRONMENTAL STUDIES

Preamble: This paper introduces the students to various methods used in the collection of data and analysis for environmental studies. Simulation model are increasingly used to investigate the complexity of environmental processors. The paper introduces the students to the basics of modeling along with the application of remote sensing and GIS in different aspects of environmental studies.

Data collection, survey and processing including social and cultural parameters. Statistics: Normal and binomial distribution. Hypothesis testing, t and chi square tests. Correlation and regression. Introductory analysis of variance. Multi-criteria analysis.

Modeling: Types of models: Mechanistic, economic, simulation etc. Fundamentals of building a model. Treatment of 2 or 3 environmental related models: Eutrophication model, global climate change model, wildlife habitat suitability model, air pollution model, ground water pollution model.

Remote Sensing: definition, principles, satellites and sensors. Aerial photography to Satellite Remote Sensing. Digital Image processing and image interpretation. GPS principles and applications. Geographic Information System: concepts, database generation and analysis.

Applications of Remote Sensing-GIS for Environmental Studies. Case studies, such as, (a) Land use / land cover change, Forest degradation, Urban sprawling. (b) Mining Hazards / Impacts, and (c) Forest Fire / Coal Fire Monitoring.

Applications of Biostatistics for Environmental Studies. Quantitative and qualitative research, Research question, Experimental design, Exercises on choice of statistical tools, presentation and interpretation of statistical results. Case studies based on contemporary research in ecology and environment.

Practical/Field Study: Combined based on Papers 1 & 4.

Suggested Readings

Burrough, P.A., McDonnell, R.A. and Lloyd, C.D. 2015. Principles of Geographical Information Systems. Oxford University Press.

Dillon, J. and Wals, A.E. 2016. On the dangers of blurring methods, methodologies and ideologies in environmental education research. In Towards a Convergence Between Science and Environmental Education (pp. 113-124). Routledge.

Freund, R.J., Wilson, W.J. 2003. Statistical Methods, Academic Press.

Lillesand, T.M. & Kiefer. R.W. 1999. Remote sensing and image interpretation (4thEd). Wiley.

Nieuwenhuijsen, M.J. ed. 2015. Exposure Assessment in Environmental Epidemiology. Oxford University Press, USA.

Wainwright, J. and Mulligan, M. eds. 2005. Environmental Modelling: Finding Simplicity in Complexity. John Wiley & Sons.

Paper 5

ENVIRONMENTAL RISK AND IMPACT ASSESSMENT

Preamble: This paper is an introduction to EIA, a systematic process that examines the environmental consequences of development actions, in advance. This process is firmly on the agenda of all environmental agencies as a result of introduction of legislations in various countries.

Introduction: Defining environmental risk in different perspectives.

Principles and procedures: Nature and purpose of environmental impact assessment (EIA). Characteristics of big project. Current issues in EIA. Worldwide spread of EIA. EIA regulations in India. Risk Assessment v/s Environmental Impact Assessment. Life cycles Assessment. Strategic Environmental Assessment.

Process and Methods of EIA: Stages, Scoping, Alternatives, Impact Identification, Establishing the Environmental base line. Impact prediction, evaluation and mitigation. Criteria and standards for assessing significant Impact. Cost- Benefit Analysis and valuation of Environmental Impacts. Public Participation, presentation and review. EIA monitoring and auditing.

Practice: Air quality Assessment; Water Impact Assessment; Social Impact Assessment; Ecological Impact Assessment; Landscape and visual Impact Assessment; Environmental Impact of surface and underground mining of metals, minerals and fossil fuels. Cumulative Effects Assessment.

Issues and problems in environmental assessment.

Practical/Field Study/Tutorial: Combined based on Papers 5 & 6.

Suggested Readings

Blaikie, P., Cannon, T., Davis, I. and Wisner, B. 2003. At Risk: Natural Hazards, People's Vulnerability and Disasters(2nd Ed.). Abington: Routledge.

Brown, K. 2015. Resilience, Development and Global Change. London: Routledge

Glasson, J. and Therivel, R. 2013. Introduction To Environmental Impact Assessment. Routledge.

Morris. P. &Therivel. R., 2001, Methods of environmental impact assessment, 2nd Ed. Spon Press, New York, With a chapter on GIS and EIA by A.R. Bachiller& G. Wood, p. 381-401.

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

Pandit, M.K. and Grumbine, R.E., 2012. Potential effects of ongoing and proposed hydropower development on terrestrial biological diversity in the Indian Himalaya. *Conservation Biology*, 26: 1061-1071.

Petts, J. 1999. Handbook Of Environmental Impact Assessment. Vol. 1, Blackwell Science.

Paper 6

ENVIRONMENTAL POLLUTION AND HEALTH

Preamble: Environmental pollution end results in adverse effect on the health of the people exposed to it. A large number of diseases are caused and spread by contaminated soil, water and air. The paper will deal with the impact of environmental pollution on health and includes the guidelines for pollution control in the context of public health.

Water sources, quality and standards. Water purification and surveillance of drinking water quality. Infections and diseases spread by contaminated water.

Air pollution: composition and sources. Air quality monitoring. National and international standards for monitoring air quality. Diseases caused by air pollution. Quality of indoor air and its effect on health. Ventilation: standards, methods and health hazards. Radiation pollution: sources, biological effects and protection. Meteorological environment monitoring. Air temperature and biological effects.

Noise pollution: source and standards. Noise pollution: health hazard and protective measures.

Housing standards and effect on health. Methods of disposal of solid waste. Diseases related to soil pollution. Problems and methods of excreta disposal.

Arthropods of medical importance. Vector-borne diseases: transmission and control. Impact of fleas, ticks and mites on health. Zoonotic diseases and their prevention and control. Hospital environment in the context of health and disease.

Pollution control in India: Government obligation, mechanism and legislation in the context of public health.

Practical/Field Study/Tutorial: Combined based on Papers 5 & 6.

Suggested Readings

Holgate, S.T., Koren, H.S., Samet, J.M. and Maynard, R.L. eds. 1999. Air pollution and health. Elsevier.

Kampa, M. and Castanas, E. 2008. Human health effects of air pollution. *Environmental Pollution, 151*: 362-367.

McGranahan, G. and Murray, F., 2012. Air pollution and health in rapidly developing countries. Earthscan.

Murray J.F. and Nadel. J.A. 2000. Text book of respiratory medicine, 3rd Edn., W.B. Saunders & Co.

Partdos, C.D., Ignatius, R. and Schneider, T. 2005. Topley and Wilson's microbiology and microbial infections. Oxford University Press.

Park. J.E. and Park. K. 1994. Text book of preventive and social medicine, Banarsi Das &Bhanot, Jabalpur.

Smith, K.R. 2013. Biofuels, air pollution, and health: a global review. Springer Science & Business Media.

Paper 7

URBAN ECOSYSTEMS

Preamble: Much of environmental policy making and popular struggles in India have the rural scenario as their object of inquiry. This paper looks at the emerging importance of the urban setting as the locus of environmental conflict and governance in India, across a range of urban clusters including metros, cities and towns. Their importance for policy, community mobilization, law and governance are explored.

City, region and modernity

Places the city in its regional context, both in terms of drawing upon resources and transferring waste.

Nature in the city: Parks, Gardens and Public spaces.

Examines the principles and techniques through which green spaces are organized in the city to produce 'controlled nature'.

Infrastructure

A variety of infrastructure from sewage and water to transport and communication are studied from an environmental perspective.

Planning and environment

Town planning Acts and their environmental aspects are studied across a range of Indian cities. Historical and contemporary developments in urban planning and environmental management are addressed.

Slums and neighborhoods.

Examines the housing scenario across large-medium-small cities and the presence of slums as a specific environmental issue in urban contexts.

Occupational environment

Environmental aspects of a variety of informal and formal work spaces are examined.

Pollution and waste

Major forms of urban pollution - air, water, noise and land - are explored historically and across various urban sites. Spatial dimensions of waste circulation are explored.

Consuming nature

Introduce the issue of consumption from a variety of perspectives - materials, symbolic and aesthetic.

Energy and environment

Examines the major techniques for providing energy in urban contexts - generation, transportation, usage, alternatives and environmental impacts.

Sustainability and urban futures

Tutorial : Combined Tutorials for Papers 7 & 8.

Suggested Readings

(Urban Ecosystems – a journal by Springer can be a good reading material).

Berkowitz, A.R., Nilon, C.H. and Hollweg, K.S. (eds.). 2003. *Understanding urban ecosystems: a new frontier for science and education*. Springer Science & Business Media.

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

Douglas, I. 2012. Peri-urban ecosystems and societies: transitional zones and contrasting values. In The Peri-urban Interface (pp. 41-52). Routledge.

Kopecká, M., Nagendra, H. and Millington, A. 2018. Urban Land Systems: An Ecosystems Perspective.

Kumar, P. 2009. Assessment of economic drivers of land use change in urban ecosystems of Delhi, India. AMBIO:A Journal of the Human Environment, **38**: 35-39.

Nagendra, H., Sudhira, H.S., Katti, M., Tengö, M. and Schewenius, M. 2014. Urbanization and its impacts on land use, biodiversity and ecosystems in India. INTERdisciplina, 2.

Pelling, M. and S. Blackburn (eds.). 2003. Megacities and the Coast: Risk, Resilience and Transformation, Abington: Routledge.

Singh, V.S., Pandey, D.N. and Chaudhry, P. 2010. Urban forests and open green spaces: lessons for Jaipur, Rajasthan India. Jaipur: Rajasthan State Pollution Control Board.

Oldenburg, V.T. 2014. The Making Of Colonial Lucknow, 1856-1877. Princeton University Press.

Verma, G.D. 2002. Slumming India: A Chronicle Of Slums And Their Saviours. Penguin Books, New Delhi.

Paper 8

NATURAL RESOURCES: THEIR CONSERVATION AND MANAGEMENT

Preamble: This paper takes an objective view of the nature of Earth's resources, particularly the non-renewable resources, how and where they are generated, how they are extracted and used, and how these activities impact Earth's environment. It also addresses sustainability by looking into different ways of conservation of the natural resources and their management. The contributions of community based governance and co-management of resources is also examined.

Introduction to natural resources and their consumption patterns. Supply and demand of natural resources. Types of natural resources: renewable and non-renewable resources. Time frame. Approaches to natural resource management.

The nature of soil, characteristics and value. Soil formation, soil profile and soil classification. Soil fertility. Soil conservation and sustainable agriculture: nature of soil erosion; factors affecting soil erosion by water and its control. Alternative agriculture, sustainable agriculture. Land use and environmental problems of soil. Soil surveys and Land use planning.

Minerals resources, their use, mining and sustainability. Genesis of mineral deposits: endogenous and exogenous processes and their time frame. Environmental impact of mineral production. Mineral conservation strategies: the resource cycle.

Non-renewable energy resources: patterns of consumption, issues and options. Global energy source: an overview. Fossil fuels: reserves of coal, its classification and basic geology. Environmental impact of coal mining. Reserves of oil and gas, basic geology. Environmental impact of their production and consumption. Nuclear energy, its sources. Nuclear power plants. Nuclear waste disposal. Geothermal energy: water dominated and vapour dominated systems.

