A.C.-15.04.2026
Appendix-80

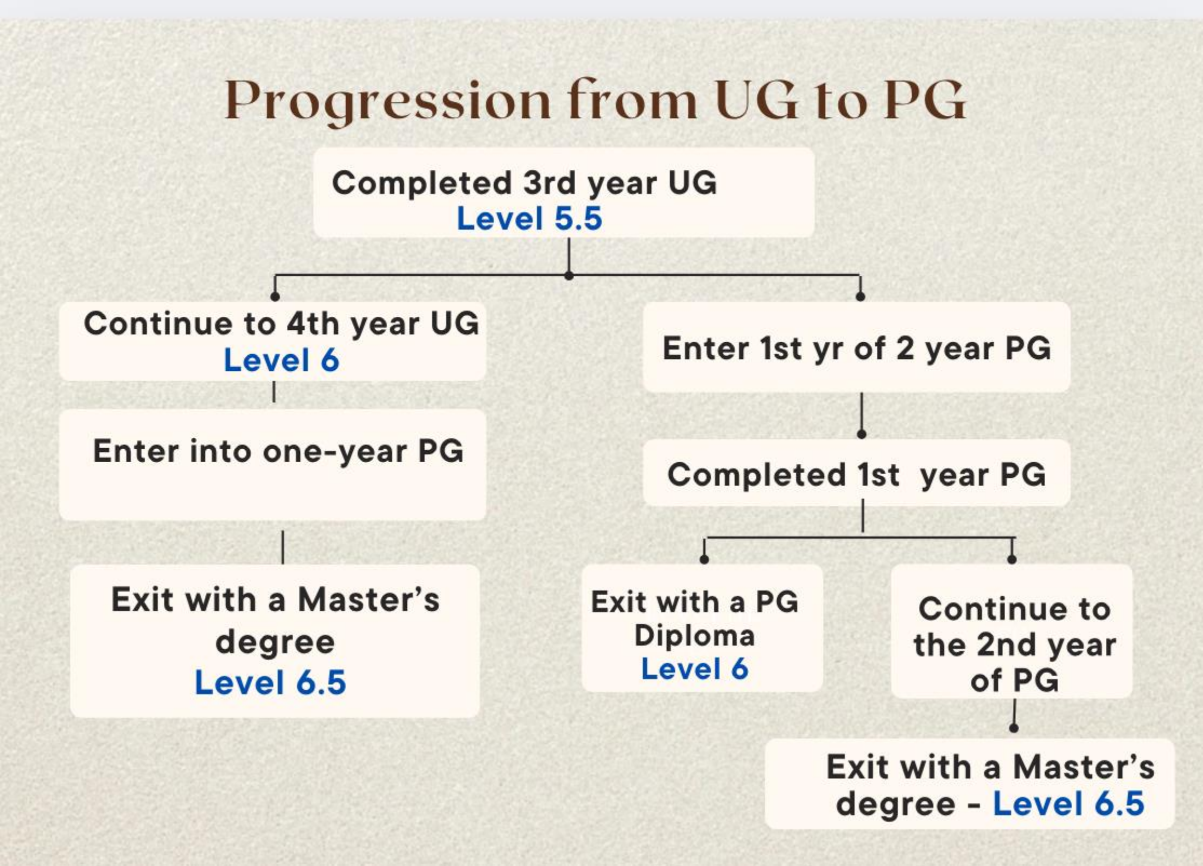
UNIVERSITY OF DELHI

MASTER OF SCIENCE/ MASTER OF ARTS
BY
THE DEPARTMENT OF ENVIRONMENTAL STUDIES

(Effective from academic Year 2025 – 2026)

Syllabus for Semester III and IV as per PG Curricular Framework 2024 (PGCF-2024) based on NEP-2020 considered by Academic Council and approved by Executive Council

PG Curricular Framework 2024 based on NEP 2020



Programme of Study and the corresponding qualification levels

First year UG programme – Level 4.5

Second Year UG Programme – Level 5

Third Year UG Programme – Level 5.5

Fourth Year UG Programme – Level 6

First year of Two Year PG Programme – Level 6

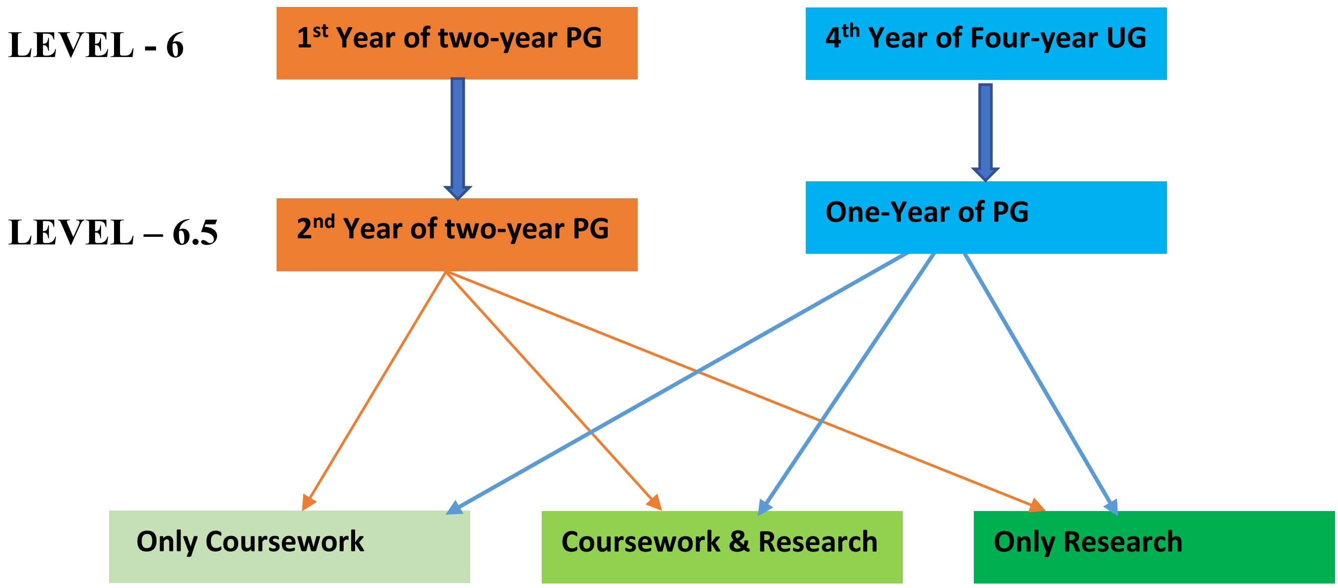
Second Year of Two Year PG Programme – Level 6.5

One year of PG Programme after 4 Year UG – Level 6.5

First year of Two Year PG Programme after 4 Year UG – Level 6.5

Second year of Two Year PG Programme after 4 Year UG – Level 7

Postgraduate Curricular Framework 2024 (based on NEP 2020)



1st Year of PG curricular structure for 2 year PG Programmes (3+2)

Semester	DSC	DSE	2 Credit course	Dissertation/ Academic Project/ Entrepreneurship	Total Credits
Semester- I	**DSC-1** **DSC -2** **DSC - 3** **(12 credits)**	**DSE - 1** **DSE – 2** OR **DSE-1 & GE-1** **(8 credits)**	Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning **(2 credits)**	Nil	**22**
Semester- II	**DSC-4** **DSC -5** **DSC - 6** **(12 credits)**	**DSE- 3** **DSE – 4** OR **DSE-2 & GE-2** **(8 credits)**	Skill-based course/ workshop/ Specialised laboratory/ Hands on Learning **(2 credits)**	Nil	**22**

One year PG Programme after completion of Four-Year UG Programme (4+1)

Structure 1 (Level 6.5) : PG Curricular Structure with only course work

Semester	DSC	DSE	2 Credit course	Dissertation/ Academic Project/ Entrepreneurship	Total Credits
Semester- III	DSC- 7 DSC -8 (8 credits)	DSE- 5 DSE – 6 DSE - 7 OR DSE-3, DSE-4 & GE-3 (12 credits)	Skill-based course/ workshop/ Specialised laboratory/ Internship/ Apprenticeship/ Hands on Learning (2 credits)	Nil	22
Semester- IV	DSC - 9 DSC -10 (8 credits)	DSE- 7 DSE – 8 DSE - 9 OR DSE-5, DSE - 6 & GE-4 (12 credits)	Skill-based course/ workshop/ Specialised laboratory/ Internship/ Apprenticeship/ Hands on Learning (2 credits)	Nil	22

One year PG Programme after completion of Four-Year UG Programme (4+1)

Structure 1 (Level 6.5) : PG Curricular Structure with only course work

Semester	DSC	DSE	2 Credit course	Dissertation/ Academic Project/ Entrepreneurship	Total Credits
Semester- III	DSC- 7 DSC -8 (8 credits)	DSE- 5 DSE – 6 DSE - 7 OR DSE-3, DSE-4 & GE-3 (12 credits)	Skill-based course/ workshop/ Specialised laboratory/ Internship/ Apprenticeship/ Hands on Learning (2 credits)	Nil	22
Semester- IV	DSC - 9 DSC -10 (8 credits)	DSE- 7 DSE – 8 DSE - 9 OR DSE-5, DSE - 6 & GE-4 (12 credits)	Skill-based course/ workshop/ Specialised laboratory/ Internship/ Apprenticeship/ Hands on Learning (2 credits)	Nil	22

Structure 2 (Level 6.5): PG Curricular Structure with Course work + Research

Semester	DSC	DSE	2 Credit course	Dissertation/ Academic Project/ Entrepreneurship	Total Credits
Semester- III	DSC- 7 DSC -8 (8 credits)	DSE- 5 DSE – 6 OR DSE-3, GE-3* (8 credits)	Nil	See detailed outcomes below (6 credits)	22
Semester- IV	DSC-9 DSC -10 (8 credits)	DSE- 7 DSE – 8 OR DSE-4, GE-4* (8 credits)	Nil	See detailed outcomes below (6 credits)	22

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Structure 3 (Level 6.5): Research

Semester	DSC	DSE (related to identified research field)	Research Methods/ Tools/ Writing (2 courses)	One intensive problem-based research	Total Credits
Semester - III	1 DSC (course related to the area identified for research) (4 Credits)	1 DSE (course related or allied to the area identified for research (4 Credits)	(a) Advanced Research Methodology of the core discipline + (b) Tools for Research (2x2 = 4 credits)	Outcomes are listed below the table (10 credits)	22
Semester IV	-	1 DSE or a DSE of an allied subject related to the area identified for research (4 Credits)	Techniques of research writing (2 credits)	(16 credits)	22

CONTENTS

M.Sc. Environmental Science / M.A. Environmental Studies
(Structures 1: Coursework; Sem-III and Sem-IV)

Programme	Semester	Course Type	Title	Credit
M.Sc. Environmental Science	**Semester III**	DSC-7	Biodiversity and Conservation Biology	**04**
		DSC-8	Environmental Chemistry	**04**
		SBC	Techniques for Environmental Monitoring – I	**02**
		DSE	Any 3 from Pool of Odd Semester DSEs	**04×3=12**
				Total = 22 Credits
	Semester IV	DSC-9	Soil–Water Interface and Sustainable Ecosystems	**04**
		DSC-10	Atmosphere and Global Climate Change	**04**
		SBC	Techniques for Environmental Monitoring – II	**02**
		DSE	Any 3 from Pool of Even Semester DSEs	**04×3=12**
				Total = 22 Credits

Programme	Semester	Course Type	Title	Credit
M.A. Environmental Studies	**Semester III**	DSC-7	Environmental Communication for Sustainability	**04**
		DSC-8	Urban Ecosystems and Sustainable Cities	**04**
		SBC	Techniques for Environmental Monitoring – I	**02**
		DSE	Any 3 from Pool of Odd Semester DSEs	**04×3=12**
				Total = 22 Credits
	Semester IV	DSC-9	Ecological and Sustainability Economics	**04**
		DSC-10	Environmental Impact and Carrying Capacity Studies	**04**
		SBC	Techniques for Environmental Monitoring – II	**02**
		DSE	Any 3 from Pool of Even Semester DSEs	**04×3=12**
				Total = 22 Credits

M.Sc. Environmental Science / M.A. Environmental Studies
(Structures 2: Coursework+Research; Sem-III and Sem-IV)

Programme	Semester	Course Type	Title	Credit
M.Sc. Environmental Science	**Semester III**	DSC-7	Biodiversity and Conservation Biology	**04**
		DSC-8	Environmental Chemistry	**04**
		DSE	Any 2 from Pool of Odd Semester DSEs	**04×2=8**
			Dissertation/Academic Project/Entrepreneurship	**06**
				Total = 22 Credits
	Semester IV	DSC-9	Soil–Water Interface and Sustainable Ecosystems	**04**
		DSC-10	Atmosphere and Global Climate Change	**04**
		DSE	Any 2 from Pool of Odd Semester DSEs	**04×2=8**
		D/AP/E	Dissertation/Academic Project/Entrepreneurship	**06**
				Total = 22 Credits

Programme	Semester	Course Type	Title	Credit
M.A. Environmental Studies	**Semester III**	DSC-7	Environmental Communication for Sustainability	**04**
		DSC-8	Urban Ecosystems and Sustainable Cities	**04**
		DSE	Any 2 from Pool of Odd Semester DSEs	**02**
		D/AP/E	Dissertation/Academic Project/Entrepreneurship	**04×3=12**
				Total = 22 Credits
	Semester IV	DSC-9	Ecological and Sustainability Economics	**04**
		DSC-10	Environmental Impact and Carrying Capacity Studies	**04**
		DSE	Any 2 from Pool of Odd Semester DSEs	**04×2=8**
			Dissertation/Academic Project/Entrepreneurship	**06**
				Total = 22 Credits

M.Sc. Environmental Science / M.A. Environmental Studies
(Structures 3: Only Research; Sem-III and Sem-IV)

Programme	Semester	Course Type	Title	Credit
M.Sc. Environmental Science	**Semester III**	DSC-7	Advances in Instrumentation for Environmental Research	**04**
		DSE	Any 1 Related to Research Domain from Pool of Odd Semester DSEs	**04**
		DS-RM	Advanced Methods in Environmental Research	**02**
		DS-TR	Tools for Environmental Research	**02**
		Research	Research Project	**10**
				Total = 22 Credits
	Semester IV	DSE	Any 1 Related to Research Domain from Pool of Odd Semester DSEs	**04**
		DS-RW	Techniques for Research Writing	**02**
		Research	Research Project	**16**
				Total = 22 Credits

Programme	Semester	Course Type	Title	Credit
M.A. Environmental Studies	**Semester III**	DSC-7	Advances in Instrumentation for Environmental Research	**04**
		DSE	Any 1 Related to Research Domain from Pool of Odd Semester DSEs	**04**
		DS-RM	Advanced Methods in Environmental Research	**02**
		DS-TR	Tools for Environmental Research	**02**
		Research	Research Project	**10**
				Total = 22 Credits
	Semester IV	DSE	Any 1 Related to Research Domain from Pool of Odd Semester DSEs	**04**
		DS-RW	Techniques for Research Writing	**02**
		Research	Research Project	**16**
				Total = 22 Credits

Discipline Specific Electives Courses

Odd Semester DSEs

25. **DSE-25:** Climate Risk, Adaptation and Disaster Resilience
26. **DSE-26:** Environmental Biotechnology
27. **DSE-27**: Environmental Innovation and Sustainable Enterprise Design
28. **DSE-28:** Ethics, Sustainability and Responsible Development Systems
29. **DSE-29:** Life Cycle Assessment (LCA) and Environmental Auditing

Even Semester DSEs

29. **DSE-30:** Climate Technology Systems and Sustainable Innovation
30. **DSE-31:** Corporate Social Accountability and Environmental Transparency
31. **DSE-32:** Environmental and Ecological Engineering
32. **DSE-33:** Environmental Enterprise Policy, Finance, and Governance
33. **DSE-34:** Global Environmental Politics
34. **DSE-35:** Sustainability Paradigms Beyond ESG
35. **DSE-36:** Systems Analysis and Modelling

M.Sc. Environmental Science (Structures 1 and 2)

Semester III and IV

M.Sc. Semester III

Structures 1 and 2

DISCIPLINE SPECIFIC CORE COURSE - (DSC-7)

Biodiversity and Conservation Biology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-7: Biodiversity and Conservation Biology	4	2	0	2	Undergraduate	NA

Course Objectives

The course aims to:

- Understand the study of diversity existing at different levels of biological organization and to understand the essential ecological and biological processes that ensure the long-term stability of ecosystems.
- Highlight the values of biodiversity and scientific approaches to conservation, which can lead to sustainable development and safeguard the interests of future generations

Learning Outcomes

After the course, students will be able to

- Understand the importance and values of biodiversity.
- Learn methods for measuring biodiversity at various levels of biological organization
- Identify and analyze natural and anthropogenic threats to biodiversity.
- Learn about various conservation methods and familiarize yourself with national and international frameworks and policies related to biodiversity conservation

Course syllabus

Theory (30 hours)

Unit 1- Concept, Origin, Levels and Magnitude of Biodiversity (8 Hours)

Speciation: Organic evolution through the geological time scale; Levels of biological organization; Levels of Biodiversity: ecosystem diversity, species diversity, genetic diversity; Magnitude of biodiversity (Global and Indian); Historical evolution of Indian flora and fauna (Gondwana legacy, Western Ghats, endemism, Himalayas, monsoon influence) and present day patterns of species richness and distribution; global and Indian biodiversity hot spots — terrestrial, marine and microbial (mycorrhizal); Genetic diversity (genes, alleles, barcoding, phylogeny, molecular evolution); Species concepts and cryptic diversity; Integrative taxonomy across microbes, fungi, plants and animals (taxonomic classification and systematics), phylogenetic and functional diversity.

