INDEX

DEPARTMENT OF ENVIRONMENTAL STUDIES

SEMESTER – II

B.Sc (Hons.) in Environment Science

COURSES OFFERED BY DEPARTMENT OF ENVIRONMENTAL SCIENCE

Category-I

Environmental Science Courses for Undergraduate Programme of study with Environmental Science as a Single Core Discipline

DISCIPLINE SPECIFIC CORE COURSE – 4 (DSC-EVS-4): WATER AND WATER RESOURCES

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		
WATER AND WATER RESOURCES	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into the hydrological cycle, properties of water, physico-chemical and biological
- Understand parameters and indies of water quality
- Classify types of water resources and thus develop practices for their sustainable use and management
- Investigate problems associated with water shortages in India and familiarize with case studies on international and national conflicts on water.

Learning outcomes

After this course, students will be able to learn the following skills.

- Acquire skills to identify potential water resources in a given region and manage existing water resources
- Analyze data on water resources to understand the current environmental challenge and prevent the future ones
- Make informed decisions on using and choosing appropriate methods for water resource management and develop nature-based methods to improve the health of water bodies
- Develop low-cost methods for purifying drinking and natural water
- Correlate water resource management practices with socio-economic challenges and prospects

- Relate and interpret the data on water resources data with other related sustainability challenges

SYLLABUS OF DSC-4

Theory (02 Credits: 30 lectures)

UNIT – I Introduction (1 Week) (2 lectures)
Sources and types of water; hydrological cycle; precipitation, runoff, infiltration, evaporation, evapo- transpiration; classification of water resources (oceans, rivers, lakes and wetlands).

UNIT – II Properties of water (2 Weeks) (4 lectures)
Physical: temperature, colour, odour, total dissolved solids and total suspended solids; Chemical: major inorganic and organic constituents, dissolved gases, DO, COD, BOD, acidity and alkalinity, electrical conductivity, sodium adsorption ratio; Biological: phytoplankton, phytobenthos,zooplankton, macro-invertebrates and microbes.

UNIT – III Surface and subsurface water (3 Weeks) (6 lectures)
Introduction to surface and ground water; surface and ground water pollution; water table; vertical distribution of water; formation and properties of aquifers; techniques for ground water recharge; river structure and patterns; watershed and drainage basins; importance of watershed and watershed management; rain water harvesting in urban settings.

UNIT – IV Wetlands and their management (2 Weeks) (4 lectures)
Definition of a wetland; types of wetlands (fresh water and marine); ecological significance of wetlands; threats to wetlands; wetland conservation and management; Ramsar Convention, 1971;major wetlands of India.

UNIT –V Marine resource management (1½ Weeks) (3 lectures)
Marine resources; commercial use of marine resources; threats to marine ecosystems and resources; marine ecosystem and resource management (planning approach, construction techniques and monitoring of coastal zones).

UNIT – VI Water resources in India (2 Weeks) (4 lectures)
Demand for water (agriculture, industrial, domestic); overuse and depletion of surface and ground water resources; water quality standards in India; hot spots of surface water; role of state in water resources management.

UNIT –VII Water resource conflicts (2 Weeks) (4 lectures)
Water resources and sharing problems, case studies on Kaveri and Krishna River water disputes; Multipurpose River valley projects in India and their environmental and social impacts; case studies of dams; Narmada and Tehri dam – social and ecological losses versus economic benefits; International conflicts on water sharing between India and her neighbours; agreements to resolve these conflicts.

UNIT – VIII Major laws and treaties (1½ Weeks) (3 lectures)

National water policy; water pollution (control and prevention) Act 1972; Indus water treaty; Ganges water treaty; Teesta water treaty; National River linking plan: ecological and economic impacts.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Estimate water quality based on physico-chemical parameters, such as pH, electrical conductivity, salinity, total dissolved and suspended solids, iron contents, and dissolved oxygen
2. Classify and characterize aquifers of Indian states and analyse "Safe" and "Over-exploited" zones of two states based on groundwater use.
3. Determine alkalinity, alkalinity hazard and SAR of water samples and recommend their use for various purposes.
4. Identify and map water resources in NCT Delhi and correlate its current status with changing land use in past 60 years
5. Estimate sediment load in Yamuna River at different sections of its course in Delhi regions
6. Assess water quality (pH, TDS, TH, EC, BOD, Heavy Metals) and determine the water portability of samples collected from different sites of NCT Delhi.
7. Conduct an online survey to assess people's knowledge, perception and attitude towards water quality issues and their impact on the environment and health.
8. Analyze water conservation strategies in North-eastern and Western states of India from the data available from State Government Agencies.
9. Document and compare water conservation strategies in different agroclimatic zones of India
10. Analyze watershed management strategies in selected river basins of India.
11. Develop integrated water management strategies for two contrasting river basin of India.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Essential/recommended readings

