BANKURA UNIVERSITY

SYLLABUS FOR 3-YEAR DEGREE/4-YEAR HONOURS

IN

ENVIRONMENTAL SCIENCE

Under
Curriculum and Credit Framework for Undergraduate Program (CCFUP), as per NEP-2020

w.e.f 2025-26

Objectives of the programme :-

The prime objective of the programme is:-

1. To reach the unreached and help to provide environmental education at the doorstep of the learners and according to their convenience.
2. To contribute to eco-sustainability and efficient use of natural resources through integrated nexus for the long-term benefit and welfare of society through quality education, innovative research, outreach and grassroot activities and overall networking with the environment.
3. To attract young minds to choose a career in broad areas of Environmental Science and applications.
4. To fulfil the requirement of technical manpower in various sectors including academia-industry linkage and elsewhere.

PROGRAMME OUTCOME (PO):

PROGRAMME NAME	**PROGRAMME OUTCOME (PO)**
PO 1	To demonstrate rational understanding of rudimentary concepts, principles and processes underlying the academic field of Environmental Science with its various subfields like Ecology, Biodiversity, Earth sciences, pollution control technology, Environmental Physics and Chemistry, Environmental Health & Safety, Atmospheric Sciences, Environmental Laws, Environmental Impact Assessment, Environmental Biotechnology, Toxicology, Waste Treatment Techniques, Renewable and Non-Renewable Energy, Restoration, Environmental economics, Environmental statistics, Remote sensing and GIS, Climate change and sustainability, etc.
PO 2	To know about different types of professionals in the field of Environmental Science and related subfields.
PO 3	To address the environment related issues and challenges for the protection and conservation of available natural resources and environment.
PO 4	To identify, formulates, review research literature, and analyse current environment related problems. Use of laboratory and field techniques relevant to academia and industry, generic skills, and global competencies, including knowledge and skills that enable students to undertake further studies in the field of Environmental science.
PO 5	To create, select, and apply appropriate techniques, and to model environmental activities with an understanding of the limitations. Ability to use high end equipments for the analysis of environmental resources.
PO 6	To integrate knowledge from disciplines such as biology, chemistry, geography, geology, and policy studies to understand complex environmental issues.
PO 7	To identify and appreciate the importance of the Environmental Science and its application in academic, industrial, economic, and social context

PO 8	To undertake research and on field activities which develop problem solving abilities required for successful career in Environmental Science. Impart Communication Skills; Ability to work effectively as individual or team; Ability to handle project and to manage finance related issues.

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PROGRAMME SPECIFIC OUTCOME (PSO):

PROGRAMME NAME	PSO
PSO 1	The course provides wide range of knowledge on various aspects of different spheres of the environment viz atmosphere, hydrosphere, lithosphere and biosphere and generate awareness on Environmental Pollution, toxicology along with their inter linkages to human health. Climatic Change.
PSO 2	The course conveys education among students on Environmental Impact Assessment study of various environmental components, environmental laws, their effectivity and their long term outcome from environmental point of view.
PSO 3	The course provides knowledge on concepts, tools and modern techniques and instruments for analysis of various components of eco-environment and their management. Also enable to tackle various environmental challenges in friendly and sustainable manner and educate students on natural resource management for sustainable development.
PSO 4	The course includes training for capacity building, to offer professional and job oriented course curricula, to strengthen R&D activities and extension activities.

SEMESTER-I

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
S/ENV/101/MJC-1	Earth and Earth Surface Processes Earth and Earth Surface Processes (Practical)	4	10	25 15	50	3	NA	2
S/ENV/102/MN-1	Earth and Earth Surface Processes Earth and Earth Surface Processes (Practical)	4	10	25 15	50	3	NA	2
S/ENV/103/MD-1	Environment and Society	3	10	40	50	2	NA	NA
ACSHP/104/AECC-1	Communicative English: Literature and Communication	2	10	40	50	2	NA	NA
S/ENV/ 105/SEC-1	Remote Sensing, Geographic Information System and Modeling Remote Sensing, GeographicInformation System and Modeling(Practical)	3	10	25 15	50	2	NA	2
ACS/106/VAC-1	Environmental Studies	4	10	40	50	4	NA	NA
Total in Semester - I		**20**	**60**	**240**	**300**	**16**		**6**

N.B: .MJC-Major Paper, MN – Minor Paper; MD – Multidisciplinary Paper, AEC-Ability enhancement course,SEC-Skill enhancement course,VAC-Value added course. Theory:-1Credit=1hour/Week, Practical:-1Credit=2hours/Week, Tutorial:-1Credit = 1hour/Week

SEMESTER–II

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
S/ENV/201/MJC-2	Physics and Chemistry of Environment Physics and Chemistry of Environment (Practical)	4	10	25 15	50	3	NA	2
S/ENV/ 202/MN-2	Physics and Chemistry of Environment Physics and Chemistry of Environment (Practical)	4	10	25 15	50	3	NA	2
S/ENV/ 203/MD-2	Human Wildlife Conflict and Management	3	10	40	50	2	NA	NA
ACS/204 /AECC-2	English / Hind/ MIL	2	10	40	50	2	NA	NA
S/ENV/ 205/SEC-2	Environmental Impact and Risk Assessment Environmental Impact and Risk Assessment (Practical)	3	10	25 15	50	2	NA	2
ACS/206 /VAC-2	A: Health and Wellness B: Understanding India:Indian Philosophycal Traditional and Value System C:Basics of Indian Constitution D:Arts and Crafts of Bengal E:Historical tourism in West Bengal	4	10	40	50	4	NA	NA
Total in Semester - II		**20 + 4**	**60**	**240**	**300**	**16**		**6**
TOTAL IN FIRST YEAR		**40 + 4**	**120**	**480**	**600**			

N.B: .MJC-Major Paper, MN – Minor Paper; MD – Multidisciplinary Paper, AEC-Ability enhancement course,SEC-Skill enhancement course,VAC-Value added course. Theory:-1Credit=1hour/Week, Practical:-1Credit=2hours/Week, Tutorial:-1Credit = 1hour/Week

*** Certificate course in Environmental Science will be awarded to a student if he or she completes Summer Internship of 4 credits in addition to total 40 credits in Semester I & II**

SEMESTER–III

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
S/ENV/301/ MJC-3	Water and Water Resources	4	10	25	50	3	NA	
	Water and Water Resources (Practical)			15				2
S/ENV/ 302/MJC-4	Land and Soil Conservation and Management	4	10	25	50	3	NA	
	Land and Soil Conservation and Management (Practical)			15				2
S/ENV/ 303/MN-3	Water and Water Resources	4	10	25	50	3	NA	
	Water and Water Resources (Practical)			15				2
S/ENV/ 304/MD-3	Gender and Environment	3	10	40	50	2	NA	
S/ENV/ 305/SEC-3	Soil Conservation Management and Ecotourism.	3	10	25	50	2	NA	2
	Soil Conservation Management and Ecotourism (Practical)			15				
ACS/30 6/AEC-3	MIL	2	10	40	50	2	NA	NA
Total in Semester - III		**20**	**60**	**240**	**300**	**15**		**14**

N.B. MN – Minor Paper; MD – Multidisciplinary Paper; Theory:- 1 Credit= 1 hour/Week, Practical:- 1 Credit= 2 hours/Week, Tutorial:- 1 Credit= 1hour/Week

SEMESTER-IV

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
S/ENV/ 401/MJC - 5	Ecology and Ecosystem Ecology and Ecosystem (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 402/MJC - 6	Environmental Biotechnology Environmental Biotechnology(Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 403/MJC - 7	Atmosphere and Global Climate Change Atmosphere and Global Climate Change(Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 404/MJC - 8	Systematics and Biogeography Systematics and Biogeography(Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 405/MN-4	Ecology and Ecosystem Ecology and Ecosystem(Practical)	4	10	25 15	50	3	NA	 2
ACS/4 06/AEC-4	MIL	2	10	40	50	2	NA	NA
Total in Semester - IV		**22**	**60**	**240**	**300**	**17**		**10**
TOTAL IN SECOND YEAR		**42**	**120**	**480**	**600**			

N.B:-MJC-Major Paper, MN – Minor Paper; MD– Multidisciplinary Paper ; Theory: 1 Credit= 1 hour/Week, Practical:- 1 Credit= 2 hours/Week, Tutorial:- 1 Credit= 1 hour/Week. * Diploma in Environmental Science will be awarded to a student if he or she completes Summer Internship of 4 credits at least 1 in 2 years in addition to total 82 credits in Semester III & IV

SEMESTER-V

Third Year (Degree in Environmental Science)

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
S/ENV/ 501/MJC-9	Urban Ecosystem Urban Ecosystem (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 502/MJC-10	Environmental Legislation and Policy Environmental Legislation and Policy (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 503/DSE-1	Energy and Environment Energy and Environment (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 504/DSE-2	Environmental Economics Environmental Economics (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 505/MN-5	Urban Ecosystem Urban Ecosystem (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 506/SI-1	Summer Internship	2	10	40	50	4	NA	4
Total in Semester – V		**22**	**60**	**240**	**300**	**19**		**14**

SEMESTER-VI

Course Code	Course Title	Credit	Marks			No. of Hours/Week		
			I.A.	ESE	Total	Lec.	Tu.	Pr.
S/ENV/ 601/MJC-11	Biodiversity and Conservation Biodiversity and Conservation (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 602/MJC-12	Organismal and Evolutionary Biology Organismal and Evolutionary Biology (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 603/DSE-3	Natural Hazards and Disaster Management Natural Hazards and Disaster Management (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 604/DSE-4	Solid Waste Management Solid Waste Management (Practical)	4	10	25 15	50	3	NA	 2
S/ENV/ 605/MN-6	**Biodiversity and Conservation** **Biodiversity and Conservation (Practical)**	4	**10**	25 **15**	**50**	**3**	**NA**	 **2**
Total in Semester – VI		**20**	**50**	**200**	**250**	**15***		**10**
TOTAL IN THIRD YEAR		**42**	**110**	**440**	**550**			

SEMESTER –I
Major T- 1
EARTH AND EARTH SURFACE PROCESSES
(S/ENV/101/MJC-1)

Total credit- 04
COURSE OUTCOME (CO):

1. Students should develop a comprehensive understanding of Earth as a system, including its structure, composition, and the interactions between its various components such as the atmosphere, hydrosphere, lithosphere, and biosphere.
2. Theywill develop an understanding of natural hazards associated with Earth's surface processes, such as earthquakes, landslides, floods, volcanic eruptions, and coastal erosion, including their causes, effects, and mitigation strategies.

Theory (50 Lectures): Marks: 25

Unit 1: History of Earth **(10 Lectures)**
Solar system formation and planetary differentiation; Big Bang theory, formation of the Earth: formation and composition of core, mantle, crust, atmosphere and hydrosphere; Chemical differentiation; geological time scale; evolution of Earth's surface features.

Unit 2: Earth system processes **(10 Lectures)**
Movement of lithospheric plates; mantle convection and plate tectonics, major plates and hot spots, plate boundaries; Sea Floor Spreading; Earthquakes, volcanism and orogenesis in the light of Plate Tectonic Theory; Models of Isostasy; Pratt and Airy; Continental Drift: Mechanisms and Evidences.

Unit 3: Minerals and rocks. **(10 Lectures)**
Minerals and important rock forming minerals; Rock Cycle: Lithification and metamorphism; rock structure, igneous, sedimentary and metamorphic rocks; weathering: physical and biochemical processes; erosion: physical processes of erosion, factors affecting erosion.

Unit 4: Earth surface processes. **(10 Lectures)**
Atmosphere: evolution of earth's atmosphere, composition of atmosphere, physical and optical properties, circulation; interfaces: atmosphere–ocean interface, atmosphere–land interface, ocean–land interface; Evolution of landforms in fluvial, glacial, Aeolian and coastal processes.

Unit 5: Mountain: Origin and Evolution. **(10 Lectures)**
Formation of Peninsular Indian mountain systems - Western and Eastern Ghats, Formation of the Himalaya; Evolution of Himalayan and peninsular river systems; formation of Indo-Gangetic Plains.

Practical: Marks 15

a. Identification of rocks and mineral specimens and their characteristics.
b. Identification of different land features from toposheet.

Suggested Readings

1. Bridge, J., & Demicco, R. 2008. Earth Surface Processes, Landforms and Sediment deposits. Cambridge University Press.
2. Duff, P. M. D., & Duff, D. (Eds.). 1993. Holmes' Principles of Physical Geology. Taylor & Francis.
3. Gupta, A. K., Anderson, D. M., & Overpeck, J. T. 2003. Abrupt changes in the Asian southwest monsoon during the Holocene and their links to the North Atlantic Ocean. Nature 421: 354- 357.
4. Gupta, A. K., Anderson, D. M., Pandey, D. N. & Singhvi, A. K. 2006. Adaptation and human migration, and evidence of agriculture coincident with changes in the Indian summer monsoon during the Holocene. Current Science 90: 1082-1090.
5. Keller, E.A. 2011. Introduction to Environmental Geology (5th Edition). Pearson Prentice Hall.
6. Krishnan, M. S. 1982. Geology of India and Burma. CBS Publishers & Distributors.