Types of renewable energy source and their environmental significance. Sustainable development of energy resources.

Tutorial : Combined Tutorials for Papers 7 & 8.

Suggested Readings

Agarwal, B. 2010. Gender and Green Governance, Oxford and Delhi: Oxford University Press.

Brosius, P.J., Tsing, A.L. and Zerner, C. (eds.). 2005. Communities and Conservation: Histories and Politics of Community-Based Natural Resource Management. Rowman Altamira.

Craig, J.R., Vaughan, D.J. Skinner, B.J. 1996. Resources of the Earth: Origin, Use, And Environmental Impact, (2^{nd} Ed). Prentice Hall, New Jersey.

Klee, G.A. 1991. Conservation of Natural Resources. Prentice Hall Publ. Co., New Jersey.

Owen, O.S, Chiras, D.D. & Reganold, J.P. 1998. Natural Resource Conservation – Management For Sustainable Future, (7^{th}Edn.), Prentice Hall.

M. Sc. Stream

Paper 9

ATMOSPHERE AND GLOBAL CLIMATE CHANGE

Preamble: This paper introduces the student to the development of the Earth's atmosphere, its dynamic nature and variability in turns of the global energy balance. It also deals with elements of the climate, climate change and human impacts on climate initiative policies.

Earth Systems: Atmosphere, Hydrosphere, Lithosphere, Biosphere and their linkage. Earth's geological history and development and evolution of the atmosphere; Milutin Milankovitch and Milankovitch Cycles; James E. Lovelock and Gaia Hypothesis.

Atmosphere and climate. Basic atmospheric properties, climatic controls. Climatic classifications and variability. Movement in the atmosphere: global scale, regional scale, local scale.

Oceans: General circulation patterns. Air- Sea interaction.

Global Energy balance: Source, transfer, distribution. Energy balance of the atmosphere.

Wind, stability and turbulence; Monsoons; El Nino, Southern Oscillations, cyclones. Natural climate changes: Records of climate change (glacial cycles, ocean sediments, corals, tree rings).

Indian climate through ages; impact of the Himalayan mountain building and the Indian Summer Monsoon.

Anthropocene & the Human Impacts on climate:

Causes and consequences of Global warming: Greenhouse effect; Global and regional trends in greenhouse gas emissions; Sea level rise; role of oceans and forests as carbon sinks; Ozone depletion-stratospheric ozone shield; Ozone hole.

Impacts of Climate change: Effects on organisms including humans; effects on ecosystems and productivity; species responses in terms of distribution ranges, adaptation; spread of diseases; Extinction risk for temperature-sensitive species; UV effects

Climate change and Policy: Montreal Protocol; Kyoto Protocol; Paris Agreement; Carbon trading; clean development mechanism (CDM).

Practicals

Future projections of species' distribution ranges in response to climate change; effectiveness of boundaries of national parks or conservation areas under future climate change scenarios.

Project reports based on any of the above topics including on long term data collected from India Meteorological Department (IMD) and National Physical Laboratory (NPL) on various atmospheric parameters and their analysis including worldclim data.

Visit to IMD to learn about real time monitoring and prediction of weather.

Viva-Voce based on the above practicals.

Suggested Readings

Barry, R. G., 2003. Atmosphere, weather and climate. Routledge Press, UK

Ellis, E.C., Kaplan, J.O., Fuller, D.Q., Vavrus, S., Goldewijk, K.K. and Verburg, P.H. 2013. Used planet: A global history. Proceedings of the National Academy of Sciences, **110**: 7978-7985.

Firor, J., & Jacobsen, J. E. 2002. The crowded greenhouse: population, climate change and creating a sustainable world. Yale University Press.

Graham, S. 2000. https://earthobservatory.nasa.gov/Features/Milankovitch/

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

Huybers, P. and Curry, W. 2006. Links between annual, Milankovitch and continuum temperature variability. Nature, **441**: 329.

Kneževič, Z. 2010. Milutin Milankovič and the astronomical theory of climate changes. Europhysics News, 41, 3, 17–20, DOI: 10.1051/epn/2010301.

Kump, L. R.Kasting, J.F. and Carne, R. G. 2004. The Earth System. 3rd Ed. Prentice-Hall.

Lovelock, J. 2000. Gaia: A New Look at Life on Earth, Oxford University Press.

Raymo, M.E. 1992. Global climate change: a three million year perspective. In Start of a Glacial (pp. 207-223), Springer, Berlin, Heidelberg.

Steffen, W., Grinevald, J., Crutzen, P. and McNeill, J., 2011. The Anthropocene: conceptual and historical perspectives. Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences, **369**: 842-867.

Zhang, S., Wang, X., Hammarlund, E.U., Wang, H., Costa, M.M., Bjerrum, C.J., Connelly, J.N., Zhang, B., Bian, L. and Canfield, D.E., 2015. Orbital forcing of climate 1.4 billion years ago. Proceedings of the National Academy of Sciences, **112**: 1406-1413.

Paper 10

NATURAL AND MANAGED ECOSYSTEMS

Preamble: This paper deals with the understanding of the structure and functions of plant communities in natural and managed ecosystems.

Introduction to ecosystems: concepts; components; flow of energy; productivity, nutrient cycling (nitrogen, phosphorus and sulphur), food chain and food web.

Communities: concept; development; structure; niche; nature of plant communities, classification and analysis of plant communities.

Ecosystem dynamics and functioning: role of biodiversity in patterns and processes of communities and ecosystems; stability, ecological role of disturbances for example fire or grazing in vegetation changes, primary plant strategies.

Plant competition: competition for resources, light, water. Theories of competitive mechanisms

Allelopathy: functioning of plant chemicals in the environment and its role in community assembly

Biological Invasions: introduction, hypotheses and causes of plant invasion, case studies

Plant facilitation: direct and indirect mechanisms of plant facilitation, interaction between plant facilitation and plant competition, role of facilitation in community assembly.

Plant defense: cost of fitness, direct defense, indirect defense, constitutive and induced defense.

Human influences: human alteration of N cycle, human-mediated vegetation changes.

Brief account of the major ecosystems of the world: forests, grasslands, wetlands, oceans, rivers and lakes, deserts, agri-Ecosystems, aquaculture, urban ecosystems and community forests.

Ecosystem services: biodiversity and ecosystem services, causes and consequences of biodiversity, benefits of ecosystem services to humans

Sustainable management: concept of sustainability, mechanisms to ensure sustainability of ecosystems.

Practicals:

1. Formulation of objectives, hypothesis, experimental design and research plan, and methods in community ecological research.
2. Basic training on the importance of control, replicates, formation of standards and standard curves in chemical ecology.
3. Experiments: organic carbon, exchangeable phosphate-P, total phenolics, nitrate, ammonium-N, sulphate-S.
4. Phytosociology studies in natural environment: species area curve, density, frequency, abundance, tree height.

Suggested Readings

Research papers published in ecology journals will be provided to students on selected topics.

Allen, S. E. 1989. Chemical Analysis of Ecological Material. Blackwell.

Callaway, R.M. 2007. Positive Interactions and Interdependence in Plant Communities. Springer.

Clapham Jr., W.B., 1983, Natural Ecosystem: Chapters I, II, III and IV. Macmillan Publishers, London

Grime, J. P. 2002. Plant strategies and vegetation processes. John Wiley.

Gurevitch J., Scheiner, S.M. and Fox G.A. 2006. The ecology of plants. Sinauer.

Heywood, V.H. (Executive Editor). 1995. Global Biodiversity Assessment: Chapters 5 and 6. UNEP, University Press, Cambridge

Inderjit. 2005. Invasive plants: ecological and agricultural aspects. Birkhäuser Verlag AG

Jennifer, A., Burch. W.R., Conover, B. and Field, D., 1998. Ecosystem Management Adaptive strategies for Natural Resources organizations in the 21st Century. Taylor and Francis, London.

Odum, E. P. and Barrett, G.W. 2004. Fundamentals of ecology. Cengage Learning.

Reid, W.V. et al (Ed.). 2005. Ecosystems and Human well-being: Synthesis. p.1-37. Millennium Ecosystem Assessment, World Resource Institute, Island Press, Washington DC.

Samson, B.F, and Knoff, F.L.. 1996. Ecosystem Management. Springer-Verlag, New York.

Paper 11

BIODIVERSITY AND CONSERVATION BIOLOGY

Preamble: This course entails the study of diversity existing at different levels of Biological organization and understanding the essential ecological and biological processes which ensures long terms stability of ecosystems. The course highlights the values of biodiversity and scientific approaches to conservation which only can lead to sustainable development and safeguard the interests of future generations.

Section A. Biodiversity:

Concepts: Organic evolution through geological time scale. Levels of organisation in the biological world – molecules to ecosystems, biomes to the biosphere.

Levels of Biodiversity: Community diversity (alpha, beta and gamma biodiversity), Gradients of Biodiversity (latitudinal, insular), ecosystems diversity: biomes, mangroves, coral reefs, wetlands and terrestrial diversity (equilibrium mix of *G* and W).

Species diversity: richness and evenness; magnitude of biodiversity (Global and Indian); global biodiversity hot spots; geography of species; species richness gradients and their drivers; mountain biodiversity and richness gradients; drivers of species richness through ages with specific reference toi India.

Direct and indirect benefits from biodiversity including ecosystem services, bio-prospecting (molecular techniques like RAPD, RFLP, AFLP, DNA sequencing etc).

Genetic diversity: sub species, breeds, race, varieties and forms. Variation in genes and alleles at DNA sequence levels (selected case studies). Microbial diversity and useful prokaryotic genes. Speciation (amount of genetic variation is the basis of speciation). Consequences of monotypic agricultural practice (Detailed case studies).

Threats to Biodiversity: Species extinctions and their drivers – deforestation, landuse changes, over-exploitation, biological invasions; habitat loss; projection of species extinction using species area relationship model.

Human intervention and Biodiversity loss: Global Environmental changes, land in water use changes.

Section B. Conservation Biology

History of Conservation movements: International and National. Ecologically relevant parameters (viable population, minimum dynamic area, effective population size, metapopulations); reproductive parameters in conservation (breeding habitats, mating systems, inbreeding depression, genetic bottlenecks, genetic constraints).

IUCN categorized-endangered, threatened, vulnerable species. Red data book and related documentation.

Methods of conservation. *In situ* (Biosphere reserves, National Parks, Sanctuaries, Sacred groves, etc.) &*ex situ* (Botanical gardens, Zoological gardens, Gene banks, Pollen, seed and seedling banks, tissue culture and DNA banks etc) modes of conservation.

Benefits of conservation: Biodiversity as a source of food and improved varieties; source of drugs and medicines; Aesthetics and cultural benefits. Sustainable development. Ecosystems services (maintenance of gaseous composition of the atmosphere, climate control by forests and oceanic systems, Natural pest control, pollination of plants by insects and birds, formation and protection of soil, conservation and purification of water, nutrient cycling).

Practicals

Measurement of species diversity (calculation of diversity indices from data collected on plant species in Delhi ridge/forest; Measurement of species richness gradients and patterns and their drivers.

Measurement of biodiversity at molecular level by RFLP, RAPD, AFLP analyses.

Blast analyses of selected DNA sequences from the International Gene Banks.