Unit II - Patterns and processes in biodiversity (7 Hours)

Biodiversity gradients and their drivers; Island biogeography theory; Evolutionary and ecological processes (speciation, adaptation, extinction, dispersal, niche segregation, natural selection, drift); Species interactions (trophic, symbiotic, pollination network) and ecosystem functioning; Ecosystem services and direct benefits; Bio-prospecting (molecular techniques like RFLP, DNA sequencing, etc), Aesthetics and cultural benefits; Ecological economics.

Unit III – Threats to Biodiversity (7 Hours)

Status of biodiversity and population declines in threatened groups; Knowledge shortfalls (Linnean, Darwinian, Wallacean, etc.); Microbial diversity challenges; Threats to Biodiversity: Species extinctions and their drivers – deforestation, land use changes, over-exploitation, biological invasions, habitat loss, diseases, effects of climate change; Biodiversity-climate interactions; Ecologically relevant parameters (viable population, minimum dynamic area, effective population size, phenological mismatches, metapopulations, population genetics); Climate change-biodiversity linkages; assessment and monitoring of biodiversity.

Unit IV- Conservation Biology (8 Hours)

History of Conservation (global, India); IUCN categories and Red List; Rights of nature movement and constitutional position of nature in India; In situ & ex situ conservation; reproductive parameters in conservation (breeding habitats, mating systems, inbreeding depression, genetic bottlenecks, genetic constraints); Conservation genomics, museomics and paleobiology; Conservation prioritization (species, habitats, ecosystem); Protected Area Network of India; Conservation case studies from India. Ecological restoration and rewilding, Citizen Science, Biodiversity governance: CBD, TRIPS regulations on patenting of lifeforms, with emphasis on microbial patenting.

Suggested Practicals/Applied Exercises/Field Studies (60 hours)

- Measurement of species diversity (calculation of diversity indices from data collected on plant, microbial and animal(?) species in Delhi ridge/forest;
- In-vitro demonstration of evolution with bacterial cultures
- Use of Biodiversity databases- India Biodiversity Portal, GBIF, etc.
- Methodology of assessment and analysis of different species groups (Rank abundance plot, Fisher plot, etc)
- Measurement of species richness gradients and patterns and their drivers.
- Measurement of biodiversity at the molecular level by RFLP, RAPD, AFLP, DNA barcoding, and molecular phylogenetic analyses.
- Use of multiple integrative approaches to assess and describe biodiversity (morphological, phylogenetic, behavioural, ecological, geographical data).
- Blast analyses of selected DNA sequences from the International Gene Banks and construction of phylogenetic trees using various methods and tools to assess genetic diversity and evolutionary patterns.
- Mark-recapture method of estimating population size.
- Use of bioacoustics as a rapid biodiversity assessment method.

- DNA barcoding and e-DNA for biodiversity assessment
- Working with biodiversity databases

Essential Reading

- Singh, J. S., S. P. Singh, and S. R. Gupta. *Ecology, environmental science & conservation*. S. Chand Publishing, 2014.
- Primack, R.B. (2014). Essentials of Conservation Biology, 6th Ed., Sinauer Associates, Sunderland, Ma. USA.
- Sodhi, N. S., Gibson, L., and Raven, P. H. (2013). Conservation Biology: Voices from the Tropics. John Wiley and Sons Ltd.: UK.
- Myers, Norman, et al. "Biodiversity hotspots for conservation priorities." *Nature* 403.6772 (2000): 853-858.
- May, R.M., How many species are there on Earth. Science, 1988. 241(4872): p. 1441-1449.
- Biju, S.D., and Bossuyt. F. (2003). "New frog family from India reveals an ancient biogeographical link with the Seychelles." *Nature*. 425: 711–714.
- Kothamasi, D., Deepika, S., Vermeylen, S. (2023). Are ecological processes that select beneficial traits in agricultural microbes nature's intellectual property rights? *Nature Biotechnology* 41:1381–1384.

Suggested Readings

- Krebs, C.J. (2013) Ecology: The Experimental Analysis of Distribution and Abundance. New International Edition, 6E, New York
- Wilson, E. O. (1993). Diversity of Life. Harvard University Press, Cambridge, MA.
- Page, R.D., & Holmes, E.C. (1998). Molecular evolution: a phylogenetic approach. John Wiley & Sons.

M.Sc. Semester IV

Structures 1 and 2

DISCIPLINE SPECIFIC CORE COURSE - (DSC-8)

Environmental Chemistry

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-8: Environmental Chemistry	4	2	0	2	Undergraduate	-

Course Objectives

- Develop an in-depth understanding of chemical processes in environmental systems.
- Equip students with analytical techniques and field-based skills to monitor environmental chemical processes.
- Analyze transformation mechanisms, reaction pathways, and elemental cycles.
- Evaluate chemical behavior of pollutants and remediation strategies.
- Apply advanced analytical techniques in environmental chemistry.

Learning Outcomes

By the end of the course, students will be able to:

- Explain chemical speciation, equilibria, and reaction mechanisms in environmental systems.
- Use analytical and separation techniques for environmental samples.
- Interpret transformation pathways and pollutant fate.
- Compare treatment and remediation technologies.
- Design chemistry-based solutions to environmental problems.

Course Syllabus

Theory (30 hours)

Unit I – Geochemistry (8 hours)

Bulk composition of the Earth; thermodynamic stability of minerals; Structure and chemistry of silicate minerals; isomorphism, polymorphism, and solid solutions; Ionic substitution and crystal chemistry; geochemical partitioning; Weathering reactions as chemical processes: dissolution, hydrolysis, oxidation–reduction; Stable isotopes and isotopic fractionation; applications in geochemical tracing; Soil–mineral interfacial chemistry; adsorption–desorption and ion exchange; trace element speciation; sorption isotherms; organo–mineral interactions; Elemental cycling and geochemical reservoirs with emphasis on reaction pathways.

Unit II – Water Chemistry (7 hours)

Fundamentals of aquatic chemistry: characteristics of water bodies, water quality, physico-chemical properties of water, chemical interactions of water; Water pollutants: inorganic, organic, radioactive, emerging micropollutants and biological contaminants-intrusion and accumulation; Water treatment chemistry: coagulation–flocculation, oxidation–reduction, disinfection kinetics.

Speciation of dissolved species; solubility and precipitation reactions; Separation and preconcentration: LLE, SPE, ion exchange, adsorption; Analytical techniques for water analysis; Instrumental techniques for trace-level analysis

Unit III – Atmospheric Chemistry (7 hours)

Atmospheric composition and trace species; Chemical kinetics of atmospheric reactions; radical chemistry; Photochemistry and radiation balance; Chapman mechanism and ozone chemistry; Tropospheric chemistry: VOC–NOx systems and ozone formation pathways; Aerosol chemistry: nucleation, growth, and heterogeneous reactions; Greenhouse gases and radiative forcing from a molecular perspective.

Unit IV: Chemistry of Waste Substances (8 hours)

Chemical composition and classification of wastes: municipal, hazardous, biomedical, e-waste, industrial; Transformation processes: thermal, oxidation–reduction, hydrolysis, biodegradation; Water toxicants: heavy metal speciation, POPs, microplastics; Leachate chemistry and waste system reactions; stabilization, detoxification, and immobilization; waste-to-energy and valorization pathways; green chemistry approaches.

Suggested Practical / Applied Exercises / Field Studies (60 hours)

- Compare cation exchange capacity of different soil types
- Determination of DO, BOD/COD and interpretation of water quality.
- Determination of carbonate–bicarbonate equilibrium and alkalinity relationships.
- Determination of toxic metal ions by UV-visible Spectrophotometry
- Colorimetric and Potentiometric methods to quantify water quality
- Sampling and analysis of ambient SO_2 using improved West and Gaeke method
- Titrimetric analyses of water and soil squality parameters
- Waste leachate characterization and analysis
- Study the absorption spectra of water-soluble aerosol organic compounds
- Preconcentration (SPE/ion exchange) and estimation of heavy metals in water samples.
- Removal of a metal/organic pollutant using adsorbents; evaluation using isotherm models.
- Estimation of SO_2/NOx or particulate matter and data interpretation.
- Physicochemical characterization of solid waste and leachate analysis.
- Interpretation of chromatographic/spectroscopic environmental data.
- Case-based study on contamination and design of a chemical remediation strategy.

Essential readings

- Kuo, J. (2024). *Chemistry, thermodynamics, and reaction kinetics for environmental engineers*. CRC Press.
- Lung, W. S. (2022). *Water quality modeling that works*. Springer Nature.
- Manahan, S. E. (2022). *Environmental chemistry*. CRC press.
- Möller, D. (2022). *Chemistry for Environmental Scientists*. Walter de Gruyter GmbH & Co KG.
- Seinfeld, J. H., & Pandis, S. N. (2016). *Atmospheric chemistry and physics: from air pollution to climate change*. John Wiley & Sons.
- Speight, J. G. (2016). *Environmental organic chemistry for engineers*. Butterworth-Heinemann.
- Stumm, W., & Morgan, J. J. (2013). *Aquatic chemistry: chemical equilibria and rates in natural waters*. John Wiley & Sons.

Suggested readings

- Birkett, J., & Lester, J. (2018). *Microbiology and chemistry for environmental scientists and engineers*. CRC Press.
- Connell, D. W., & Miller, G. J. (2022). *Chemistry and toxicology of pollution: ecological and human health*. John Wiley & Sons.
- Dunnivant, F. M., & Ginsbach, J. W. (2024). *Essential Methods of Instrumental Analysis*. John Wiley & Sons.
- Russell, D. L. (2024). *Remediation manual for contaminated sites*. CRC press.
- Schwarzenbach, R. P., Gschwend, P. M., & Imboden, D. M. (2016). *Environmental organic chemistry*. John Wiley & Sons.

M.Sc. Semester IV
Structures 1 and 2

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSC-9)

Soil–Water Interface and Sustainable Ecosystems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-9: Soil–Water Interface and Sustainable Ecosystems	**4**	**2**	**0**	**2**	**Undergraduate**	

Course Objectives

The course aims to:

- Develop an integrated understanding of soil–water systems as living, microbially mediated socio-ecological systems
- Translate soil ecology, ecohydrology, and biogeochemical principles into diagnostic, treatment, and management applications
- Examine soil–water–microbe–plant interactions in regulating ecosystem functions and resilience
- Build competencies in soil and water assessment, contamination analysis, and remediation strategies
- Equip students to design multi-scale (farm to basin) sustainable management and restoration solutions for real-world environmental challenges

Learning Outcomes

By the end of this course, students will be able to:

- Develop an integrated understanding of soil–water systems as living, microbially mediated socio-ecological systems
- Translate soil ecology, ecohydrology, and biogeochemical principles into diagnostic, treatment, and management applications
- Examine soil–water–microbe–plant interactions in regulating ecosystem functions and resilience
- Build competencies in soil and water assessment, contamination analysis, and remediation strategies
- Equip students to design multi-scale (farm to basin) sustainable management and restoration solutions for real-world environmental challenges

Course Syllabus
Theory (30 hours)

Unit I: Soil Microbiome, Functional Ecology, and Soil Health (7 hours)
Soil as a living system (structure, organic matter, functional zones); soil microbial diversity and functional guilds; rhizosphere interactions (mycorrhizae, rhizobia, PGPR); microbiome-holobiont and symbiogenesis; microbial cycling of C, N, P, S; soil degradation and microbial disruption; integrated soil health indicators; microbiome-based restoration.

Unit II: Hydrological Processes and Ecohydrology (8 hours)
Hydrological processes (infiltration, runoff, groundwater); soil–water–root interactions; ecohydrology (vegetation–soil moisture–hydrology links); groundwater–surface water coupling; land use and climate impacts; biological processes driven water quality; natural/engineered water treatment and recharge; watershed and urban water management.

Unit III: Soil–Water–Microbe–Plant Interface (7 hours)
Coupled soil–water–microbe–plant systems; microbial control of nutrient fluxes and contaminants; rhizosphere nutrient uptake and pollutant attenuation; microbiomes and vegetation in carbon sequestration, GHG fluxes, contaminant dynamics; ecosystem-based treatment (wetlands, riparian buffers); risk assessment.

Unit IV: Multi-Scale Management, Restoration, and Nature-Based Solutions (8 hours)
Soil–water management across scales (farm → watershed → basin); microbiome-based restoration; conservation practices (agroecology, soil carbon management, water harvesting); nature-based/hybrid systems (constructed wetlands, biofilters, algal-bacterial and advanced methods, phytoremediation); watershed restoration; eco-engineering integration; GIS/remote sensing; climate resilience; policy and governance.

Suggested Practicals/Applied Exercises/Field Studies (60 hours)

- Soil Morphology & Texture: Field and lab-based description and analysis.
- Soil Nutrients & Microbial Biomass: Linking nutrients with biological properties of soils
- Analyzing environmental DNA for soil health
- Metagenomic and metatranscriptomics for assessment and comparison of microbiome
- 16S rRNA sequence and community profiling for microbial diversity analyses
- Water Quality Analysis and its assessment for different use
- Catchment Delineation & Hydrograph Construction: GIS-based mapping and runoff estimation.
- Aquifer Characterization: Modeling permeability, transmissivity, and porosity.
- Redox and Microbial Activity: Wetland soil and water systems under aerobic/anaerobic conditions.
- Contaminant Leaching: Soil column experiments on nitrate and metal mobility.
- Groundwater–Surface Water Interactions: Case studies and field modeling.
- Wetland Ecosystem Assessment: Role in filtration, biodiversity, and nutrient cycling.
- River Basin Management Case Review: Integrated policy–ecology–hydrology perspective.

Essential Readings

- Belete, M. D. (2022). *Ecohydrology-based landscape restoration: Theory and practice*. Routledge.
- Brady, N.C. & Weil, R.R. (2017). *The Nature and Properties of Soils*. Pearson.
- Porporato, A., & Yin, J. (2022). *Ecohydrology: Dynamics of life and water in the critical zone*. Cambridge University Press.
- Sparks, D. L., Singh, B., & Siebecker, M. G. (2022). *Environmental soil chemistry*. Elsevier.
- Tate III, R. L. (2020). *Soil microbiology*. John Wiley & Sons.
- Wall, D. H. (2012). *Soil ecology and ecosystem services*. Oxford University Press.
- Watson, I. (2017). *Hydrology: An environmental approach*. Routledge.
- Yong, R. N., Nakano, M., & Pusch, R. (2012). *Environmental soil properties and behaviour*. CRC Press.

Suggested Readings

- Binkley, D., & Fisher, R. F. (2019). *Ecology and management of forest soils*. John Wiley & Sons.
- Brooks, K. N., Ffolliott, P. F., Gregersen, H. M., & DeBano, L. F. (2003). *Hydrology and the Management of Watersheds* (No. Ed. 3, pp. xiii+-574).
- Gentry, T., Fuhrmann, J. J., & Zuberer, D. A. (Eds.). (2021). *Principles and applications of soil microbiology*. Elsevier.
- IPCC (2023). *Climate Change and Water Resources: Technical Report*.
- Kutílek, M., & Nielsen, D. R. (2015).*Soil: The Skin of the Planet Earth*. Dordrecht: Springer Netherlands.
- Legros, J. P. (2012). *Major Soil Groups of the World: Ecology, Genesis, Properties and Classification*. CRC Press.
- Nannipieri, P., Pietramellara, G., & Renella, G. (2013). *Omics in soil science* (pp. 1-198). Caister Academic Press.

M.Sc. Semester IV

Structures 1 and 2

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSC-10)

Atmosphere and Global Climate Change

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-10: Atmosphere and Global Climate Change	**4**	**2**	**0**	**2**	**UG**	**-**

Course Objectives

The course aims to:

- Introduce the dynamics of Earth's atmosphere within the larger Earth system and the drivers of climate variability and change.
- Explore natural and anthropogenic influences on climate, with emphasis on global energy balance, atmospheric circulation, and biosphere feedbacks.
- Analyze historical and projected climate changes and their ecological and societal implications.
- Examine international climate policy frameworks, adaptation strategies, and the ethical dimensions of global climate governance.