7. Leeder, M., Arlucea, M.P. 2005. Physical Processes in Earth and Environmental Sciences. Blackwell Publishing.
8. Pelletier, J. D. 2008. Quantitative Modeling of Earth Surface Processes (Vol. 304). Cambridge: Cambridge University Press. Chicago.
9. Erach Bharucha: Text book of Environmental Studies for Undergraduate Course. Orient Blackswan Pvt Ltd.

Multidisciplinary- T-I
ENVIRONMENT AND SOCIETY
(S/ENV/ 103/MD-1)

Total credit- 03
COURSE OUTCOME (CO):

1. Students will gain insights into how human activities impact the environment and how environmental changes, in turn, affect societies.
2. Students will explore issues related to environmental justice, including how environmental benefits and burdens are distributed among different social groups.
3. Students will be able to critically analyze how different factors (e.g., economic systems, cultural values, policy frameworks) influence environmental outcomes and societal responses.

Theory (40 Lectures): Marks: 40

Unit 1: Perspectives on Environment (05 Lectures)
Social and cultural construction of 'Environment'; Environmental thought from historical and contemporary perspective; Environmental education and ethics; deep and shallow ecology.

Unit 2: Issues in environmentalism. (07 Lectures)
Significant global environmental issues such as climate change, and resource depletion; historical developments in cultural, social and economic issues related to land, forest, and water management in a global context; interface between environment and society.

Unit 3: Urbanization - environment conflict. (10 Lectures)
Development-induced displacement, resettlement, and rehabilitation: discussion on Project Affected People (PAPs). Production and consumption oriented approaches to environmental issues in Indian as well as global context; impact of industry and technology on environment; urban sprawl, traffic congestion and social-economic problems.

Unit 4: Environment and social inequalities. (05 Lectures)
Inequalities of race, class, gender, region, and nation-state in access to healthy and safe environments; history and politics surrounding environmental, ecological and social justice.

Unit 5: Regulatory framework. (05 Lectures)
Brief account of Forest Conservation Act, 1988; Land Acquisition Act, 2011, Land Acquisition Rehabilitation and Resettlement Act, 2013.

Unit 6: Community participation. (08 Lectures)
State, corporate, civil society, community, and individual-level initiatives to ensure sustainable development; case studies of environmental movements (Appiko Movement, Chipko Movement, Narmada Bachao Andolan); corporate responsibility movement; appropriate technology movement; environmental groups and movements, citizen groups; role played by NGOs.

Suggested Readings

1. Chokkan, K.B., Pandya, H. & Raghunathan, H. (Eds). 2004. Understanding Environment. Sagar Publication India Pvt. Ltd., New Delhi.
2. Elliot, D. 2003. Energy, Society and Environment, Technology for a Sustainable Future. Routledge Press.
3. Guha, R. 1989. Ecological change and peasant resistance in the Himalaya. Unquiet Woods, Oxford University Press, Delhi.
4. Leopold, A. 1949. The Land Ethic. pp. 201-214. Chicago, USA.
5. National Research Council (NRC). 1996. Linking Science and Technology to Society's Environmental Goals. National Academy Press.
6. Pandit, M.K. 2013. Chipko: Failure of a Successful Conservation Movement. In: Sodhi, N.S., Gibson, L. & Raven, P.H. Conservation Biology: Voices from the Tropics. pp. 126-127. Wiley- Blackwell, Oxford, UK.

SKILL ENHANCEMENT COURSE – T-I
REMOTE SENSING, GEOGRAPHIC INFORMATION SYSTEM AND MODELLING
(S/ENV/105/SEC-1)

Total credit – 03

Course Outcome (CO):

1. Students will understand the principles of remote sensing, including the types of sensors and platforms (e.g., satellites, drones), types of data (e.g., optical, radar, thermal), and how to interpret remote sensing imager
2. Students will grasp GIS fundamentals, including spatial data types, data sources, coordinate systems, and data management. They'll learn about GIS software tools and how to use them for spatial analysis.
3. Students will develop skills in interpreting and analyzing remote sensing imagery to identify features and changes in the environment.

Theory (Lecture: 40): Marks: 25

Unit 1: Basic concept of remote sensing (10Lectures)

Remote Sensing: definitions and principles; electromagnetic spectrum; interaction of EMR with Earth's surface; spectral signature; satellites and sensors; aerial photography and image interpretation. Advantages and limitations of remote sensing.

Unit 2: **Geographical Information Systems (10 Lectures)**

Geographical Information Systems: definitions and components; spatial and non-spatial data; database generation; database management system; land use/ land cover mapping; data import, processing, and mapping.

Unit 3: Application of Geographical Information Systems (10 Lectures)

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

Unit 4: Environmental statistics (10 Lectures)

Basic elements of statistical analyses: Frequency Distribution; sampling; types, errors and fluctuation; measures of central tendency and dispersion; skewness; correlation and regression; curve fitting; Standard Error of Estimate; Absolute Regression Residual Mapping.

Practical / Project: Marks-15

Submit a project on the following:

A. Geo referencing of maps and images.

B. Image classification, post-classification analysis and class editing.

Suggested Readings

1. Das N.G. 2010, Statistical Methods Combined Edition (Vol-I & II), Tata McGraw Hill Education Private Ltd., New Delhi
2. Mahmood A. 2012, Statistical Methods in Geographical Studies, Rajesh Publications, New Delhi
3. Sarkar A. 2013, Quantitative Geography: Techniques and Presentations, Orient Black Swan, Kolkata
4. Zar, J.H. 2010. Biostatistical Analysis (5th Edition). Prentice HallPublications.
5. Edmondson, A. & Druce, D.1996.Advanced Biology Statistics. Oxford University Press.
6. Demers, M.N. 2005. Fundamentals of Geographic Information System. Wiley & Sons.
7. Fazal, S. 2008, GIS Basics, New Age International Publishers, New Delhi
8. Richards, J. A. & Jia, X. 1999. Remote Sensing and Digital Image Processing. Springer.
9. Sabins, F. F. 1996. Remote Sensing: Principles an Interpretation. W. H. Freeman

Value Added Courses Common for All

ENVIRONMENTAL STUDIES
(ACS/ 106/ VAC-1)

Total Credit- 04
Marks: 50 (10 + 40)

Unit 1: Introduction to Environmental Studies **(08 Lectures)**

- Multidisciplinary nature of environmental studies
- Definition, Nature, Scope and Importance of environmental studies
- Types and Components of environment
- Sustainable development

Unit 2: Ecosystems **(07 Lectures)**

- Concept of Ecology and Eco-system, Structure and Function of an Ecosystem
- Different types of ecosystem; Forest, Desert and Aquatic (Ponds and Oceans) Biomes
- Energy flow in the ecosystem, energy flow models
- Food chains, food weds and ecological pyramids
- Ecological Succession

Unit 3: Natural Resources: Renewable and Non- Renewable Resources **(07 Lectures)**

- Land resources: Land degradation, Landslides, Soil erosion
- Forest resources: Uses, types and importance, deforestation and its effects, Forest biodiversity and tribal population
- Water resources: Distribution of water on Earth; Use and over-exploitation of surface and groundwater; conflicts over water Energy resources: Renewable and Non-renewable energy sources; Use of alternative energy Sources

Unit 4: Biodiversity and conservation **(07 Lectures)**

- Introduction – Definition: Levels of biological diversity: Genetics, Species and Eco-System Diversity, Biodiversity hot spots and mega biodiversity countries.
- Threats to biodiversity; Value (services) of biodiversity; man-wildlife conflicts, biological invasions
- Conservation of biodiversity: In situ and Ex situ conservation of biodiversity; Endangered and endemic species of India

Unit 5: Environmental Pollution **(07 Lectures)**

- Environmental pollution: types, causes, effects and controls; Air, water, soil and noise pollution

- Nuclear hazards and human health risks.
- Solid waste management: Control measures of urban and industrial waste
- Fireworks Pollution

Unit 6: Environmental Policies and Environment Laws (07 Lectures)

- Climate change, global warming, ozone layer depletion, acid rain and its impacts on human communities and agriculture
- Environment Laws: Environment Protection Act, 1986; Air (Prevention, Practices & Control of Pollution) Act, 1981;
- Water (Prevention and control of Pollution) Act, 1972; Wildlife Protection Act, 1972, Forest Conservation Act, 1920,
- 1988; International agreements: Montreal protocols, 1987 and Kyoto protocols, 1997 and Convention on Biological
- Diversity (CBD)
- Tribal populations and rights

Unit 7: Human Communities and the Environment (07 Lectures)

- Human population growth: Population Explosion, Impacts on environment, human health and welfare
- Disaster management: floods, earthquake, cyclones and landslides
- Environmental movements: Chipko, Silent valley
- Environmental ethics: Role of Indian and other religions and cultures in environmental Conservation
- Environment and human health: Concept of health and diseases (Vector Borne Diseases)
- Human Rights, Value Education, Role of Information Technology in Environment

Unit 8: Field Work (Project Work)

- Visit to an area to document environmental assets: river/ forest/ flora/fauna, etc
- Visit to a local polluted site-Urban/Rural/Industrial/Agricultural
- Study of common plants, insects, birds and basic principles of identification
- Study of simple ecosystems-pond, river etc

N.B: Marks Division: 40 theory+10 (Project Work/Field Work/Internal) = 50 Marks

Suggested Readings:

1. Carsen, R. 2002. Silent Spring, Houghton Mifflin, Harcourt.
2.Rao, M.N &DattaA.K. 1987.WasteWaterTreatment, oxford and IBH Publishing Co. Pvt. Ltd.
3. Raven, P., H Hassenzahl, D.M. & Berg L.R. 2012. Environment.8th Edition. John Wiley & Sons.
4. Singh, J.S., Singh, S.P. and Gupta, S.R. 2014. Ecology, Environmental Science and Conservation. S. Chand Publishing, NewDelhi.
5. Agarwal, K.C. 2001 Environmental Biology, Nidi Publication. Ltd. Bikaner.
6. Bharucha Erach, The Biodiversity Biology of India, Mapin Publishing Pvt. Ltd. Ahmedbad, India
7.Cunningham,W.P., Cooper,T.H., Gorhani & Hepworth, M.T. 2001. Environmental Encyclopedia. Jai coPubl. House. Mumbai.1196p.
8. Heywood,V.H. & Watson, R.T. 1995. Global Biodiversity Assessment. Cambridge University Press.
9. Jadhav, H & Bhosale, V.M. 1995. Environmental Protection and Laws, Himalaya Publishing House, Delhi
10. Mckinney,M.L. & Schoch.R.M. 1996. Environmental Science systems & Solutions, Webenhanc ededition.
11. Saha T.K. 2010. Ecology and Environmental Biology, Books and Allied (P) Ltd. Kolkata.
12. Santra S.C. 2005. Environmental Science, New Central Book Agency (P) Ltd. Kolkata.
13. Singh, S. 1991. Environmental Geography, Prayag Pustak Bhawan, Allahabad.
14. Roy, S. 2003.Environmental Science, Publishing Syndicate, Kolkata
15. Sharma, P. D. 2012. Ecology and Environment, Rastogi Publication
16. Dash, M. C. 2001. Fundamentals of Ecology, Tata McGraw-Hill Publishing Company Ltd
17. Arora, Mohan P. 2009. Ecology, Himalaya Publishing House
18. Saha T.K. 2010. Ecology and Environmental Biology, Books and Allied (P) Ltd. Kolkata.

19. Santra S.C. 2005. Environmental Science, New Central Book Agency (P) Ltd. Kolkata.
20. Rana, S.V.S. 2007. Environmental Studies. Rastogi Publication.
21. Charles J. Krebs. 2014. Text book of Ecology: The Experimental Analysis of distribution & abundance. Pearson Education.
22. Erach Bharucha. 2016. Text Book of Environmental Studies for Undergraduate Courses (Second Edition) for UGC. University

SEMESTER – II

Major T- II:
PHYSICS AND CHEMISTRY OF ENVIRONMENT
(S/ENV/201/MJC-2)

Total credit 04

COURSE OUTCOME (CO):

1. The students will be develop a comprehensive understanding of Earth's environmental systems, including the atmosphere, hydrosphere, lithosphere, and biosphere, and the physical and chemical interactions that occur within and between these systems.
2. They will learn about the physics and chemistry of climate change, including the greenhouse effect, radiative forcing, feedback mechanisms, and the role of anthropogenic activities in altering Earth's climate.

Theory (50 Lectures): Marks: 25

Unit 1: Fundamentals of environmental physics (10 Lectures)

PartA: Basic concepts of light and matter; quantum mechanics (relation between energy, wave length and frequency), Electromagnetic spectrum; black body radiation, Kirchhoff's law, Boltzmann equation, photovoltaic and solar cells; scattering of light, Rayleigh and Mie scattering.