Suggested Readings

Biju, S.D. and Bossuyt, F. 2003. New frog family from India reveals an ancient biogeographical link with the Seychelles. Nature, **425**: 711-714.

Daily, G.C., Ed. 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, D.C.

Dobson, A.P. 1996. Conservation and Biodiversity. Scientific American Library, New York, NY.

Groombridge, B., and M. Jenkins. 2000. Global Biodiversity: Earth's Living Resources in the 21st Century. World Conservation Press, Cambridge, UK.

IUCN. 2004. Red list of threatened species. A global species assessment. IUCN, Gland, Switzerland

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

Pandit, M.K. 2017. Life in the Himalaya: An Ecosystem at Risk. Harvard University Press.

Primack, R.B., 2002, Essentials of Conservation Biology, 3rd Edn., Sinauer Associates, Sunderland, Ma. USA.

Sodhi, N. S., Gibson, L., and Raven, P. H. 2013. Conservation Biology: Voices from the Tropics. John Wiley and Sons Ltd.: UK.

Wilson, Edward O. 1993. Diversity of Life. Harvard University Press, Cambridge, MA.

Paper-12

SOIL BIOLOGY

Preamble: Soil is a living biological system that provides home for soil communities, litter decomposition, nutrient cycling, and strongly regulate the ecosystem processes. This course covers the fundamentals of soil science, the processes of its development and the major principles of its classifications and mapping of soils. The course will discuss the interactions between underground processes involving soil and plant communities. This paper is designed to understand how differences in soil structure and functions in different ecosystem would influence aboveground diversity and nutrient cycling.

Soil genesis and provenance, pedosphere, Soil organic matter: sources, composition, microbial decomposition of organic matter, Humus formation

Taxonomy and biology of soil organisms. position and role of soil fauna in soil, ecological niche. Economic importance of soil microbes.

Role of soil biota in ecological interactions such as biological invasions, allelopathy or plant-soil feedbacks. Effects of soil-driven ungulates on plant communities.

Root exudates: fate of plant allelochemicals in soil. Effect of root exudates on soil biota, and its role on plant growth.

Role of soil biota in nutrient cycles such as carbon, nitrogen, sulphur, phosphorus.

Soil mutualistic associations: mycorrhizal (arbuscular, ecto- and ercoid) symbioses, role of mycorrhizae in biological invasion, nitrogen fixing symbioses.

Environmental problems related to soils in India: desertification, salinization, and erosion.

Brief account of bioremediation of contaminated soils and ground water, soil composting

Practicals

1. Soil texture, bulk density, porosity and water retention.
2. Measurement of phosphorus and different forms of nitrogen in soil modified with organic carbon.
3. Identification of major groups of organisms in soil from different ecosystems.
4. Experiment to study the role of soils in illustrating the role of soil biota in plant growth.
5. Experiments to study the role of soil biota in ecological functioning of plant chemicals in the soil environment.

Suggested Readings

Alexander, M. 1977. Introduction to Soil Microbiology (2nd Edn.) Wiley John.

Alexander, M. 1994. Biodegradation and Bioremediation, Academic Press.

Anderson, J.M. and Ingram, J.S.I. eds. 1989. Tropical Soil Biology and Fertility (p. 171). Wallingford: CAB international.

Castellano, M.J., Mueller, K.E., Olk, D.C., Sawyer, J.E. and Six, J. 2015. Integrating plant litter quality, soil organic matter stabilization, and the carbon saturation concept. *Global ChangeBiology*, **21 :** 3200-3209.

Coleman, D.C., Callaham, M.A. and Crossley Jr, D.A. 2017. Fundamentals of soil ecology. Academic Press.

Greenland, D.J. and Hayes, M.H.B. 2016. The chemistry of soil constituents.

Hudson, N., 2015. Soil Conservation: Fully Revised and Updated (No. Ed. 3). New India Publishing Agency.

Killham, K. 1994, Soil Ecology, Cambridge University Press.

Paul, E.A. 2014. Soil Microbiology, Ecology and Biochemistry. Academic press.

Smith, J.L. 2018. Cycling of nitrogen through microbial activity. In Soil Biology (pp. 97-126). CRC Press.

Schinner F. et al. 1996. Methods in Soil Biology. Springer

Steinauer, K., Tilman, D., Wragg, P.D., Cesarz, S., Cowles, J.M., Pritsch, K., Reich, P.B., Weisser, W.W. and Eisenhauer, N. 2015. Plant diversity effects on soil microbial functions and enzymes are stronger than warming in a grassland experiment. Ecology, **96**: 99-112.

Weil, R.R. and Brady N. C. 2017. The nature and properties of soils. Pearson, Boston.

Paper 13

ECOTOXICOLOGY AND ENVIRONMENTAL HEALTH

Preamble: This paper discusses the source, origin and effect of various toxic materials and heavy metals that adversely affect environmental health. In addition, the lectures would focus on the methods to detect and estimate the concentration of toxic chemicals and other contaminating substances that are polluting the environment with an adverse effect on it.

Section A: Ecotoxicology

Ecotoxicology as a Synthetic Science: Goals and relevance.

Major classes of Environmental Pollutants and their Ecotoxic Potential: Inorganic, (heavy metals, radioactive isotopes), Organics, Organometallics, Gases, Nano-materials, Ecotoxicity challenges of selected contaminants of recent origin.

Entry and Movement of Toxicants into Ecosystems and Environment: Routes of entry of ecotoxicants (surface waters, land, atmosphere); Long-range movement and global transport of pollutants. Fate of Toxicants in Ecosystems and Environment: Biotransformation, Bioaccumulation & Bio-magnification; Role of biotic and abiotic interactions.

Toxicant Effects: Cellular, organismic, population & ecosystem-level effects; Global Effects – Acid rain, etc.;

Biochemical and Molecular Ecotoxicology: Metabolism of selected ecotoxicants; Ecophysiological toxicity, Role of enzymes, genes and growth regulators, Quantitative and qualitative assessment of biochemical and molecular ecotoxicity

Toxicity Testing and Bio-monitoring: Concept of dosimetry: lethal, sub-lethal & chronic tests, dose response curves, LC50, MATC-NOEC, Brief statistical methodology. Test organisms used in bioassays, Types of bio-monitoring and significance of biomarkers and bio-indicators

Section B: Environmental Health

Toxicology & Epidemiology and occupational health.

Sources: Solid & Hazardous wastes, untreated sewage, Automobile exhausts, Industrial Effluents, Industrial emissions into atmosphere, Agricultural run-off of Pesticides. Carcinogens, Mutagens, Asbestos issues.

Human adaptation to cold and hot climates, high altitude environment and man-made environments.

Water pollution – Caused diseases (Gastroenteritis, Hepatitis, etc.). Air pollution caused diseases (allergies, respiratory diseases). Food-borne diseases (Food poisoning, parasites etc). Vector transmitted diseases. Radioactive effects. Risk assessment.

Practicals

Section A: Ecotoxicology – based on the syllabus and contemporary research, such asEstimation of heavy metals; Analyses of biochemical and molecular responses in living organisms to contaminants; Determination of fate of toxicants in living organisms or environment; Analyses of markers in living organisms from contaminated sites; Effect of contaminants on genetic .structure of a plant population.

Section B: Environmental Health –

Air quality assessment ; Potable water quality assessment ; Analysis of toxic heavy metals in soil and water.

Suggested Readings

Ecotoxicology

Colin, W. 2014. Ecotoxicology: Effects of Pollutants on the Natural Environment, 1st (ed), CRC Press

Sparling,D.W.2017. Basics of Ecotoxicology, 1stEdn CRC Press.

Newman, M.C. 2015. Fundamentals of Ecotoxicology: The Science of Pollution, 4thEdn. CRC Press.

Hauser-Davis, R.A. and Parente, T.E. eds., 2018. *Ecotoxicology: Perspectives on Key Issues*. CRC Press.

Walker, C.H., Sibly, R.M., Hopkin, S.P., Peakall, D.B. 2017. Principles of Ecotoxicology. 4thEdn. Taylor & Francis, London.

Environmental Health

Centeno, J.A., Finkelman, R.B., Fuge, R., Lindh, U. and Smedley, P. eds., 2013. Essentials of Medical Geology (p. 820). New York, NY, USA, Springer.

Moore, G.S. 2002. Living with the Earth: concepts in Environmental Health Science (2nd ed.), Lewis publishers, Michigan.

Paper 14

ENVIRONMENTAL BIOTECHNOLOGY

Preamble: The course is aimed at providing comprehensive training in investigating the natural environment and to develop potential solutions to remedy its damage using chemical, biochemical and molecular technologies.

Structure and perpetuation of nucleic acids: Pioneering experiments leading to development of molecular genetics, Fine structure of gene,. DNA replication models, mechanism of replication, enzymes involved in replication.

Introduction to nature of genetic information and gene expression: Transcription of DNA; RNA polymerase, initiation, chain elongation, termination, post-transcriptional modifications. The genetic code; protein synthesis: tRNA as adaptor molecule, ribosome structure, ribosomal genes, initiation, elongation and termination of protein synthesis. Inhibition of protein synthesis.

Recombinant DNA technology: Early discoveries, restriction endonucleases, ligases modification enzymes, DNA and RNA markers, cloning and expression vectors (plasmids, bacteriophage, phagmids, cosmids, artificial chromosomes), selection of recombinant clones, DNA sequencing, gene probes. CDNA synthesis and cloning (mRNA enrichment, reverse transcription, DNA promers, linkers, adaptors and their chemical synthesis, library construction and screening). Nucleic acid microarrays.

Wastewater Treatment: Water as a scarce natural resource, Measurement of water pollution, sources of water pollution. Wastewater treatment: anaerobic, aerobic process, methanogenesis, bioreactors, cell and protein (enzyme) immobilization techniques. Treatment schemes for waste water, dairy, distillery, tannery, sugar, antibiotic industries.

Solid waste treatment: Sources and management (composting, wormiculture and methane production, landfill. Hazardous waste treatment. Biofuels.

Bioremediation: Remediation of degraded ecosystems, degradation of xenobiotics in environment, decay behaviour & degradative plasmids, hydrocarbons, substituted hydrocarbons, oil pollution, surfactants, pesticides, heavy metals degradative pathways.

Practicals

Ames tests for mutagenicity in microbes. Demonstration of the use of *lux*-reporter genes in monitoring environmental toxicity.

PCR-based assays to detect microbes in sewage water and contaminated soil samples collected during field trips.

Bio-toxicity assays to evaluate effectiveness of Bt spores against pests & beneficial insects.

A web-based project on multiples sequence alignments of putative environmentally useful gene families from plants and/or microbes.

Suggested Readings

Gardner, E.J., Simmons, M.J. and Snustad, D.P. 2006. Principles of Genetics. John Wiley, 8th Edition.

Mohapatra, P. K. 2006. Text Book of Environmental Biotechnology. I K International.

Olguin, E., Sanchez, G. and Hernandez, E. 1999. Environmental Biotechnology and Cleaner Bioprocesses, Taylor & Francis, London.

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

Scragg, A. H. 2005. Environmental Biotechnology. Oxford University of Press.

Wainwright, M. 1999. An introduction to environmental biotechnology. Springer Verlag, New York.