- McNabb, D.E., 2017. *Water Resource Management: Sustainability in An Era of Climate Change*. Springer.
- Loucks, D.P., Stedinger, J.R. & Haith, D. A. 1981. *Water Resource Systems Planning andAnalysis*. Englewood Cliffs, NJ, Prentice Hall.
- Brebbia, C.A. 2013. *Water Resources Management VII*. WIT Press.
- CEA. 2011. *Water Resources and Power Maps of India*. Central Board of Irrigation & Power.
- Bogardi, J.J., Gupta, J., Nandalal, K.W., Salamé, L., van Nooijen, R.R., Kumar, N., Tingsanchali, T., Bhaduri, A. and Kolechkina, A.G. eds., 2021. *Handbook of Water Resources Management: Discourses, Concepts and Examples*. Springer International Publishing.
- de Oliveira Vieira, E., Sandoval-Solis, S., de Albuquerque Pedrosa, V. and Ortiz-Partida, J.P., 2020. *Integrated Water Resource Management*. Springer International Publishing.
- Garg, V., Singh, V.P. and Raj, V. eds., 2017. *Development of Water Resources in India*. Springer International Publishing.
- Grigg, N.S., 2016. *Integrated Water Resource Management: An interdisciplinary Approach*. Springer.
- Mimikou, M.A., Baltas, E.A. and Tsihrintzis, V.A., 2016. *Hydrology and Water Resource Systems Analysis*. CRC Press.
- Vickers, A. 2001. *Handbook of Water Use and Conservation*. WaterPlow Press.

Suggestive readings

- Bansil, P.C. 2004. *Water Management in India*. Concept Publishing Company, India.
- Hidalgo, M.E.A., 2013. A Decision Framework for Integrated Wetland-River Basin Management in a Tropical and Data Scarce Environment: UNESCO-IHE PhD Thesis. CRC Press.
- Information Resources Management Association (Editor) (2017). *Hydrology and Water Resource Management: Breakthroughs in Research and Practice*, 1st edition IGI Global.
- Mays, L.W. 2006. *Water Resources Sustainability*. The McGraw-Hill Publications.
- McNabb, D.E., 2017. *Water Resource Management: Sustainability in An Era of Climate Change*. Springer.
- Schward & Zhang, 2003. *Fundamentals of Groundwater*. John Willey and Sons.
- Souvorov, A.V. 1999. *Marine Ecologonomics: The Ecology and Economics of Marine Natural Resource Management*. Elsevier Publications.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 5 (DSC-EVS-5): LAND AND SOIL: CONSERVATION AND 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		
LAND AND SOIL: CONSERVATION AND MANAGEMENT	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into fundamentals of land and soil degradation
- Understand deeply the properties of soil and how the quality of land and soil degrades due to anthropogenic activities
- Develop solutions to combat land and soil degradation based on natural processes

Learning outcomes

After this course, students will be able to

- Acquire skills in managing soil and land sustainably
- Analyze data on soils and land use to identify the principal factor(s) governing sustainability
- Develop methods to address environmental issues related to soil health and changing land use
- Correlate positive or negative impacts of soil and land use on ecosystems and society
- Relate and interpret the soil and land use data with the sustainability of a region
- Use soil and land use data to develop evidence-based land use guidelines

SYLLABUS OF DSC-2

Theory (02 Credits: 30 lectures)

UNIT – I Introduction (1½ Weeks) (3 lectures)

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

UNIT – II Fundamentals of soil science (2½ Weeks) (5 lectures)
Soil formation; classification of soil; soil architecture; physical properties of soil; soil texture; soil water holding capacity; soil temperature; soil colloids; soil acidity and alkalinity; soil salinity and sodicity; soil organic matter; micronutrients of soil; nitrogen, sulphur, potassium and phosphoruseconomy of soil; soil biodiversity; soil taxonomy maps.