Learning Outcomes

By the end of the course, students will be able to:

- Understand key processes governing Earth's atmospheric and climate systems.
- Interpret climatic variability through scientific and historical records.
- Evaluate human-induced climate change and its global and regional impacts.
- Engage critically with global climate policy mechanisms and sustainability strategies.
- Use data-driven approaches to analyze climate trends and ecological responses.

Course Syllabus
Theory (30 hours)
Unit I: Earth Systems and Atmospheric Evolution (7 hours)
Components of the Earth's systems—Atmosphere, Hydrosphere, Lithosphere, Biosphere, Cryosphere, and their interactions; Goldilocks' hypothesis, Earth's geological history and evolution of the atmosphere; Paleoclimate; Milutin Milankovitch Cycles and orbital forcing; Gaia Hypothesis and Earth system feedbacks; Anthropocene as a conceptual and scientific framework.

Unit II: Atmospheric and Oceanic Dynamics (8 hours)
Atmospheric structure and properties, climate classifications (Köppen, Thornthwaite), and controls, Synoptic weather maps; Global and regional atmospheric circulation (Hadley cells, jet streams, trade winds); Local wind systems; Ocean circulation: thermohaline flow, ENSO, Indian Ocean Dipole; Monsoons and cyclones; Ocean–atmosphere coupling and climate regulation.

Unit III: Energy Balance and Climate Variability (7 hours)
Solar radiation, albedo, heat transfer, radiative forcing; Feedback mechanisms in climate systems (e.g., water vapor, ice-albedo); Climate archives (ocean sediments, corals, tree rings) and natural variability—glacial cycles, volcanic activity, solar output; Indian monsoon evolution and Himalayan uplift.

Unit IV: Anthropogenic Climate Change and Global Policy (8 hours)
Greenhouse gas emissions and global warming; Carbon sinks (oceans, forests), sea level rise, ocean acidification; Ozone depletion and recovery; Ecological impacts: Ecosystem productivity, species range shifts, extinction risks, disease spread; Global agreements: Montreal Protocol, Kyoto Protocol, Paris Agreement; Market mechanisms: CDM, carbon trading, REDD+; Climate justice, adaptation, and international climate finance.

Suggested Practical / Applied Exercises / Field Studies (60 hours)

- Modeling future species distribution under climate change scenarios using bioclimatic envelope models (e.g., MaxEnt, WorldClim)
- Generation of precipitation and temperature anomalies using analysis of long-term climate data from the Indian Meteorological Department (IMD) and the National Physical Laboratory (NPL)
- Mapping the effectiveness of existing protected areas under projected climate conditions using GIS tools
- Visit to IMD for experiential learning on real-time weather monitoring and prediction systems
- Project report and data interpretation on atmospheric parameters, GHG trends, or monsoonal variation
- Real-time weather monitoring and generation of synoptic weather maps
- Urban heat island mapping and albedo measurements.

Essential Readings

- Barry, R. G. (2009). Atmosphere, weather and climate. 9th Ed. Routledge Press, UK
- Kasting, J.F., Kump, L. R.,and Carne, R. G. (2022). The Earth System. Kendall/Hunt

Publishing Company; 4th ed. edition

- Wallace, J. M., & Hobbs, P. V. (2006). Atmospheric science: an introductory survey. 2nd ed. Elsevier.
- Jacobson, M. Z. (2002). Atmospheric pollution: history, science, and regulation. Cambridge University Press.

Suggested Readings

- Lovelock, J. (2000). Gaia: A New Look at Life on Earth. Oxford University Press.
- M. Z. Jacobson (2005). Fundamentals of Atmospheric Modeling, 2nd Edition, Cambridge University Press, New York (2005)
- Tarbuck, E. J., Lutgens, F. K., & Tasa, D. (2014). Earth science. Pearson Prentice Hall.
- Ruddiman, W. F. (2013). *Earth's climate: past and future*. 3rd Ed. W.H.Freeman & Co Ltd

M.A. Environmental Studies (Structures 1 and 2)

Semester III and IV

M.A. Semester III
Structures 1 and 2

DISCIPLINE SPECIFIC CORE COURSE - (DSC-7)

Environmental Communication For Sustainability

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-7: Environmental Communication for Sustainability	**4**	**3**	**0**	**1**	**Undergraduate**	

Course Objectives

- Analyze environmental communication in the context of climate change, digital media, and global governance.
- Develop strategic, ethical, and audience-centric communication for policy, industry, and civil society.
- Apply interdisciplinary tools (behavioral science, storytelling, data visualization, digital media) for impact.
- Evaluate media, misinformation, and public discourse shaping environmental decisions.
- Build professional competencies for careers in sustainability communication, policy, media, and CSR.

Learning Outcomes

By the end of the course, students will be able to:

- Critically evaluate environmental narratives across media ecosystems.
- Apply communication and behavior-change theories to sustainability challenges.
- Design data-driven, inclusive communication campaigns and education modules.
- Translate complex environmental science into accessible, ethical messaging.
- Demonstrate professional skills in digital media, advocacy, and stakeholder engagement.

Course Syllabus

Theory (45 hours)

Unit I: Foundations of Environmental Communication and Education (11 hours)

Evolution of environmental education and communication (Tbilisi Declaration, UN SDGs 4,7); eco-literacy and environmental behavior; communication ecosystems (actors, networks, feedbacks); stakeholder mapping and audience segmentation; environmental movements and public engagement; risk perception, climate psychology, and intercultural communication.

Unit II: Strategic Communication, Storytelling, and Digital Tools (12 hours)

Communication theories (framing, agenda-setting, diffusion, narratives); Science communication (trust, uncertainty, misinformation); Strategic messaging for behavior change; Digital storytelling (video, podcast, data visualization); Tools—infographics, social media analytics, citizen journalism; AI in communication, data-driven campaigns, UX design, and platform algorithms; ethics and media law.

Unit III: Media, Advocacy, and Public Discourse (11 hours)

Media systems (print, broadcast, digital, social); Discourse shaping policy and governance; Greenwashing vs sustainability branding; Media literacy and critical analysis; Campaigns and movements (e.g., Silent Spring, etc.); Investigative journalism, advocacy strategies for NGOs, government, and corporate sectors; Climate diplomacy communication and ESG reporting.

Unit IV: Environmental Education, Behvavior Change and Public Engagement (11 hours)

Formal, informal, and non-formal education; Curriculum design for sustainability; Experiential and place-based learning; Communication in communities, museums, and digital platforms; Eco-labeling and sustainability communication; Consumer behaviour and nudges; Youth and marginalized engagement; Gamification, digital learning platforms, and social innovation communication.

Suggested Practicals/Applied Exercises/Field Studies (30 hours)

- Analyze and redesign an environmental awareness campaign for a chosen audience
- Develop a social media strategy for a local or global environmental issue
- Create a short video, infographic, or podcast on a sustainability topic
- Conduct media audits of environmental reporting across newspapers or digital outlets
- Participate in a simulation exercise of stakeholder communication in an environmental conflict
- Draft an environmental education module for a specific age or demographic group
- Field assignment: Evaluate public environmental signage, eco-labels, or sustainability advertising
- Reflective essay on a canonical text (e.g., *Silent Spring*, *Earth in Mind*, *This Changes Everything*)
- Prepare a public talk or presentation using science storytelling principles
- Role-play exercise on ethical dilemmas in environmental communication

Essential readings

- Abbati, M. (2019). Communicating the Environment to Save the Planet. *Switzerland: Springer*.
- Craig, G. (2019). *Media, sustainability and everyday life*. London, UK: Palgrave macmillan.
- Klöckner, C. A. (2015). *The psychology of pro-environmental communication: beyond standard information strategies*. Springer.
- Martinez, D., & Virtue, D. (2025). *Strategies for Effective Environmental Communication: A Beginner's Guide to Writing and Content Creation*. Palgrave Macmillan.
- Nofri, S. (2012). *Cultures of environmental communication: A multilingual comparison*. Springer Science & Business Media.
- Pezzullo, P. C., & Cox, R. (2025). *Environmental communication and the public sphere*. Sage publications.

Suggested readings

- Attenborough, D. (2020). *A life on our planet: My witness statement and a vision for the future*. Random House.
- Bennett, W. L. (2020). *Communicating the future: solutions for environment, economy and democracy*. John Wiley & Sons.
- Bergman, O., Park, S., & Bagniewska, J. (2025). *The communicating scientist: a practical handbook*. Springer Nature.
- Romm, J. J. (2022). *Climate change: What everyone needs to know*. Oxford University Press.
- Thaler, R. H., & Sunstein, C. R. (2021). *Nudge: The final edition*. Penguin.

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSC-8)

Urban Ecosystems and Sustainable Cities

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-8: Urban Ecosystems and Sustainable Cities	**4**	**3**	**0**	**1**	Undergraduate	

Course Objectives

The course aims to:

- Analyze cities as complex socio-ecological and techno-economic systems.
- Evaluate urbanization impacts on climate, resources, biodiversity, and equity.
- Apply data-driven tools, spatial analysis, and systems thinking to urban challenges.
- Design resilient, inclusive, and nature-based urban solutions.
- Build competencies for careers in urban planning, ESG, sustainability consulting, policy, and smart cities.

Learning Outcomes

By the end of the course, students will be able to:

- Model urban systems using ecological, spatial, and socio-economic frameworks.
- Assess infrastructure, governance, and land-use impacts on sustainability.
- Evaluate risks (climate, pollution, informality) using data and policy tools.
- Design nature-based, circular, and low-carbon urban interventions.
- Develop professional outputs: policy briefs, sustainability plans, spatial analyses.

Course syllabus

Theory (45 hours)

Unit I: Urban Systems, Metabolism, and Data-Driven Analysis (11 hrs)

Cities as complex socio-ecological systems; urban metabolism, ecological footprint, and planetary boundaries; Evolution of urbanization (industrial → megacities → smart cities); Peri-urban dynamics and urban–rural linkages; Urban commons and green–blue networks (parks, wetlands, corridors); Geospatial analytics (GIS/remote sensing), digital twins, and urban data platforms for evidence-based planning.

Unit II: Infrastructure, Planning, and Climate Risk Governance (11 hrs)
Urban infrastructure systems (water, sanitation, mobility, energy, waste); Planning frameworks, governance, and informality; Environmental risks—urban heat islands, flooding, air pollution; Climate-resilient and disaster-resilient infrastructure, nature-based solutions (NbS), and urban climate modeling; Integration of policy, planning, and risk governance.

Unit III: Urban Pollution, Resource Flows, and Circular Economy Transitions (11 hrs)
Urban pollution (air, water, soil, noise) and spatial dynamics; Waste systems (formal–informal linkages); Circular economy (urban mining, recycling, industrial symbiosis, zero-waste cities); Sustainable energy transitions; Life-cycle assessment (LCA), carbon accounting, and consumption-based emissions; Environmental costs of urban lifestyles and resource use; Case studies from cities across India and the world.

Unit IV: Urban Biodiversity, Equity, and Future Sustainable Cities (12 hrs)
Urban biodiversity and ecosystem services; Urban heat islands; Green–blue infrastructure and urban commons governance; environmental justice (equity, gender, class, displacement, green gentrification); Participatory and community-led restoration; Smart and regenerative cities, climate action planning, ESG frameworks, SDG localization, low-carbon mobility, green buildings, and AI/IoT-enabled urban innovation; Futures thinking and co-production for inclusive transitions.

Suggested Practicals/Applied Exercises/Field Studies (30 hours)

- Explore ecological assets and challenges in a selected urban neighborhood
- Analyze an Indian city's master plan from an ecological and sustainability perspective
- Design a 2050 sustainable urban vision for a medium-sized Indian city
- Evaluate portrayal of urban environmental issues in news, cinema, or campaigns
- Contrast waste or water management models across Indian and global cities
- Urban metabolism analysis of a selected city (material/energy flows)
- GIS-based land-use, green cover, and urban sprawl mapping
- Urban heat island assessment using remote sensing data
- Air/water quality dataset analysis and visualization
- Waste audit and circular economy strategy for a locality
- Life Cycle Assessment (LCA) of an urban product/system
- Carbon footprint and consumption-based emissions estimation
- Climate risk and vulnerability assessment (flood/heat mapping)
- Design of a nature-based solution (NbS) (e.g., urban wetland, green corridor)
- Policy brief / urban sustainability action plan (city-level or sectoral)

Essential Readings

- Beatley, T. (2012). *Green Urbanism: Learning from European Cities*. Island Press.
- Forman, R. T. (2014). *Urban Ecology: Science of Cities*. Cambridge University Press.
- Glaeser, E., & Cutler, D. (2021). *Survival of the City: Living and Thriving in an Age of Isolation*. Penguin.
- James, P., & Douglas, I. (2023). *Urban Ecology: An Introduction*. Routledge.
- Parris, K. M. (2016). *Ecology of Urban Environments*. John Wiley & Sons.

Suggested Readings

- Beatley, T. (2011). *Biophilic cities: Integrating nature into urban design and planning* (Vol. 28). Washington, DC: Island Press.
- Foster, S. R., & Iaione, C. (2022). *Co-cities: Innovative transitions toward just and self-sustaining communities*. MIT Press.
- Reid, C. (2015). *Roads were not built for cars: How cyclists were the first to push for good roads & became the pioneers of motoring*. Island Press.
- Sant, A. (2022). *From the ground up: Local efforts to create resilient cities*. Island Press.
- Wang, J. (2024). *Reimagining the more-than-human city: Stories from Singapore*. MIT Press.

M.A. Semester IV
Structures 1 and 2

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSC-9)

Ecological and Sustainability Economics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-9: Ecological and Sustainability Economics	**4**	**3**	**0**	**1**	**Undergraduate**	

Course Objectives
- Understand the foundational principles of environmental and ecological economics and their relevance to sustainability.
- Analyze market failures, externalities, and valuation techniques related to environmental goods and services.
- Examine economic models for renewable and non-renewable resource use, and assess sustainability transitions.
- Evaluate policy instruments for pollution control, resource management, and ecosystem conservation.
- Explore global environmental challenges through ecological-economic frameworks and tools.

Learning Outcomes
By the end of the course, students will be able to:
- Apply economic reasoning to assess environmental issues and resource use.
- Evaluate and apply methods for valuing ecosystem services and environmental impacts.
- Analyze trade-offs in managing common pool, renewable, and exhaustible resources.
- Design and critique environmental policy instruments using economic principles.
- Interpret global economic-environmental linkages and propose sustainability-oriented solutions.

Course Syllabus
Theory (45 hours)

Unit I: Ecological Economics, Resource Foundations, and Planetary Limits (11 hrs)
Foundation principles of environmental economics vs resource economics vs ecological economics; Market failure and externalities; Renewable vs non-renewable resource use and scarcity; Ecological economics (steady-state, resilience); Natural capital and ecosystem services;

Planetary boundaries, carrying capacity, equity; Introduction to natural capital accounting and beyond-GDP metrics.

Unit II: Valuation of Ecosystem Services and Natural Resources, and Decision Tools (11 hrs)
Valuation of environmental goods (CVM, travel cost, hedonic, choice modeling); Applications in water, forests, and biodiversity; Limits of monetization (ecological perspective); Cost–benefit and multi-criteria analysis; Natural capital accounting (SEEA), green GDP; Discounting, uncertainty, and decision-making tools; Economics of biodiversity conservation for sustainability.

Unit III: Economics of Natural Resources and Pollution for Circular Economy (12 hrs)
Resource economics (optimal extraction, resource rent); Common-pool resources and Elinor Ostrom principles; Environmental economics of pollution (taxes, permits, regulation); Circular economy and industrial ecology; Sustainable consumption; Life-cycle assessment and carbon accounting; Economics of climate change.

Unit IV: Sustainability Transitions, Trade and Global Policy (11 hrs)
Environment–development–trade linkages; Global governance (WTO, UNEP, IPCC, MEAs); Carbon markets and climate policy: REDD+, CDM, and Article 6 of the Paris Agreement; ESG, green bonds, and sustainable finance; Natural capital in policy and planning; environmental justice; future pathways—degrowth, doughnut economics, and just transitions.