Paper 15

ENVIRONMENTAL CHEMISTRY

Preamble: The course introduces the students to some basic chemistry relevant to the course, and to the general chemistry of the lithosphere, hydrosphere and atmosphere. Emphasis is also placed on understanding the chemistry of various anthropogenic pollutants and basic analytical techniques.

Basic Chemistry: Structure of atoms, their properties, their nuclear stabilities and their arrangement in the Periodic Table; fundamentals of chemical thermodynamics and solution formation; basic organic chemistry and biochemistry.

Geochemistry: Structure and chemistry of silicate and ore minerals; bulk composition of the earth, crust, & oceans; rock weathering, clay minerals and soil formation; cycling of chemical elements in the earth system.

Chemistry of waters: properties of water; sources of water and their linkages – hydrologic cycle; concepts of pH, Eh and their variations in waters; metal solubility, complexation and cheletion; aquatic life and water chemistry; organic and inorganic including radioactive water pollutants and their removal methods.

Atmospheric Chemistry: Physical and chemical properties of atmospheric air and their variation with latitude and altitude; chemical reactions in air and the residence time of CO_2 and the greenhouse gases aerosols, their chemistry, sources and transport; organic compounds in air and their sources; physical and health effects of air chemistry changes, global warming and acid rain.

Chemistry of waste substances: Nature and types of various wastes such as mining, industrial, agricultural, municipal, medical and nuclear; chemical and biological treatment of wastes before disposal; chemistry of toxic inorganic and organic compounds in the environment and their interactions with living system.

Practicals

Sample preparation methods: Types & calibration of standards for soil & water analysis.

Chemical analysis of water & waste water; Analyses of wastes & solids; Air & gas analysis; Analysis of biological materials.

Familiarity with instrumental techniques for basic Chemical analysis: chromatography, spectrophotometer, fluorometry.

Suggested Readings

Manahan, S. E. 2000. Environmental Chemistry 7th Edn. Lewis Publishers.

Stumm, W. and Morgan, J.J. 2012. Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters, John Wiley & Sons.

Wayne, R. P. 2000. Chemistry of Atmospheres: An Introduction to the Chemistry of the Atmospheres of Earth, the Planets, and their Satellites (3rd Ed.), Oxford University Press.

Williams, I. 2001. Environmental Chemistry –a modular approach, Willey John & Sons

Williams. R.J.P and Frausto da. J.J.R. 1996. The Natural Selection of the Chemical Elements, Oxford University Press.

Willard, H.H., Merritt Jr, L.L., Dean, J.A. and Settle Jr, F.A. 1988. Instrumental methods of analysis. 7th edition. United States: N. P. Web.

Paper 16

ENVIRONMENTAL HAZARDS

Preamble: This paper introduces the students to various environmental hazards, their causes, nature, preparedness and assessment of loss. It teaches them to model hazards and familiarizes them with methods of disaster management.

Concept of hazard, disaster, risk, vulnerability, exposure and response. Distinction between natural hazards and anthropogenic environmental disturbances, Hybrid hazards.

Environmental Hazards: Classification, Causes and Distribution.

Natural Hazards:

Geological Hazards: Earthquakes – a plate tectonic perspective and seismic zonation, Volcanoes – types and geographical distribution, Mass-movement.

Hydrological Hazards: Floods, Droughts, Water Contamination; Arsenic problem; Tsunami; Cyclones, Hurricanes; Cryosphere – distribution, melting of snow, ice and ice-sheets, avalanches, Glacial Lake Outburst Floods (GLOF).

Atmospheric/Climatic Hazards: Extreme weather events, Cloud-bursts, Landslides; Lake or Dam break/ breach; Global Climatic Change driven environmental hazards.

Man-made Hazards:

Biophysical Hazards: Frost Hazards in agriculture, epidemics, wildfires

Technological Hazards: Nature and significance. Lessons from Bhopal and Chernobyl disasters.

Modelling of Hazards: Hill slopes and landslides.

Disasters and Hazard Management: Human and ecological impacts; Risk assessment and vulnerability analysis; National preparedness and adaptation strategies; Hazards policies and agencies; Land use classification. Role of GIS and remote sensing in surveillance, monitoring, risk assessment, estimation of losses and planning.

Practicals

Preparation of Hazard Zonation map of India for land slides, earthquakes, floods etc.

Earthquake-loss estimation using remote sensing and GIS

Preparation of master plan for any Environmental Hazard mitigation

Suggested Readings

Allen, S.K., Linsbauer, A., Randhawa, S.S., Huggel, C., Rana, P. and Kumari, A. 2016. Glacial lake outburst flood risk in Himachal Pradesh, India: an integrative and anticipatory approach considering current and future threats. *Natural Hazards*, 84: 1741-1763.

Barry, R. and Gan, T.Y. 2011. The Global Cryosphere: Past, Present And Future. Cambridge University Press.

Bartak, R., Page, D., Sandhu, C., Grischek, T., Saini, B., Mehrotra, I., Jain, C.K. and Ghosh, N.C. 2015. Application of risk-based assessment and management to riverbank filtration sites in India. *Journal of Water and Health*, **13**: 174-189.

Bell, F.G. 2003. Geological Hazards: Their Assessment, Avoidance and Mitigation. CRC Press.

Bilham, R. 2004. Earthquakes in India and the Himalaya: tectonics, geodesy and history. *Annals of GEOPHYSICS, 47*(2-3).

Blaikie, P., Cannon, T., Davis, I. and Wisner, B. 2014. At Risk: Natural Hazards, People's Vulnerability and Disasters. Routledge.

Burton, I. 1993. The Environment as Hazard. Guilford Press.

Margottini, C. and Casale, R. 2004. Natural disasters and sustainable development. Environmental Science Series, Springer.

Hewitt. K. 1997. Regions of Risk, Longman Press.

Henrry J.G. and Heinke , G.W. 2004, Environmental Science and engineering, Pearson education, Delhi, India.

Shroder, J. & Wyss, M. (eds). 2014. Earthquake Hazard, Risk and Disasters (1st Edition). Elsevier.

Smith, K. 2003. Environmental Hazards: Assessing Risk and Reducing Disaster. Routledge.

Watts, M. 2017. On the poverty of theory: natural hazards research in context. In Environment (pp. 57-88), Routledge.

Paper 17

HYDROLOGY AND WATER RESOURCES

Preamble: The course introduces the student to the hydrologic cycle and various characteristics of surface and groundwater resources including different techniques of water management. It also introduces them to basic analytical methods to quantify water quality and determine hydrological parameters.

Introduction: The hydrologic cycle; Structure and properties of water, Inventory of Earth's water, quality and quantity. Distribution of water - local, regional and global. Limits of cations and anions in portable water including fluoride and arsenic, phosphate, nitrate and heavy metals. Application of isotopes in hydrology. Hydrogeology of India.

Surface water resources: precipitation, infiltration, water balance, Evapo-transpiration and runoff, Drainage basin. Stream discharge parameters and its measurement, River Hydrographs, Stage-discharge relationship and rating curves. Surface water and ground water interaction.

Groundwater resources: classification of formations according to their groundwater bearing properties. Vertical distribution of subsurface water: zone of aeration and saturation. Geologic formations as aquifers. Types of aquifer. Rock properties affecting ground water and aquifer parameters: porosity, permeability, hydraulic conductivity, transmissivity and storage coefficient. Darcy's law and the viscous character of groundwater flow. Ground water exploration.

Environmental Influences on water resources: surface and groundwater resources of arid and semiarid regions. Snowmelt hydrology from glaciers. Groundwater level fluctuations due to urbanization, evapo-transpiration, meteorological phenomena and tides. Recent development in surface and groundwater resources monitoring and assessment. Salinity ingress in ground water. Water logging and soil salinity-conjunctive use of surface water and ground water.

Water resource management: Flood and flood plain management; Water-shed management, water harvesting and artificial recharge to ground water; water pollution and water treatment. Wetland and riparian management; forest management on water resources. Concept of the environmental flow of a River and environmental rejuvenation of a deteriorated River system. Water resources management in the perspective of possible climate change. Environmental issues: River linking debate.

Practicals

Estimation of physico-chemical properties of water: Turbidity, Light penetration, Conductivity, Total suspended solids, Alkalinity, Hardness, Dissolved oxygen, BOD, COD, pH, Eh,

Analysis of water quality on Tri-linear diagram,

Evaluation and estimation of hydrologic parameters; catchment delineation; water balance and groundwater resources estimation. Hydrograph analysis.

Suggested Readings

Aggarwal, A. 199. Floods, Floodplains and Environmental Myths. Centre for Science and Environment, New Delhi.

Ward, A.D. and Stanley, T. 2004. Environmental Hydrology,2nd Ed., Lewis Publishers.

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

Karanth, K.R.C. 1988. Ground Water: Exploration, Assessment and Development. Tata-Mcgraw Hill, New Delhi.

Mahajan, G. 1989. Evaluation and Development of Groundwater. Ashish Publishing House, New Delhi.

Pandit, M.K. 2017. Life in the Himalaya: an ecosystem at risk. Harvard University Press.

Rao, K.L. 1982, India's water wealth. Orient Longman, Delhi.

Timothy, D. 2003. Fundamentals of Hydrology. Taylor and Francis, U.K.

Todd, D.K. 2004. Groundwater Hydrology, John Wiley & Sons Inc.

Singh, V.P. 1995. Environmental Hydrology. Kluwer Academic Publications, The Netherlands.

Wright. R.T and Nebel. B.J. 2002. Environmental Science: toward a sustainable future, Prentice Hall India Ltd, 8th Edition.

Paper 18

ENVIRONMENTAL GEOLOGY

Preamble: All human activities take place on earth using a large variety of its resources. How do we live here and use these resources, so that not only sustainable society but also life itself is sustained, need the knowledge of the science of the earth (= Geology) for all its citizens. The subject Environmental Geology is an applied one, wherein basic geologic knowledge is used to maximize the utilization of all natural resources, minimize their degradation as well as minimize the destructive potential of natural processes and to sustain a healthy biosphere on earth.

Planet Earth: Earth in the solar system; differentiation of the earth into core, mantle, crust, hydrosphere and atmosphere; rock-forming, ore-forming and soil-forming minerals; energy, mineral, water and soil resources.

Earth processes: Plate-tectonic processes, rock-forming and ore-forming processes, hydrologic, weathering and erosional processes; development of large-scale physiographic features such as oceans, land, mountains, plateau, floodplains and deltas. Rivers and their relation to geology and climate; erosional, transportational and depositional processes of water, air, waves and glaciers.

Resources: Concepts of resources and reserves in energy, mineral and water resources; geological constraints in their availability and use; environmental consequences of their exploitation to air, water, soil, climate and life.

Natural hazards: Floods, landslides, earthquakes-tsunami and volcanism, cyclones, coastal erosion and sea level changes; impact of urbanization on the rate of these processes; general methods to identify the hazard potential, to mitigate and to cope with natural processes.

Land use: Land evaluation and land use planning for construction and waste disposal; landscape geochemistry and human health; Desertification and associated problems.

Practicals

Identification of common minerals & major rock types in hand specimens and under petrological microscope.

Geomorphological, Land use, LISS mapping,

Plate tectonics and hazard zonation maps.