Part B: Coriolis force, gravitational, centripetal, and centrifugal force; concept of heat transfer, conduction, convection; concept of adiabatic lapse rate (dry and moist adiabatic); concept of heat and work, laws of thermodynamics; concept of entropy and enthalpy.

Unit 2: Movement of pollutantsin environment (06 Lectures)

Diffusion and dispersion, point and area source pollutants, pollutant dispersal; Gaussian plume model, mixing heights, hydraulic potential, Darcy's equation, types of flow, turbulence.

Unit 3: Fundamentals of environmental chemistry (10 Lectures)

Part A: Atomic structure, periodic properties of elements, types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds); mole concept, molarity and normality.

Part B: Thermodynamic system; types of chemical reactions; acids, bases and salts, solubility products; solutes and solvents; redox reactions, concepts of pH.

Part C: Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, xenobiotic compounds, synthetic dyes and polymers.

Unit 4: Atmospheric chemistry (08 Lectures)

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

Unit 5: Water chemistry (08 Lectures)

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

Unit 6: Soil chemistry (08 Lectures)

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

potassium in soil; phenolic compounds in soil.

Practical: Marks 15

a) Measurement of soil horizon.

b) To study a soil profile; Measurement of soil temperature and moisture.

c) Measurement of soil pH, organic carbon and NPK.

Suggested Readings :

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

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

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

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

. Girard, J. 2013. Principles of Environmental Chemistry (3 rd edition). Jones & Bartlett.

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

7. Hites, R.A. 2012. Elements of Environmental Chemistry (2 nd edition). Wiley & Sons.

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

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

Minor T- II

PHYSICS AND CHEMISTRY OF ENVIRONMENT

(S/ENV/202/MN-2)

Total credit 04

COURSE OUTCOME (CO)

1. They will learn about the sources, transport, transformation, and fate of air pollutants, including greenhouse gases, particulate matter, ozone, and nitrogen oxides, and the impacts of air pollution on human health and the environment
2. The student will understand the principles of thermodynamics and kinetics as they apply to environmental processes, including phase transitions, chemical reactions, and energy transfer mechanisms

Theory (50 Lectures): Marks: 25

Unit 1: Fundamentals of environmental physics (10 Lectures)

Part A: Basic concepts of light and matter; quantum mechanics (relation between energy, wave length and frequency), Electromagnetic spectrum; black body radiation, Kirchhoff's law, Boltzmann equation, photovoltaic and solar cells; scattering of light, Rayleigh and Mie scattering.

Part B: Coriolis force, gravitational, centripetal, and centrifugal force; concept of heat transfer, conduction, convection; concept of adiabatic lapse rate (dry and moist adiabatic); concept of heat and work, laws of thermodynamics; concept of entropy and enthalpy.

Unit 2: Movement of pollutants in environment (06 Lectures)

Diffusion and dispersion, point and area source pollutants, pollutant dispersal; Gaussian plume model, mixing heights, hydraulic potential, Darcy's equation, types of flow, turbulence.

Unit 3: Fundamentals of environmental chemistry (10 Lectures)

Part A: Atomic structure, periodic properties of elements, types of chemical bonds (ionic, covalent, coordinate and hydrogen bonds); mole concept, molarity and normality.
Part B: Thermodynamic system; types of chemical reactions; acids, bases and salts, solubility products; solutes and solvents; redox reactions, concepts of pH.

Part C: Basic concepts of organic chemistry, hydrocarbons, aliphatic and aromatic compounds, organic functional groups, xenobiotic compounds, synthetic dyes and polymers.

Unit4: Atmospheric chemistry (08 Lectures)
Composition of atmosphere; photochemical reactions in atmosphere; smog formation, types of smog (sulphur smog and photochemical smog), aerosols; chemistry of acid rain, ozone layer depletion, role of CFCs in ozone depletion.

Unit5: Water chemistry (10 Lectures)
Chemical and physical properties of water; alkalinity and acidity of water, hardness of water, calculation of total hardness; solubility of metals, complex formation and chelation; colloidal particles; heavy metals in water.

Unit 6: Soil chemistry (08 Lectures)
Soil composition; relation between organic carbon and organic matter, inorganic and organic components in soil; soil humus; cation and anion exchange reactions in soil; nitrogen, phosphorus and potassium in soil; phenolic compounds in soil.

Practical: Marks 15

A. Measurement of soil horizon.
B. To study a soil profile; Measurement of soil temperature and moisture.
C. Measurement of soil pH, organic carbon and NPK.

Suggested Readings

1. Beard, J.M. 2013. Environmental Chemistry in Society (2nd Edition). CRCPress.
2. Boeker, E. & Grondelle, R. 2011. Environmental Physics: Sustainable Energy and Climate Change. Wiley.
3. Connell, D.W. 2005. Basic Concepts of Environmental Chemistry (2nd Edition). CRCPress.
4. Forinash, K. 2010. Foundation of Environmental Physics. Island Press.
5. Girard, J. 2013. Principles of Environmental Chemistry (3rd Edition). Jones & Bartlett.
6. Harnung, S.E. & Johnson, M.S. 2012. Chemistry and the Environment. Cambridge University Press.
7. Hites, R.A. 2012. Elements of Environmental Chemistry (2nd Edition). Wiley &Sons.
8. Manhan, S. E. 2000. Fundamentals of Environmental Chemistry. CRC Press.
9. Pani, B. 2007. Textbook of Environmental Chemistry. IK international Publishing House.

Multidisciplinary- T-II
HUMAN-WILDLIFE CONFLICT AND MANAGEMENT
(S/ENV/ 203/MD-2)

Total credit- 03
COURSE OUTCOME (CO)

1. They will be gain a deep understanding of the various ways in which human activities intersect with wildlife populations, leading to conflicts such as crop raiding, property damage, livestock predation, and human injuries or fatalities.
2. They develop knowledge about the behavior, ecology, and natural history of wildlife species involved in human-wildlife conflicts, including their habitat requirements, movement patterns, feeding behaviors, and reproductive strategies.

Theory (40 Lectures): Marks: 40

Unit 1: Introduction to wildlife management. (04 Lectures)

Need and policy frame of wildlife conservation: philosophy of wildlife management; Role of government, wildlife biologists and social scientists.

Unit 2: Evolution of the concept of wildlife management (06 Lectures)

Journey of mankind from predator to conservator; prehistoric association between wildlife and humans: records from Bhimbetka wall paintings; excerpts from rock edicts; Bishnoi community.

Unit 3: Wildlife conservation laws in India (10 Lectures)

Brief introduction to Wildlife Protection Act, 1972; Forest Act, 1927; Environmental Protection Act, 1986; and Forest conservation Act, 1920, 1980; Introduction of Tiger task force, Status of current protected areas in India.

Unit 4: Human wildlife and legal basis of conflicts (10 Lectures)

Reasons of human wildlife conflicts, human and elephant conflicts of Junglemahal, Fisherman and tiger conflict of Sundarbans. Concepts of development and encroachment, Impact of conflict on humans and wildlife, impact of habitat fragmentation, social inequality in terms of forest conservation: luxury hotels within protected areas *vs*. displacement of native tribes, forest produce as a need *vs.* forest exploitation, introduction to tribal rights in India, demographic profile of tribes in India, importance of forest product, Scheduled tribes and other traditional Forest dwellers (Recognition of forest right) Act, 2006.

Unit 5: Human wild life coexistence (10 Lectures)

Symbiotic relationship between tribals and forest, forest and development, focus on the inclusive growth of tribes: community participation in forest management, case study of Chipko movement, sacred groves forests, India's Bishnoi community and their conservation practices; ecological- economic welfare and development: conservation of indigenous culture and traditions, role of international organizations: Man and biosphere programmes; concept of conservation reserves and community reserves, importance of wildlife corridors in minimizing the conflicts and conservation.

Suggested Readings

1. Conover, M. 2001. Resolving Human Wildlife Conflicts, CRC Press.
2. Dickman, A. J. 2010. Complexities of conflict: the importance of considering social factors for effectively resolving human–wildlife conflict. Animal Conservation, 13: 458-466.
3. Messmer, T. A. 2000. The emergence of human–wildlife conflict management: Turning challenges into opportunities. International Biodeterioration & Biodegradation, 45: 97-102.
4. Paty, C. 2007. Forest Government and Tribe. Concept Publishing Company.
5. Treves, A. & Karanth, K. U. 2003. Human--carnivore conflictand perspectives on carnivore management worldwide. Conservation Biology, 17: 1491-1499.
6. Woodroffe, R., Thirgood, S., & Rabinowitz, A. 2005. People and Wildlife, Conflict or Co- existence? (No. 9). Cambridge University Pr**ess.**

SKILL ENHANCEMENT COURSE-T-II
ENVIRONMENTAL IMPACT AND RISK ASSESSMENT
(S/ENV/205/SEC-2)

Total credit-03

COUIRSE OUTCOME (CO)

1. They learn about the principles and methodologies used in Environmental Risk Assessment, including hazard identification, exposure assessment, toxicity assessment, and risk characterization.
2. **2**.The Students will be understand how to assess ecological impacts on biodiversity, ecosystems, and ecosystem services, including techniques for habitat assessment, species impact assessment, and ecosystem modeling.

Theory (40 Lectures): Marks: 25

Unit 1: Environmental impact assessment (EIA) (12 Lectures)

Definitions, introduction and concepts; rationale and historical development of EIA; scope and methodologies of EIA; Impact identification and prediction; baseline data collection; Environmental Impact Statement (EIS), Environmental Management Plan (EMP): principles, problems and strategies

Unit 2: Strategic environmental assessment (08 Lectures)

Social Impact Assessment; Cost-Benefit analysis; Life cycle assessment; environmental appraisal; environmental planning; environmental audit; Principles of International Standard Organizations

Unit 3: EIA regulations (08 Lectures)

EIA regulations in India, status of EIA in India, current issues in EIA, case study of hydropower projects / thermal projects.

Unit 4: Risk assessment (12 Lectures)

Introduction and scope; project planning; toxicity assessment; hazard identification and assessment; risk characterization; risk communication; environmental monitoring; community involvement; legal and regulatory framework; human and ecological risk assessment.

Practical/ Project: Marks: 15

Submit any one project from the followings:

a) Impact Assessment Methods- Adhoc, Checklist methods.
b) Preparation of Environmental Impact Statement (EIS).
c) Risk zone mapping.

Suggested Readings

1. Barrow, C.J. 2000. Social Impact Assessment: An Introduction. Oxford University Press.
2. Glasson, J., Therivel, R. & Chadwick, A. 1994. Introduction to Environmental Impact Assessment. London, Research Press, UK.
3. Judith, P. 1999. Handbook of Environmental Impact Assessment. BlackWell Science.
4. Marriott, B. 1997. Environmental Impact Assessment: A Practical Guide. McGraw-Hill, New York, USA.
5. Westman, W.E. 1985, Ecology, Impact Assessment and Environmental Planning, John Wiley, New York

SEMESTER –III

Major T- 3
WATER AND WATER RESOURCES
(S/ENV/301/MJC-3)

Total credit- 04

COURSE OUTCOME (CO)

1. Students will grasp the fundamental concepts of the hydrological cycle, including precipitation,

evaporation, condensation, and the movement of water through different reservoirs.
2. Students will learn about the strategies and practices involved in managing water resources, including water conservation, allocation, and sustainable usage.
3. Students will be able to identify and analyze key global and local issues related to water resources, such as water scarcity, pollution, climate change, and the socio-economic impacts of water management.

Theory (50 Lectures): Marks: 25

Unit1: Introduction of water resources (04 Lectures)
Sources and types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapotranspiration; classification of water resources (oceans, rivers, lakes and wetlands). lentic and Lotic water.

Unit 2: **Properties of water (08 Lectures)**
Physical: temperature, colour, odour, total dissolved solids and total suspended solids; Chemical: major inorganic and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity, pH, electrical conductivity, sodium adsorption ratio; Biological: phytoplankton, benthos, zooplankton, micro and macro- invertebrates.

Unit 3: **Surface and subsurface water (8 Lectures)**
Introduction to surface and ground water; surface and ground water pollution; water table; vertical distribution of ground water; formation,types and properties of aquifers;artificial techniques for ground water recharge; river structure and patterns; importance of watershed and watershed management; rain water harvesting in urban settings.

Unit 4: Wetlands and their management (06 Lectures)
Definition of a wetland; types of wetlands (fresh water,tidal,estuarian and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention, 1971 major wetlands of India.Ramsar sites of India.

Unit 5: Marine resource management (04 Lectures)
Marine resources; commercial use of marine resources; threats to marine ecosystems and resources; resource management of marine ecosystem (planning approach, construction techniques and monitoring of coastal zones). drinking water quality standards of India, latest water conservation initiatives in India, Amrit sarovar yojona

Unit 6: Water resource in India (06 Lectures)
Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; role of state in water resources management.

Unit 7: Water resources conflicts (08 Lectures)
Water resources and sharing problems, case studies on Kaveri and Krishna river water disputes; Multi- purpose river valley projects in India and their environmental and social impacts; case studies of dams- Narmada and Tehri dam – social and ecological losses versus economic benefits; International conflicts on water sharing between India and her neighbours; agreements to resolve these conflicts.