Suggested Practicals/Applied Exercises/Field Studies (30 hours)

- Perform an ecosystem service valuation (primary or secondary data) using contingent valuation or travel-cost method.
- Cost–benefit analysis of an environmental project (dam, highway, conservation)
- Natural capital accounting for a local ecosystem or landscape
- Simulate a cap-and-trade carbon market with students as firms and regulators.
- Behavioral economics experiment (nudges for sustainable consumption)
- Circular economy assessment of a city/industry (material flow analysis)
- Prepare a policy brief comparing tradable permits vs pollution taxes for air pollution control.
- Analyze and critique a CBA of a real-world infrastructure or conservation project.
- Map ecological footprints of selected cities using available datasets.
- Resource extraction modeling (renewable vs non-renewable scenarios)
- Design a sustainability transition plan for a common-pool resource using Ostrom's framework.
- Debate the merits and limits of green GDP and ecological accounting.
- Green GDP / adjusted national income estimation exercise
- Analysis of the negotiation of a global carbon agreement between developed and developing nations.
- Case study analysis: economics of biodiversity offsets or PES in India or elsewhere.
- Apply natural capital accounting in policy decision-making
- Analyse trade–environment conflicts in global governance frameworks.
- Evaluate environmental justice and propose just transition strategies.
- Field visit/report: wetland, forest, industrial zone, or urban ecosystem valuation

Essential Readings

- Daly, H.E. & Farley, J. (2011). *Ecological Economics: Principles and Applications*. Island Press.
- Hanley, N., Shogren, J. F., White, B., & White, B. (2019). *Introduction to Environmental Economics*. Oxford University Press.
- Harris, J. M., & Roach, B. (2026). *Environmental and Natural Resource Economics: A Contemporary Approach*. 6th Edition, Routledge.
- Smith, V. (2013). *Economics of Natural & Environmental Resources,* Routledge.
- Spash, C. L. (2017). *Routledge Handbook of Ecological Economics*. New York: Routledge.
- Tietenberg, T., & Lewis, L. (2023). *Environmental and Natural Resource Economics*. Routledge.

Suggested Readings

- Barbier, E. (2022). *Economics for a fragile planet*. Cambridge University Press.
- Bruckmeier, K. (2020). *Economics and Sustainability: Social-ecological Perspectives*. Springer Nature.
- Costanza, R. (2020). Valuing natural capital and ecosystem services toward the goals of efficiency, fairness, and sustainability. *Ecosystem Services*, *43*, 101096.
- Dasgupta, P. (2021). *The Economics of Biodiversity: The Dasgupta Review*. HM Treasury.
- Jackson, T. (2017). *Prosperity Without Growth: Foundations for the Economy of Tomorrow*. Routledge.
- Raworth, K. (2018). *Doughnut economics: Seven ways to think like a 21st century economist*. Chelsea Green Publishing.

M.A. Semester IV

Structures 1 and 2

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSC-10)

Environmental Impact and Carrying Capacity Studies

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-10: Environmental Impact and Carrying Capacity Studies	**4**	**3**	**0**	**1**	**Undergraduate**	**-**

Course Objectives

- Develop expertise in Environmental Impact Assessment (EIA) and Environmental Risk Assessment (ERA) and sustainability assessment frameworks for infrastructure and policy.
- Integrate SEA, LCA, ESG, and circular economy principles into decision-making.
- Apply data-driven, geospatial, and systems-based tools for impact and risk analysis.
- Evaluate ecological thresholds, carrying capacity, and planetary limits in planning.
- Prepare for careers in environmental consulting, ESG analytics, compliance, and climate risk advisory.

Learning Outcomes

By the end of the course, students will be able to:

- Conduct end-to-end EIA and ERA using standard methodologies and tools.
- Evaluate environmental risks, uncertainties, and resilience strategies.
- Integrate LCA, SEA, ESG, and SDG frameworks into project and policy assessment.
- Apply GIS, modeling, and data analytics in impact prediction and monitoring.
- Produce professional outputs: EIA reports, risk assessments, EMPs, and policy briefs.

Course Syllabus
Theory (45 hours)
Unit I: Foundations of Impact and Sustainability Assessment (10 hours)
EIA evolution and global frameworks (e.g., National Environmental Policy Act, EU Directive, India EIA 2006 and amendments); Principles of sustainability and impact assessment; EIA vs ERA; Introduction to SEA, LCA, and cumulative ismpact assessment; ESG reporting, Sustainable finance, and role of EIA in global infrastructure investments.

Unit II: EIA Methods, Tools and Practices (12 hours)
EIA stages—screening, scoping, baseline, impact prediction (matrices, modeling, GIS/remote sensing); Mitigation and Environmental Management Plans (EMP) design; Environmental valuation and cost–benefit analysis; Stakeholder engagement and public participation; AI, big data, remote sensing, and digital twins in impact assessment; EIA reporting and audit.

Unit III: Environmental Risk Analytics and Resilience (11 hours)
Risk concepts (hazard, exposure, vulnerability, uncertainty); ERA steps—hazard identification, exposure, risk characterization, management; Risk communication and perception; Disaster risk reduction and climate risk; Sectoral applications (energy, mining, coastal, industrial); ISO frameworks (e.g., ISO 31000), Climate risk analytics, and resilience planning.

Unit IV: Carrying Capacity, Thresholds, and Sustainability Planning (12 hours)
Carrying capacity (ecological, socio-economic, urban, tourism); Ecological footprint, biocapacity, and planetary boundaries; Sustainability indicators and thresholds; Modeling and scenario analysis; Case studies (e.g., Delhi air quality, Himalayan ecosystems); Integration into regional planning, smart cities, and NbS; Linkages with UN SDGs, circular economy, and long-term sustainability transitions.

Suggested Practicals / Applied Exercises/Field Studies (30 hours)
- Simulated EIA for infrastructure or energy project (road, dam, mine, SEZ)
- Carrying capacity estimation of a protected area or urban center using GIS and footprint analysis
- Stakeholder engagement simulation and public hearing design
- Impact prediction using matrix and modeling tools
- Environmental Management Plan (EMP) design
- Life Cycle Assessment (LCA) of a product/system
- Climate risk and vulnerability assessment (heat/flood)
- Environmental risk assessment (industrial contamination case)
- Policy review: Comparative analysis of EIA regulations in India, EU, and the US
- Data-based risk assessment of air/water contamination in an industrial zone
- Analysis of real EIA reports and EMPs from MoEFCC or global agencies
- Viva-Voce based on case reports, policy interpretation, and project evaluations
- Carrying capacity analysis using ecological footprint tools
- ESG assessment of a real project/company
- Stakeholder consultation and public hearing simulation
- Cost–benefit and environmental valuation exercise
- Field visit/report: Environmental compliance audit or consultation with EIA professionals

Essential reading

- Crowley, C. K., & Gunn, J. (2014). Impact assessment: practical solutions to recurrent problems and contemporary challenges.
- Eccleston, C. H. (2011). *Environmental impact assessment: A guide to best professional practices*. CRC Press.
- Glasson, J., & Therivel, R. (2013). *Introduction to environmental impact assessment*. Routledge.
- Mareddy, A. R. (2017). *Environmental impact assessment: theory and practice*. Butterworth-Heinemann.

Suggested readings

- Gigerenzer, G. (2015). *Risk savvy: How to make good decisions*. Penguin.
- Lawrence, D. P. (2013). *Impact assessment: practical solutions to recurrent problems and contemporary challenges*. John Wiley & Sons.
- Renn, O. (2017). *Risk governance: coping with uncertainty in a complex world*. Routledge.
- Wood, C. (2014). *Environmental impact assessment: a comparative review*. Routledge.

M.Sc./M.A. Semester III
Structure 1

SKILL-BASED COURSE (SBC-3):

Techniques for Environmental Monitoring – I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SBC-3: Techniques for Environmental Monitoring – I	**2**	**1**	0	**1**	**Undergraduate**	**-**

Course Objectives

The course aims to:

- Develop an integrated understanding of environmental monitoring across major environmental matrices
- Build skills in designing sampling strategies and applying analytical techniques
- Understand measurement systems for reliable environmental data generation

Learning Outcomes

After the course, students will be able to:

- Design sampling strategies for air, water, and soil systems
- Apply appropriate analytical techniques for pollutant detection
- Interpret environmental data in relation to pollution processes

Course syllabus

Theory (15 hours)

Unit 1- Environmental Sampling and Monitoring Design (7 hours)

Environmental pollutants and their occurrence: air, water, soil, and emerging contaminants; Biological contaminants, E-waste materials; Principles of monitoring design: spatial-temporal variability, representativeness, and uncertainty; Sampling techniques: air, water, and soil sampling approaches; Sample handling: preservation, contamination control, and preparation; Basic extraction and preconcentration methods for environmental analysis (solid-phase, liquid-liquid, membran-based)

Unit II – Analytical Techniques and Measurement Systems (8 Hours)

Principles of environmental measurement: sensitivity, selectivity, and interferences; Spectroscopic techniques: UV-visible and atomic absorption for pollutant detection; Chromatographic techniques: gas chromatography and HPLC for organic contaminants; Electrochemical methods and basic radiochemical approaches; Data interpretation: calibration, validation, and measurement reliability

Suggested Practicals/Applied Exercise/Visits to Instrumental Facilities/Workshops (30 hours)

- Sample preservation and preparation, and heavy metal analysis using spectroscopy
- Electrochemical analysis of environmental pollutants
- Hands-on experience in handling selected instruments for environmental analysis
- Comparative analysis of techniques being used for monitoring the same pollutant
- Interference analysis in measurements and QA/QC basic exercise
- Calibration, standard preparation, data validation and error analysis
- Mini monitoring project, Field–lab data integration and reporting of analytical data
- Visit to instrumental facilities and hands-on experience
- Workshops on selected thematic areas related to the syllabus

Essential Readings

- Hounslow, A. (2018). *Water quality data: analysis and interpretation*. CRC Press.
- Keith, L. (2017). *Environmental sampling and analysis: a practical guide*. Routledge.
- Li, N., Hefferren, J. J., & Li, K. A. (2013). *Quantitative chemical analysis*. World Scientific Publishing Company.
- Nielsen, D. M., & Nielsen, G. (2006). *The essential handbook of ground-water sampling*. CRC Press.
- Skoog, D.A., Holler, F.J. and Crouch, S.R. (2017) Principal of Instrumental Analysis. 7th Edition, Sunder College Publisher, New York.

Suggested Readings

- Adams, V. D. (2017). *Water and wastewater examination manual*. Routledge.
- Cheremisinoff, P. N. (2019). *Handbook of water and wastewater treatment technology*. Routledge.
- Hauser, B. (2018). *Drinking water chemistry: a laboratory manual*. CRC Press.
- Rouessac, F., & Rouessac, A. (2013). *Chemical analysis: modern instrumentation methods and techniques*. John Wiley & Sons.

M.Sc./M.A. Semester IV
Structure 1

SKILL-BASED COURSE (SBC-4)

Techniques for Environmental Monitoring – II

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Prerequisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
SBC-4: Techniques for Environmental Monitoring – II	**2**	**1**	**0**	**1**	**Undergraduate**	

Course Objectives

The course aims to:

- Introduce advanced techniques for monitoring emerging environmental contaminants
- Develop competence in environmental data quality and interpretation
- Promote sustainable and green approaches in environmental analysis

Learning Outcomes

After the course, students will be able to:

- Evaluate advanced techniques for monitoring complex environmental systems
- Apply quality assurance and quality control in environmental data
- Interpret environmental data for decision-making
- Use green analytical approaches for sustainable monitoring

Unit I – Advanced Monitoring of Emerging Environmental Contaminants (7 Hours)

Emerging pollutants: microplastics, pharmaceuticals, e-waste and radioactive contaminants; Advanced detection approaches: trace-level monitoring and multi-matrix analysis; Membrane and selective techniques: adsorption and molecular imprinting; Nanotechnology-based monitoring: nanosensors and nano-enabled detection; Biosensors; Integration of monitoring systems across environmental compartments

Unit II – Data Quality, QA/QC, and Green Analytical Techniques (8 hours)
Environmental data quality: accuracy, precision, and uncertainty; Quality assurance and quality control protocols: calibration, validation, and standardization; Data interpretation for environmental assessment and decision-making; Green analytical techniques: green solvents, low-waste and energy-efficient methods; Sustainable monitoring systems: reducing environmental footprint of analysis

Suggested Practicals/Applied Exercise/Visits to Instrumental Facilities/Workshops (30 hours)

- Detection of emerging pollutants (case-based)
- Adsorption or membrane-based separation experiment
- Demonstration of nano-enabled detection (concept/lab)
- Environmental data interpretation
- Green solvent-based analysis and waste minimization
- Comparison of conventional vs green methods
- Monitoring system design exercise
- Case study of real-time monitoring
- Data visualization and reporting
- Ethical data handling exercise
- Mini research project

Essential Reading

- Keith, L. (2017). *Environmental sampling and analysis: a practical guide*. Routledge.
- Okamoto, S. and Oanh, N.T.K. (2026). *Statistics in Environmental Monitoring and Assessment.* CRC press
- Popek, E. P. (2017). *Sampling and analysis of environmental chemical pollutants: a complete guide*. Elsevier.
- Rouessac, F., & Rouessac, A. (2013). *Chemical analysis: modern instrumentation methods and techniques*. John Wiley & Sons.

Suggested Reading

- Koel, M., & Kaljurand, M. (2019). *Green analytical chemistry 2nd Edition*. Royal Society of Chemistry.
- Spellerberg, I. F. (2005). *Monitoring ecological change*. Cambridge University Press.
- Petrozzi, S. (2012). *Practical instrumental analysis: methods, quality assurance, and laboratory management*. John Wiley & Sons.
- Manahan, S. E. (2022). *Environmental Chemistry*. CRC Press.

M.Sc. Environmental Science
M.A. Environmental Studies
(Structure 3)
Semester III

Semester – III
MSc./M.A. Structure – 3

DISCIPLINE SPECIFIC-CORE (DSC-7):

Advances in Instrumentation for Environmental Research

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advances in Instrumentation for Environmental Research	**4**	**2**	0	**2**	**UG EVS with Research/ UG with Major in EVS**	**-**

Course Objectives

The course aims to:

- Develop advanced understanding of environmental research using high-end instrumentation and analytical systems
- Enable critical selection and application of advanced tools in research contexts
- Integrate biological systems and data-driven approaches in environmental research
- Build capacity for interpreting and evaluating contemporary research

Learning Outcomes

After the course, students will be able to:

- Select and justify advanced instruments for environmental research problems
- Interpret complex datasets from analytical and biological systems
- Critically evaluate research using high-end tools
- Integrate instrumentation outputs into research and scientific communication

Course syllabus

Theory (30 hours)

Unit I: Instrumentation Principles, Selection, and Data Quality (7 hours)

Recent advances in spectroscopy, chromatography, mass spectrometry, and sensor-based systems; principles and criteria for instrument selection based on research objectives, scale, and environmental matrices; calibration, QA/QC protocols, uncertainty, and data validation for reliable environmental measurements.

Unit II: Advanced Laboratory and Molecular Analytical Systems (8 hours)
Overview of advanced analytical systems (GC-MS, HPLC, TOC, CHNS/O analyzers, qPCR, genome sequencing platforms); applications in environmental analysis and ecosystem studies; integration of chemical and molecular data for understanding biodiversity and ecosystem processes.

Unit III: Field Instrumentation, Model Organisms, and Bioanalytical Approaches (8 hours)
Applications of field-based instruments (bioacoustic sensors, camera traps, spectroradiometers, automated weather stations, portable XRF, ion chromatography) in biodiversity and ecosystem monitoring; role of model organisms and bioindicators in environmental assessment; linking biological responses with instrument-derived environmental data.

Unit IV: Data Integration, Genomics, and Large Dataset Analytics (7 hours)
Integration of multi-source datasets (analytical, biological, monitoring systems); advances in genome sequencing and metagenomic approaches; handling and interpretation of large environmental datasets; translating data into research insights, policy relevance, and practical applications.

Suggested Practicals / Applied Exercise/Field Studies/Hands-On Sessions (60 hours)

- Calibration and operation of UV-Vis and FTIR spectrometers
- Determining the heavy metal profile of an environmental sample using ICP-MS
- Soil and water nutrient analysis using TOC/auto-analyzer
- Field deployment of PM and gas sensors for ambient air monitoring
- Critically evaluate a recent research paper focusing on instrumentation choice and data interpretation
- Estimating the quality of different water samples using a multiparameter water quality analyzer
- Use of camera traps and bioacoustics tools in biodiversity research
- Develop an instrument selection plan aligned with a defined environmental research problem
- Interpret datasets generated from advanced analytical or molecular platforms
- Compare research studies using different analytical techniques for similar environmental questions
- Analyze genomic or biological datasets to infer environmental patterns
- Design an experimental framework using model organisms for environmental assessment
- Integrate chemical and biological datasets for comprehensive interpretation using R
- Perform a structured critique of a research article focusing on data quality and uncertainty
- Develop a synthesis matrix comparing multiple research studies
- Interpret large environmental datasets to identify trends and relationships
- Prepare graphical representations of complex environmental data
- Identify methodological limitations in instrument-based studies
- Develop a concept note applying advanced tools to a real environmental issue

Essential Readings

- Bibby, C.J., Burgess, N.D., Hill, D.A., Mustoe, S.H. (2000). Birds Census Techniques. Academic Press, London, UK
- Davis, D. E. (2021). *CRC Handbook of Census Methods for Terrestrial Vertebrates*. CRC Press.
- Dunnivant, F. M., & Ginsbach, J. W. (2024). *Essential Methods of Instrumental Analysis*. John Wiley & Sons.
- Green, M. R., & Sambrook, J. (2019). *Molecular cloning: A laboratory manual* (4th ed.). Cold Spring Harbor Laboratory Press.
- Rocha, M., & Ferreira, P. G. (2018). *Bioinformatics algorithms: design and Implementation in Python*. Academic Press.
- Sutherland, W. J. (2006). *Ecological Census Techniques: A Handbook*. Cambridge University Press.