UNIT – III Soil degradation – causes (2½ Weeks) (5 lectures)
Soil resistance and resilience; nature and types of soil erosion; non-erosive and erosive soil degradation; losses of soil moisture and its regulation; nutrient depletion; soil pollution due to mining and mineral extraction, industrial and urban development, toxic organic chemicals, and organic contaminants in soils; fertilizers and fertilizer management; recycling of soil nutrients.

UNIT – IV Landuse changes and land degradation (3½ Weeks) (7 lectures)
Land resources: types and evaluation; biological and physical phenomena in land degradation; visual indicators of land degradation; drivers of land degradation - deforestation, desertification; habitat loss, loss of biodiversity; range land degradation; land salinization; human population pressure, poverty, socio-economic and institutional factors; drivers of land use and land cover change in major geographic zones and biodiverse regions with particular reference to the Himalaya and the Western Ghats.

UNIT – V Costs of land degradation (3½ Weeks) (7 lectures)
Economic valuation of land degradation; onsite and offsite costs of land degradation; loss of ecosystem services; effects on farming communities; effects on food security; effects on nutrient cycles; future effects of soil degradation; emerging threats of land degradation to developing countries.

UNIT – VI Controlling land degradation (1½ Weeks) (3 lectures)
Sustainable land use planning; role of databases and data analysis in landuse planning control and management; land tenure and land policy; legal, institutional and sociological factors; participatory land degradation assessment; integrating land degradation assessment into conservation.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Determine and assess soil texture, color, structure, water, and temperature using the jar test and soil textural triangle. Discuss and describe the soil profiles for different types of ecosystems.
2. Characterize the given soil samples for the proportion of soil particle size fractions.
3. Determine bulk density, moisture content, and water holding capacity of garden soil and compare it with other soil types
4. Estimate variations in pH, alkalinity, acidity, and salinity of the given soil sample. Establish the relationship between soil quality and crop productivity.
5. Evaluate given soils samples for soil organic matter contents and comment on their productivity
6. Calculate permeability of soil samples and comment on its impact on plant growth
7. Separate minerals using the selective dissolution method
8. Estimate PO_4-P of soils using ammonium molybdate reactions by spectrophotometric analysis
9. Estimate SO_4-S contents of soils by titrating with the barium chloride solution
10. Extract, investigate and interpret soil health data (micronutrient status, macronutrient status, and pH) for Northern, Western, and North-Eastern states of India. For the selected states, discuss the various soil types, agriculture practices, cropping patterns, crop production, conservation, and management strategies.
11. Extract, investigate and interpret the available datasets on soil maps, soil databases, and land degradation maps for India and draw suitable inferences. Conduct a perception-based study on the importance of soils and various impacts of soil and land degradation through an online survey.
12. Assessment of fertilizer management and integrated nutrient management practices for selected crops in India.

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Brady, N.C. & Well, R.R. 2007.*The Nature and Properties of Soils* (13th edition), Pearson Education Inc.
- Hazelton, P. and Murphy, B., 2021. *Understanding Soils in Urban Environments*. CSIRO publishing.
- Johnson, D.L. 2006. *Land Degradation* (2nd edition). Rowman & Littlefield Publishers.
- Kutz, M., 2018. *Handbook of Environmental Degradation of Materials*. William Andrew.
- Mir, B.A., 2021. *Manual of Geotechnical Laboratory Soil Testing*. CRC Press.

- Pansu, M. and Gautheyrou, J., 2007. *Handbook of Soil Analysis: Mineralogical, Organic and Inorganic Methods*. Springer Science & Business Media.
- Peterson, G. D., Cumming, G. S. & Carpenter, S. R. 2003. Scenario planning: a tool for conservation in an uncertain world. *Conservation Biology* 17: 358-366.