Unit 8: Major laws and treaties (06 Lectures)
National water policy; water pollution (control and prevention) Act 1972; Indus water treaty;
Ganges water treaty, Teesta water treaty; National river linking plan: ecological and economic impacts.

Practical: Marks: 15

A) Estimation of Surface water parameters - DO, combined CO2, salinity. BOD.
B) Estimation of Ground water parameters- hardness, alkalinity, acidity. chloride.

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

2. Brebbia, C.A. 2013. Water Resources Management VII. WIT Press.
3. CEA. 2011. Water Resources and Power Maps of India. Central Board of Irrigation & Power.
4. Grumbine, R.E. & Pandit, M.K. 2013. Threats from India's Himalaya dams. Science 339: 36-37.
5. Loucks, D.P., Stedinger, J.R. & Haith, D. A. 1981. Water Resource Systems Planning and Analysis. Englewood Cliffs, NJ, Prentice Hall.
6. Mays, L.W. 2006. Water Resources Sustainability. The McGraw-Hill Publications.
7. Schward & Zhang, 2003. Fundamentals of Groundwater. John Willey and Sons.
8. Souvorov, A.V. 1999. Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource Management. Elsevier Publications.
9. Vickers, A. 2001. Handbook of Water Use and Conservation. Water Plow Press

SEMESTER –III

Major T- 4

LAND AND SOIL CONSERVATION AND MANAGEMENT

(S/ENV/302/MJC-4)

Total credit- 04

COURSE OUTCOME (CO)

1. Students will become familiar with the fundamental principles of land and soil conservation, including erosion control, soil degradation, and sustainable land management practices.
2. Students will develop practical skills in soil management techniques such as soil testing, soil amendment, and the use of cover crops and conservation tillage to enhance soil health and productivity.
3. Students will understand the causes and consequences of soil erosion and degradation. They will learn to identify signs of soil erosion, assess its impact, and implement strategies to mitigate and prevent it.

Theory (50 Lectures): Marks: 25

Unit1: Introduction of soil as a resource (05 Lectures)

Land as a resource, soil health; ecological and economic importance of soil; types of soil in India, soil profile, types and causes of soil degradation; impact of soil loss and soil degradation on agriculture and food security; need for soil conservation and restoration of soil fertility.

Unit 2: Fundamentals of soil science (10 Lectures)

Soil formation; soil weathering processes (physical, chemical and biological). Classification of soil; soil architecture; physical properties of soil; soil texture; soil erosion, soil water holding capacity; soil temperature; soil colloids; soil acidity and alkalinity; soil organic matter. Development of soil profile: Laterite and Pedzol.

Unit 3: Soil degradation–causes (10 Lectures)

Soil resistance and resilience; nature and types of soil erosion; non-erosive and erosive soil degradation; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, industrial and urban development, toxic organic chemicals, and organic contaminants in soils; recycling of soil nutrients.

Unit 4: Land use changes and land degradation (10 Lectures)

Land resources: types and evaluation; biological and physical phenomena in land degradation; visual indicators of land degradation; drivers of land degradation - deforestation, desertification; habitat loss, loss of biodiversity; land salinization; human impact.

Unit 5: Costs of land degradation (10 Lectures)

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

degradation; emerging threats of land degradation to developing countries.

Unit 6: Controlling land degradation (05 Lectures)
Sustainable land use planning; role of databases and data analysis in land use planning control and management; land tenure and land policy; legal, institutional and sociological factors; participatory land degradation assessment; integrating land degradation assessment into conservation.

Practical: Marks: 15

A. Characterization of soil, Laterite, Pedzol— Texture, bulk density, porosity
B. Determination of Soil physical parameters—pH and colour, conductivity.

Suggested Readings

1. Brady, N.C. & Well, R.R. 2007. The Nature and Properties of Soils (13th Edition A) Characterization of soil Laterite, Pedzol— Texture, Bulk density, Porosity), Pearson Education Inc.
2. Gadgil, M. 1993. Biodiversity and India's degraded lands. Ambio 22: 167-172.
3. Johnson, D.L. 2006. Land Degradation (2nd Edition).Rowman & Little field Publishers.
4. Marsh, W. M. & Dozier, J. 1983. Landscape Planning: Environmental Applications. John Wiley and Sons.
5. Oldeman, L. R. 1994. The global extent of soil degradation. Soil resilience and sustainable land use, 9. (http://library.wur.nl/isric/fulltext/isricu_i26803_001.pdf).
6. Pandit, M.K. et al., 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. Biodiversity Conservation, 16: 153-163.
7. Pandit, M.K. & Kumar, V. 2013. Land use and conservation challenges in Himalaya: Past, present and future. In: Sodhi, N.S., Gibson, L. & Raven, P.H. Conservation Biology: Voices from the Tropics. pp. 123-133. Wiley-Blackwell, Oxford, UK
8. Peterson, G. D., Cumming, G. S. & Carpenter, S. R. 2003. Scenario planning: a tool for conservation in an uncertain world. Conservation Biology, 17: 358-366.
9. Scherr, S. J. 1999. Soil degradation: A threat to developing-country food security by 2020 (Vol. 27). International Food Policy Research Institute.
10. Mahua Basu & S. Xavier: Fundamentals of Environmental Studies. Cambridge University press.
11. Chapman: Ecology. Cambridge University press

SEMESTER –III

Minor T- III:
WATER AND WATER RESOURCES
(S/ENV/303/MN-3)

Total credit -04
COURSE OUTCOME (CO)

1. Students will recognize the ethical and social dimensions of water resource management, including issues related to equity, access, and community involvement.
2. Students will understand the principles of water quality, including the identification and measurement of contaminants, water purification processes, and the impact of pollutants on ecosystems and human health.

Theory (50 Lectures): Marks: 25
Unit1: Introduction of water resources (04 Lectures)
Sources and types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapotranspiration; classification of water resources (oceans, rivers, lakes and wetlands). lentic and Lotic water

Unit 2: Properties of water (08 Lectures)
Physical: temperature, colour, odour, total dissolved solids and total suspended solids; Chemical: major inorganic

and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity,P^H electrical conductivity, sodium adsorption ratio; Biological: phytoplankton, benthos, zooplankton, micro and macro- invertebrates.

Unit 3: Surface and subsurface water (10 Lectures)
Introduction to surface and ground water; surface and ground water pollution; water table; vertical distribution of ground water; formation, types and properties of aquifers; artificial techniques for ground water recharge; river structure and patterns; importance of watershed and watershed management; rain water harvesting in urban settings.

Unit 4: Wetlands and their management (06 Lectures)
Definition of a wetland; types of wetlands (fresh water tidal, estuarian and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention, 1971; major wetlands of India,Ramsar sites of India.

Unit 5: Marine resource management (06 Lectures)
Marine resources; commercial use of marine resources; threats to marine ecosystems and resources; resource management of marine ecosystem (planning approach, construction techniques and monitoring of coastal zones). drinking water quality standards of India, latest water conservation initiatives in India, Amrit sarovar yojona

Unit 6: Water resource in India (06 Lectures)
Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; role of state in water resources management.

Unit 7: Water resources conflicts (06 Lectures)
Water resources and sharing problems, case studies on Kaveri and Krishna river water disputes; Multi- purpose river valley projects in India and their environmental and social impacts; case studies of dams- Narmada and Tehri dam – social and ecological losses versus economic benefits; International conflicts on water sharing between India and her neighbours; agreements to resolve these conflicts.

Unit 8: Major laws and treaties (04 Lectures)
National water policy; water pollution (control and prevention) Act 1972; Indus water treaty; Ganges water treaty; Teesta water treaty; National River linking plan: ecological and economic impacts.

Practical: Marks: 15

A) Estimation of water parameters - DO, combined CO2, salinity.
B) Estimation of water parameters- hardness, alkalinity, acidity.
C) Estimation of water parameters- chloride and BOD.

Suggested Readings

1. Bansil, P.C. 2004. Water Management in India. Concept Publishing Company, India.
2. Brebbia, C.A. 2013. Water Resources Management VII. WIT Press.
3. CEA. 2011. Water Resources and Power Maps of India. Central Board of Irrigation & Power.
4. Grumbine, R.E. & Pandit, M.K. 2013. Threats from India's Himalaya dams. Science 339: 36-37.
5. Loucks, D.P., Stedinger, J.R. & Haith, D. A. 1981. Water Resource Systems Planning and Analysis. Englewood Cliffs, NJ, Prentice Hall.
6. Mays, L.W. 2006. Water Resources Sustainability. The McGraw-Hill Publications.
7. Schward & Zhang, 2003. Fundamentals of Groundwater. John Willey and Sons.
8. Souvorov, A.V. 1999. Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource Management. Elsevier Publications.
9. Vickers, A. 2001. Handbook of Water Use and Conservation. Water Plow Press

SEMESTER-III

GENDER AND ENVIRONMENT

S/ENV/304/MD-3

Total Credits: 3
COURSE OUTCOME (CO):

1. Students will become familiar with key theoretical frameworks and concepts related to gender and the environment, such as ecofeminism, gender and sustainability, and environmental justice.
2. Students will understand how environmental changes and policies differentially impact men, women, and non-binary individuals, including the roles they play in both causing and mitigating environmental issues.
3. Students will learn about gender-sensitive approaches to environmental management and policy, including strategies to ensure equitable participation and benefit-sharing in environmental initiatives.

Theory (40 Lectures): Marks: 40

Unit 1: Socioal construction of gender (02 Lectures)
The socially constructed 'gender'concept.

Unit 2: Gender and society (04 Lectures)
Gender existence in society; gender: matriarchy and patriarchy (case studies in an Indian context); gender equity issues in rural and urban settings.

Unit 3: Gender and the environment (08 Lectures)
Relevance of the concept in an environmental context; evolution of gender hierarchies in historical and contemporary perspective; gendered division of roles in cultural, social and economic perspective; gender inequalities.

Unit 4: Gender, resources and the environment (08 Lectures)
Human –Environment relationship; Relationship between gender and environment, differential dependencies on environmental resources; implications of gendered responses to environmental degradation.

Unit 5: Gender and environmental management (08 Lectures)
Women's participation in environmental movements and conservation; Role of women in environmental education, awareness and sustainable development. Case study of Chipko movement.

Unit 6: Strategies for change (10 Lectures)
Need for gender equity; Instruments for change: education, media, action groups, policy and management; role of ICT in resource availability and consumption.

Suggested Readings

1. Agarwal, B. 1992. The Gender and Environment Debate: Lessons from India. Feminist Studies (Minnesota).
2. Agarwal, B. 1997. Gender, Environment and Poverty Interlinks: Regional Variations and Temporal Shifts in Rural India: 1971-1991. World Development, 25: 1-42.
3. Agarwal, B. 2001. Participatory exclusions, community forestry, and gender: An analysis for South Asia and a conceptual framework. World Development, 29: 1623-1648.
4. Jackson, C.1993.Doingwhatcomesnaturally? Women and environment in development
World Development, 21: 1947-63.
5. Krishna, S. 2004. Livelihood and Gender. New Delhi, Sage.
6. Leach, M. 2007. Earth Mother myths and other ecofeminist fables: How a strategic notion rose and fell. Development and Change, 38: 67-85.

7. Miller, B. 1993. Sex and Gender Hierarchies. Cambridge University Press
8. Stein, R. 2004. New Perspectives on Environmental Justice: Gender, Sexuality, and Activism. Rutgers University Press.
9. Steingraber, S. 1998. Living Downstream: A Scientist's Personal Investigation of Cancer and the Environment. New York: Vintage Books.
10. Zwarteveen, M.Z. 1995. Linking women to the main canal: Gender and irrigation management. Gatekeeper Series, 54, IIED

SEMESTER-III

SOIL CONSERVATION, MANAGEMENT AND ECOTOURISM
(S/ENV/305/SEC-3)

Total Credits: 3

COURSE OUTCOME (CO):

1. Students will be able to explain the importance of soil conservation and the factors affecting soil erosion.
2. They will understand the principles of ecotourism and its role in sustainable development
3. Students will design ecotourism initiatives that promote soil conservation and environmental stewardship.
4. They will assess the socio-economic and environmental impacts of ecotourism activities on local communities and ecosystems.

Theory (50 Lectures): Marks: 25

Unit 1: Fundamentals of soil science (06 Lectures)

Soil formation; classification of soil; soil architecture; physical properties of soil; soil texture; soil water holding capacity; soil temperature; soil colloids; soil acidity and alkalinity; soil organic matter. Development of soil profile: Laterite and Pedzol, need for soil conservation and restoration of soil fertility.

Unit 2: Soil degradation – causes (06 Lectures)

Soil resistance and resilience; nature and types of soil erosion; non-erosive and erosive soil degradation; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, industrial and urban development.

Unit 3: Controlling land degradation (08 Lectures)

Sustainable landuse planning; role of databases and data analysis in landuse planning control and management; land tenure and land policy; legal, institutional and sociological factors; participatory land degradation assessment; integrating land degradation assessment into conservation.