Suggested Readings

- Hafner, S. (2019). An introduction to R for beginners. *Hafner Consulting LLC*.
- Harris, D. C. (2010). Quantitative Chemical Analysis. Macmillan.
- Valcárcel, M. (2000). *Principles of analytical chemistry: a textbook*. Springer Science & Business Media.
- Van Straalen, N. M., & Roelofs, D. (2012). *An introduction to ecological genomics*. OUP Oxford.
- Yergey, A. L., Edmonds, C. G., Lewis, I. A., & Vestal, M. L. (2013). *Liquid chromatography/mass spectrometry: techniques and applications*. Springer Science & Business Media.

Semester – III

MSc./M.A. Structure – 3

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

DISCIPLINE SPECIFIC-Research Methodology (DS-RM):

Advanced Methods in Environmental Research

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Advanced Methods in Environmental Research	2	0	0	2	UG EVS with Research/ UG with Major in EVS	

Course objectives
The course aims to:

- Develop advanced understanding of interdisciplinary research approaches in environmental studies
- Train students in designing scientifically robust and problem-oriented research
- Enable integration of ecological, social, and technological dimensions in research frameworks

Learning Outcomes
After the course, students will be able to:

- Formulate research problems grounded in environmental systems
- Conduct critical and structured literature reviews
- Design appropriate research methodologies for environmental studies
- Develop research proposals integrating field, laboratory, and analytical approaches

Course syllabus
Suggested Practicals / Applied Exercises / Field Studies (60 hours)

- Conduct a field-based exercise to identify a real environmental problem, followed by formulation of research questions grounded in ecological and societal relevance
- Perform a structured literature review using scientific databases such as Scopus or Web of Science and prepare an annotated bibliography
- Develop a research gap analysis matrix by comparing findings across multiple peer-reviewed studies

- Construct a conceptual framework linking environmental variables, processes, and expected outcomes
- Formulate hypotheses and research objectives based on the identified problem and literature review
- Design a detailed research methodology specifying sampling strategy, variables, and data collection techniques
- Prepare a field sampling plan for air, water, soil, or biodiversity assessment including site selection and frequency
- Conduct a pilot field survey to test feasibility of the research design and data collection tools
- Develop data collection instruments such as questionnaires, field observation sheets, or sampling protocols
- Perform stakeholder mapping to identify relevant actors influencing or affected by the research problem
- Integrate ecological, social, and technological dimensions into a unified research design
- Prepare documentation addressing research ethics, consent, and environmental responsibility
- Write a complete research proposal including introduction, objectives, methodology, and expected outcomes
- Present the research proposal in a seminar format and incorporate peer feedback
- Critically review and evaluate research proposals of peers for methodological soundness
- Revise the research design based on feedback and pilot study findings
- Prepare a pilot study report summarizing methods, observations, and improvements required
- Identify potential research outputs such as publications, patents, or applied environmental solutions
- Develop a timeline and workflow plan for full-scale research implementation
- Maintain a research logbook documenting field observations, challenges, and methodological adjustments

Suggested Readings

- Booth, W. C., Colomb, G. G., & Williams, J. M. (2009). *The craft of research*. University of Chicago Press.
- Creswell, J. W., & Creswell, J. D. (2017). *Research design: Qualitative, quantitative, and mixed methods approaches*. Sage Publications.
- Karban, R., Huntzinger, M., Pearse, I.S. (2014). How To Do Ecology: A Concise Handbook, Princeton University
- Walliman, N. (2021). *Research methods: The basics*. Routledge.

Essential Readings

- Dawson, C. (2019). *Introduction to research methods 5th edition: A practical guide for anyone undertaking a research project*. Hachette UK.
- Silverman, D. (2019). *Doing qualitative research* (5th ed.). Sage.
- Sutherland, W. J. (2008). *The conservation handbook: research, management and policy*. John Wiley & Sons.
- Wardropper, C. B., Dayer, A. A., Goebel, M. S., & Martin, V. Y. (2021). Conducting conservation social science surveys online. *Conservation Biology*, *35*(5), 1650-1658.

Assessment mode: Continuous assessment as per guidelines

Semester – III

MSc./M.A. Structure – 3

DISCIPLINE SPECIFIC-Tools for Research (DS-TR):

Tools for Environmental Research

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Tools for Environmental Research	2	0	0	2	UG EVS with Research/ UG with Major in EVS	

Course objectives

The course aims to:

- Equip students with analytical, spatial, and computational tools for environmental research
- Develop skills in handling environmental datasets and monitoring systems
- Enable integration of tools for analysis, modelling, and visualization

Learning Outcomes

After the course, students will be able to:

- Apply geospatial tools for environmental analysis
- Analyze environmental datasets using statistical tools
- Use monitoring instruments for field-based data collection
- Interpret and visualize environmental data effectively

Course syllabus

Suggested Practicals / Applied Exercises / Field Studies (60 hours)

- Perform GIS-based mapping of environmental variables such as land use, vegetation cover, or pollution distribution
- Analyze satellite imagery to assess environmental changes such as deforestation or urban expansion
- Conduct land use/land cover classification using remote sensing datasets

- Collect field data using environmental monitoring instruments and record observations systematically
- Calibrate field instruments and evaluate their accuracy and reliability
- Develop a dataset from field observations and prepare it for analysis
- Perform statistical analysis including descriptive statistics to summarize environmental data
- Conduct inferential statistical tests such as correlation and regression to examine relationships between variables
- Clean and preprocess raw environmental datasets to remove errors and inconsistencies
- Create a structured environmental database for storing and managing research data
- Visualize environmental data using graphs, maps, and dashboards
- Perform time-series analysis to understand trends in environmental parameters
- Develop a simple environmental model to simulate changes in a selected variable
- Integrate spatial (GIS) and statistical datasets to derive meaningful interpretations
- Use reference management software to organize research literature
- Conduct plagiarism checks on research documents using digital tools
- Collaborate on data analysis using shared digital platforms
- Prepare a technical report based on analyzed environmental data
- Interpret monitoring data in relation to environmental processes and impacts
- Complete a mini-project combining GIS analysis, statistical interpretation, and reporting

Suggested Readings

- Wickham, H., & Grolemund, G. (2022). *R for data science* (2nd ed.). O'Reilly.
- O'Sullivan, D., & Unwin, D. (2021). *Geographic information analysis* (3rd ed.). Wiley.
- Field, A. (2023). *Discovering statistics using SPSS* (6th ed.). Sage.
- Longley, P. A., et al. (2021). *Geographic information science and systems* (5th ed.). Wiley.
- Chang, W. (2021). *R graphics cookbook* (2nd ed.). O'Reilly.

Essential Readings

- O'Sullivan, D., & Unwin, D. (2021). *Geographic information analysis* (3rd ed.). Wiley.
- Longley, P. A., Goodchild, M. F., Maguire, D. J., & Rhind, D. W. (2021). *Geographic information science and systems* (5th ed.). Wiley.
- Wickham, H., & Grolemund, G. (2022). *R for data science* (2nd ed.). O'Reilly.
- Field, A. (2023). *Discovering statistics using IBM SPSS statistics* (6th ed.). Sage.
- Chang, W. (2021). *R graphics cookbook* (2nd ed.). O'Reilly.

Suggested Readings

- James, G., et al. (2021). *An introduction to statistical learning* (2nd ed.). Springer.
- Zuur, A. F., et al. (2021). *A beginner's guide to R*. Springer.
- Hijmans, R. J. (2023). *Spatial data analysis with R*. CRC Press.

Assessment mode: Continuous assessment as per guidelines

M.Sc. Environmental Science
M.A. Environmental Studies
(Structure 3)
Semester IV

Semester – IV

MSc./M.A. Structure – 3

DISCIPLINE SPECIFIC-Research Writing (DS-RW):

Techniques of Research Writing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Techniques of Research Writing	2	0	0	2	UG EVS with Research/ UG with Major in EVS	

Course objectives

The course aims to:

- Develop scientific writing and communication skills in environmental research
- Train students in preparing dissertations, reports, and research papers
- Enable effective dissemination of research findings

Learning Outcomes

After the course, students will be able to:

- Write structured research documents including dissertations and manuscripts
- Prepare publishable research papers
- Present research findings effectively using visual and oral formats
- Understand publication processes and ethical standards

Course syllabus

Suggested Practicals / Applied Exercises / Field Studies (60 hours)

- Write a clear and concise research problem statement with defined objectives and scope
- Prepare a comprehensive literature review chapter integrating multiple scientific sources
- Draft a detailed methodology chapter describing research design and data collection methods
- Analyze research data and write results and discussion sections with proper interpretation
- Create scientific tables, graphs, and figures for data presentation

- Develop maps for spatial representation of environmental data
- Use reference management software to organize citations and generate bibliographies
- Format references according to APA and journal-specific styles
- Conduct plagiarism checks and revise text to ensure originality
- Write an abstract summarizing research objectives, methods, and key findings
- Prepare a complete research manuscript suitable for journal submission
- Identify appropriate journals based on scope, impact, and indexing
- Format manuscript according to journal guidelines
- Simulate manuscript submission and documentation process
- Draft responses to reviewer comments in a peer-review scenario
- Design and present a conference poster based on research findings
- Deliver an oral presentation communicating research outcomes effectively
- Write a policy brief translating research findings for decision-makers
- Prepare a technical report for stakeholders or agencies
- Compile and submit a complete dissertation/report following academic standards
- Edit and proofread research documents for clarity, coherence, and accuracy

Essential Readings

- Belcher, W. L. (2019). *Writing your journal article in 12 weeks* (2nd ed.). Sage, London.
- Davis, M., Davis, K. J., & Dunagan, M. (2012). *Scientific papers and presentations*. Academic press.
- Day, A. (2017). *How to get research published in journals*. Routledge.
- Murray, R. (2025). *How to Write a Thesis 5e*. McGraw-Hill Education (UK).
- Sword, H. (2012). *Stylish academic writing*. Harvard University Press.

Suggested Readings

- Green, E. P. (2021). *Healthy presentations: How to craft exceptional lectures in medicine, the health professions, and the biomedical sciences*. Springer Nature.
- Hofmann, A. H. (2023). *Scientific writing and communication*. Oxford University Press, Oxford.
- Silvia, P. J. (2019). *How to write a lot* (2nd ed.). American Psychological Association.

Assessment mode: Continuous assessment as per guidelines

Discipline Specific Electives Courses

Odd Semester DSEs

30. **DSE-25:** Climate Risk, Adaptation and Disaster Resilience
31. **DSE-26:** Environmental Biotechnology
32. **DSE-27**: Environmental Innovation and Sustainable Enterprise Design
33. **DSE-28:** Ethics, Sustainability and Responsible Development Systems
34. **DSE-29:** Life Cycle Assessment (LCA) and Environmental Auditing

Even Semester DSEs

36. **DSE-30:** Climate Technology Systems and Sustainable Innovation
37. **DSE-31:** Corporate Social Accountability and Environmental Transparency
38. **DSE-32:** Environmental and Ecological Engineering
39. **DSE-33:** Environmental Enterprise Policy, Finance, and Governance
40. **DSE-34:** Global Environmental Politics
41. **DSE-35:** Sustainability Paradigms Beyond ESG
42. **DSE-36:** Systems Analysis and Modelling

Discipline Specific Electives Courses

Odd Semester

Odd Semester DSEs

35. **DSE-25:** Climate Risk, Adaptation and Disaster Resilience
36. **DSE-26:** Environmental Biotechnology
37. **DSE-27**: Environmental Innovation and Sustainable Enterprise Design
38. **DSE-28:** Ethics, Sustainability and Responsible Development Systems
39. **DSE-29:** Life Cycle Assessment (LCA) and Environmental Auditing

DSE – Odd Semester

DISCIPLINE SPECIFIC-ELECTIVE (DSE-25):

Climate Change and Disaster Management

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-25: Climate Risk, Adaptation and Disaster Resilience	4	3	0	1	Undergraduate	

Course Objectives

The course aims to:

- Analyze climate and disaster risks as integrated socio-ecological systems
- Apply quantitative, spatial, and policy tools for risk and vulnerability assessment
- Design adaptation and disaster risk reduction (DRR) strategies across sectors
- Evaluate governance, finance, and institutional frameworks for resilience
- Develop professional outputs for consulting, policy, and development practice

Learning Outcomes

By the end of the course, students will be able to:

- Conduct integrated climate–disaster risk assessments
- Apply DRR and adaptation frameworks in real-world contexts
- Design resilience strategies for communities, ecosystems, and infrastructure
- Evaluate policies, institutions, and finance mechanisms
- Produce consultancy-grade outputs (risk reports, DRR plans, adaptation strategies)

Course syllabus

Theory (45 hours)

UNIT I — Climate and Disaster Risk Systems (11 hours)

Risk framework (hazard–exposure–vulnerability–risk); Typologies of hazards (climate-induced and geophysical); Multi-hazard risk and cascading impacts; Sectoral risks (water, agriculture, health, infrastructure); Risk indicators, indices, and scenario analysis; Uncertainty and decision-making under risk.

Unit II: Adaptation and Disaster Risk Reduction Strategies (12 hours)
Adaptation approaches (ecosystem-based, infrastructure-based, community-based); DRR strategies (prevention, preparedness, mitigation); Nature-based solutions (NbS); Climate-resilient infrastructure; Indigenous and local knowledge; Integration of CCA–DRR frameworks; Monitoring and evaluation of resilience outcomes.

Unit III: Governance, Policy, and Climate–Disaster Finance (11 hours)
Global and national frameworks (United Nations Framework Convention on Climate Change, United Nations Office for Disaster Risk Reduction); Sendai and Hyogo Frameworks; National Adaptation Plans; Disaster management policies; Climate and disaster finance (GCF, insurance, risk transfer); Institutional coordination; Climate justice and equity.

Unit IV: Disaster Systems, Response, and Resilient Recovery (11 hours)
Disaster management cycle (preparedness, response, recovery); Hazard assessment and early warning systems; Risk communication and decision support systems; Emergency planning and logistics; Community-based disaster management; Post-disaster recovery and "build back better"; Climate-linked disasters (heatwaves, floods, cyclones).

Suggested Practicals/Field visits/Applied Exercise (30 hours)
- Analyze trends in temperature, precipitation, and CO_2 using real-time NOAA/NASA datasets.
- Map climate vulnerability for a selected region using GIS tools.
- Develop hazard zonation maps for floods, droughts, or cyclones.
- Design a disaster communication and early warning system model.
- Plan a nature-based solution to mitigate flood and heat risks in a selected region.
- Evaluate disaster response effectiveness through a case study analysis.
- Estimate carbon footprint (individual/institutional) and propose reduction strategies.
- Develop an adaptation plan for a climate-vulnerable community (case-based).
- Apply simple climate models (e.g., MAGICC/SCENGEN) for scenario analysis.
- Conduct a comparative analysis of two disaster response cases (local vs national).
- Undertake a field visit to a DRR organization and prepare a protocol assessment report.
- Write a policy brief on a climate–disaster linkage issue.
- Perform stakeholder mapping and analysis for local climate adaptation.
- Conduct and analyze a survey on climate risk perception and awareness.
- Develop a climate/disaster finance proposal (mock funding case).
- Prepare a field report based on visits to DDMA/NDMA or DRR sites.

Essential Readings

- Burch, S., & Harris, S. (2014). *Understanding climate change: science, policy, and practice*. University of Toronto Press.
- Keller, E. A., & DeVecchio, D. E. (2019). *Natural hazards: earth's processes as hazards, disasters, and catastrophes*. Routledge.
- Lizarralde, G. (2021). *Unnatural disasters: Why most responses to risk and climate change fail but some succeed*. Columbia University Press.

- Pelling, M. (2010). *Adaptation to climate change: from resilience to transformation*. Routledge.
- Tanner, T., & Horn-Phathanothai, L. (2014). *Climate change and development*. Routledge.
- Tomaszewski, B. (2020). *Geographic information systems (GIS) for disaster management*. Routledge.

Suggested Readings

- Blaikie, P., Cannon, T., Davis, I., & Wisner, B. (2014). *At risk: natural hazards, people's vulnerability and disasters*. Routledge.
- Kelman, I. (2020). *Disaster by choice: How our actions turn natural hazards into catastrophes*. Oxford University Press.
- Molthan-Hill, P. (2017). *The business student's guide to sustainable management: Principles and practice*. Routledge.
- Tanner, T., & Horn-Phathanothai, L. (2014). *Climate change and development*. Routledge.
- Trumbull, G. (2025). A Concise Business Guide to Climate Change: What Managers, Executives, and Students Need to Know. Harvard Business Review Press

DSE – Odd Semester

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSE-26)

Environmental Biotechnology

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-26: Environmental Biotechnology	**4**	**3**	**0**	**1**	**Undergraduate**	

Course Objectives

- Understand molecular mechanisms governing genetic information and gene expression.
- Apply recombinant DNA technology and molecular tools in environmental systems.
- Analyze biological treatment processes and biotechnological strategies for pollution control.
- Evaluate microbial and enzymatic processes for sustainable environmental remediation.
- Explore ecological restoration and emerging biotechnologies for environmental resilience.