Suggestive readings

- Fahad, S., Sonmez, O., Saud, S., Wang, D., Wu, C., Adnan, M. and Turan, V. eds., 2021. *Sustainable Soil and Land Management and Climate Change*. CRC Press.
- Jones, J.B., 2001. *Laboratory Guide for Conducting Soil Tests and Plant Analysis*. CRC press.
- Loconto, P.R., 2022. *Laboratory Experiments in Trace Environmental Quantitative Analysis*. CRC Press.
- Marsh, W. M. & Dozier, J. 1983. *Landscape Planning: Environmental Applications*. John Wileyand Sons.
- Patnaik, P., 2017. *Handbook of Environmental Analysis: Chemical Pollutants in Air, Water, Soil, and Solid Wastes*. CRC Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE – 6 (DSC-EVS-6): ECOLOGY AND 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		
ECOLOGY AND ECOSYSTEMS	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Develop an understanding of ecosystems and their structural and functional aspects
- Reveal interconnectedness and interdependentness among all the biotic and abiotic components of the environment
- Gain insights into the dynamic nature of the ecological processes in maintaining equilibrium in nature.

Learning outcomes

After this course, students will be able to

- Acquire skills in ecological census techniques
- Analyze the status of biodiversity and ecosystem structure
- Develop methods to assess the changes in ecosystems with time and space
- Correlate effects of anthropogenic factors on ecosystem stability
- Relate and interpret the connections between environmental factors and ecosystem changes
- Use ecological data to predict the impact of a given factor on ecosystem and biodiversity

SYLLABUS OF DSC-6

Theory (02 Credits: 30 lectures)

UNIT – I Introduction (1½ Weeks) (3 lectures)

Basic concepts and definitions: ecology, landscape, habitat, ecozones, biosphere, ecosystems, ecosystem stability, resistance and resilience; autecology; synecology; major terrestrial biomes.

UNIT – II Ecology of individuals (2½ Weeks) (5 lectures)
Ecological amplitude; Liebig's Law of the Minimum; Shelford's Law of Tolerance; phenotypic plasticity; ecotypes; ecoclines; acclimation; ecological niche; types of niches: Eltonian niche, Hutchinsonian niche, fundamental niche, realized niche; niche breadth; niche partitioning; niche differentiation; thermoregulation; strategies of adaptation in plants and animals.

UNIT – III Ecology of populations (2½ Weeks) (5 lectures)
Concept of population and meta-population; r- and K-selection; characteristics of population: density, dispersion, natality, mortality, life tables, survivorship curves, age structure; population growth: geometric, exponential, logistic, density-dependent; limits to population growth; deterministic and stochastic models of population dynamics; ruderal, competitive and stress-tolerance strategies.

UNIT – IV Ecology of communities (2½ Weeks) (5 lectures)
Discrete versus continuum community view; community structure and organization: physiognomy, sociability, species associations, periodicity, biomass, stability, keystone species, ecotone and edge effect; species interactions: mutualism, symbiotic relationships, commensalism, amensalism, protocooperation, predation, competition, parasitism, mimicry, herbivory; ecological succession: primary and secondary successions, models and types of successions, climax community concepts, examples of succession.

UNIT – V Ecosystem ecology (2½ Weeks) (5 lectures)
Types of ecosystem: forest, grassland, lentic, lotic, estuarine, marine, desert, wetlands; ecosystem structure and function; abiotic and biotic components of ecosystem; ecosystem boundary; ecosystem function; ecosystem metabolism; primary production and models of energy flow; secondary production and trophic efficiency; ecosystem connections: food chain, food web; detritus pathway of energy flow and decomposition processes; ecological efficiencies; ecological pyramids: pyramids of number, biomass, and energy.

UNIT – VI Biogeochemical cycles and nutrient cycling (2 Weeks) (4 lectures)
Carbon cycle; nitrogen cycle; phosphorus cycle; sulphur cycle; hydrological cycle; nutrient cycle models; ecosystem input of nutrients; biotic accumulation; ecosystem losses; nutrient supply and uptake; role of mycorrhizae; decomposition and nutrient release; nutrient use efficiency; nutrient budget; nutrient conservation strategies.