Unit 4: Ecotourism (04 Lectures)

Elementary idea of Mass tourism and its Impact on environment and culture; concept of ecotourism, guideline and policy (National and International) of ecotourism; Planning of ecotourism; ecotourism circuit development; types of alternative tourism, elementary idea of rural truism, adventure tourism; development, economical benefits and impacts of ecotourism; management of ecotourism; ecotourism potentiality in India - case study (ecotourism in Kenya, India and Australia)

Practical: Marks: 15

A) Characterization of soil Laterite, Pedzol— Texture, Bulk density, Porosity
B) Determination of Soil parameters—pH, Colour, and conductivity.

Suggested Readings

1. Brady, N.C. & Well, R.R. 2007.The Nature and Properties of Soils (13th Edition), Pearson Education Inc.
2. Gadgil, M. 1993. Biodiversity and India's degraded lands. Ambio, 22: 167-172.
3. Johnson, D.L. 2006. Land Degradation (2nd Edition). Rowman & Little field Publishers.

4. Marsh, W. M. & Dozier,J. 1983. Landscape Planning: Environmental Applications. John Wiley and Sons.
5. Oldeman, L. R. 1994. The global extent of soil degradation. Soil resilience and sustainable land use, 9. (http://library.wur.nl/isric/fulltext/isricu_i26803_001.pdf).
6. Pandit, M .K. et al., 2007. Unreported yet massive deforestation driving loss of endemic biodiversity in Indian Himalaya. Biodiversity Conservation 16: 153-163.
7. Pandit, M.K. & Kumar, V. 2013. Land use and conservation challenges in Himalaya: Past, present and future. In: Sodhi, N.S., Gibson, L. & Raven, P.H. Conservation Biology: Voices from the Tropics. pp. 123-133. Wiley-Blackwell, Oxford, UK
8. Peterson, G. D., Cumming, G. S. & Carpenter, S. R. 2003. Scenario planning: a tool for conservation in an uncertain world. Conservation Biology 17: 358-366.
9. Scherr, S. J. 1999. Soil degradation: A threat to developing-country food security by 2020 (Vol. 27). International Food Policy Research Institute

SEMESTER-IV

Major T-5

ECOLOGY AND ECOSYSTEM

(S/ENV/401/MJC-5)

Total credit- 04

COURSE OUTCOME (CO)

1. Students will gain a solid foundation in key ecological concepts such as energy flow, nutrient cycling, population dynamics, and community interactions.
2. Students will learn about the structure and functioning of various ecosystems, including the roles of producers, consumers, decomposers, and the impact of abiotic factors on ecosystem processes.

Theory (50 Lectures): Marks: 25

Unit1: Introduction to ecology (05 Lectures)

Basic concepts and definitions: ecology, landscape, habitat, biosphere, ecosystems, autecology; synecology; major terrestrial biomes.

Unit 2: Ecology of individuals (08 Lectures)

Liebig's Law of the Minimum; Shelford's Law of Tolerance; ecotypes; ecoclines; acclimation; ecological niche; types of niche.

Unit 3: Ecology of populations (08 Lectures)

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

Unit 4: Ecology of communities (08 Lectures)

Community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; species interactions: mutualism, symbiotic relationships, commensalism, amensalism, protocooperation, predation, competition, parasitism, mimicry, herbivore; ecological succession: primary and secondary successions types of successions, climax community concepts.

Unit 5: Ecosystem ecology (08 Lectures)

Types of ecosystem(Terrestrial and aquatic):, ecosystem structure and function; abiotic and biotic components of ecosystem; primary and secondary production; ecosystem connections: food chain, food web; models of energy flow; ecological efficiencies; ecological pyramids: pyramids of number, biomass, and energy.

Unit 6: Biogeochemical cycles and nutrient cycling (08 Lectures)

Carbon cycle; nitrogen cycle; phosphorous cycle, hydrological cycle; nutrient cycle models; ecosystem input of nutrients; biotic accumulation; nutrient supply and uptake; role of mycorrhizae; decomposition and nutrient release; nutrient use efficiency; nutrient budget; nutrient conservation strategies.

Unit 7: Biological invasions (05 Lectures)

Concept of exotics and invasives; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities. .

Practical: Marks: 15

1. Identification with reasons of the following

a) Study of microfauna of water viz., plankton, (e.g., Keratella, Cyclops, Cypris, Nauplius larva, Bosmina, Moina).

b) Study of aquatic flora, e.g., Spirogyra, Zygnema, Pistia, Eichhornia, Hydrilla, Ipomoea, Azolla, Lemna (minor and major), Marselea, Nymphae, Nelumbo.

2. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.

Suggested Readings

1. Groom. B. & Jenkins. M. 2000.Global Biodiversity: Earth's Living Resources in the 21st Century. World Conservation Press, Cambridge, UK.
2. Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2002. The Ecology of Plants. Sinauer associates incorporated.
3. Loreau, M. & Inchausti,P.2002.Biodiversity and Ecosystem functioning: Synthesis and Perspectives. Oxford University Press, Oxford, UK.
4. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders.
5. Pandit, M.K., White, S.M.& Pocock, M.J.O. 2014. The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis. New Phytologist, 203: 697-703.
6. Pimentel, D. 2011. Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species. CRC Press.
7. Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications.
8. Wilson, E. O. 1985. The Biological Diversity Crisis. Bio Science, 35: 700-706

SEMESTER-IV

Major T- 6

ENVIRONMENTAL BIOTECHNOLOGY

(S/ENV/402/MJC-6)

Total credit- 04

COURSE OUTCOME (CO):

1. Students will understand the role of microorganisms in bioremediation processes, including the mechanisms by which microbes degrade or detoxify pollutants and the design of microbial treatments for contaminated environments.
2. Students will explore the use of plants for environmental cleanup, including the mechanisms of phyto-remediation, the selection of appropriate plant species, and the design of phyto-remediation systems.
3. Students will learn about biotechnological approaches to waste management, including the treatment of solid waste, liquid waste, and hazardous waste using biological methods.

Theory (50 Lectures): Marks: 25

Unit 1: Cell and Cellular Organelles (10 Lectures)

Cell, types of cell, cell cycle, Genetic material of prokaryotes, eukaryotes and organelles (mitochondria and chloroplast); Chromosomal organization (euchromatin, heterochromatin-constitutive and facultative heterochromatin).

Unit 2: The structure and function of DNA, RNA and Protein (10 Lectures)

DNA: structural forms and their characteristics (B, A, Z); RNA: structural forms and their characteristics (rRNA, mRNA, tRNA), types of amino acids; post- translational modifications and their significance; synthesis; types and their role: structural, functional (enzymes).Central dogma of biology, Fundamentals of Recombinant DNA Technology.

Unit 3: Ecological restoration and bioremediation (20 Lectures)

Wastewater treatment: Primary, Secondary and Tertiary; solid waste treatment: sources and management (vermiculture and methane production, landfill. hazardous waste treatment); specific bioremediation technologies: land farming, biopiles, composting, bioventing.

Unit 4: Ecologically safe products and processes (10 Lectures)

PGPR bacteria: biofertilizers, microbial insecticides and pesticides, bio-control of plant pathogen, integrated pest management; development of stress tolerant plants, biofuel.

Practical: Marks: 15 Credit: 02

1. Cytological preparation and Identification of Mitosis of *Alium sp*
2. Estimate ABO blood grouping.

Suggested Readings

1.Evans, G.G. & Furlong, J. 2010. Environmental Biotechnology: Theory and Application (2nd Edition). Wiley-Blackwell Publications.
2. Jordening, H.J. & Winter J. 2005. Environmental Biotechnology: Concepts and Applications. John Wiley & Sons.
3. Lodish, H.F., Baltimore, D., Berk, A. Zipursky, S.L. Matsudiara, P. & Darnell, J.1995. Molecular Cell Biology. W.H. Freeman.
4. Nelson, D.L. & Cox, M.M. 2013. Lehninger's Principles of Biochemistry. W.H. Freeman.
5. Rittman, B.E. & McCarty, P.L. 2001. Environmental Biotechnology. Principles and Applications. L McGraw-Hill, New York.
6. Scagg, A.H. 2005. Environmental Biotechnology. Oxford University Press.
7. Snustad, D.P. & Simmons, M.J. 2011. Principles of Genetics (6th Edition). John Wiley & Sons.
8. Wainwright, M. 1999. An Introduction to Environmental Biotechnology. Springer.
9. Bhattacharyya, B.C. & Banerjee. R. 2007. Environmental Biotechnology. Oxford University Press.

SEMESTER-IV

Major T- 7

ATMOSPHERE AND GLOBAL CLIMATE CHANGE

(S/ENV/403/MJC-7)

Total credit- 04

COURSE OUTCOME (CO)

1. Students will gain a solid foundation in the principles of atmospheric science, including the composition, structure, and dynamics of the Earth's atmosphere.
2. Students will learn about climate systems and processes, including how atmospheric components interact with the Earth's surface, oceans, and biosphere to influence climate patterns.
3. Students will understand the mechanisms of climate change, including the role of greenhouse gases, aerosols, and natural climate variability in driving changes in global and regional climates.

Theory (50 Lectures): Marks: 25

Unit1: Introduction of atmosphere (04 Lectures)

Evolution and development of earth's atmosphere; atmospheric structure and composition; significance of atmosphere in making the earth, Milankovitch cycles.

Unit 2: Global energy balance (04 Lectures)

Earth's energy balance; energy transfers in atmosphere; Earth's radiation budget; green house gases (GHGs); greenhouse effect; global conveyor belt.

Unit 3: Atmospheric circulation (10 Lectures)

Movement of air masses; atmosphere and climate; air and sea interaction; southern oscillation; western disturbances; El Nino and La Nina; tropical cyclone; Indian monsoon and its development.

Unit 4: Meteorology and atmospheric stability (08 Lectures)

Meteorological parameters (temperature, relative humidity, wind speed and direction, precipitation); atmospheric stability and mixing heights; temperature inversion; plume behavior; Gaussian plume model.

Unit 5: Atmospheric chemistry (08 Lectures)

Chemistry of atmospheric particles and gases; smog – types and processes; photochemical processes; ions and radicals in atmosphere; acid-base reactions in atmosphere; atmospheric water; role of hydroxyl and hydroperoxyl radicals in atmosphere.

Unit 6: Global warming and climate change (08 Lectures)

Earth's climate through ages; trends of global warming and climate change; drivers of global warming and the potential of different green house gases (GHGs) causing the climate change; atmospheric windows; impact of climate change on atmosphere, weather patterns, sea level rise.

Unit 7: Ozone layer depletion (08 Lectures)

Ozone layer or ozone shield; importance of ozone layer; ozone layer depletion and causes; Chapman cycle; process of spring time ozone depletion over Antarctica; ozone depleting substances (ODS); effects of ozone depletion; mitigation measures and international protocols.

Unit 8: Climate change and policy (04 Lectures)

Environmental policy statement; International agreements; Montreal protocol 1987; Kyoto protocol 1997; convention on climate change; carbon credit and carbon trading.

Practical: Marks: 15

a) Measures the atmospheric parameters:- Temperature; humidity; and atmospheric pressure.
b) Measure CO_2, CO and HCHO levels in different environment (Indoor and Outdoor).
c) Measure particulate matter (PM 2.5, PM 10) in urban and rural areas.

Suggested Readings:

1. Barry, R. G. 2003. Atmosphere, Weather and Climate. Rout ledge Press, UK.
2. Lal D.S. 2006, Climatology, Sharda Pustak Bhawan, Allahabad.
3. Singh S. 2009, Climatology, Prayag Pustak Bhawan, Allahabad.
4. Siddhartha K. 2005, Atmosphere, Weather and Climate, Kisalaya Publications Pvt. Ltd, New Delhi.
5. Gillespie, A. 2006. Climate Change, Ozone Depletion and Air Pollution: Legal Commentaries with Policy and Science Considerations. Martinus Nijhoff Publishers.
6. Hardy, J.T. 2003. Climate Change: Causes, Effects and Solutions. John Wiley & Sons.
7. Harvey, D. 2000. Climate and Global Climate Change. Prentice Hall.
8. Manahan, S.E. 2010. Environmental Chemistry. CRC Press, Taylor and Francis Group.
9. Maslin, M. 2014. Climate Change: A Very Short Introduction. Oxford Publications.
10. Mathez, E.A. 2009. Climate Change: The Science of Global Warming and our Energy Future. Columbia University Press.
11. Mitra, A.P., Sharma, S., Bhattacharya, S., Garg, A., Devotta, S. & Sen, K. 2004. Climate Change and India. Universities Press, India.
12. Philander, S.G. 2012. Encyclopedia of Global Warming and Climate Change (2nd Edition) Sage Publications.

SEMESTER-IV

Major T- 8

SYSTEMATICS AND BIOGEOGRAPHY

(S/ENV / 403/MJC-8)

Total credit- 04

COURSE OUTCOME (CO)

1. Students will gain a thorough understanding of the principles and methods of taxonomy and systematics, including how organisms are classified and the criteria used to determine their relationships.
2. Students will understand the evolutionary processes that drive diversification and speciation, including natural selection, genetic drift, and gene flow.
3. Students will explore the distribution patterns of organisms across different geographic regions and the factors that influence these patterns, such as historical events, climate, and ecological interactions.