Suggested Readings

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

Kesler, S. F. 1994. Mineral resources, economics and the environment. Upper Saddle River, NJ: Prentice Hall.

Owen, O.S., Chiras, D.D., Reganold. John P. 2002. Natural Resource Conservation, 7th Ed., Prentice Hall, Upper Saddle River, New Jersey

Skinner, Brian J., Porter, Stephen C. 1995. The Dynamic Earth: An Introduction to Physical Geology, Casebook, 3rd Edition (Paperback), John Wiley, New York

Skinner, B. J., and Porter, S. C. 1995. The Blue Planet, An Introduction to Earth System Science, John Wiley & Sons, Inc.

Slaymake, Olav, (Ed). 2000. Geomorphology, Human Activity and Global Environmental Change. John Wiley, New York.

Paper 19

SYSTEMS ANALYSIS AND MODELLING

Preamble: The paper introduces the student to the concept of systems and sub-systems, and modelling and simulations as well as computational techniques. These concepts are used to model various environmental systems, particularly those dealing with ecology and ecosystems and study of environmental pollution in modelling air and water quality.

Introduction: Definitions and concepts of system, sub-system, variables and parameters, systems analysis, modeling and simulation. Linear vs. non-linear models; Non-linear forecasting. Prey-predator systems, Environmental systems. Time series analysis.

Types of systems: open and cybernetic systems; feedback; Ecosystem as a cybernetic system; Critical points of a system; stability of critical points. Limitations of modeling.

Models in Ecology: Stochastic and Deterministic model; Development of Ecological models. Fundamental interactions in ecology: predator-prey, competition, mutualism and interference.

Models in Ecosystem Analysis, Synthesis and forecasting: statistical regression approach, differential equation approach and computational approaches, Lotka-Voltera model.

Air and water quality modelling

Introduction to computational technology: Fuzzy logic; artificial neural networks; Genetic algorithms; Evolutionary algorithm, Natural Distribution functions.

Practicals

Computer lab: Introduction to computational techniques.

Simulations based on various environmental models.

Environmental niche models including predictive modeling for species area richness and bioc responses to climate change.

Suggested Readings

Bennett, J. and Blamey, R. (eds). 2001. The choice modelling approach to environmental valuation. Edward Elgar Publishing.

Beven, K. 2007. Environmental Modelling: An Uncertain Future*?*. CRC press.

Fotheringham, S. and Rogerson, P. (eds). 2014. Spatial analysis and *GIS*. CRC Press.

Gallager R. 1996. Discrete Stochastic Processes, Kluwer Academic Publishers.

Grant, W.E., Pederson, E.K. and Sendra, L.M., 1997, Ecology and Natural Resource Management: Systems Analysis and Simulation, John Wiley, New York.

Illian, J., Penttinen, A., Stoyan, H. and Stoyan, D. 2008. Statistical Analysis and Modelling of Spatial Point Patterns (Vol. 70). John Wiley & Sons.

Recknagal, F., (Ed.), 2003, Ecological Informatics, chapters I, II, III and IV. Springer, Germany.

Refsgaard, J.C., van der Sluijs, J.P., Højberg, A.L. and Vanrolleghem, P.A. 2007. Uncertainty in the environmental modelling process–a framework and guidance. *Environmental Modelling &Software*, *22*:1543-1556.

Wainwright, J., Mulligan, M. (Eds). 2004. Environmental Modelling: Finding Simplicity in Complexity. John Wiley, New York

Zannetti, P. 1990. Air pollution modeling, theories computational methods and available softwares. Van NostrandRheinhold, New York.

Paper 20

ENVIRONMENTAL ENGINEERING

Preamble: This paper provides an overview of the basic concepts of environmental engineering. It covers various treatment technologies and their application to water and waste water, liquid and solid wastes, and gaseous materials and their management.

Introduction to Engineering Fundamentals: Principles of environmental quality objectives, standards and guidelines; Environmental processes: Engineered systems and policies; Professional directions in

environmental engineering; Material Balances and Separations. Science of environment: physical & chemical processes, Environmental Biology, Basics of Microbiology

Treatment technology and control: Aerobic and anaerobic processes; aeration, coagulation and flocculation, sedimentation, filtration, disinfection. Tertiary treatment technologies.

Technological considerations and Engineering applications

Water Treatment Processes; Water transmission, distribution, storage. Wastewater Flow rates & Collection; Wastewater Treatment Processes. Constructed wetlands.

Air Pollution Control: Treatment of Emissions; Dispersion; Control of Moving Sources; Air Pollution control costs.

Solid waste management: Characteristics and collection system. Separation, processing and conversion. Land filling. Future opportunities.

Hazardous Wastes: nuclear waste, biomedical waste, chemical waste. Hazardous waste management.

Waste Minimization; Pollution Prevention and control strategies

Practicals

Reports on the visits to water treatment, waste water treatment and sewage treatment plants.

Report on the visits to Air pollution monitoring station; making flow sheets.

Viva-Voce based on the above reports.

Suggested Readings

Henry Glya, J. and Heinke, G.W. 2004. Environmental Science and Engineering. Pearson low priced edition.

Kiely, G. 1998. Environmental Engineering, Irwin McGraw Hill, Boston.

Masters, M.G. 1998. Introduction to Environmental Engineering and Science (2nd Ed), Prentice Hall, London.

Peavy, H.S., Rowe, D.R. and George, T. 1987. Environmental Engineering, McGraw Hill, New York.

Vesilind, P.A. 1997. Introduction to Environmental Engineering. PWS publishing, Boston.

M.A. Stream

Paper 9

ENVIRONMENTAL AND RESOURCE ECONOMICS

Preamble: Economics & ecology must be completely integrated in decision making & law making processes and there should be an effort to increase understanding of intriguing policy problems. Environmental and resource economics makes use of ideas and tools developed in other branches of economics to make significant contribution to valuation techniques, design of policy instruments for pollution control and management of commons.

Introduction: Overview of Central Issues; Refresher on Supply and Demand.

Basics of Welfare Economics: Consumer and Producer Consumer Surplus, Market failure, Externalities, Public Goods and Pareto Optimality.

Cost-Benefit Analysis and Valuation: Discounting, Principles of Cost-Benefit Analysis, Estimation of Costs and Benefits, Techniques of Valuation.

Non-Renewable Resources: Economics of Fuels and Minerals, Hotelling's rule and Extensions, Taxation, Recycling, Waste Management.

Renewable Resources: Economics of water use, forests and fisheries.

Population Ecology: Demography and Development.

Common Property Resources: Poverty, Inequality and Sustainability.

Natural Resource Accounting: Evolution of Techniques, Issues and Methodologies.

Global Concerns: Growth, Resource Scarcity, Environment and Trade.

Pollution Control: Policies for controlling air and water pollution, Disposal of toxic and hazardous waste

Tutorials based on the theory.

Suggested Readings

Baumol, W.J. & Oates, W.E. 1988. The Theory of Environmental Policy. Cambridge University Press.

Bhattacharya, R.N. (Ed). 2001. Environmental Economics: An Indian Perspective. Oxford University Press.

Bromley, D.W. (Ed). 1995. Handbook of Environmental Economics. Blackwell.

Hanley, N., Shogren, J.F. and White, B. 2002. Environmental Economics in Theory and Practice. Palgrave Macmillan.

Kadekodi, G.K., (Ed). 2004. Environmental Economics & Practice. Oxford University Press.

Kolstad, C. 2000. Environmental Economics. Oxford University Press.

Martinez-Alier, J. and Muradian, R. (eds). 2015. Handbook of Ecological Economics, Edward Elgar.

Tietenberg, T. 2003, Environmental and Natural Resource Economics (6thed), Pearson Education.

Paper 10

SOCIAL THEORY, SOCIOLOGY OF DEVELOPMENT AND ENVIRONMENT

Preamble: The concept of development is rooted in a particular view of society and emerged at a particular historical point. This paper introduces the student to theoretical debates about development. A major purpose of this paper is to establish the relationship between development and the environment and explore the extent to which development is beneficial for the environment. The following issues will be taken up:

The relationship between 'development', 'progress', science, capitalism and industrialism.

Green critiques of industrialism.

Post-colonial and post-structuralist critiques of development and the discourse of participation

The impact of development on marginal peoples.

Re-evaluation of development in light of sustainability and social equity; contemporary critiques and models.

Tutorials based on the theory.

Suggested Readings

Agarwal, B. 2016. The gender and environment debate, in Gender Challenges: Environmental Change and Collective Action, Vol. 3, Oxford University Press, Delhi and UK

Chambers, R. 1983. Rural Development: Putting the Last First. London, Longman.

Crush, J. (Ed). 1995. The Power of Development, New York, Routledge.

Escobar, A. 1995. Encountering Development: The making and unmaking of the third world, Princeton University Press.

Guy, S. and Shove, E. 2014. The Sociology of Energy, Buildings and the Environment: Constructing Knowledge, Designing Practice. Routledge.

Hobart, M. 1993. An Anthropological critique of Development: The Growth of Ignorance, Routledge.

Kuper, A. 1988. The Invention of Primitive Society. Routledge.

Mol, A.P. and Sonnenfeld, D.A. 2014. Ecological Modernisation Around the World: Perspectives and Critical Debates. Routledge.

O'Connor, M. (Ed.). 1994. Is Capitalism Sustainable: Political Economy and the Politics of Ecology, New York, Guilford Press.

Sachs, C.E. 2018. Gendered Fields: Rural Women, Agriculture, and Environment. Routledge.

Paper 11

INDIAN AND INTERNATIONAL ENVIRONMENTAL LAW

Preamble: Environmental law is that branch of law for planetary housekeeping, protecting the planet and its people from activities that upset the earth and its life-sustaining capacities. This paper aims to understand and apply a range of regulatory instruments to preserve and protect the environment. It also emphasizes on identifying the strengths and weaknesses in law and its enforcement and develops strategies to overcome the same.

Environmental laws: an introduction. Legal meaning of environment. Forms of pollution-causes and effects. Need for legal control.

International Perspective: Human right to environment. From Stockholm 1972; to Rio 1992 and beyond; Johannesburg Summit 2002, Delhi Summit 2002.

Fundamental principles of environmental protection: sustainable development-Brundtland report 1987. Intergenerational and intra-generational Equity, Polluter pays principle, precautionary principle, Environmental Impact Assessment, Environmental audit, Public Trust Doctrine, Indian judicial response.

Constitutional Perspective: Fundamental right to wholesome environment. Article 14, 19 (1) (g), 21 & 32 of the constitution. Directive principles of state policy-Article 47, 48A of the constitution. Fundamental duty-Article 51A (g) of the constitution. Public interest litigation-Nature, standing and doctrine of Pro Bono Publico, Judicial response.

Environmental Protection Legislations: The Water (Prevention and control of Pollution) Act 1974; The Air (Prevention and Control of Pollution) Act 1981; The Environment (Protection) Act 1986; Forest Act 1927; Forest Conservation Act 1980; The Wild life Protection Act 1972(2002 Amendment); Biodiversity Act 2002; The Noise Pollution (Regulation) 2000.

