BANKURA UNIVERSITY

(West Bengal Act XIX of 2013- Bankura University Act, 2013)

Main Campus, Bankura Block-II, P.O.: Purandarpur, Dist.: Bankura, Pin- 722155, West Bengal

Office of the Secretary

Faculty Council for Undergraduate Studies

Ref: BKU/FCUG/174/2025 Date: 01/07/2025

NOTIFICATION

As directed, the undersigned is pleased to inform all concerned that Bankura University has initiated the process to implement New Curriculum and Credit Framework for Undergraduate Programme, UGC 2022 (as per NEP 2020) for 4-years Undergraduate programme with Environmental Science as Major, Minor etc. from the academic session 2023-2024. The syllabus as framed / drafted and partially implemented deserves to be analysed after receiving feedback from different stakeholders. As an important corollary to the process, a workshop will be organized on the date mentioned herewith to get the feedback from the stakeholders. Present Students, Alumni, Guardians, Academicians and other stakeholders related to the specific programme/course are requested for their kind participation in the workshop and to present their views/ observations, etc. The stakeholders may go through the draft syllabus attached herewith and convey their observations to the office of the undersigned on ugsecretaryoffice@bankurauniv.ac.in within seven days from the date of publication of this notice.

Date: 7th July, 2025

Time: 12 noon

Sd/-
Dr. Arindam Chakraborty
Secretary
Faculty Council for Undergraduate Studies

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 2024-25

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)**
PO1	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.
PO2	To know about different types of professionals in the field of Environmental Science and related subfields.
PO3	To address the environment related issues and challenges for the protection and conservation of available natural resources and environment.
PO4	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.
PO5	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.
PO6	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.

PO7	To identify and appreciate the importance of the Environmental Science and its application in academic, industrial, economic, and social context
PO8	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
PSO1	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.
PSO2	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.
PSO3	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.
PSO4	The course includes training for capacity building, to offer professional and job oriented course curricula, to strengthen R&D activities and extension activities.

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	4	10	25	50	3	NA	
	Biodiversity and Conservation (Practical)			15				2
S/ENV/ 602/MJC-12	Organismal and Evolutionary Biology	4	10	25	50	3	NA	
	Organismal and Evolutionary Biology (Practical)			15				2
S/ENV/ 603/DSE-3	Natural hazards and disaster management	4	10	25	50	3	NA	
	Natural hazards and disaster management (Practical)			15				2
S/ENV/ 604/DSE-4	Solid waste Management	4	10	25	50	3	NA	
	Solid waste Management (Practical)			15				2
S/ENV/ 605/MN-6	Biodiversity and conservation	4	**10**	25	**50**	**3**	**NA**	
	Biodiversity and Conservation (Practical)			**15**				**2**
Total in Semester – VI		**20**	**50**	**200**	**250**	**15***		**10**
TOTAL IN THIRD YEAR		**42**	**110**	**440**	**550**			

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; metros, 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, roomdensity.
b) Urban Water Supply.
c) Solid Waste Disposal system.
d) 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 ActorNetwork 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.

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. P.D.Sharma.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 (biofuels, wind energy, solar energy, geothermal energy; ocean energy 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.

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 microeconomics (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.

Suggested Readings

1. Arrow, K., Bolin, B., Costanza, R., Dasgupta, P., Folke, C., Holling, C.S., Jansson, B.O., Levin, S., Maler, K.G., Perrings, C., Pimentel, D. 1995. Economic growth, carrying capacity, and the environment. Ecological Economics 15:91-95.2. Hanley, N., Shogren, J. F., & White, B. 2007. Environmental Economics: In Theory and Practice. Palgrave Macmillan.
3. Kolstad, C.D. 2010. Environmental Economics. Oxford University Press.
4. Perman, R. 2003. Natural Resource and Environmental Economics. Pearson Education.
5. Singh, K. & Shishodia, A. 2007. Environmental Economics: Theory and Applications. Sage Publications.
6. Thomas, J.M. &Callan, S.J. 2007.Environmental Economics. Thomson LearningInc.
7. Tietenberg, T. 2004. Environmental and Natural Resource Economics (6thEdition). Pearson Education Pvt. Ltd.
8. Tietenberg, T. H. & Lewis, L. 2010. Environmental Economics and Policy. Addison-Wesley.

9. Turner, R. K., Pearce, D., & Bateman, I. 1994. Environmental Economics: An Elementary Introduction. Harvester 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; metros, . 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, 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 (10Lectures)

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 ActorNetwork 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 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 Biology26:1061-1071. 4. Primack, R.B. 2002. Essentials of Conservation Biology (3rdedition). Sinauer Associates, Sunderland, USA.
5. Singh, J. S. & Singh, S. P. 1987. Forest vegetation of the Himalaya. The Botanical Review 53:80-192.
6. Singh, J. S., Singh, S.P. & Gupta, S. 2006. Ecology, Environment and Resource Conservation. Anamaya Publications, New Delhi.
7. Sodhi, N.S. & Ehrlich, P.R. (Eds). 2010. Conservation Biology for All. Oxford University Press.
8. Sodhi,N.S.,Gibson,L.&Raven,P.H.2013.ConservationBiology:VoicesfromtheTropi cs. Wiley-Blackwell, Oxford, UK.
9. D.K.Asthana: Text book of Environmental Studies. S. Chand Publication. 10. H.R.Singh: Environmental Biology. S. Chand Publication.

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 (e.g., 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; The Evolutionary Synthesis.
Geography of evolution: Biogeographic 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; study of Miller; 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; 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* (2ndedition). SinauerAssociates.
2. Gillespie, J. H. 1991. *The Causes of Molecular Evolution*. Oxford University Press.
3. Graur, D. & Li, W.H. 1999. *Fundamentals of Molecular Evolution* (2ndedition). Sinauer Associates.
4. Kimura, M. 1984. *The Neutral Theory of Molecular Evolution*. Cambridge University Press.
5. Minkoff, E.C. 1983. *Evolutionary Biology*. Addison Wesley. Publishing Company.
6. Nei, M. & Kumar, S. 2000. *Molecular Evolution and Phylogenetics*. Oxford University Press.
7. Nei, M. 1975. *Molecular Population Genetics and Evolution*. North-Holland Publishing Company.
8. Nei, M. 1987. *Molecular Evolutionary Genetics*. Columbia university press.
9. Thorne, J. L., Kishino, H., & Painter, I. S. 1998. Estimating the rate of evolution of the rate of molecular evolution. *Molecular Biology and Evolution* **15**: 1647-1657.

SEMESTER-VI

DSE- T-3

NATURAL HAZARDS AND DISASTER MANAGENT

(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 geoinformatics 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

a. Construction of Hydrograph, Unit Hydrograph, Rating Curve

b. Risk and Vulnerability Analysis of any hazard

c. 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; 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. WashingtonD.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 Biology26:1061-1071. 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.ConservationBiology:VoicesfromtheTropi cs. Wiley-Blackwell, Oxford, UK.
9. D.K.Asthana: Text book of Environmental Studies. S. Chand Publication. 10. H.R.Singh: Environmental Biology. S. Chand Publication.