Theory (50 Lectures): Marks: 25

Unit 1: Concept and systematic approaches (06 Lectures)

Definition of systematics; taxonomic identification; keys; field inventory; herbarium; museum; botanical gardens; taxonomic literature; nomenclature; evidence from anatomy, palynology, ultrastructure, cytology, numerical and molecular methods; taxonomy databases.

Unit2: Taxonomic hierarchy (06 Lectures)

Concept of taxa (species, genus, family, order, class, phylum, kingdom); concept of species (taxonomic, typological, biological, evolutionary, phylogenetic); categories and taxonomic hierarchy.

Unit 3: Nomenclature and systems of classification (06 Lectures)

Principles and rules (International Code of Botanical and Zoological Nomenclature); ranks and names; types and typification; author citation; principle of priority and its limitations; names of hybrids; classification systems of

Bentham and Hooker; Angiosperm Phylogeny Group (APG III)classification.

Unit 4: Numerical and molecular systematic (06 Lectures)
Characters; variations; Operational Taxonomic Units; character weighting and coding; phenograms; cladograms; DNA barcoding; phylogenetic tree; clades: monophyly, paraphyly, polyphyly; homology and analogy; parallelism and convergence.

Unit 5: Introduction to Biogeography (06 Lectures)
Genes as unit of evolutionary change; mutation; genetic drift; gene flow; natural selection; geographic and ecological variation; bio-geographical rules – Gloger's rule, Bergmann's rule, Allen's rule, Geist rule; bio-geographical realms and their fauna; endemic, rare, exotic, and cosmopolitan species.

Unit 6: Speciation and extinction (06 Lectures)
Types and processes of speciation – allopatric, parapatric, sympatric; ecological diversification; adaptive radiation, convergent and parallel evolution; dispersal and immigration; extinction.

Unit 7: Historical biogeography (06 Lectures)
Earth's history; paleo-records of diversity and diversification; continental drift and plate tectonics and their role in biogeographic patterns – past and present.

Unit 8: Ecological biogeography (06 Lectures)
Species' habitats; environment and niche concepts; biotic and abiotic determinants of communities; species-area relationships; concept of rarity and commonness; Island Biogeography theory; Equilibrium Theory of Insular Biogeography; geography of diversification and invasion; phylogeography.

Unit 9: Conservation biogeography (02 Lectures)
Application of biogeographical rules in design of protected area and biosphere reserves; use of remote sensing in conservational planning.

Practical: Marks: 15

A. Analysis of OTU.
B. Listing the procedure of typification.
C. Preparation of Phylogenetic tree from hypothetical data.

Suggested Readings
1. Lomolino, M.V., Riddle, B.R., Whittaker, R.J. & Brown, J.H. 2010. Biogeography (4th Edition). Sinauer Associates, Sunderland.
2. Mani, M.S. 1974. Ecology and Biogeography in India. Dr. W Junk Publishers. The Hague.
3. Singh, G. 2012. Plant Systematics: Theory and Practice (3rdedition). Oxford & IBH Pvt. Ltd., New Delhi.
4. Wheeler, Q.D. & Meier R. 2000. Species Concepts and Phylogenetic Theory: A Debate. Columbia University Press, New York.
5. Williams, D. M., Ebach, M.C. 2008. Foundations of Systematics and Biogeography. Springer.
6. Wilkins, J. S. 2009. Species: A History of the Idea (Vol. 1). University of California Press

SEMESTER-IV

Minor T-4

ECOLOGY AND ECOSYSTEM

(S/ENV/405/MN-4)

Total credit 04

COURSE OUTCOME (CO)

1. Students will gain a comprehensive understanding of ecological principles, ecosystem dynamics, and the relationships between organisms and their environments. Here are some common course outcomes for such a class.
2. Students will assess the impacts of human activities on ecosystems, including habitat destruction, pollution, climate change, and invasive species, and explore strategies for mitigating these impacts.
3. Students will study different types of ecosystems, both global (e.g., tropical rainforests, deserts) and local (e.g., wetlands, grasslands), and understand their specific characteristics and ecological processes.

Theory (50 Lectures): Marks: 25

Unit1: Introduction to ecology (05 Lectures)

Basic concepts and definitions: ecology, landscape, habitat, biosphere, ecosystems, autecology; synecology; major terrestrial biomes.

Unit 2: Ecology of individuals (08 Lectures)

Liebig's Law of the Minimum; Shelford's Law of Tolerance; ecotypes; ecoclines; acclimation; ecological niche; types of niche.

Unit 3: Ecology of populations (08 Lectures)

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

Unit 4: Ecology of communities (08 Lectures)

Community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; species interactions: mutualism, symbiotic relationships, commensalism, amensalism, protocooperation, predation, competition, parasitism, mimicry, herbivore; ecological succession: primary and secondary successions types of successions, climax community concepts.

Unit 5: Ecosystem ecology (08 Lectures)

Types of ecosystem: forest, grassland, lotic, marine, ecosystem structure and function; abiotic and biotic components of ecosystem; primary and secondary production; ecosystem connections: food chain, food web; models of energy flow; ecological efficiencies; ecological pyramids: pyramids of number, biomass, and energy.

Unit 6: Biogeochemical cycles and nutrient cycling (06 Lectures)

Carbon cycle; nitrogen cycle; hydrological cycle; nutrient cycle models; ecosystem input of nutrients; biotic accumulation; nutrient supply and uptake; role of mycorrhizae; decomposition and nutrient release; nutrient use efficiency; nutrient budget; nutrient conservation strategies.

Unit 7: Biological invasions (07 Lectures)

Concept of exotics and invasives; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities. .

Practical: Marks: 15

1. Identification with reasons of the following:

a) Study of microfauna of water viz., plankton, (e.g*.: Keratella, Cyclops, Cypris, Nauplius larva, Bosmina, Moina*).

b) Study of aquatic flora, e.g*.: Spirogyra, Zygnema, Pistia, Eichhornia, Hydrilla, Ipomoea, Azolla, Lemna* (minor and major), *Marselea, Nymphae, Nelumbo.*

2. Study of life tables and plotting of survivorship curves of different types from the hypothetical/real data provided.

Suggested Readings

1. Groom. B. & Jenkins. M. 2000.Global Biodiversity: Earth's Living Resources in the 21st Century. World Conservation Press, Cambridge, UK.
2. Gurevitch, J., Scheiner, S. M. & Fox, G. A. 2002. The Ecology of Plants. Sinauer associates incorporated.
3. Loreau, M.& Inchausti,P. 2002. Biodiversity and Ecosystem functioning: Synthesis and Perspectives. Oxford University Press, Oxford, UK.
4. Odum, E.P. 1971. Fundamentals of Ecology. W.B. Sounders.
5. Pandit, M.K., White, S.M.& Pocock, M.J.O. 2014. The contrasting effects of genome size, chromosome number and ploidy level on plant invasiveness: a global analysis. New Phytologist, 203: 697-703.
6. Pimentel, D. 2011. Biological invasions: Economic and environmental costs of alien plant, animal, and microbe species. CRC Press.
7. Singh, J.S., Singh, S.P. & Gupta, S.R. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications.
8. Wilson, E. O. 1985. The Biological Diversity Crisis. Bio Science, 35: 700-706

SEMESTER-V

Major T- 9

URBAN ECOSYSTEM
(S/ENV/ 501/MJC-9)

Total credit- 04

Course Outcome (CO)

1. To explain the principles of ecology in urban environments and how cities function as ecosystems.
2. To analyze the role of urban ecosystems in providing essential services such as air and water purification, temperature regulation, and biodiversity conservation.
3. To evaluate the relationship between human activities and natural systems in urban areas, including land use, pollution, and resource consumption.
4. To apply ecological principles to urban planning and design for sustainable cities, including green infrastructure, urban forests, and smart growth strategies.

Theory (50 Lectures): Marks: 25

Unit 1: Environment in an urban setting (10 Lectures)
Man as the driver of urban ecosystem; commodification of nature; metropolitan cities, resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; high rise buildings, increasing challenges posed by modernity for the environment; urban pollution (air, water and soil).

Unit 2: Urban dwelling (10 Lectures)
Housing scenario across a range of large-medium-small cities; poverty and slums in an urban context; Town planning Acts and their environmental aspects; energy consumption and waste disposal as well as accumulation; environmental costs of urban infrastructure.

Unit 3: Urban interface with the environment (10 Lectures)
Management of urban environment; alternative resources; policy and management decisions; urban settings as loci of sustainability; challenges associated with sustainability and urban future.

Unit 4: Natural spaces in a city (10 Lectures)
Concept of 'controlled nature'; scope, importance and threats to nature in the city; organization and planning of green spaces such as parks, gardens and public spaces; concept of green belts; urban natural forest ecosystem as green lungs.

Unit 5: Planning and environmental management (10 Lectures)
Urban planning and its environmental aspects from historical and contemporary perspectives; benefits of environmental management; introduction to green buildings; urban governance; political complexity of applying ecological science to urban policy and planning, smart-cities.

Practical: Marks: 15

Project File, containing the following reports is to be submitted
a) Urban Dwelling types- pucca or katcha house, room density.
b) Urban Water Supply.
c) Solid Waste Disposal system.
d) Urban Sanitation and hygiene.

Suggested Readings

1. D'Monte, Darryl. 1985. Temples or Tombs? Industry versus Environment. Three Controversies, Delhi, CSE.
2. Ernstson, H. 2011. Re-translating nature in post-apartheid Cape Town: The material semiotics of people and plants at Bottom Road. In: Heeks, R. (Ed.) Conference on "Understanding Development through Actor Network Theory", London School of Economics, 30 June, London.
3. Gaston, K.J. 2010. Urban Ecology. Cambridge University Press, New York.
4. Grimm, N. B., Faeth, S. H., et al. 2008. Global Change and the Ecology of Cities. Science, 319: 756-760.
5. Hinchliffe, S. & Whatmore, S. 2006. Living cities: Towards a politics of conviviality. Science as Culture 15: 123–138.
6. McIntyre, N.E. 2000. Urban ecology as an interdisciplinary field: differences in the use of 'urban' between the social and natural sciences. Urban Ecosystems, 4: 5-24.
7. Montgomery, M.R. 2009. Urban transformation of the developing world. Science, 319: 761-764.
8. Richter, M. & Weiland, U. (Ed.). 2012. Applied Urban Ecology. Wiley-Blackwell, UK.

SEMESTER-V

Major T- 10
ENVIRONMENTAL LEGISLATION AND POLICY
(S/ENV/502/MJC-10)

Total credit- 04

Course Outcome (CO)

1. To explain key national and international environmental laws, regulations, and policies governing environmental protection and management.
2. To analyze the role of government agencies, international organizations, and legal institutions in enforcing environmental laws and policies.
3. To evaluate policies related to air, water, soil, and noise pollution, including regulatory standards and compliance mechanisms.
4. To assess legal frameworks for biodiversity conservation, wildlife protection, and natural resource management.

Theory (50 Lectures): Marks: 25

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

Ancient period: Kautilya's Arthashastra, Yajnavalkya smriti and Charaksamhita; Medieval period: forests as woodland and hunting resources during Mughal reign; British India: Indian Penal Code 1860, Forest Act, 1865; Fisheries Act, 1897; Independent India: Van Mahotsava (1950), National Forest Policy, 1952; Ganga Action Plan.

Unit 2: Environmental legislation (06 Lectures)

Constitution of India; fundamental rights; fundamental duties; Legal definitions (environmental pollution, natural resource, biodiversity, forest, sustainable development); Article 48A; Article 51 A.

Unit 3: Legislative Instruments (12 Lectures)

Basic Principle of-The Indian Forest Act, 1927; The Wildlife (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; The Forests (Conservation) Act, 1980; The Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; Motor Vehicle Act, 1988; The Public Liability Insurance Act, 1991; Noise Pollution (Regulation and Control) Rules, 2000; The Biological Diversity Act, 2002; The National Green Tribunal Act,2010.

Unit 4: Government institutions (06 Lectures)
Role of Ministry of Environment, Forests and Climate Change in environmental law and policy making; role of central and state pollution control boards in environmental law and policy making.

Unit 5: Case studies (06 Lectures)
National Green Tribunal: Aditya N Prasad vs. Union of India & Others; Ganga Tanneries Case: M.C. Mehta vs. Union of India 1988; Environmental Education Case: M.C. Mehta vs. Union of India, WP 860/1991.

Unit 6: International laws and policy (10 Lectures)
Stockholm Conference (1972); United Nations Conference on Environment and Development (1992); Rio de Janeiro (Rio Declaration, Agenda 21); Copenhagen and Paris summits; Ramsar convention. Eco-politics.

Practical: Marks: 15

Submit a project report on case study based.