Legal control of Hazardous waste – Biomedical waste, genetic waste, e-waste. Industrial accidents-principle of 'no-fault' and absolute liability. Public liability insurance-Act 1991. National environment tribunal 1995.

National Appellate Environmental Authority-Act 1997. Constitution, Powers, Functions, Roles.

Tutorials based on the theory

Suggested Readings

Bodansky, D., Brunnée, J. and Rajamani, L. 2017. International Climate Change Law, Oxford University Press: New Delhi.

Bell, S.&McGillvray, D. 2001. Environmental Law, Universal Law Publishing Co.

Divan, S.&Rosencrantz, A. (eds). 2001. Environmental Law and Policy in India: Cases, Materials and Statutes. New Delhi: Oxford University Press.

Jariwala C.M. 2004. Environmental Justice, APH Publishing Corporation, N. Delhi

Mcinerney-Lankford S., Darrow, M. and Rajamani, L. 2011. Human Rights and Climate Change: A Review of the International Legal Dimensions. The World Bank.

Mohanty. S. K. 2004. Environment and Pollution Law, Universal Law Publishing Co. Pvt. Ltd.

Plater, Z.J., Abrams, R.H., Graham, R.L., Heinzerling, L., Wirth, D.A., Hall, N.D., Abrams, R.H. and Graham, R.L. 2016. Environmental Law and Policy: Nature, Law, and Society. Wolters Kluwer Law & Business.

Percival, R.V., Schroeder, C.H., Miller, A.S. and Leape, J.P. 2017. Environmental Regulation: Law, Science, and Policy. Wolters Kluwer Law & Business.

Rajamani, L. 2006. Differential Treatment in International Environmental Law. Oxford University Press: New Delhi.

Rengarajan, S., Palaniyappan, D., Ramachandran, P. and Ramachandran, R. 2018. National Green Tribunal of India—an observation from environmental judgements. Environmental Science and Pollution Research, pp.1-6.

Singh, G. 2004. Environmental Law in India, Mcmillan& Co.

Shastri, S. C. 2005. Environmental Law, Eastern Book Company.

White, R. ed., 2017. Transnational Environmental Crime. Routledge.

Paper 12

ENVIRONMENTAL ETHICS AND PHILOSOPHY

Preamble: The main objective of this course will be to familiarise the students with the broad theories and parameters of environmental philosophy, including issues of animal rights, human rights and wilderness ideas. The effort will be to look at the philosophical basis of current conservation theories and competing views of environmentalism.

An Introduction to Environmental Ethics and Philosophy: Ethics in society; Environmental Consequences; Responsibility for Environmental Degradation

Theories of Environmental Ethics and Philosophy: Different types of schools of thought vis-à-vis nature and environmental management. Values in modernity, anti-modernity, eastern and western cultures, nature and religion etc.

Eco Centric Theories of Nature: Deep ecology and animal rights theories, environmental rights, environmental racism.

Cross-cultural views on Nature: The relationship between humans, nature and adaptation. Theoretical frameworks of cultural and social ecology; debates on culture/nature divide.

Environment and Business Ethics: Foundations of Environmental Ethics for Business, Corporate Environmental Ethics, Environmental Disclosure, Social and Ethical Issues for Sustainable Development, Business Ethics and Corporate Environmental Performance.

Environmental Ethics and Issues of National and International Governance: changing nature of environmental ethics in relation to international and national paradigms of environmental governance.

Resource consumption patterns and the need for equitable utilization; Equity disparity in the northern and southern countries; Urban – rural equity issues; Need for gender equities; Preserving resources for future generations; The ethical basis of Environmental education and awareness; The conservation ethics and traditional value system of India.

Tutorial based on the theory

Suggested Readings

(Environmental Ethics - the Journal, will be the relevant reading here).

Cooper, D.E. & Palmer. J.A. (Eds). 1992. The Environment in question: Ethics & Global Issues, London, Routledge.

Des Jardius, J.R. 2001. Environmental Ethics: An invitation to Environmental philosophy (3Ed.), Wadsworth Publ., Belmont, California.

Grim, J. A. 2001. Indigenous Traditions and Ecology (Ed.), Harvard University Press.

Sivaramakrishnan, K. 2015. 'Ethics of Nature in Indian Environmental History', *Modern Asian Studies,* Vol.49, No.4. pp. 1261-1310.

Traer, R. 2018. Doing Environmental Ethics. Routledge.

Vandeveer, D.C.P. and Vandeveer, D., 2002, The Environmental Ethics and policy book: Philosophy, Ecology, Economics (3Ed.), Wadsworth publishing, California.

Paper 13

ENVIRONMENTAL HISTORY AND ENVIRONMENTALISM

Preamble: The course is a concise history, from ancient to modern times, of the interactions between human societies in relationship to ecosystems. It involves a consideration of present day environmental dilemmas, conflicts and choices that have their roots in the past. The course looks into the ways in which environmental changes, often the result of human actions, have caused historical trends in human societies. These processes have happened in every historical period and in every part of inhabited earth.

Introduction to the ideology of environmentalism and environmental history, Modern environmental movements. The Gaia theory.

History of the development of environmental history as a discipline and its relationship with social and economic history. Methods and Sources of Environmental History: Distributions from other types of history.

Environmental History as Natural History: In the developed and developing nations. Ideas of wilderness and conservation.

The Rise of European power and its consequences not only for peoples, but also for plants and pathogens, animals and landscapes.

Environmental History as a History of Industrialization and Anti-Industrialization: debates on the nature of modernization and industrialization in developed and developing countries. Issues of its links with history of science and technology.

Nature and Empire: Debate on 'colonialism as a watershed'. Colonialism and the unleashing of destructive forces and the threat of general environmental decline.

Environmental History as the History of the State: State and state policy

Environmental History and Marginalized People: Issues of castes, identity politics and ethnicity

Environmental History as a Global History: Challenges posed by globalization.

Tutorial based on the theory

Suggested Readings

Arnold, D.& Guha, R. (eds). 1995. Nature, Culture, Imperialism: Essays on the Environmental History of South Asia, Oxford University Press, Delhi.

Botkin, D.B. 2012. The Moon in the Nautilus Shell: Discordant Harmonies Reconsidered. Oxford University Press.

Balée, W. and Balée, W.L., 2002. Advances in historical ecology. Columbia University Press.

Coulter, K. and Mauch, C. 2011. The Future of Environmental History: Needs and Opportunities, Rachel Carson Centre Perspectives.

Greenough, P. & Tsing, A.L. 2003. Nature in the global south: environmental projects in South and Southeast Asia. Duke University Press.

Grove, R.H., Damodaran, V.& Sangwaned, S. 1998. Nature and the Orient. Essays on the Environmental, History of South and South East Asia, O.U.P., Delhi.

Guha, R. 2000. Environmentalism, A Global History, Delhi, O.U.P.

Hughes, D.J. 2009. An Environmental History of the World : Humankind's Changing Role in the Community of Life, Routledge.

Kumar, M. 2013. Monsoon Ecologies: Irrigation, Agriculture and Settlement Patterns in Rajasthan during Pre-Colonial Period, Delhi, Manohar.

McNeill, R. 2002. Something New Under the Sun, an Environmental History of the 20thCentury, Penguin Press, Allen Lane.

Sivaramakrishnan, K. 2015. Ethics of Nature in Indian Environmental History, *Modern Asian Studies*, Vol.49, No.4. pp. 1261-1310.

Paper 14

ENVIRONMENTAL POLICIES AND POLITICS

Preamble: The paper introduces the student to the politics of environmental issues at the national and international levels. It also familiarizes the student with the debates on environmental policies and regulations and environmental movements in India.

Introduction to Environmental Politics: Nature of environmental politics at both the global and national level. The different paradigms of environmental politics

Environmental Politics and the Path of Development Debate: Critiques of modern development and proposed alternatives to it in the contemporary world.

Varieties of Environmentalism and Environmental Movements in Developing Countries: Nature of environmental movements and their material basis in some selected developing countries.

The Indian Environmental Movement and its Ideologies: Emergence of environmental issues on the political agenda and its relationship with the Indian environmental movement in different sectors.

Environmental Politics and Issues of Governance in India: Issues of local governance, decentralization and nature of local participation and state control.

Methods and Forms of Environmental Regulations and Policies: Evolution of environmental regulation in selected countries, the debates that surround them and the responses to them.

Global Environmental Politics: Selected global environmental issues; Global politics between developed and developing nations in IUCN, WTO etc.

Tutorial based on the theory

Suggested Readings

Allay, K. 2002. On the Banks of the Ganga, University of Michigan Press.

Donahue, John & Johnston, Barbara (Ed). 1998. Water, Culture and Power: Local struggles in a Global context, Island Press, Washington D.C.

Herring, R. 2014. Handbook of Food, Politics and Society, Oxford University Press, New York.

Fortune, K. 2003. Advocacy after Bhopal – Environmentalism, Disaster, New Global Orders, University of Chicago Press.

Patterson, M. 1996. Global warming and global politics, London, Routledge.

MukundR. 1997. Global Environmental Politics: India and the North-South Politics of Global Environmental Issues, O.U.P, Delhi

Peets, R.& Watts, M. 1996. Liberation Ecologies: Environment, development, social movements, Routledge.

Persoon, G. & Kalland, A. 1998. Environmental Movements in Asia, London, Curzon press.

Sainath, P. 1996. Everybody Loves a Good Drought, Delhi, Penguin.

Singh, C. 1986. Common Property, Common Poverty. Delhi: ILI

Sabarwal, V. 1999, Pastoral Politics: shepherds, bureaucrats & conservation in western Himalayas, O.U.P.

Sharma, M. 2015. Caste and Nature: Dalits and Indian Environmental Politics: Delhi, OUP.

Sundar, N., Jefferey, R.&Thin, N. 2001. Branching Out: Joint Forest Management in India, Delhi, O.U.P.

Sundar, N. et al. 2005. Land and Identity in Jharkhand. Special Section on laws and Natural resources in Economic and Political Weekly, Xl (41), October, 8th, pp. 4430-4462.

Paper 15

ENVIRONMENTAL COMMUNICATIONS AND EDUCATION

Preamble: This paper focuses on methods of communication to the masses and consumers for environmental issues. It also provides an overview of the scenario of environmental education and communication at the national and international levels.

Environmental education and environmental literacy: Need for public awareness. Growth of environmental communication; Taxonomy of environmental groups; Environmental ideologies

Basics of Science & Technology (S&T) Communication: Role of Communication in Modern Science; 'Public' nature of science; Science and Public: Historical overview; Why communicate S&T; When public meets science

Types of media and their role in environmental communication and education; Strategic communication; Environmental attitudes and behaviours; Environmental message; Environmental advocacy; Advertising and environment;

Pragmatic aspect and contexts of science & environmental communication: Strategies for Communication; Use of analogies; Metaphor and Simile; Human and With Examples and illustrations; Anecdotes and personalizing; Context for science and environmental communication; Human interest; Cultural needs; Survival needs; Sources of information; ethics in reporting & fundamentals of media laws.

Educating Consumers: Consumer Behavior and Environment: Role of Information, Eco- Labeling

Environmental communication Today: Introduction; Over view of the scenario in the country; International scenario; Canonical texts (Critical reading of Books on Environmental communications such as Silent spring); case studies of media reports that had impact; Analysis of mass media coverage of complex environmental issues and the media's effects on public opinion and government environmental policies.