Learning Outcomes

By the end of this course, students will be able to:

- Describe the molecular basis of heredity and expression of genetic material.
- Employ molecular techniques such as cloning, PCR, and sequencing in environmental applications.
- Evaluate the design and operation of biological wastewater treatment systems.
- Apply enzymes, microbes, and immobilization technologies in pollution control.
- Propose biotechnological interventions for ecological restoration and sustainable development.

Course syllabus
Theory (45 hours)
Unit I: Molecular Foundations of Environmental Biotechnology (10 hours)

Ladmark experiments in molecular genetics (Frederick Griffith, Oswald Avery, Alfred Hershey–Chase, Matthew Meselson–Stahl); DNA/RNA structure–function; gene organization (cistrons, introns, exons, operons); DNA replication (prokaryotic focus); central dogma—transcription, translation, regulation; coding and regulatory RNAs; protein synthesis inhibitors; epigenetics, gene editing basics, and RNA interference (RNAi).

Unit II: Genetic Engineering and Molecular Tools in Environmental Contexts (11 hours)

Recombinant DNA tools (restriction enzymes, ligases, vectors—plasmids, BACs, YACs); gene cloning workflow; DNA sequencing (Sanger, next-generation sequencing); probes, hybridization, cDNA libraries; microarrays, metagenomics, molecular diagnostics (eDNA/eRNA); CRISPR-based editing, environmental DNA surveillance, bioinformatics pipelines, and AI-driven genomic analysis.

Unit III: Biotreatment Systems and Environmental Remediation (12 hours)
Biological treatment (aerobic/anaerobic); microbial consortia (UASB, trickling filters, activated sludge); bioreactors (batch, continuous, fixed-film, fluidised-bed); immobilised cells/enzymes; biosensors; phytoremediation and bioaugmentation; omics tools (metagenomics, proteomics, metabolomics); bacteriophages in wastewater (pathogen control, biofilm disruption, biosensing); emerging contaminants (microplastics, pharmaceuticals), antimicrobial resistance tracking, and nature-based treatment systems.

Unit IV: Innovations and Sustainable Futures in Environmental Biotechnology (12 hours)
Ecological restoration (passive, active, assisted); microbial/enzymatic tools (rhizo-, mycoremediation; laccases, oxidoreductases); constructed wetlands and bioengineered systems; synthetic biology, CRISPR, biodegradable bioplastics, biosensing; phage engineering for remediation and antimicrobial resistance control; microalgae and engineered microbes for wastewater treatment; microbial fuel cells (waste-to-energy); carbon capture biotechnology, climate-resilient bioengineering, circular bioeconomy, and SDG-linked environmental solutions.

Suggested Practicals / Applied Exercises/Field Studies (30 hours)
- Isolation and quantification of genomic DNA from environmental samples (e.g., soil microbes, wastewater bacteria).
- Agarose gel electrophoresis and restriction digestion of plasmid DNA.
- Polymerase Chain Reaction (PCR) for amplification of environmental gene markers (e.g., 16S rRNA, degradation pathway genes).
- Analysis of gene expression via simple dot blot or microarray demonstration (conceptual if resources limited).
- DNA sequencing interpretation (Sanger/NGS output – simulated data analysis).
- Measurement of key water quality parameters (DO, BOD, COD, pH, turbidity, conductivity, nutrients).
- Laboratory-scale wastewater treatment using activated sludge or mixed microbial cultures.
- Construction and performance monitoring of a batch or continuous bioreactor for pollutant removal.
- Immobilisation of microbial cells or enzymes and evaluation of pollutant degradation efficiency.
- Assessment of enzyme activity relevant to bioremediation (e.g., laccase, peroxidase assay).
- Detection of environmental DNA (eDNA) from soil/water samples for biodiversity monitoring (conceptual lab).
- Demonstration or data interpretation from biosensors for pollutant detection.

- Case-study analysis of ecological restoration projects using environmental biotechnology tools.
- Simulation/modelling of bioreactor performance or ecological restoration success under different scenarios.

Essential Readings

- Glick, B. R., & Patten, C. L. (2022). *Molecular biotechnology: Principles and applications of recombinant DNA* (5th ed.). ASM Press.
- Reineke, W., & Schlömann, M. (2023). *Environmental Microbiology*. Berlin, Germany:: Springer.
- Rittmann, B. E., & McCarty, P. L. (2012). *Environmental biotechnology: Principles and applications* (2nd ed.). New York: McGraw-Hill.
- Vallero, D. A. (2015). *Environmental biotechnology: a biosystems approach*. Academic press.

Suggested Readings

- Timmis, K. N. (Ed.). (2010). *Handbook of hydrocarbon and lipid microbiology*. Berlin: Springer.
- Zhang, C., & Wang, Y. (2020). *Synthetic biology and environmental biotechnology*. Elsevier.
- United Nations Environment Programme. (2021). *Making peace with nature: A scientific blueprint to tackle the climate, biodiversity and pollution emergencies*. UNEP.

DSE – Odd Semester

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSE-27)

Environmental Innovation and Sustainable Enterprise Design

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-27: Environmental Innovation and Sustainable Enterprise Design	4	3	0	1	Undergraduate	-

Course Objectives

The course aims to:

- Develop an understanding of environmental innovation as a response to ecological limits and industrial sustainability challenges
- Examine the integration of environmental technologies within industrial systems for reducing ecological impacts
- Build capacity for designing environmentally responsible products, processes, and enterprise models
- Analyze barriers and risks associated with adoption of sustainable innovations in real-world contexts
- Enable translation of ecological knowledge into viable green enterprise opportunities

Learning Outcomes

After the course, students will be able to:

- Explain the distinction between conventional innovation and environmentally grounded innovation within ecological constraints
- Analyze industrial systems using concepts of material flows and ecological impacts
- Evaluate environmental technologies in terms of their applicability, risks, and ecological performance
- Identify socio-technical and environmental barriers to adoption of sustainable innovations
- Design conceptual green enterprise models incorporating ecological principles and sustainability goals
- Critically assess ethical issues such as greenwashing and ecological integrity in innovation processes

Course syllabus
Theory (45 hours)

Unit I: Environmental Foundations of Industrial Innovation (11 hours)
Innovation vs invention in environmental systems: ecological problem framing and solution pathways; Drivers of eco-innovation: climate, biodiversity, pollution; Industrial metabolism and ecological implications; Sustainability-oriented innovation systems; Role of innovation actors: academia, industry, and grassroots in sustainability transitions.

Unit II: Environmental Technologies for Industrial Applications (11 hours)
Cleaner production and low-impact industrial processes: pollution prevention and resource minimization; Circular material flows and industrial symbiosis: closing loops in real industrial systems; Nature-based and bio-inspired solutions: biomimicry, ecological engineering in production; Digital environmental technologies: monitoring, sensors, and data-driven environmental management.

Unit III: Innovation Adoptions, Impact, and Scalability (11 hours)
Pathways from concept to industrial application: pilot transitions and system integration; Barriers to adoption: socio-technical lock-ins, infrastructure constraints, behavioural resistance; Ecological performance of innovations; Risk and uncertainty: unintended ecological consequences and long-term sustainability; Scaling sustainable technologies: partnerships, pilots, licensing

Unit IV: Translating Research into Marketable Solutions (12 hours)
From research to enterprise: incubation and field application of environmental solutions; Green enterprise models: circular, regenerative, and service-oriented systems; Market differentiation through ecological value: sustainability as competitive advantage; Ethics and integrity: avoiding greenwashing and ensuring ecological credibility; Environmental entrepreneurship case studies: from lab to field; IPR and environmental patents.

Suggested Practicals /Applied Exercise/Field Studies (30 hours)
- Cleaner production audit of a selected industry
- Design of a waste-to-resource innovation pathway
- Development of a conceptual eco-innovation prototype
- Analyze a grassroots eco-innovation (case study method)
- Ecological risk assessment of a technology
- Sustainability benchmarking of products
- Market analysis for a green product
- Compare scalability potential of two green energy startups
- Conduct a SWOT for a bio-innovation prototype
- Patent search in environmental technologies
- Evaluate open-source vs. patent models for environmental tech
- Build a value chain map for an environmental product
- Write a tech profile summary for a nature-based solution
- Identify at least 3 barriers to the diffusion of clean-tech in India
- Green branding strategy development

- Prepare a visual infographic explaining TRL to lay stakeholders
- Draft a one-page proposal for a university tech transfer initiative
- Scenario analysis for scaling innovation
- Startup pitch with ecological value
- Field visit to industry / startup

Essential Readings

- Arceivala, S. J. (2014). Green technologies: For a better future. McGraw Hill Education (India).
- Borges, W., & Grosskopf, J. (2025). *Sustainability Programs: A Design Guide to Achieving Financial, Social, and Environmental Performance*. John Wiley & Sons.
- Debref, R. (2018). *Environmental Innovation and Ecodesign: Certainties and Controversies*. John Wiley & Sons.
- Hoff, P. (2012). *Greentech innovation and diffusion: a financial economics and firm-level perspective*. Springer Science & Business Media.
- Martínez, C. I. P., & Poveda, A. C. (2021). *Environment and Innovation. Strategies to Promote Growth*. CRC Press, Boca Raton.
- Wells, P. E. (2013). *Business models for sustainability*. Edward Elgar Publishing.

Suggested Readings

- Gassmann, O., Frankenberger, K., Sauer, R., Blohm, I., & Palmié, M. (2025). *Exploring the Field of Business Innovation: New Theoretical Perspectives*. Springer Nature.
- Jordan, A., & Lenschow, A. (Eds.). (2009). *Innovation in environmental policy?: integrating the environment for sustainability*. Edward Elgar Publishing.
- Lehner, O. M. (2016). *Routledge handbook of social and sustainable finance*. Routledge.
- Manahan, S. E. (2006). *Environmental science and technology: a sustainable approach to green science and technology*. CRC Press.
- Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M., & Scapolo, F. (2022). *Towards a green & digital future*. Publications Office of the European Union, Luxembourg.
- Schoenmaker, D., & Schramade, W. (2018). *Principles of sustainable finance*. Oxford University Press.
- Tidd, J. (2023). Managing innovation. *IEEE Technology and Engineering Management Society Body of Knowledge (TEMSBOK)*, 95-108.

DSE – Odd Semester

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSE-28)

Ethics, Sustainability and Responsible Development Systems

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-27: Ethics, Sustainability and Responsible Development Systems	4	3	0	1	Undergraduate	

Course Objectives

The course aims to:

- Introduce philosophical traditions and ethical frameworks concerning nature, justice, and sustainability.
- Examine contemporary environmental issues through moral, spiritual, and cultural perspectives.
- Analyze environmental rights, responsibilities, and ethical dilemmas in conservation, development, and policy.
- Integrate Indian ecological thought with global environmental ethics.
- Equip students to apply ethical reasoning to environmental conflicts and governance.

Learning Outcomes

After the course, students will be able to:

- Apply ethical frameworks to analyze environmental and sustainability challenges.
- Evaluate trade-offs and ethical implications in policy, business, and development decisions.
- Integrate justice, equity, and intergenerational ethics into sustainability solutions.
- Interpret and apply Indian and traditional ecological knowledge systems in contemporary contexts.
- Develop ethically informed strategies and policy recommendations for sustainability transitions.

Course Syllabus

Theory (45 hours)

Unit I: Foundations of Environmental Philosophy and Sustainability Thinking (11 hours)

Core concepts: anthropocentrism, biocentrism, ecocentrism; Intrinsic vs instrumental vs relational values; Ethics in the Anthropocene; moral responsibility and sustainability; Systems thinking and ethical decision-making frameworks.

Unit II: Ethical Frameworks — Global and Indian Knowledge Systems (12 hours)
Indian ecological thought: Dharma, Ahimsa, Ṛta, Vriksha Dharma, Vasudhaiva Kutumbakam; Western ethics: utilitarianism, deontology, virtue ethics, rights-based approaches; Comparative frameworks; traditional ecological knowledge (TEK) and indigenous sustainability practices; Relevance to modern sustainability challenges.

Unit III: Justice, Equity, and Sustainability (12 hours)
Environmental justice (social, gender, spatial, intergenerational); Rights of nature; Commons governance; Ethical dimensions of development and conservation conflicts; Just transitions, climate justice, and sustainability trade-offs; Ethical evaluation of real-world case studies.

Unit IV: Ethics in Governance, Business, and Global Sustainability Systems (11 hours)
Ethics in environmental governance and policy; SDGs and accountability frameworks; corporate responsibility, ESG ethics, and greenwashing critique; ethical decision-making in climate, biodiversity, and resource systems; planetary boundaries, ecological debt, and responsible innovation.

Suggested Practicals/Applied Exercises/Field Studies (30 hours)
- Analyze an environmental issue using multiple ethical frameworks.
- Evaluate a policy or project using justice and equity criteria.
- Conduct a stakeholder ethical analysis for a sustainability conflict.
- Develop a case study on Indian ecological practices and their modern relevance.
- Compare Western and Indian ethical approaches for a real-world problem.
- Assess ethical dimensions of ESG or corporate sustainability reports.
- Conduct a debate on development vs conservation trade-offs.
- Analyze a case of environmental injustice or conflict.
- Develop an ethical decision-making framework for a sustainability issue.
- Evaluate greenwashing claims using ethical and sustainability criteria.
- Prepare a policy brief incorporating ethical and cultural perspectives.
- Design a community-based sustainability strategy integrating traditional knowledge.
- Develop an argument for or against granting rights to nature (e.g., rivers, species, ecosystems).

Essential Readings

- Attfield, R. (2018). *Environmental ethics: a very short introduction* (Vol. 585). Oxford University Press.
- Bassham, G. (2020). *Environmental ethics: the central issues*. Hackett Publishing.
- DesJardins, J. R. (2013). *Environmental ethics: An introduction to environmental philosophy*. Cengage Learning.
- Hourdequin, M. (2024). *Environmental ethics: From theory to practice*. Bloomsbury Publishing.
- Rolston III, H. (2020). *A new environmental ethics: the next millennium for life on earth*. Routledge.
- Traer, R. (2019). *Doing environmental ethics*. Routledge.

Suggested Readings

- Biasetti, P. (2026). *Conservation Ethics: The Challenges of Preserving Nature*. Taylor & Francis.
- Guha, R. (2006). *How much should a person consume?: Environmentalism in India and the United States*. Univ of California Press.
- Jamieson, D. (2008). Ethics and the environment: An introduction. Cambridge University Press.
- Jamieson, D. (2014). *Reason in a dark time: why the struggle against climate change failed--and what it means for our future*. Oxford University Press.
- Nixon, R. (2011). *Slow Violence and the Environmentalism of the Poor*. Harvard University Press.
- Norton, B.G. (2021). *Why Preserve Natural Variety?* Princeton University Press.
- Plumwood, V. (2005). Environmental culture: The ecological crisis of reason. Routledge.

DSE – Odd Semester

DISCIPLINE SPECIFIC-ELECTIVE (DSE-29):

Life Cycle Assessment (LCA) and Environmental Auditing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-29: Life Cycle Assessment (LCA) and Environmental Auditing	4	3	0	1	Undergraduate	-

Course Objectives

The course aims to:

- Develop advanced life cycle thinking and systems-based environmental analysis for products, processes, and infrastructure.
- Apply ISO-based LCA frameworks and environmental auditing protocols in real-world contexts.
- Build competencies in LCA software, databases, and uncertainty analysis.
- Integrate LCA with environmental auditing, circular economy, and sustainability metrics.
- Enable data-driven decision-making for sustainable design, compliance, and resource optimization.

Learning Outcomes

After the course, students will be able to:

- Conduct full LCA studies (goal → inventory → impact → interpretation) using standard frameworks.
- Apply LCA tools (SimaPro, OpenLCA, GaBi) for comparative and scenario analysis.
- Perform environmental audits and compliance assessments using ISO and regulatory frameworks.
- Integrate carbon, water, and material footprints into decision-making.
- Evaluate trade-offs, uncertainties, and system boundaries in sustainability analysis.
- Recommend optimized, circular, and low-impact system designs.

Course syllabus

Theory (45 hours)

UNIT I – Life Cycle Thinking, Systems Boundaries and Impact Frameworks (11 hours)

Principles of life cycle thinking; systems theory and industrial ecology foundations; functional units and system boundaries; ISO 14040/14044; LCI and LCIA; midpoint vs endpoint indicators; allocation methods, cut-off criteria, and uncertainty; environmental impact categories (climate, toxicity, water, land use).