UNIT – VII Biological invasions (1½ Weeks) (3 lectures)
Concept of exotics and invasives; natural spread versus man-induced invasions; characteristics of invaders; stages of invasion; mechanisms of invasions; invasive pathways; impacts of invasion on ecosystem and communities; invasive ecogenomics – role of polyploidy and genome size in determining invasiveness; economic costs of biological invasions.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Using and choosing quadrat types for vegetation analyses
2. Carry out vegetation analysis using line-transect techniques
3. Estimate the populations of aquatic beetles and bugs in ponds by the mark-capture method
4. Conduct bird surveys in your college/nearby garden using the point transect method
5. Determine the variations in abundance of micro-, meso-, and macrofauna in soils of different land use
6. Estimate the diversity of species within a community or habitat and comment on alpha diversity
7. Analyze the rate and extent of change in species along a gradient from one habitat to others and comment on beta diversity
8. Considering the analyses of practicals 6 and 7, estimate the gamma diversity and comment.
9. Prepare and interpret the species accumulation curve for the total species richness of an area

10-13 Compare and classify communities for (a) similarity and differences, (b) influential environmental variables, (c) interspecific association

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Gurevitch, J., Scheiner, S. M., & Fox, G. A. 2020. *The Ecology of Plants. 3rd Ed.* Sinauer associatesincorporated.
- Henderson, P.A., 2009. *Practical Methods in Ecology*. John Wiley & Sons.
- Jorgensen, S.E. ed., 2009. *Ecosystem Ecology*. Academic press.
- Morin, P.J., 2009. *Community Ecology*. John Wiley & Sons.
- Odum, E.P. 1971. *Fundamentals of Ecology*. W.B. Sounders.
- Rockwood, L.L., 2015. *Introduction to Population Ecology*. John Wiley & Sons.
- Sutherland, W.J. ed., 2006. *Ecological Census Techniques: A Handbook*. Cambridge university press.

Suggestive readings

- Groom. B. & Jenkins. M. 2000. *Global Biodiversity: Earth's Living Resources in the 21st Century.* World Conservation Press, Cambridge, UK.
- Loreau, M. & Inchausti, P. 2002. *Biodiversity and Ecosystem Functioning: Synthesis and Perspectives.* Oxford University Press, Oxford, UK.
- Pastor, J., 2008. Mathematical Ecology of Populations and Ecosystems. John Wiley & Sons.
- Pimentel, D. (Ed.). 2011. *Biological invasions: Economic and Environmental Costs of Alien Plant, Animal, and Microbe Species*. CRC Press.
- Ranta, E., Lundberg, P. and Kaitala, V., 2005. Ecology of Populations. Cambridge University Press.
- Wilson, E. O. 1985. The biological diversity crisis. *BioScience* **35**: 700-706.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-EVS-05): CIRCULAR ECONOMY AND ENVIRONMENTAL 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
		Lecture	Tutorial	Practical/ Practice		
CIRCULAR ECONOMY AND ENVIRONMENTAL SUSTAINABILITY	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Critically evaluate five mega trends involving climate, development, ecology, economy, and technology and their linkages with energy and resources
- Inculcate principles and methods of circular economy and design resource-efficient, low carbon paradigm.
- Analyze business models/institutes/communities and associated processes and services and develop recommendations for integrating principles of circular economy
- Adopt routes of circular economy in personal, family, community, and institutional settings.

Learning outcomes

After the course, the students will be

- Equipped with tools and techniques of circular economy to develop a sustainable institute or community
- Acting as a consultant to industries and international organizations aiming for a circular economy
- Serving as a catalyst in evolving an ecoliterate society and industry and promoting sustainable polices

SYLLABUS OF GE-1

Theory (02 Credits: 30 lectures)

UNIT – I Circular economy (1½ Weeks) (03 lectures)

Concept and definitions; Closed loop ecosystems; Systems thinking; Benefits to environment, economy and society (03 lecture)

UNIT – II Principles of circular economy (2 Weeks) (04 lectures)
Sustainable procurement; Ecodesign; Industrial and territorial ecology; Economics of functionality; Responsible consumption; Extending the duration of use; Recycling (04 lecture)

UNIT – III Steps for transition towards a circular economy (3½ Weeks) (07 lectures)
Large-scale transition to non-polluting sources of energy; Durable products requiring less materials and energy; Incentivization of recycling, re-use, and repair; Replacement of hazardous materials with safer alternatives (07 lecture)

UNIT – IV Circular economy implementation (3½ Weeks) (07 lectures)
Micro-level: Firm-level engineering and managerial level; Meso-level: Industrial ecology, Industrial symbiosis, Eco-clusters, Eco-industrial parks; and Macro level: General policies, Plans, Green and sustainable entrepreneurship. (07 lecture)