Tutorial based on the theory.

Suggested Readings

Greenough, P., et al. 2003. Nature in the Global South: Environmental Projects in South and South-East Asia, Orient Longman.

Jennifer, P. & Depoe, S. 2014. Voice and Environmental Communication (Palgrave Studies in Media and Environmental Communication), Palgrave Macmillan;

Pietari, K. 2018. Environmental Management of the Media: Policy, Industry, Practice (Routledge Studies in Environmental Communication and Media) 1st Edition, Routledge

Phaedra, C. P. &Cox, R. 2017. Environmental Communication and the Public Sphere 5th ed, SAGE Publication.

Krarup, S. and Russell, C. S. 2005. Environment, Information and Consumer Behaviour (Ed.), Edward Elgar, UK.

Orr, D. 1994. Earth in mind: on education, environment and the human prospect, Island Press, Washington, D.C.

Saberwal, V., et al. 2001. People, Parks, Wildlife: Towards Co-Existence, Orient Longman.

Wals, A.E., Brody, M., Dillon, J. & Stevenson, R.B., 2014. Convergence between science and environmental education. Science, **344**: 583-584.

Paper 16

TECHNOLOGY, ENVIRONMENT AND SOCIETY

Preamble: A study of the relationship between technology and environment with the aim to understand the role and contribution of different types of economic and social mechanisms that the contemporary societies have been able to evolve to shape the technological changes in the direction of sustainable development and to achieve ecological and social justice.

Relationship of technology with environment in societies in the countries of technologically advanced and developing world; Technology as a curse or blessing; Technology and human evolution; Technology as a driver of environmental and social change; Environmental justice.

Types of technology; Appropriate technology; Levels of technology; Technological innovations as a solution for environmental problems; Technological impacts / innovation and technology adoption effects of environmental policies.

Developments in science and technology for sustainable development; Social and environmental impacts of technologies for energy, transportation, climate change, handling of toxics, agriculture, water, forests, etc.

Environmental policy and its environmental costs; Technology transitions and environmental technology innovations for ecological and social justice; Policy tools for integrated technologies and technology innovations for sustainable development.

Impacts of social movements on ecological and social justice in India; Corporate responsibility movement; Appropriate technology movement, industrialization, urbanization, and globalization,

Tutorials based on the theory

Suggested Readings

Charles, H. 2011. Environment and Society: Human Perspectives on Environmental Issues, 5th Edition Routledge.

Agarwal, B. 1986. Cold Hearths and Barren Slopes: The Wood-fuel Crisis in the Third World. London: Zed Books.

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

Jasanoff, S. 2002. New Modernities: Reimagining Science, Technology and Development, In Environmental values.

Jasanoff, S. 2003. Technologies of Humility: Citizen participation in governing science, In Minerva.

Juma, C. and Konde, V. 2002. Technical change and sustainable development: developing country perspectives. In *American Association for the Advancement of Science (AAAS) Annual Meeting and Science Innovation Exposition, Boston, USA* (pp. 14-19).

Magnus, B., Davidson, D.J. (Eds). 2018. Environment and Society: Concepts and Challenges (Palgrave Studies in Environmental Sociology and Policy). Palgrave Macmillan.

Makofske, W.J. & Karlin, E.F. 1995. Technology and Global Environmental issues, Addison Wesley Longman, Toronto.

Mawdsley, E. 2004. India's middle classes and the environment. *Development and Change, 35*:79-103.

Kaku, M. 2012. Physics of the Future: How Science Will Shape Human Destiny and Our Daily Lives by the Year 2100, Penguin UK

Paul, R., Hintz, J. & Moore, S.A. 2014. Environment and Society: A Critical Introduction, 2nd Edition, Wiley-Blackwell

Ruttan,V.W. 2000. Technology, Growth, and Development: An Induced Innovation Perspective, Oxford University Press, New York.

Visvanathan S. 2000. Environmental values, Policy and conflict in India, Carnegiecouncil.org

Paper 17

NATURAL RESOURCE CONFLICTS AND CHOICES

Preamble: This paper focuses on contemporary conflicts, struggles and policy choices around natural resources. Often, conserving nature is also about defining who controls it and how. Similarly, there is often a variety of explanations for who degrades nature and why. The initial introduction will be to major approaches towards natural resource issues that privilege particular factors such as population/economic growth, technology, culture and religion and specific property regimes. Looking at these ideal types critically will sharpen the ability to think creatively about conflict and concord in general. There will be special emphasis on the roles of ideas and institutions in environmental politics. Case studies could include issues such as big dams and endangered fauna, industrial pollution and global warming, the role of gender and empire.

Forests: Who saves forests is closely linked to who controls them and for what. The ecological implications of different kinds of forest choices are critical to the study of nature in conflict. The section takes up debates on forest protection and management, the use of NTFPs, and conflicts over commons.

Water: Water, vital for life but a source of conflict over use and abuse, is a related theme. Again, the hydrology is central to systems of renewal or of disrepair. This section will look at large dams which may mean energy and irrigation, but can also mean displacement or denudation; the problems involved in river sharing; conflicts between different stakeholders in water use (industry or agriculture, towns' people or farmers, fishers or factories); oceans and fisheries: issues and conflicts including sovereignty; water wars and the prospects for peace via water harvesting and water sharing.

Land Use: Land use conflicts range across many productive activities related to mining, industry, agriculture and also conservation, afforestation and wasteland development. How far are such conflicts evitable and to what extent can they be minimized? Debates over common property, open access resources and privatization.

Wildlife and Biodiversity: Wildlife conservation, management and policies regarding National Parks, conservation and community conflicts; regulations and practices of (il) legal trade in wildlife products. Debates over the ownership of biodiversity and links to traditional knowledge; gender and biodiversity management, the implications of the introduction of genetically modified crops.

Policy Issues: Overview of the policies and institutional innovations across the range of themes discussed above and their critiques as offered from within policy circles, by communities and by environmentalists and activists. Similarities and differences between policy options considered by India and other international bodies such as the United Nations and World Bank. Contrasts between different states in India.

Tutorials based on the theory.

Suggested Readings

Agarwal, B. 2016. Participatory Exclusions, Community Forestry and Gender: An analysis and conceptual framework, in Gender Challenges, Vol. 3 on Environmental Change and Collective Action, Oxford University Press.

Brittlebank, K., 2013. Julie E. Hughes, Animal Kingdoms: Hunting, the Environment, and Power in the Indian Princely States.

D'Monte, D. 1985. Temples or Tombs? Delhi: CSE.

Govindrajan, R. 2018. Animal Intimacies: Interspecies Relatedness in India's Central Himalayas: Chicago, Chicago University Press.

Greenough, P. & Tsing, A.L. 2003. Nature in the global south: environmental projects in South and Southeast Asia. Duke University Press.

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

Martinez-Alier, J. 2002. Environmentalism of the Poor. Edward Elgar Publisher

Mc Neill, R. 2002. Something new under the sun, an environmental history of the 20th century, Penguin, Allen Lane: NY.

Omvedt, G. 1993. Reinventing Revolution: New Social Movements and the Socialist Tradition in India. New York: ME Sharpe.

Peluso, N. & Watts, M. (Eds). 2001. Violent Environments, Cornell, Cornell University Press.

Prasad, A.2004. Environmentalism and the Left, Delhi.

Rangarajan, M., Madhusudan, M.D. and Shahabuddin, G. (eds). 2017. Nature Without Borders, Orient Blackswan.

Saberwal, V.K. and Rangarajan, M. (eds). 2003. Battles over Nature: Science and the Politics of Conservation, New Delhi: Permanent Black.

Sharma, M. 2012. Green and Saffron: Hindu Nationalism and Indian Environmental Politics: Ranikhet, Permanent Black.

Sundar, A. 1999. Sea Changes: Organising around the Fishery in a South Indian Community. In Jonathan Barker ed., Street level Democracy, Toronto, Between the Lines Press.

Tucker, R. 2000. Insatiable Appetite, America's impact on the tropical world, Berkeley: Univ. of California Press.

Paper 18

GENDER AND ENVIRONMENT

Preamble: This paper focuses on gender differences in human relationships with the environment and the differential impact of environmental change on men and women. In particular, it explores how the gendered division of labour and gender inequalities in access to economic resources can make for differences in the ways women and men depend on the environment, their knowledge of the environment, how they are affected by environmental degradation and their responses to environmental change. It focuses both on conceptual issues and on empirical case studies in the Indian context. The course will encourage students to examine all environmental issues from a gender perspective.

Gender Differences, Hierarchies and inequalities: The historical construction of Gender, including the gendered division of labour; Cultural, social and economic perspectives; Evolution of gender hierarchies in a materialist perspective; Nature, Culture, Gender debates.

Conceptual and theoretical perspectives: Ecofeminism, Feminist environmentalism, feminist ecology.

Natural Resources, Sustainable Development and Women: Gender differences in dependence on environmental resources and the gender division of labour in use of forests and water; gender and knowledge about the environment; gender, environment and globalization

Gender implications of environmental degradation and poverty: gender/class/poverty links with the environment, the domestic energy crisis, the crisis of water and sustainability

Women and Environmental movements: Women's perspectives of environmentalism; Women's participation in environmental movements and conservation.

Tutorial based on the theory.

Suggested Readings

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

Agarwal, B. 1994. A Field of One's Own: Gender and Land Rights in South Asia, Cambridge University Press, Cambridge and Delhi.

Agarwal, B. 1997. Gender, Environment and Poverty Interlinks: Regional Variations and Temporal Shifts in Rural India: 1971-1991. World Development (Washington DC), 25 (1).

Agarwal, B. 2010. Gender and Green Governance, Oxford University Press, Oxford and Delhi

Braidotti, R. et al. 1994. Women, the Environment and Sustainable Development: Towards a Theoretical Systhesis, Zed Books, UK

Elson, Diane. 1991. Male Bias in the Development Process, Manchester University Press.

Jackson, C. 1993. Questioning Synergism: Win-Win with Women in Population and Environmental Policies. Journal of International Development, 5 (6): pp. 651-68

Kabeer, N. 1994. Reversed Realities: Gender Hierarchies in Development Thought, Delhi: Kali for Women; London: Verso Press.

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

Mellor, M. 2017. Ecofeminist political economy: a green and feminist agenda. In Routledge Handbook of Gender and Environment (pp. 108-122). Routledge.

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

Nanda, M. 1991. Is Modern Science a Western, Patriarchal Myth? A Critique of the Populist Orthodoxy, *Social Science Bulletin*, *11*: 32-60.

Rocheleau, D., et al. 1996. Feminist Political Ecology: Global issues and Local experiences, New York, Routledge.

Sachs, C.E. 2018. Gendered Fields: Rural Women, Agriculture, and Environment. Routledge.

Vishwanathan, N. 1997. The Women, Gender and Development Reader, London: Zed Books.

Paper 19

GLOBAL ENVIRONMENTAL ISSUES

Preamble: This paper introduces the students to some of the important environmental issues that have become a matter of global policy making, international negotiations and trade disputes. It will also provide an understanding of the links between environment, property regimes, trade and information economies.