National Green Tribunal: Aditya N Prasad vs. Union of India & Others.
Or
Environmental Education Case: M.C. Mehta vs. Union of India,

Suggested Readings

1. Abraham, C.M. 1999. Environmental Jurisprudence in India. Kluwer Law International.
2. Agarwal, V.K. 2005. Environmental Laws in India: Challenges for Enforcement. Bulletin of the National Institute of Ecology 15:227-238.
3. Divan, S. & Rosencranz, A. 2001. Environmental Law and Policy in India. Oxford University Press.
4. Divan, S. & Rosencranz, A. 2002. Environmental Law and Policy in India: Cases, Materials and Statues (2ndedition). Oxford University Press.
5. Gupta, K.R. 2006. Environmental Legislation in India. Atlantic Publishers and Distributors.
6. Leelakrishnan, P. 2008. Environmental Law in India (3rd edition). Lexis Nexis India.
7. Naseem, M. 2011. Environmental Law in India Mohammad. Kluwer Law International.
8. Venkat, A. 2011. Environmental Law and Policy. PHI Learning Private Ltd.
9. Sharma, P.D. 2016. Ecology and Environment. 13th Revised & Updated Edition, Rastogi Publication

SEMESTER-V

DSE- T-1
ENERGY AND ENVIRONMENT
(S/ENV/503/DSE-1)

Total credit- 04
Course Outcome (CO)

1. To explain various energy sources, including renewable (solar, wind, hydro, biomass) and non-renewable (fossil fuels, nuclear), and their environmental implications.
2. To analyze the environmental consequences of energy generation, such as air pollution, greenhouse gas emissions, and resource depletion.

3. To evaluate alternative and clean energy technologies for sustainable development and climate change mitigation.
4. To understand strategies for energy conservation, demand-side management, and efficiency improvements in various sectors (industrial, transportation, residential).

Theory (50 Lectures): Marks: 25

Unit 1: Energy resources (08 Lectures)
Defining energy; forms and importance; Global energy resources; renewable and non-renewable resources: distribution and availability; energy-use scenarios in rural and urban setups; energy over-consumption and conservation.

Unit 2: Energy demand (10 Lectures)
Global energy demand: historical and current perspective; energy demand and use in domestic, industrial, agriculture and transportation sector; generation and utilization in rural and urban environments; changes in demand in major world economies; energy subsidies and environmental costs.

Unit 3: Energy, environment and society (10 Lectures)
Nature, scope and analysis of local and global impacts of energy use on the environment; fossil fuel burning and related issues of air pollution, greenhouse effect, global warming and, urban heat island effect; nuclear energy and related issues such as radioactive waste, spent fuel; social inequalities related to energy production, distribution, and use.

Unit 4: Energy, ecology and the environment (08 Lectures)
Energy production, transformation and utilization associated environmental impacts (Chernobyl and Fukushima nuclear accidents, construction of dams, environmental pollution); energy over-consumption and its impact on the environment, economy, and global change.

Unit 5: Politics of energy policy (06 Lectures)
Political choices in energy policy: global and Indian context (historical and contemporary case studies); domestic and international energy policy; energy diplomacy and bilateral ties of India with her neighbors.

Unit 6: Future of energy (08 Lectures)
Current and future energy use patterns in the world and in India; evolution of energy use over time; alternative sources as green energy (solar energy, wind energy, geothermal energy; ocean energy, biofuels and nuclear energy); need for energy efficiency; energy conservation and sustainability; Strategies for sustainable energy mix and management.

Practical: Marks: 15

Submit a project report on energy audit of a domestic unit or an office.

[The student needs to analyze energy consumption to identify areas of inefficiency followed by recommendations for improvement (including energy-saving measures) and potential cost savings.]

Suggested Readings
1. McKibben, B. 2012. Global Warming's Terrifying New Math, Rolling Stone Magazine.
2. Craig. J.R., Vaughan, D.J. & Skinner. B.J. 1996. Resources of the Earth: Origin, use, and environmental impact (2ndedition). Prentice Hall, New Jersey.
3. Elliott, D. 1997. Sustainable Technology. Energy, Society and Environment (Chapter 3). New York, Routledge Press.

4. Rowlands, I.H. 2009. Renewable Electricity: The Prospects for Innovation and Integration in Provincial Policies in Debora L. Van Nijnatten and Robert Boardman (Eds), Canadian Environmental Policy and Politics: Prospects for Leadership and Innovation, Third Edition. Oxford University Press, pp.167-82.
5. Oliver, J. 2013. Dispelling the Myths about Canada's Energy Future, Policy: Canadian Politics and Public Policy, June-July.
6. Mallon, K. 2006. Myths, Pitfalls and Oversights, Renewable Energy Policy and Politics: A Handbook for Decision-Making. Earth Scan

SEMESTER-V

DSE- T-2
ENVIRONMENTAL ECONOMICS
(S/ENV/504/DSE-2)

Total credit- 04

Course outcome (CO)

1. To explain fundamental economic concepts and their application to environmental issues, including market failures and externalities.
2. To evaluate economic instruments for environmental management, such as carbon pricing, pollution taxes, and tradable permits.
3. To analyze the balance between economic growth and environmental sustainability through green economy strategies and circular economy models.
4. To evaluate the relationship between economic development and environmental degradation, considering industrialization, urbanization, and globalization.

Theory (50 Lectures): Marks: 25

Unit1: Introduction to micro-economics (10 Lectures)

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

Unit 2: Environmental economics (10 Lectures)

Characteristics of environmental goods; marginal analysis; markets and market failure; social benefit, costs and welfare functions; meaning and types of environmental values; measures of economic values; tangible and intangible benefits; Hardin's Thesis of 'The Tragedy of Commons' Externalities; social cost benefit analysis; cost-effectiveness analysis.

Unit 3: Economic solutions to environmental problems (15 Lectures)

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

Unit 4: Natural resource economics (05 Lectures)

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

Unit 5: Tools for environmental economic policy (10 Lectures)

Growth and environment; environmental audit and accounting, Environmental Kuznet's Curve (EKC), environmental risk analysis, comparison of environmental benefits and costs.

Practical: Full Marks: 15

Submit a project report on environmental economics.

[The student needs to analyze how economic principles are applied to address environmental issues.The report should consider the cost-benefit analysis and role of sustainability in environmental decision-making.]

Suggested Readings

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

SEMESTER-V

Minor- T-5

URBAN ECOSYSTEMS

(S/ENV/ 505/MN-5)

Total credit: 04

Course Outcome (CO):

1. To explain the principles of ecology in urban environments and how cities function as ecosystems.
2. To analyze the role of urban ecosystems in providing essential services such as air and water purification, temperature regulation, and biodiversity conservation.
3. To evaluate the relationship between human activities and natural systems in urban areas, including land use, pollution, and resource consumption.
4. To apply ecological principles to urban planning and design for sustainable cities, including green infrastructure, urban forests, and smart growth strategies.

Theory (50 Lectures): Marks: 25

Unit 1: Environment in an urban setting (10 Lectures)

Man as the driver of urban ecosystem; commodification of nature; metropolitan cities. resource consumption and its social, cultural, economic and ecological perspectives; urban transformation; High -rise buildings, increasing challenges posed by modernity on the environment; urban pollution (air, water, soil).

Unit 2: Urban dwelling (10 Lectures)

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

Unit 3: Urban interface with the environment (10 Lectures)

Management of urban environment; alternative resources; policy and management decisions; urban settings as loci

of sustainability; challenges associated with sustainability and urban future.

Unit 4: Natural spaces in a city (10 Lectures)
Concept of 'controlled nature'; scope, importance and threats to nature in the city; organization and planning of green spaces such as parks, gardens and public spaces; concept of green belts; urban natural forest ecosystem as green lungs.

Unit 5: Planning and environmental management (10 Lectures)
Urban planning and its environmental aspects from historical and contemporary perspectives; benefits of environmental management; introduction to green buildings; urban governance; political complexity of applying ecological science to urban policy and planning, smart-cities.

Practical: Marks: 15

Project File, containing the following reports is to be submitted
a) Urban Dwelling types- pucca or katcha house.
b) Urban Water Supply or Solid Waste Disposal system or Urban Sanitation and hygiene.

Suggested Readings
1. D'Monte, Darryl. 1985. Industry versus Environment Temples or Tombs. Three Controversies, Delhi, CSE.
2. Ernstson, H. 2011. Re-translating nature in post-apartheid Cape Town: The material semiotics of people and plants at Bottom Road. In: Heeks, R. (Ed.) Conference on "Understanding Development through Actor Network Theory", London School of Economics, 30 June, London.
3. Gaston, K.J. 2010. Urban Ecology. Cambridge University Press, New York.
4. Grimm, N. B., Faeth, S. H., et al. 2008. Global Change and the Ecology of Cities. Science, 319: 756-760.
5. Hinchliffe, S. & Whatmore, S. 2006. Living cities: Towards a politics of conviviality. Science as Culture, 15: 123–138.
6. McIntyre, N.E. 2000. Urban ecology as an interdisciplinary field: differences in the use of 'urban' between the social and natural sciences. Urban Ecosystems, 4: 5-24.
7. Montgomery, M.R. 2009. Urban Transformation of the developing world. Science, 319: 761-764.
8. Richter, M. & Weiland, U. (Ed.). 2012. Applied Urban Ecology. Wiley-Blackwell, UK.

SEMESTER-VI

Major- T- 11
BIODIVERSITY AND CONSERVATION
(S/ENV/ 601/MJC-11)

Total credit- 04
Course Outcome (CO):

1. To explain the concept of biodiversity, including genetic, species, and ecosystem diversity.
2. To describe the ecological, economic, and social values of biodiversity in maintaining ecosystem balance.
3. To identify major threats such as habitat destruction, climate change, invasive species, pollution, and overexploitation.
4. To describe the ecological, economic, and social values of biodiversity in maintaining ecosystem balance.

Theory (50 Lectures): Marks: 25
Unit 1: Levels of organization in living world (03 Lectures)

Organic evolution through geographic time scale; species concept and types of speciation.

Unit 2: Biodiversity patterns (04 Lectures)
Spatial patterns: latitudinal and elevational trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns; importance of biodiversity patterns in conservation.

Unit 3: Biodiversity assessment (06 Lectures)
Sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity index, biomass estimation; community diversity estimation: alpha, beta and gamma diversity.

Unit 4: Importance of biodiversity (09 Lectures)
Economic values – medicinal plants, drugs, fisheries and livelihoods; ecological services – primary productivity, role in hydrological cycle, biogeochemical cycling; ecosystem services – purification of water and air, nutrient cycling, climate control, pest control, pollination, and formation and protection of soil; social, aesthetic, consumptive, and ethical values of biodiversity.

Unit 5: Threats to biodiversity (08 Lectures)
Natural and anthropogenic disturbances; habitat loss, habitat degradation, and habitat fragmentation; climate change; pollution; hunting; over-exploitation; deforestation; hydropower development; invasive species; land use changes; overgrazing; consequences of biodiversity loss; Intermediate Disturbance Hypothesis.

Unit 6: Conservation of biodiversity (12 Lectures)
In-situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries); Ex-situ conservation (botanical gardens, zoological gardens, gene banks, seed and seedling banks and pollen culture), role of local communities and traditional knowledge in conservation; People's Biodiversity Register (PBR), biodiversity hotspots; IUCN Red List categorization; Red Data Book; ecological restoration; social forestry; agro forestry; joint forest management; role of remote sensing in management of natural resources.

Unit 7: Biodiversity in India (08 Lectures)
India as a mega diversity nation; phytogeographic and zoogeographic zones of the country; forest types and forest cover in India; National Biodiversity Action Plan.

Practical: Marks: 15

A. Determination of population density in a natural or hypothetical community by quadrate method and calculation of Shanon-Weiner diversity index for community study.
B. Analysis of frequency distribution of plants by quadrate method.

Suggested Readings

1. Gaston, K J. & Spicer, J.I. 1998. Biodiversity: An Introduction. Blackwell Science, London, UK.
2. Krishnamurthy, K.V. 2004. An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
3. Pandit, M.K. & Grumbine R.E. 2012. Ongoing and proposed hydropower development in the Himalaya and its impact on terrestrial biodiversity. Conservation Biology, 26: 1061-1071.
4. Primack, R.B. 2002. Essentials of Conservation Biology (3rd Edition). Sinauer Associates, Sunderland, USA.
5. Singh, J. S. & Singh, S. P. 1987. Forest vegetation of the Himalaya. The Botanical Review, 53: 80-192.
6. Singh, J. S., Singh, S.P. & Gupta, S. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
7. Sodhi, N.S. & Ehrlich, P.R. (Eds). 2010. Conservation Biology for All. Oxford University Press.
8. Sodhi, N.S., Gibson, L. & Raven, P.H. 2013.Conservation Biology: Voices from the Tropics. Wiley-Blackwell, Oxford, UK. ISBN: 978-0-470-65863-5
9. Asthana, D.K. & Asthana M. 2012. Text book of Environmental Studies. 2nd Edition, S. Chand Publication.
10. Singh, H.R. 2004. Environmental Biology. S. Chand Publication. ISBN : 9788121924764

SEMESTER-VI

Major- T- 12

ORGANISMAL AND EVOLUTIONARY BIOLOGY

(S/ENV/ 602/MJC-12)

Total credit- 04

Course Outcome (CO):

1. To explain the structure, function, and physiological adaptations of organisms across different biological kingdoms.
2. To understand and apply key concepts of evolution, including natural selection, genetic drift, gene flow, and speciation.
3. To analyze ecological relationships (Like- predation, mutualism, competition) and their role in organismal survival and evolution.
4. To explain human evolution, including genetic and cultural aspects, and assess human influence on evolutionary processes.