UNIT –V Challenges in implementing circular economy (3½ Weeks) (07 lectures)
Achievability and desirability; Disrupting consumer's convenience; Local regulations versus the circular economy concept; Lack of infrastructure for waste treatment; Lack of recycling technology; Poor business model plan (07 lecture)

UNIT –VI Case studies from India and other parts of the world (1 Week) (02 lecture)

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Evaluate the status of your institute with respect to efforts on circular economy using qualitative and quantitative surveys
2. Survey your institute and depict the journey of waste in your institute highlighting the factors/actors that are barrier to and facilitator of complete waste recycling
3. Collect spatial and temporal data on types of wastes being generated and identify the recycling hotspots and the gap in adopting circular economy principles
4. Based on activities 1 – 3, develop a consolidated waste recycling plan highlighting targets for Institute and each Department
5. Recycle and reuse the waste clothes produced at home and make a presentation in the class to increase their lifecycle and estimate its impact on ecological footprint of the family/institute

6. Coordinate with different groups working on waste recycling focusing on different types of wastes segregated at home/institute, for example, plastics/ glass/furniture/ metal/cans/paper waste and present as group activity
7. Visit an industrial area to analyse the status of circular economy concepts being practiced and give recommendations to improve the industrial sustainability (submit the report)
8. Conduction workshop in the Institute to educate students of other courses for converting wastes into useful products
9. Run a repair café where students and staff bring their broken stuff and get it repaired with the help of experts available at the Institute
10. Conduct a swap shop and swap party where people bring their old clothes for exchange
11. Estimate the impact of activities 8–10 reduction in ecological footprints
12. Conduct a drive to collect e-waste from the institute and the neighbourhood localities and donate it to the recycling facilities and estimate its impact on environment.
13. Based on the activities 1–12, plan and conduct awareness camps in the neighbourhood to educate and motivate people about importance of reuse and recycling and empower them with recycling methods

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Charter, M. ed., 2018. *Designing for the Circular Economy*. Routledge, London, UK.
- Hawken, P., Lovins, A.B. and Lovins, L.H., 2013. *Natural Capitalism: The Next Industrial Revolution*. Routledge.
- Lacy, P. and Rutqvist, J., 2015. *Waste to Wealth: The Circular Economy Advantage*. London: Palgrave Macmillan.
- Mavropoulos, A. and Nilsen, A.W., 2020. *Industry 4.0 and Circular Economy: Towards a Wasteless Future or A Wasteful Planet*? John Wiley & Sons.
- Stahel, W.R. and MacArthur, E., 2019. *The Circular Economy: A User's Guide*. Routledge, NY, USA.

Suggestive readings

- Crocker, R., Saint, C., Chen, G. and Tong, Y. eds., 2018. *Unmaking Waste in Production and Consumption: Towards the Circular Economy* (pp. 1-353). Bingley, UK: Emerald Publishing Limited.
- Delchet-Cochet, K. ed., 2020. Circular Economy: From Waste Reduction to Value Creation. John Wiley & Sons.
- Frodermann, L., 2018. *Exploratory Study on Circular Economy Approaches*. Springer, Fachmedien Wiesbaden.
- Ghosh, S.K., Samanta, S., Hirani, H. and da Silva, C.R.V. eds., 2022. *Effective Waste Management and Circular Economy: Legislative Framework and Strategies*. CRC Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-EVS-6): WETLANDS FOR INDUSTRIES AND ENVIRONMENT

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
		Lecture	Tutorial	Practical/ Practice		
WETLANDS FOR INDUSTRIES AND ENVIRONMENT	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Delineate, and classify the target wetland
- Identify common wetland plants and indicators of wetlands
- Assess landscape for wetland management and conservation
- Evolve a wetland construction and restoration plan
- Suggest appropriate changes for effective wetland regulation law and policy

Learning outcomes

After successful completion of this course, students will be able to:

- Apply basic principles of wastewater treatment for environmental and industrial applications
- Develop plans for monitoring wetland health and designing a constructed wetland
- Assess the feasibility of constructed wetlands for wastewater treatment
- Operate and maintain wetlands in nature and industries

SYLLABUS OF GE-EVS-6

Theory (02 Credits: 30 lectures)

UNIT – I Ecology and socio-economy of wetlands (5½ Weeks) (11 lectures)