UNIT II – LCA Modeling, Databases and Analytical Tools (11 hours)

LCA software (SimaPro, GaBi, OpenLCA); databases (Ecoinvent, ELCD); data quality and uncertainty analysis; sensitivity and scenario modeling; hybrid LCA (process + input-output); spatial and temporal LCA; interpretation and critical review; digital tools and automation in LCA workflows.

UNIT III – Environmental Auditing, Standards and Performance Systems (11 hours)

Environmental auditing principles; EMS and ISO 14001 frameworks; compliance vs performance audits; environmental indicators and KPIs; eco-labeling, EPDs, and certification systems; regulatory frameworks and reporting; integration of LCA into auditing and corporate sustainability systems

UNIT IV – Integrated Applications, Circular Economy and Decision Systems (12 hours)

Sectoral applications (energy, construction, food, manufacturing); product environmental footprint (PEF); carbon, water, and material flow analysis; circular economy and industrial symbiosis; life cycle sustainability assessment (LCSA); decision frameworks (MCDA); policy and design integration; AI, digital twins, and real-time sustainability analytics.

Suggested Practicals/Applied Exercise/Field Studies (30 hours)

- Conduct a cradle-to-grave LCA of a selected product or system.
- Perform comparative LCA analysis using SimaPro/OpenLCA.
- Develop a life cycle inventory (LCI) using real or secondary datasets.
- Apply LCIA methods to evaluate environmental impacts across categories.
- Conduct sensitivity and uncertainty analysis for an LCA model.
- Perform an environmental audit of a facility using ISO 14001 criteria.
- Evaluate eco-labels and environmental product declarations (EPDs).
- Calculate carbon, water, and material footprints for a system.
- Apply multi-criteria decision analysis (MCDA) for sustainable alternatives.
- Conduct a circular economy assessment using material flow analysis.
- Develop a compliance and performance audit report for a case study.
- Prepare a final integrated LCA + audit-based sustainability report.

Essential Readings

- Barton, H., & Bruder, N. (2014). *A Guide to Local Environmental Auditing*. Routledge.
- Curran, M. A. (2015). *Life Cycle Assessment Student Handbook*. John Wiley & Sons.
- Johnson, G. (2020). *The ISO 14000 EMS audit handbook*. CRC Press.

- Klöpffer, W., & Grahl, B. (2014). *Life cycle assessment (LCA): a guide to best practice*. John Wiley & Sons.
- Nakamura, S., & Nansai, K. (2016). Special Types of Life Cycle Assessment. *Spec. Types Life Cycle Assess., 1st ed., Springer Netherlands*.

Suggested readings

- Aagaard, A. (2019). *Sustainable Business Models*. Palgrave Macmillan.
- Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). *Life cycle assessment* (Vol. 2018). Springer International Publishing, Cham.
- Pain, S. W. (2010). *Safety, health, and environmental auditing: a practical guide*. CRC Press.
- Rezaee, Z. (2017). *Business sustainability: Performance, compliance, accountability and integrated reporting*. Routledge.

Discipline Specific Electives

Even Semester

Even Semester DSEs

29. **DSE-30:** Climate Technology Systems and Sustainable Innovation
30. **DSE-31:** Corporate Social Accountability and Environmental Transparency
31. **DSE-32:** Environmental and Ecological Engineering
32. **DSE-33:** Environmental Enterprise Policy, Finance, and Governance
33. **DSE-34:** Global Environmental Politics
34. **DSE-35:** Sustainability Paradigms Beyond ESG
35. **DSE-36:** Systems Analysis and Modelling

DSE – Even Semester

DISCIPLINE SPECIFIC-ELECTIVE (DSE-30):

Climate Technology Systems and Sustainable Innovation

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-30: Climate Technology Systems and Sustainable Innovation	4	3	0	1	UG	-

Course Objectives

The course is designed to:

- Develop a systems-level understanding of advanced climate technologies, integrating engineered and nature-based solutions.
- Examine next-generation technologies (hydrogen, CCUS, storage) in terms of performance, scalability, and system integration.
- Apply techno-economic and lifecycle frameworks (TEA, LCA, MCDA) to evaluate trade-offs and impacts.
- Integrate ecological principles and indigenous/Indian knowledge systems into climate technology design.
- Build practical skills in technology assessment, carbon accounting, and integrated system design.

Learning Outcomes

After the course, students will be able to:

- Evaluate climate technologies using performance metrics and system frameworks.
- Apply TEA, LCA, and decision tools to assess cost, efficiency, and environmental impacts.
- Design integrated solutions combining technology, nature-based approaches, and indigenous knowledge.
- Conduct carbon accounting and system-level analysis.
- Assess feasibility, scalability, and real-world deployment constraints.

Course syllabus
Theory (45 hours)
UNIT I – Climate Technology Systems and Transition Frameworks (11 hrs)
Climate technology landscape; technology readiness levels (TRLs); System boundaries and performance metrics; Diffusion of Innovations and Multi-Level Perspective; Energy–material flows; Ecological constraints and planetary limits in technology systems; Introduction to hybrid techno-ecological thinking.

UNIT II – Advanced Conversion, Storage, and Carbon Technologies (10 hrs)
Hydrogen systems, advanced storage, CCUS, DAC, BECCS; electrification of hard-to-abate sectors; thermodynamic and efficiency principles; infrastructure constraints; bio-based and nature-integrated technologies (biochar, biomass-carbon systems).

UNIT III – Techno-Economic, Lifecycle and Decision Frameworks (12 hrs)
Techno-economic analysis (TEA); LCOE; Life Cycle Assessment; carbon accounting; Multi-Criteria Decision Analysis; trade-offs (cost–efficiency–ecology); uncertainty and sensitivity analysis; Valuation of ecological co-benefits; Carbon finance and market; Project analysis: LCOE, co-benefits assessment, systems modeling; Multi-scale impacts, feedbacks, and policy integration for long-term sustainability

UNIT IV – Indigenous Knowledge and Nature-Based Solutions (12 hrs)
Hybrid systems (technology + ecology); Nature-based solutions (NbS) in engineered systems (urban cooling, wetland–wastewater integration, carbon landscapes); Industrial Ecology; Sector coupling; Digital systems (AI, IoT, digital twins); Indigenous and Indian knowledge systems in climate design (water harvesting, agroecology, passive cooling, landscape-based resilience); Scaling and performance under real-world constraints.

Suggested Practicals/Field Studies/Applied Exercise (30 hours)
- Techno-economic analysis (TEA) of a climate technology
- Carbon accounting including ecosystem sinks
- Climate technology performance benchmarking
- Indigenous knowledge case analysis (e.g., traditional water systems as climate solutions)
- Industrial ecology/material flow analysis
- Climate tech innovation mapping (TRL framework)
- Case study: failure/success of integrated climate solutions
- Project: tech + ecology integrated system design
- Lifecycle analysis (LCA) of a solar vs coal-based electricity system
- Energy audit of a campus facility or laboratory
- Solar PV system design and performance estimation using real datasets
- Wind energy potential mapping for a selected district using wind atlas/GIS
- Carbon mitigation modeling using open-source tools (e.g., EN-ROADS)
- Nature-based carbon estimation (e.g., tree carbon stock or wetland sequestration potential)
- Identify and categorize funding mechanisms for climate tech/NbS

- Field visit/report - Observe and document a renewable energy or ecosystem restoration project

Essential Readings

- Gates, B. (2021). *How to avoid a climate disaster: the solutions we have and the breakthroughs we need*. Vintage.
- Hauschild, M. Z., Rosenbaum, R. K., & Olsen, S. I. (2018). *Life cycle assessment* (Vol. 2018). Springer International Publishing, Cham.
- Jacobson, M. Z. (2020). *100% clean, renewable energy and storage for everything*. Cambridge University Press.
- Sayigh, A. (2024). *Transition Towards a Carbon-Free Future*. Springer
- Smil, V. (2018). *Energy and Civilization: A History*. Cambridge, MA: MIT Press.

Suggested Readings

- Allwood, J., & Cullen, J. (2015). *Sustainable materials without the hot air: making buildings, vehicles and products efficiently and with less new material*. Bloomsbury Publishing.
- Helm, D. (2020). *Net zero: How we stop causing climate change*. HarperCollins UK.
- Hickel, J. (2020). *Less is more: How degrowth will save the world*. Random House.
- Martin, L. J. (2022). *Wild by design: The rise of ecological restoration*. Harvard University Press.
- Tester, J. W., Drake, E. M., Driscoll, M. J., Golay, M. W., & Peters, W. A. (2012). *Sustainable energy: choosing among options*. MIT Press.
- Yergin, D. (2020). *The new map: energy, climate, and the clash of nations*. Penguin UK.

Semester

DISCIPLINE SPECIFIC-ELECTIVE (DSE-31):

Corporate Social Accountability and Environmental Transparency

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-31: Corporate Social Accountability and Environmental Transparency	4	3	0	1	UG	0

Course Objectives

The course is designed to:

- Examine corporate accountability through environmental, social, and governance (ESG) lenses
- Equip students with environment-focused frameworks for evaluating corporate conduct in the Anthropocene.
- Understand environmental transparency as a mechanism for ecological justice, sustainability, and democratic governance
- Analyze corporate environmental harm, climate liability, and accountability failures using real-world cases
- Introduce ESG-related accountability tools (disclosures, governance safeguards, social safeguards) as applied instruments.

Learning Outcomes

After the course, students will be able to:

- Explain corporate environmental accountability as a core component of sustainable development.
- Analyze how E, S, and G dimensions intersect in environmental decision-making and corporate behavior.
- Critically evaluate corporate transparency claims and detect environmental greenwashing.

- Assess environmental conflicts involving corporations, communities, and ecosystems.
- Design ethically grounded, ecologically informed corporate accountability frameworks

Course syllabus
Theory (45 hours)
UNIT I – Foundations of Corporate Environmental Accountability (12 hours)
Evolution from CSR to environmental accountability and ESG thinking; Ecological ethics, planetary boundaries, and corporate responsibility; Environmental externalities, risk transfer, and ecological debt; Environmental justice movements and corporate accountability; Case studies: Bhopal Gas Disaster, BP Deepwater Horizon, Amazon deforestation

UNIT II – Environmental Laws, Governance, and Transparency Regimes (11 hours)
Environmental laws and corporate compliance (EPA, EIA, Forest & Coastal laws); Transparency mechanisms: RTI, Aarhus Convention, public hearings; Environmental liability, polluter pays principle, climate litigation; Whistleblowing in environmental violations; Role of regulators, tribunals, and watchdog institutions

UNIT III – Environmental Disclosure, Greenwashing, and ESG Interfaces (11 hours)
Environmental disclosures: emissions, waste, water, biodiversity impacts; ESG as a **risk and accountability framework**; Greenwashing, selective disclosure, and narrative control; Role of NGOs, citizen science, and investigative journalism; Environmental audits, lifecycle thinking, and third-party verification

UNIT IV – Community Rights, Social Accountability, and Governance Futures (11 hours)
Corporate impacts on land, water, forests, and livelihoods; Indigenous rights, FPIC, displacement, and ecological consent; Social accountability tools: grievance mechanisms, ombudsman models; ESG failures in extractives, infrastructure, and agribusiness; Future pathways: digital transparency, climate liability, planetary governance

Suggested Practicals/Applied Exercise/Field Studies (30 hours)
- Compare environmental transparency of two corporations
- Evaluate sustainability claims vs actual environmental performance
- Mock public hearing and **s**imulate an EIA consultation for a high-impact project
- Map environmental risks to communities posed by a corporate activity
- Draft an environmental violation reporting system
- Analyze a corporate disaster or violation through a case study
- Prepare an RTI seeking environmental compliance data
- Develop an environmental accountability scoring rubric
- Corporate–community–regulator negotiation simulation

Essential Readings

- Carnegie, G. D., & Napier, C. J. (2023). *Handbook of accounting, accountability and governance*. Edward Elgar Publishing.
- Grubnic, S. (2014). Accountability, social responsibility and sustainability: Accounting for society and the environment.

- Morgera, E. (2020). *Corporate environmental accountability in international law*. Oxford University Press.

Suggested Readings

- Aarhus Convention (UNECE) – Access to Environmental Information
- Ele, M. (2026). Corporate Environmental Responsibility and Pollution Control Laws: The Case of Oil Spills in the Niger Delta. Routledge.
- IPBES & IPCC reports on corporate environmental responsibility
- KPMG – Environmental and ESG Risk Surveys
- National Green Tribunal (India) – Landmark judgments
- Voigt, C. (2013). *Rule of law for nature: new dimensions and ideas in environmental law*. Cambridge University Press.

Semester

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSC-32)

Environmental and Ecological Engineering

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-32: Environmental and Ecological Engineering	4	3	–	1		

Course Objectives

The course aims to:

- Provide a foundational and advanced understanding of environmental and ecological engineering principles.
- Integrate ecological design and engineering technologies for sustainable management of water, air, soil, and waste.
- Examine nature-based solutions, circular economy models, and resilient infrastructure for environmental protection.
- Equip students with quantitative tools, modeling skills, and ethical frameworks to design and evaluate complex ecological systems.
- Prepare students for global challenges in climate adaptation, pollution control, ecosystem restoration, and regenerative engineering.

Learning Outcomes

After the course, students will be able to:

- Analyze environmental systems using ecological and engineering principles.
- Design integrated solutions for water, wastewater, air, and waste systems that align with ecological sustainability.
- Apply technologies such as constructed wetlands, green infrastructure, bioreactors, and clean energy systems.
- Model material and energy flows in environmental systems and evaluate treatment performance.
- Critically assess environmental engineering decisions in the context of resilience, climate justice, and global sustainability goals (SDGs).

Course syllabus

Theory (45 hours)

Unit I: Foundations of Environmental and Ecological Engineering (12 hours)

Environmental and ecological engineering concepts; Systems thinking and resilience; Material and energy balances in environmental systems; Abiotic–biotic process coupling in ecological engineering; Environmental regulations, standards, and global protocols (e.g., ISO 14000, SDGs); Bioengineering, microbial communities in treatment ecosystems; Introduction to ecological modeling and life cycle frameworks.

Unit II: Eco-centric Water and Wastewater Engineering (12 hours)

Water quality, sourcing, and transmission systems; Integrated wastewater treatment and detoxification technologies (physico-chemical, biological, aerobic and anaerobic, hybrid and integrated); Advanced and emerging technologies: Membrane Bioreactors (MBR), Moving Bed Biofilm Reactors (MBBR), membrane filtration (UF, NF, RO), and hybrid systems; Constructed wetlands, biofiltration, vermifiltration; Water-sensitive urban design (WSUD); Water reuse, decentralized systems, and real-time digital monitoring in circular water economies.

Unit III: Air, Climate, and Urban Ecological Engineering (10 hours)

Air pollution control (physico-chemical, biological, mechanical); ecological technologies (bioscrubbers, green walls, phytoremediation, catalytic converters); urban heat & emission management (blue-green infrastructure, passive ventilation, carbon sinks); air quality monitoring (low-cost sensors) and climate model integration; co-benefits of ecological strategies; mobile emission control (cleaner vehicles, fuels, maintenance, traffic efficiency).

Unit IV: Waste, Resource Recovery, and Ecological Restoration (11 hours)

Sustainable waste management: characterization, composting, anaerobic digestion, biochar systems; Resource recovery from waste: WTE, RDF, nutrient and energy extraction; E-waste and hazardous waste (chemical, biomedical, nuclear) handling; Remediation techniques—phytotechnologies, bioremediation, leachate control; Ecological restoration of contaminated land and landfills; Circular economy principles, extended producer responsibility (EPR), and ecological footprinting.

Suggested Practicals/Applied Exercises/Field Studies (30 hours)

- Design of constructed wetlands or decentralized MBBR treatment system
- Field visits to treatment facilities using MBR, MBBR, or membrane filtration
- Wastewater characterization and pilot-scale process design
- Real-time monitoring and analysis of water and air quality indicators
- Composting, biochar, or anaerobic digestion demonstration setup
- GIS mapping of ecological engineering interventions in urban spaces
- Simulation of pollutant dispersion and ecosystem resilience modeling
- Case study review: Integration of green and grey infrastructure
- Development of ecosystem services-based design solutions

Essential Readings

- Mihelcic, J. R., & Zimmerman, J. B. (2021). *Environmental Engineering: Fundamentals, Sustainability, Design*. John Wiley & Sons.
- Riffat, R. and Husnain, T. (2022). *Fundamentals of Wastewater Treatment and Engineering*. CRC Press.
- Spellman, F. R. (2023). *Handbook of Environmental Engineering*. CRC Press.
- Tanacredi, J. T. (2019). The Redesigned Earth: A Brief Review of Ecology for Engineers, as If the Earth Really Mattered. Springer.