Theory (50 Lectures): Marks: 25

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

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

Unit 2: Theory of Evolution (16 Lectures)

Lamarck's concept of evolution; Darwin's evolutionary theory: variation, adaptation, struggle, fitness and natural selection; Mendelism; spurious mutations; Modern Synthetic Theory of Evolution. Geography of evolution: Bio-geographic evidence of evolution; patterns of distribution; historical factors affecting geographic distribution; evolution of geographic patterns of diversity. Molecular evolution: Neutral evolution; molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.

Unit 3: Evolution of unicellular life (12 Lectures)

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

Unit 4: Fundamentals of population genetics (12 Lectures)

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

Practical: Marks: 15; Credit: 02

A) Study of homology and analogy from suitable specimens.
B) Study of verification of Hardy-Weinberg Law by Chi-Square analysis.

Suggested Readings

1. Futuyma, D.J. 2009. Evolution (2nd Edition). Sinauer Associates.
2. Gillespie, J. H. 1991. The Causes of Molecular Evolution. Oxford University Press.
3. Graur, D. & Li, W.H. 1999. Fundamentals of Molecular Evolution (2nd Edition). Sinauer Associates.
4. Kimura, M. 1984. The Neutral Theory of Molecular Evolution. Cambridge University Press.
5. Minkoff, E.C. 1983. Evolutionary Biology. Addison Wesley. Publishing Company.

6. Nei, M. & Kumar, S. 2000. Molecular Evolution and Phylogenetics. Oxford University Press.
7. Nei, M. 1975. Molecular Population Genetics and Evolution. North-Holland Publishing Company.
8. Nei, M. 1987. Molecular Evolutionary Genetics. Columbia university press.
9. Thorne, J. L., Kishino, H., & Painter, I. S. 1998. Estimating the rate of evolution of the rate of molecular evolution. Molecular Biology and Evolution, 15: 1647-1657.

SEMESTER-VI

DSE- T-3

NATURAL HAZARDS AND DISASTER MANAGEMENT

(S/ENV/ 603/DSE-3)

Total credit- 04

Course Outcome (CO):

1. To identify and classify various natural hazards such as earthquakes, floods, hurricanes, tsunamis, landslides, and wildfires
2. To analyze the factors contributing to disaster risk, including vulnerability, exposure, and resilience of communities.
3. To assess the role of local communities, NGOs, and government agencies in disaster management and preparedness.
4. To explain disaster mitigation strategies, including early warning systems, structural and non-structural measures, and land-use planning.

Theory (50 Lectures): Marks: 25

Unit 1: Hazards, risks and vulnerability (05 Lectures)

Definition of hazard; context hazards; concept of risk and vulnerability; reasons of vulnerability – rapid population growth, urban expansion, environmental pollution, epidemics, industrial accidents, inadequate government policies**.**

Unit 2: Natural hazards (10 Lectures)

Natural hazards: hydrological, atmospheric and geological hazards; earthquake: seismic waves, epicenter; volcanoes: causes of volcanism, geographic distribution; Floods: types and nature, frequency of flooding; landslides: causes and types of landslides, landslide analysis; Drought: types of drought - meteorological, agricultural, hydrological, and famine; Glacial Lake Outburst Floods (GLOF); tornadoes, cyclones; tsunamis: causes and location of tsunamis; coastal erosion, sea level changes and its impact on coastal areas and coastal zone management.

Unit 3: Anthropogenic hazards (10 Lectures)

Impacts of anthropogenic activities: urbanization, ground water extraction, sand mining, deforestation, mangroves destruction; improper construction of river banks. Deforestation and landslide; Large scale developmental projects like dams and nuclear reactors in hazard prone zones; nature and impact of accidents, wildfires and biophysical hazards. Case studies of Bhopal, Minamata and Chernobyl disaster.

Unit 4: Risk and vulnerability assessment (05 lectures)

Components of risk: quantitative likelihood and consequences, qualitative likelihood measurement index; categories of consequences (direct losses, indirect losses, tangible losses, and intangible losses); application of geo-informatics in hazard, risk and vulnerability assessment.

Unit 5: Mitigation and preparedness (10 Lectures)

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

Unit 6: Disaster management in India (10 Lectures)

Lessons from the past considering the examples of Bhuj earthquake, Tsunami disaster, and Bhopal tragedy; National Disaster Management Framework, National response mechanism, role of government bodies such as NDMC and IMD; role of armed forces and media in disaster management; role of space technology in disaster management.

Practical: Marks: 15

A. Project File, comprising one exercise each is to be submitted
1. Construction of Hydrograph, Unit Hydrograph, Rating Curve
2. Risk and Vulnerability Analysis of any hazard
3. Vulnerability Mapping

Suggested Readings

1. Coppola D. P. 2007. Introduction to International Disaster Management. Butterworth Heinemann.
2. Cutter, S.L. 2012. Hazards Vulnerability and Environmental Justice. EarthScan, Routledge Press.
3. Keller, E.A. 1996. Introduction to Environmental Geology. Prentice Hall, Upper Saddle River, New Jersey.
4. Pine, J.C. 2009. Natural Hazards Analysis: Reducing the Impact of Disasters. CRC Press,Taylor and Francis Group.
5. Schneid, T.D. & Collins, L. 2001. Disaster Management and Preparedness. Lewis Publishers, New York, NY.
6. Smith, K. 2001. Environmental Hazards: Assessing Risk and Reducing Disaster. Routledge Press.
7. Wallace, J.M. & Hobbs, P.V. 1977. Atmospheric Science: An Introductory Survey. Academic Press, New York.
8. Wasson, R.J., Sundriyal, Y.P., Chaudhary, S., Jaiswal, M.K., Morthekai, P., Sati, S.P. & Juyal, N. 2013. A 1000-year history of large floods in the upper Ganga catchment, central Himalaya, India. Quaternary Science Reviews, 77: 156–166.

SEMESTER-VI

DSE- T-4

SOLID WASTE MANAGEMENT

(S/ENV/604/DSE-4)

Total credit- 04

Course Outcome (CO):

1. To explain the types, sources, and composition of solid waste and their impact on human health and the environment.
2. To understand various methods of waste collection, segregation, and transportation systems for efficient waste handling.
3. To assess the environmental and health risks associated with improper solid waste disposal and management.
4. To analyze different techniques of waste treatment, including composting, recycling, incineration, and landfill management.

Theory (50 Lectures): Marks: 25

Unit 1: Solid waste, types and characterization (03 Lectures)

Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste.

Unit 2: Effect of solid waste disposal on environment (06 Lectures)

Impact of solid waste on environment, human and plant health; effect of solid waste and industrial effluent discharge on water quality and aquatic life; mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution.

Unit 3: Solid waste management (08 Lectures)
Collection, storage, transportation and disposal of solid wastes (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; disadvantages in waste management techniques.

Unit 4: Industrial waste management (10 Lectures)
Types of industrial waste: hazardous and non-hazardous; effect of industrial waste on air, water and soil; industrial waste management and its importance; stack emission control and emission monitoring; effluent treatment plant and sewage treatment plant. Integrated waste management: Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated Waste Management.

Unit 5: Resource recovery (12 Lectures)
4R- reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation; mechanical biological treatment; green techniques for waste treatment. Waste- to- energy **:** Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification.

Unit 6: Life cycle assessment (LCA) (05 Lectures)
Cradle to grave approach; lifecycle inventory of solid waste; role of LCA in waste management; advantage and limitation of LCA; case study on LCA of a product.

Unit 7: Policies for solid waste management (06 Lectures)
Municipal Solid Wastes (Management and Handling) Rules 2000; Hazardous Wastes Management and Handling Rules 1989;The Plastic Waste Management Rules,2016;The e-Waste (Management) Rules, 2016; Bio-Medical Waste (Management and Handling) Rules 1998; Ecofriendly or green products.

Practical:Marks: 15

A) A study of local resources and types of industrial waste.
B) Demonstration of compositing technique.

Suggested Readings
1. Asnani, P. U. 2006. Solid waste management. India Infrastructure Report 570.
2. Bagchi, A. 2004. Design of Landfills and Integrated Solid Waste Management. John Wiley & Sons.
3. Blackman, W.C. 2001. Basic Hazardous Waste Management. CRC Press.
4. McDougall, F. R., White, P. R., Franke, M. & Hindle, P. 2008. Integrated Solid Waste Management: A Life Cycle Inventory. John Wiley & Sons.
5. US EPA. 1999. Guide for Industrial Waste Management. Washington D.C.
6. White, P.R., Franke, M. & Hindle P. 1995. Integrated Solid waste Management: A Lifecycle Inventory. Blackie Academic & Professionals.
7. Zhu, D., Asnani, P.U., Zurbrugg, C., Anapolsky, S. & Mani, S. 2008. ImprovingMunicipal Solid Waste Management in India. The World Bank, Washington D.C.

SEMESTER-VI

Minor- T-6
BIODIVERSITY AND CONSERVATION
(S/ENV/605/MN-6)

Total credit: 04

Course Outcome (CO):

1. To explain the concept of biodiversity, including genetic, species, and ecosystem diversity.
2. To describe the ecological, economic, and social values of biodiversity in maintaining ecosystem balance.
3. To identify major threats such as habitat destruction, climate change, invasive species, pollution, and overexploitation.
4. To describe the ecological, economic, and social values of biodiversity in maintaining ecosystem balance.

Theory (50 Lectures): Marks: 25

Unit 1: Levels of organization in living world (03 Lectures)

Organic evolution through geographic time scale; species concept and types of speciation.

Unit 2: Biodiversity patterns (04 Lectures)

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

Unit 3: Biodiversity estimation (06 Lectures)

Sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity index, biomass estimation; community diversity estimation: alpha, beta and gamma diversity.

Unit 4: Importance of biodiversity (09 Lectures)

Economic values – medicinal plants, drugs, fisheries and livelihoods; ecological services – primary productivity, role in hydrological cycle, biogeochemical cycling; ecosystem services – purification of water and air, nutrient cycling, climate control, pest control, pollination, and formation and protection of soil; social, aesthetic, consumptive, and ethical values of biodiversity.

Unit 5: Threats to biodiversity (08 Lectures)

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

Unit 6: Conservation of biodiversity (12 Lectures)

In-situ conservation (Biosphere Reserves, National Parks, Wildlife Sanctuaries); Ex-situ conservation (botanical gardens, zoological gardens, gene banks, seed and seedling banks and pollen culture), role of local communities and traditional knowledge in conservation; biodiversity hotspots; IUCN Red List categorization; Red Data book; ecological restoration; social forestry; agro forestry; joint forest management; role of remote sensing in management of natural resources.

Unit 7: Biodiversity in India (08 Lectures)

India as a mega diversity nation; phytogeographic and zoogeographic zones of the country; forest types and forest cover in India; National Biodiversity Action Plan.

Practical: Marks: 15

A. Determination of population density in a natural or hypothetical community by quadrate method and calculation of Shanon-Weiner diversity index for community Study.
B. Analysis of frequency distribution of plants by quadrate method.

Suggested Readings

1. Gaston, K. J. & Spicer, J.I. 1998. Biodiversity: An Introduction. Blackwell Science, London, UK.
2. Krishnamurthy, K.V. 2004. An Advanced Text Book of Biodiversity - Principles and Practices. Oxford and IBH Publications Co. Pvt. Ltd. New Delhi.
3. Pandit, M.K. & Grumbine R.E. 2012. Ongoing and proposed hydropower development in the Himalaya and its

impact on terrestrial biodiversity. Conservation Biology, 26: 1061-1071.
4. Primack, R.B. 2002. Essentials of Conservation Biology (3rd Edition). Sinauer Associates, Sunderland, USA.
5. Singh, J. S. & Singh, S. P. 1987. Forest vegetation of the Himalaya. The Botanical Review, 53: 80-192.
6. Singh, J. S., Singh, S.P. & Gupta, S. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
7. Sodhi, N.S. & Ehrlich, P.R. (Eds). 2010. Conservation Biology for All. Oxford University Press.
8. Sodhi, N.S., Gibson, L. & Raven, P.H. 2013.Conservation Biology: Voices from the Tropics. Wiley-Blackwell, Oxford, UK. ISBN: 978-0-470-65863-5
9. Asthana, D.K. & Asthana M. 2012. Text book of Environmental Studies. 2nd Edition, S. Chand Publication.
- 10. Singh, H.R. 2004. Environmental Biology. S. Chand Publication. ISBN : 9788121924764