Wetland types and functions; Ramsar Convention, Vegetation type and dynamics; Soil types; Geology and geomorphology; Hydrological regimes: Water quality and balance, Sedimentation; Indicators; Biodiversity and its significance; Ecological and economic benefits: Provisioning, Regulating, Cultural and Supporting services, Socio-economic and cultural diversity in human society living in and around wetlands; Income and employment generation by wetlands; Community resource use and management practices. (11 lectures)

UNIT – II Wetlands and water treatments (4 Weeks) (8 lectures)
Principles and efficacy of natural wetlands; Economics of treatment; Case studies from India and other countries; Types of constructed wetlands and their principles; Potential of constructed wetlands for treating different types of wastewaters (agriculture, domestic, industry, municipal, runoff, and sludge); Operation and maintenance; Case studies from India and other countries (8 lectures)

UNIT – II Wetland management (5½ Weeks) (11 lectures)
Delineation and mapping; Features and associated factors; Monitoring ecosystem health; Major threats; Setting up goals and objectives; Institutional arrangements, Wetlands ecosystem services maps; Ecosystem services trade-offs; Landscape-scale Management; Interventions to sustain biodiversity and ecosystem services; Mobilizing community participation and generating finance; Cross-sectoral integration; Integration of wetland conservation in development plans, acts, and rules; Adaptive management. (11 lectures)

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Identify a potential area for wetland construction, propose its purpose and goal, and develop the construction plan giving details of location, type, current land use, biodiversity, and hydrologic regime
1. Prepare water budgets and hydrographs of the selected area based on the data on water inputs and outputs collected from concerned institutes
2. Field surveys and analyze vegetation characteristics of a pristine wetland present in the nearby location of the study site
3. Analyze adaptive strategies of selected native plants to hydrologic regime suitable for wetland construction and develop planting strategies of species assemblage
4. Analyze soil type and determine its physico-chemical properties (pH, TDS, EC, CEC, Redox potential, etc.)
5. Evolve soil amendment method to improve texture, percolation, and nutrient composition. suitable for the hydrogeomorphic model and selected plant species
6. Surveying wetlands to identify suitable indicators for mapping and delineating wetlands zone of influence and evaluate anthropogenic activities as major threats to wetlands
7. Develop wetlands ecosystem services (ES) potential maps and evaluate ES trade-offs

8. Analyze different models for wetland construction and, based on the nature of the water regime and basic methods of wetland construction, recommend the hydrogeomorphic model suitable for the selected landscape

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Aber, J.S., Pavri, F. and Aber, S., 2012. *Wetland Environments: A Global Perspective*. John Wiley & Sons.
- Keddy, P.A., 2010. *Wetland Ecology: Principles and Conservation*. Cambridge University Press.
- Shuqing, An., and Jos, T.A. Verhoeven (Eds)., 2019. *Wetlands: Ecosystem Services, Restoration and Wise Use Series: Ecological Studies*, Volume 238, Springer, Cham.
- Stefanakis, A.I. ed., 2018. *Constructed Wetlands for Industrial Wastewater Treatment*, Wiley, Blackwell.
- Tiner, R.W., 2016. *Wetland Indicators: A Guide to Wetland Formation, Identification, Delineation, Classification, and Mapping*. CRC Press.

Suggestive readings

- Austin, G. and Yu, K., 2016. *Constructed Wetlands and Sustainable Development*. Routledge.
- Lopez, R.D., Lyon, J.G., Lyon, L.K. and Lopez, D.K., 2013. *Wetland Landscape Characterization: Practical Tools, Methods, and Approaches for Landscape Ecology*. CRC Press.
- Windham-Myers, L., Crooks, S. and Troxler, T.G. eds., 2018. *A Blue Carbon Primer: The State of Coastal Wetland Carbon Science, Practice and Policy*. CRC Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-EVS-7): CORPORATE, SOCIAL, AND ENVIRONMENTAL RESPONSIBILITIES FOR CONSERVATION AND SUSTAINABLE DEVELOPMENT