Suggested Readings

- Fränzle, S., Markert, B., & Wünschmann, S. (2012). *Introduction to Environmental Engineering*. John Wiley & Sons.
- Matlock, M. D., & Morgan, R. A. (2011). *Ecological Engineering Design: Restoring and Conserving Ecosystem Services*. John Wiley & Sons.
- Naddeo, V., Choo, K. H., & Ksibi, M. (Eds.). (2022). Water-Energy-Nexus in the Ecological Transition: Natural-based solutions, advanced technologies and best practices for environmental sustainability. Springer International Publishing.
- Wang, L., & Garnier, H. (Eds.). (2012). *System identification, environmental modelling, and control system design*. London: Springer.

DSE – Even Semester

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSE-33)

Environmental Enterprise Policy, Finance, and Governance

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-33: Environmental Enterprise Policy, Finance, and Governance	4	3	0	1	UG	-

Course Objectives

The course aims to:

- Provide an understanding of policy frameworks shaping environmental enterprises and sustainability transitions
- Develop knowledge of regulatory systems, compliance processes, and environmental governance mechanisms
- Introduce financial structures and investment models relevant to environmental enterprises
- Examine the role of governance, transparency, and accountability in sustainable business practices
- Build capacity for navigating institutional, financial, and regulatory landscapes for environmental entrepreneurship

Learning Outcomes

By the end of the course, students will be able to:

- Interpret environmental policies and regulatory instruments influencing enterprise development
- Analyze compliance requirements and governance structures relevant to environmental enterprises
- Evaluate financial instruments and investment pathways supporting sustainability-oriented businesses
- Assess risks related to regulation, finance, and environmental performance in enterprise contexts
- Develop strategies for transparent communication, ESG reporting, and stakeholder engagement
- Critically examine issues of legitimacy, accountability, and greenwashing in environmental enterprises

Course syllabus
Theory (45 hours)

Unit I: Environmental Policy Frameworks and Instruments (12 hours)
Environmental policy instruments: regulatory, market-based, and incentive mechanisms shaping enterprise behavior; Policy-driven markets: carbon pricing, EPR, and sustainability mandates; Institutional roles: regulatory agencies and environmental governance bodies; Global frameworks: SDGs, Paris Agreement and enterprise implications.

Unit II: Regulatory Landscapes and Compliance (11 hours)
Environmental clearance and compliance systems: EIA permitting, regulatory approvals; Compliance lifecycle: monitoring, reporting, and enforcement; Environmental ethics and responsibility: beyond compliance toward sustainability; Social license to operate: trust, stakeholder engagement, and legitimacy.

Unit III: Environmental Finance and Investment Models (11 hours)
Climate finance and green investment flows: public, private, and blended finance; Financial instruments: green bonds, ESG investing, sustainability-linked finance; Carbon markets: enterprise participation and opportunities; Financial planning: funding proposals, budgeting, and risk assessment.

Unit IV: Governance, Accountability, and Fundraising (11 hours)
Corporate environmental governance: accountability structures and decision-making; ESG metrics and reporting: tools for transparency and communication; Anti-greenwashing mechanisms: credibility and verification; Strategic positioning: investor engagement and sustainability as competitive advantage.

Suggested Practicals/Applied Exercise/Field Studies (30 hours)
- Simulate an EIA checklist for a small-scale eco-enterprise
- Map environmental licensing needs for a green product
- Draft a simplified ESG disclosure template
- Write a 2-page grant proposal for a nature-based startup
- Analyze a green bond case and trace fund utilization
- Evaluate SDG alignment of a startup idea
- Review a real ESG report and critique its metrics
- Conduct a mock regulatory compliance audit
- Develop a financial forecast spreadsheet
- Prepare a governance charter for a student-led green venture
- Policy mapping for environmental enterprise sector
- Preparation of environmental compliance checklist
- Mock Environmental Impact Assessment exercise
- Case study of regulatory approval process
- Identification of greenwashing cases
- Field interaction with regulatory body/startup

Essential Readings

- Jeucken, M. (2010). *Sustainable finance and banking: The financial sector and the future of the planet*. Routledge.
- Schoenmaker, D., & Schramade, W. (2018). *Principles of sustainable finance*. Oxford University Press.
- Thompson, S. (2025). *Green and sustainable finance: Principles and practice in banking, investment and insurance*. Kogan Page Publishers.
- Weber, O., & Feltmate, B. (2016). *Sustainable banking: Managing the social and environmental impact of financial institutions*. University of Toronto Press.

Suggested Readings

- Bouma, J. J., Jeucken, M., & Klinkers, L. (2017). *Sustainable banking: The greening of finance*. Routledge.
- Elkington, J. (2020). *Green swans: The coming boom in regenerative capitalism*. Greenleaf Book Group.
- Frank, R. H. (2012). *The Darwin economy: Liberty, competition, and the common good*. Princeton University Press.

Semester – III

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSE-34)

Global Environmental Politics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-34: Global Environmental Politics	4	3	0	1	Undergraduate	-

Course Objectives

The course aims to:

- Understand the nature, scope, and paradigms of environmental politics at global levels.
- Critically examine the relationship between development models and debates on alternative paths of development.
- Analyse varieties of environmentalism and environmental movements.
- Evaluate methods and forms of environmental regulation used in different countries and their political implications.
- Interpret key processes and conflicts in global environmental politics, including North-South negotiations and global environmental regimes.
- Apply theoretical concepts to real-world case studies of global environmental politics.

Learning Outcomes

After the course, students will be able to:

- Explain and apply key concepts and theoretical paradigms of global environmental politics.
- Critically analyse development models, alternative pathways, and varieties of environmentalism and movements.
- Evaluate environmental politics and regulatory frameworks across countries and their political implications.
- Interpret and apply knowledge to real-world environmental conflicts, policies, and global processes, including North–South dynamics.

Course syllabus
Theory (45 hours)

Unit I – Foundations of Global Environmental Politics (8 hrs)
Meaning and scope, Nature of environmental politics at global levels, Historical emergence of environmental issues in political discourse, Actors in environmental decision-making and Paradigms of Environmental Politics**.**

Unit II – Development Debate & Environmental Movements: (10 hrs)
Critiques of modern development (growth paradigm, high-energy, high-consumption model), Limits to Growth and post-development perspectives. Environmentalism of the poor vs environmentalism of affluence, Case studies of environmental movements; Latin America (e.g. anti-mining movements), Africa (e.g. land struggles, water conflicts), Asia (e.g. anti-dam, anti-nuclear, forest rights movements), Role of identity (class, caste, gender, indigeneity) in environmental struggles

Unit III – Key perspectives in global environmental Politics (12 hrs)
North -South inequalities and conflicts, scientific uncertainty in relation to climate change, conflict, and human vulnerability, technological advancements, and associated environmental risks, Global environmental security, sustainability principle, idea and future, intergenerational equity and sustainable development. competing ideologies and future pathways, including ecological modernisation, deep ecology, green economy, and de-growth, Environmental diplomacy, Environmental Justice, Consumption, specialised knowledge and expertise

Unit IV- Key issues and Political debate in Global Environmental Politics (15 hrs)
Environmental challenges and the political processes shaping global responses, including climate change, biodiversity loss, deforestation, water scarcity, and pollution. Politics surrounding these issues, including power, inequality, and competing national interests, with particular emphasis on North–South divisions, resource conflicts, and questions of equity and justice. Global institutions, international agreements, and non-state actors influence environmental political frameworks, negotiation dynamics, and the intersection of science, politics, and ethics in addressing global environmental crises.

Suggested Practicals/Applied Exercise/Field Studies (30 hrs)
- Mapping Actors and Interests in an Environmental Conflict**:**
- Comparative Study of Environmental Movements
- Select and analyse major global environmental agreements
- Assess the narrative generation in global environmental political scenarios.
- Assessments of global environmental negotiations
- Case studies of North-South politics of the environment

Essential Readings

- Chasek, P. S., & Downie, D. L. (2020). *Global environmental politics*. Routledge.
- Connelly, J., Smith, G., Benson, D., & Saunders, C. (2012). *Politics and the environment: from theory to practice*. Routledge.

- Dobson, A. (2016). *Environmental politics: A very short introduction*. Oxford University Press.

Suggested Readings

- Allay, K. (2002). On the Banks of the Ganga, University of Michigan Press.
- Donahue, John and Johnston, Barbara (Ed). 1998. Water, Culture and Power: Local struggles in a Global context, Island Press, Washington D.C.
- Fortun, K. (2009). *Advocacy after Bhopal: Environmentalism, disaster, new global orders*. University of Chicago Press.
- Herring, R. (2014). Handbook of Food, Politics and Society, Oxford University Press, New York.
- Patterson, M. (1996). Global warming and global politics, London, Routledge.

Semester

DISCIPLINE SPECIFIC-ELECTIVE (DSE-35):

Sustainability Paradigms Beyond ESG

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-35: Sustainability Paradigms Beyond ESG	4	3	0	1	UG	-

Course Objectives

The course aims to:

- Critically position ESG as a transitional framework within broader sustainability paradigms
- Integrate ecological, economic, and systems perspectives to understand sustainability beyond metrics
- Examine emerging paradigms such as regenerative systems, post-growth, and resilience-based approaches
- Develop capabilities in complexity-aware decision-making and sustainability strategy
- Prepare students for roles in sustainable finance, impact assessment, and systems transformation

Learning Outcomes

After the course, students will be able to:

- Critically evaluate ESG frameworks and identify their limitations and trade-offs
- Apply systems thinking, resilience, and complexity frameworks to sustainability challenges
- Analyze sustainability decisions under uncertainty, risk, and systemic constraints
- Integrate ecological, social, and economic dimensions into strategic sustainability solutions
- Design forward-looking sustainability and transition strategies beyond compliance and reporting

Course syllabus
Theory (45 hours)

Unit I: From ESG to Systems-Based Sustainability (11 hours)
ESG as a firm-centric, metric-driven framework—scope and limitations; transition to systems-based sustainability thinking; economy embedded within Earth systems; planetary boundaries as systemic constraints (conceptual); resilience, feedbacks, and tipping points in socio-ecological systems; implications for redefining sustainability beyond efficiency and compliance.

Unit II: Beyond ESG - Reframing Value and Accountability (11 hours)
Limits of ESG metrics and financialized sustainability; shift toward plural and relational value systems (ecological, social, cultural); reinterpretation of capital and value (conceptual); alternative paradigms—doughnut, wellbeing, post-growth (as reframing lenses); justice, equity, and intergenerational responsibility; evolving corporate purpose—stewardship and long-term system value.

Unit III: Beyond ESG Metrics – Decision-Making Under Complexity (12 hours)
Limits of ESG-driven analytics; sustainability decision-making under complexity, uncertainty, and irreversibility; reinterpretation of materiality and cost-benefit (as limitations, not tools); systems-based trade-offs; path dependency and transition lock-ins; data limitations, verification challenges, and identifying greenwashing beyond indicators.

Unit IV: Beyond ESG Transitions - Regenerative Futures (11 hours)
Limits of ESG-led incremental change; transition toward transformative and regenerative paradigms; sustainability transitions and system innovation; resilience and adaptive transformation; strategic role of finance and institutions (interpretive); corporate transformation toward stewardship; future pathways—post-growth and planetary sustainability transitions.

Suggested Practicals / Field Visits / Applied Exercises (30 hours)

- Evaluate ESG scores of selected companies using Sustainalytics, MSCI, and Refinitiv.
- Critically evaluate ESG performance using systems and planetary perspectives
- Create a double materiality matrix for a selected industry (e.g., textiles, mining, banking) using stakeholder engagement tools.
- Develop a systems map of a sustainability challenge
- Compare ESG vs post-ESG sustainability approaches
- Calculate the true environmental and social cost of a food or clothing product
- Analyze national well-being metrics and compare with GDP-based development
- Evaluate sustainability trade-offs under complexity and uncertainty
- Case study critique of ESG success/failure using a systems lens
- Identify greenwashing beyond disclosures and metrics
- Evaluate sustainability narratives in corporate or policy contexts
- Draft a mock Integrated Report (IR) for a company applying multi-capital frameworks
- Develop a conceptual transition strategy for a sector or firm
- Analyze decision-making under uncertainty using real-world cases
- Compare growth vs post-growth sustainability paradigms
- Develop transition pathways for a high-emissions sector using climate risk scenarios (e.g., IEA Net Zero 2050)

- Reflective analysis of sustainability frameworks in practice
- Field-based systems analysis of sustainability challenge

Essential Reading

- Rizzello, A. (2022). *Green investing: Changing paradigms and future directions*. Springer Nature.
- Schoenmaker, D., & Schramade, W. (2018). *Principles of sustainable finance*. Oxford University Press.
- Laine, M., Tregidga, H., & Unerman, J. (2021). *Sustainability accounting and accountability*. Routledge.
- Chomsky, N., & Pollin, R. (2020). *Climate crisis and the global green new deal: The political economy of saving the planet*. Verso Books.
- Elkington, J. (2020). *Green swans: The coming boom in regenerative capitalism*. Greenleaf Book Group.
- Fullerton, J. (2015). Regenerative capitalism. *Capital Institute: Greenwich, CT, USA*.

Suggested Readings

- Figueres, C., & Rivett-Carnac, T. (2021). *The future we choose: The stubborn optimist's guide to the climate crisis*. Vintage.
- Jackson, T. (2021). *Post growth: Life after capitalism*. John Wiley & Sons.
- Hawken, P. (2021). *Regeneration: Ending the climate crisis in one generation*. Penguin.
- Henderson, R. (2021). *Reimagining capitalism in a World on fire*. Penguin UK.
- Helm, D. (2020). *Net zero: How we stop causing climate change*. HarperCollins UK.
- Mazzucato, M. (2021). *Mission economy: A moonshot guide to changing capitalism*. Penguin UK.
- Dasgupta, P. (2024). *The economics of biodiversity*. Cambridge University Press.

Semester IV

DISCIPLINE SPECIFIC ELECTIVE COURSE - (DSE-36)

SYSTEMS ANALYSIS AND MODELLING

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSE-36: Systems analysis and modelling	**4**	**3**	0	**1**	**Undergraduate**	**-**

Course Objectives

The course aims to:

- Introduce the concept of systems and sub-systems, and modelling and simulations, as well as computational techniques.
- Model various environmental systems, particularly those dealing with ecology and ecosystems, and the study of environmental pollution in modelling air and water quality.

Learning Outcomes

After the course, students will be able to

- Analyze process of using a systems-based approach to understand, analyze, and predict the impacts of human activities on the environment.
- Combine knowledge from natural sciences to model complex environmental issues like pollution, climate change, and resource management.

Course syllabus

Theory (45 hours)

Unit 1- Introduction (12 hours)

Definitions and concepts of system, sub-system, variables and parameters, systems analysis, Conceptual and mathematical models; Stochastic and Deterministic models; Linear vs. non-linear models; Model classification and evaluation; Complexity of models; Cellular automata; Types of systems: feedback, Critical points of a system;

Unit II - Models in Ecology (11 hours)

Development of Ecological models, Population growth models: Lotka-Volterra model, theta models, Stochastic model, Population projection matrices- Leslie matrix models; Fundamental interactions in ecology: predator-prey, competition; Infectious disease models; stability of complex ecosystems; Game theory.

Unit III – Applications of Environmental models (10 hours)

Global climate change models: Development of models, Modeling the effects of climate scenarios; Air and water quality modelling: Modeling transport phenomena. atmospheric and porous media transport and transformation of pollutants; Analyzing water balance in lakes and watersheds.

Unit IV- Model Synthesis and Forecasting (12 hours)

Statistical regression approach, differential equation approach and computational approaches; Time series analysis; Introduction to computational technology: artificial neural networks; Evolutionary algorithm; Limitations of modeling.

Suggested Practicals/Field Studies/Applied Exercises (30 hours)

- Computer lab: Introduction to computational techniques.
- Simulations based on population growth models.
- Simulation of Competition and predation models using Excel spreadsheet
- Global climate change scenario using carbon stock data
- Sensitivity analysis and grid search
- Simulation of air quality models
- Environmental niche models, including predictive modelling for species area richness

Essential Reading

- Wainwright, J., Mulligan, M. (Eds). (2013). Environmental Modelling: Finding Simplicity in Complexity. John Wiley, New York
- Legendre, P., & Legendre, L. (1998). Numerical ecology. Elsevier Science & Technology, 20, 853.
- Imboden, D. M., & Pfenninger, S. (2012). *Introduction to Systems Analysis: Mathematically Modeling Natural Systems*. Springer Science & Business Media.
- Smith, J., & Smith, P. (2007). *Environmental modelling: an introduction*. Oxford University Press.
- Jacobson, M. Z. (2005). *Fundamentals of atmospheric modelling*. Cambridge University Press.

Suggested Readings

- Neal, D. (2018). *Introduction to population biology*. Cambridge University Press.
- Zar, J. H. (2014). *Biostatistical analysis*. Pearson Education India.
- Krebs, C.J. (2013) Ecology: The Experimental Analysis of Distribution and Abundance. New International Edition, 6E, New York