Climate Change: Key concerns in the climate change debate, scientific and political conflicts concerning their impacts on natural resources, food production etc. and the techno-economic measures being used to reduce greenhouse emissions.

Impact on War and Terrorism on the Environment: Nuclear Winter: Environmental Consequences of Nuclear War; Chemical & Biological Warfare; Impact of Nuclear Weapon Tests; Use of Depleted uranium shells; Impact of Destruction of Nuclear power plants; Burning of oil wells; Destruction of Chemical plants. Use of Incendiary Bombs (Napalm).

Wastes: Regional and international frameworks for regulating trade in wastes, especially toxics. Policies and environmental activism around trade in toxic wastes such as asbestos, PVCs, lead, mercury, electronic wastes and other chemicals.

Biodiversity: Approaches to understanding of biodiversity, case studies of strategies for conservation and sustainable use of biological resources, case studies of conflicts (and their possible resolution) between conservation and local community practices, links between conservation, local knowledge and intellectual property and issues of biopiracy.

Biotechnology and Genetic Engineering: Scientific, social, ethical and political issues related to the modification of a gene from one species to another for purposes of food productivity, medical advance etc. The environmental and human impacts of genetic modification and the various regulations that guide the testing and marketing of genetically modified materials. Case studies that have special implications for India (e.g. Bt cotton).

Energy: The energy sector and environment including historical studies of coal and pollution in select countries; policies relating to sustainable energy use through select case studies (e.g. Germany, the Netherlands, Brazil, India) and their implications for global and local economies. Nuclear energy as an environmentally friendly/ degrading source of energy, again through select case studies (e.g. France, England, India and China).

Global Environmental Issues in Industry: Business – Environment Debate: Ozone Depletion and Environment Change, International Business, Globalization and Sustainable Development, Environmental Management Norms and Certification, International Environmental Management Systems, Kyoto Protocol (1997); Paris Agreement (2016); Clean Development Mechanism (CDM).

International Conventions and Protocols: The treaties and conventions guiding the use of resources, disposal of waste and international cooperation in the fields of conservation and sustainability will be studied. Students will be introduced to a range of international protocols such as The Kyoto Protocol to the UN Convention on Climate Change, Basel Convention on the Control of Tran boundary Movements of Hazardous Wastes and Their Disposal, The Convention on Biological Diversity, Convention on Long-Range Tran boundary Air Pollution, The Montreal Protocol on Substances That Deplete the Ozone Layer and the United Nations Convention to Combat Desertification.

Tutorials based on the theory.

Suggested Readings

Chasek, P.S. 2018. Global Environmental Politics. Routledge.

Ehrilch, P., et al. 1983. Long Term Biological consequences of Nuclear War, Stanford University.

Gunster, S. 2017. This changes everything: Capitalism vs the climate.

Howes, R., Skea, J. & Whelan, B. 1997. Clean & Competitive? Motivating Environmental Performance in Industry

Kareiva, P.M., McNally, B.W., McCormick, S., Miller, T. & Ruckelshaus, M. 2015. Improving global environmental management with standard corporate reporting. *Proceedings of the National Academy of Sciences*, **112**: 7375-7382.

Kemp, D.D. 1990. Global Environmental issues: A climatologized approach, Taylor and Francis, London.

Klein, N. 2014. This Changes Everything: Capitalism versus the Climate. Simon & Schuster, New York.

Makofske, W.J. and Karlin, E.F. 1995. Technology and Global Environmental issues, Addison Wesley, Longman, Toronto.

Martinez-Alier, J. and Muradian, R. (eds). 2015. Handbook of Ecological Economics, Edward Elgar.

Russo, M. V. 1999. Environmental Management: Readings and Cases, ed., Houghton Mifflin Company, Boston, NY.

Smith, P. and Warr, K. 1991. Global Environmental issues, Hodder and Stoughton, London.

Susskind, L. et. al. (eds). 2002. Trans-boundary Environmental Negotiation: New Approaches to Global Cooperation.

Toman,M. (ed). 2002. Climate change, Economics and Policy, Cambridge University Press.

Welford, R. 2000. Corporate Environmental Management: Towards Sustainable Development, Book 3, Earthscan Publications Ltd, London.

Paper 20

CULTURE AND THE ENVIRONMENT

Preamble: Different cultural traditions conceive of the environment in different ways, and enjoin different attitudes towards it. Defining a sphere as environmental is itself a cultural choice. Religions have played a role both in environmental destruction and conservation. This course focuses on these aspects as also on the various cultural formations through which humans have adapted to the environment.

Introduction: Concepts and Theories: Concept of Culture, Material Culture, technology; role of culture in adaptation of human populations,

Basic Forms of Human adaptation to environment: Hunting and Food gathering Pastoralism; Shifting Cultivation; Agriculture; Transition to Market economy and Industrialization

Social and Cultural implications of various forms of adaptation: Evolution of political organizations, distribution and exchange of resources; Political economy of the state (land and forest policies: colonial to post-colonial)

Environmental Culture in Business Organizations: Development of environmentally aware corporate cultures, Linkage between Organizational Environmental Culture and Environmental Strategy.

Development and Environment: Current debates; How development policy defines degradation in largely physical terms, and not in terms of access inequities and exploitation.

Landscapes: how landscapes are invested with cultural meaning, changes in landscape over time and their cultural and ecological implications.

Tutorial based on the theory.

Suggested Readings

Agarwal, B. 1992. The gender and environment debate: lessons from India. *Feminist Studies*, **18:** 119-158.

Agarwal, B. 2016. Social Security and the Family: Coping with Seasonality and Calamity, in Gender Challenges, Vol. 1, on Agriculture, Technology and Food Security. Oxford University Press, Delhi and UK.

Anderson, A. 2013. Media, Culture and the Environment. Routledge.

Baruah, S. 2005. Durable Disorder: Understanding the Politics of Northeast India, O.U.P.

Benedict, R. 2005. Patterns of Culture: Houghton Mifflin Harcourt, New York.

Gandhi, M.K. 1987. Hind Swaraj: Ahmedabad, Navjeevan Press,

Gold, A. and Gujar, B. R. 2002. In the Time of Trees and Sorrows: Nature, Power, and Memory in Rajasthan, Durham, Duke University Press.

Guha, R. 1998. Social Ecology. Oxford University Press.

Ingold T. 1994. Companion Encyclopedia of Anthropology, Routledge.

Kelley, A. 2002. On the banks of the Ganga: when waste water meets a sacred river, University of Michigan Press, Ann Arbor.

Kruger, F., Bankoff, G., Cannon, T. & Schipper, L. (eds). 2015. Cultures and Disasters: Understanding Cultural Framings of Disaster Risk Reduction. Abington. Routledge

Leach, M. & Mearns, R. (ed). 1996. The Lie of the Land: Challenging Received Wisdom on the African Environment, London and Oxford: The International African Institute and James Curry.

Mehta, L. 2001. The Manufacture of Popular Perceptions of Scarcity: Dams and Water related Narratives in Gujarat, India. World Development **29**: 2025-2042.

Milton, K. 1993. Environmentalism: The view from Anthropology, Routledge

Schama, S. 1995. Landscape and Memory, London, Harper Collins.

Strauss, L.C. 1995. Myth and meaning: Cracking the code of Culture: Schocken

Thorner, D.(ed). 1996. Agricultural Atlas of India , 1920, Karachi, Oxford University Press.

White, L. A. 1959. The Evolution of Culture, McGraw-Hill, New York.

Zimmerman, F. 1982. The Jungle and the Aroma of Meats, Berkeley, University of California Press

OPEN ELECTIVE

Paper 21

ENVIRONMENTAL STUDIES: TOWARD A SUSTAINABLE FUTURE

Preamble: The paper focuses on the long-term well-being of the planet Earth and its myriad diversity of inhabitants and their habitats. This course is aimed at exploring the dilemma of the imperatives of economic development and criticality of conserving natural resources not only for the sake of preserving diversity of the living world including its varied ecosystem services, but also for the sake of inter-generational equity in the world dominated by the human enterprise. The course will examine successes and failures of sustainable development (SD) as the central paradigm of sustainability. The criticality of natural resources conservation and their unsustainable consumption patterns will be highlighted in the course. The need for engaging with multiple stakeholders in terms of a establishing a new world order based on the axiom of 'sustainable living' would be envisaged. With enduring human presence there is a need to ensure transition towards a sustainable society, which seeks a balance between human demands on nature and the ecological limits to growth. Establishing a sustainable society is our realistic hope and it will only evolve through addressing the root causes of the on-going environmental crisis. Addressing the causes, restructuring human systems and critical thinking would lay foundation for a sustainable society.

Evolution of sustainable development as the central paradigm of addressing the Earth's environmental crisis and human poverty; United Nations and the World Commission on Environment and Development.

Roots of the environmental crisis: Socio-economic systems characterized by resource overconsumption resulting in habitat destruction, resource depletion and degradation; cumulative failure of nations and societies to manage and restore degraded resources/ecosystems.

Restructuring human systems for sustainability: human population stabilization, management of natural resource – land, water, air and vegetation; efficient use of resources through renewable energy and recycling, restoration of natural systems, managing resource sustainability; India's water problems; declining per capita water availability; irrigation problems and agriculture distress; climate change, water availability and farmer suicides in India; climate change and biodiversity loss, species extinctions and shrinking protected/conservation areas.

Critical thinking about environmental issues and solutions: Humans as part of the problem and also part of the solution: case studies to understand the problems and sustainable solutions under the carrying capacity framework of the environment, e.g. Vehicular pollution in Delhi, and administrative and technological instruments to solve it; burning of agriculture waste (parali) in neighboring states of

Haryana and Punjab; Solid waste generation in urban centres such as Delhi and their management; Landfills in the urban environment: Sewage management.

Toward sustainability: New paradigms in economic and developmental planning; Emerging technologies and innovations for a sustainable world; Indian traditional cultural practices of recycling and reuse; ethics as the cornerstone of sustainable living; Mahatma Gandhis' philosophy of 'greed versus need'.

Suggested Readings

Gadgil, M.& Guha, R. 2001. Ecology and Equity: The use and abuse of nature in contemporary India, Delhi, Penguin.

Meadows, D.H. 2013. Club of Rome (1972) The Limits to Growth; a report for the Club of Rome's project on the predicament of mankind. Earth Island, London, UK.

Owen, O.S. & Chiras, D.D. 1995. Natural resource conservation: management for a sustainable future (No. Ed. 6). Prentice-Hall International, Inc.

Pandit, M.K., 2017. Life in the Himalaya: an ecosystem at risk. Harvard University Press; Chapter 10; pp.261-285.

Robinson, J. 2004. Squaring the circle? Some thoughts on the idea of sustainable development. *Ecological Economics*, 48:369-384.

Ruckelshaus, W. D. 1989. Toward a sustainable world. Scientific American, 261:166-175.

Tietenberg. T. 2003, Environmental and Natural Resource Economics. Pearson Education, New York.

Wals, A. E. (ed). 2007. Social learning towards a sustainable world: Principles, perspectives, and praxis. Wageningen Academic Pub.

Wright, R. T.&Nebel, B. J. 2004. Environmental science (8thEdn.). Prentice Hall. India Ltd.