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
		Lecture	Tutorial	Practical/ Practice		
CORPORATE, SOCIAL, AND ENVIRONMENTAL RESPONSIBILITIES FOR CONSERVATION AND SUSTAINABLE DEVELOPMENT	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Inculcate interdependent and interrelated theories of corporate branding, environmental sustainability, and social equity
- Understand the working and driving forces of CSR and its significance as a stepping stone to Sustainable Business Models
- Gain insights into CSR as a tool to ensure social justice and adopt environmental wisdom from industries
- Empower with emerging frameworks and practices in CSR for environmental sustainability and improve quality of life

Learning outcomes

After the course, students will be able to:

- Explain the concept of CSR from an environmental sustainability perspective and its significance in next-generation marketing strategies
- Apply concepts of CSR to develop strategies for responsible marketing, business success, and environmental protection.
- Develop systems thinking and evolve as a responsible consumer
- Decipher linkages between concepts of circular economy, sharing economy, and carbon/ecological footprints, and identify opportunities and challenges to specific businesses and target consumers.
- Gain insights into five dimensions of sustainability performance: economic, environmental, governance, social and ethical
- Practice sustainability management, implement cleaner technologies, and argue in favour of environmental protection.

SYLLABUS OF GE-EVS-7

Theory (02 Credits: 30 lectures)

UNIT – I Sustainable Development (4 Weeks) (8 lectures)
Definitions, goals and frameworks; Sustainability: Definition and concept, Bottom of the pyramid and fairtrade; Evolution of concepts, Socio-ethical and environmental aspects, Benefits in strategic planning; Associated world's leaders and corporations, Financial, social and reputational benefits, Circular and share economy (8 lectures)

UNIT – II Corporate social responsibility (CSR) (3 Weeks) (6 lectures)
CSR: Definition and concept, Philosophy and practices of CSR; Measuring CSR; Impact of CSR on rural livelihoods, natural resources management, biodiversity conservation; Carbon footprint; Cleaner technologies; Emerging CSR policies in India

UNIT – III CSR and Sustainability (4½ Weeks) (9 lectures)
Why and when to apply CSR activities, Competitiveness vs Ethical, Green markets and budget, Bottlenecks of being sustainable, Public-private partnerships for socio-ecological entrepreneurship, Vocal for local embedding sustainability; Business strategies for sustainable individuals, firms, and industries, Power-Inequality-Environment-CSR nexus, Managing, Monitoring, and Reporting CSR, Beyond framing CSR as strategic, political or utopian (9 lectures)

UNIT – IV Case studies (3½ Weeks) (7 lectures)
CSR applications for improving livelihoods, enhancing soil health and crop productivity in stress environment, adaptation to climate change, and diversification of crop patterns improving rural wastewater management (7 lectures)

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Analyze variations in CSR efforts in saving the environment by countries differing in biodiversity and ecosystem diversity
2. Critically analyze OECD Guidelines for Multinational Enterprises on corporate responsibility
3. Select a company/business organization and, based on its activities and products, identify the environmental issues that need to be addressed for societal need

4. Evaluate diverse environmental issues based on their impact on society and organizational brand value and develop its vision document and a CSR plan for environmental conservation
5. Determine priorities and evolve a code of conduct document for the selected company to maximize its CSR for environmental issues
6. Based on the activities of the target business organization, develop an action plan and policies to suit the international guidelines and standards of CSR for environmental conservation
7. Identify the constraints to implement the guidelines and standards set based on dialogue with different stakeholders and surveying the local circumstances
8. Analyze the variations in guidelines and standards to meet the CSR in countries differing in biodiversity and cultural values
9. Identify the environmental indicators to formulate a monitoring and reporting system for CSR success
10. Evolve the appropriate communication style for different internal and external stakeholders
11. Field surveys and lab-based assays for monitoring the targeted ecosystem, biodiversity, environmental compartment, and socio-ecological systems for the impact of CSR

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Bachnik, K., Kaźmierczak, M., Rojek-Nowosielska, M., Stefańska, M. and Szumniak-Samolej, J. (eds.), 2022. *Corporate Social Responsibility and Sustainability: From Values to Impact*. Routledge.
- Camilleri, M.A., 2017. *Corporate Sustainability, Social Responsibility and Environmental Management*. Cham, Switzerland: Springer International Publishing.
- Geoffrey H., 2010. *When Principles Pay: Corporate Social Responsibility and the Bottom Line*, Columbia University Press.
- McKenna, K., 2015. *Corporate Social Responsibility and Natural Resource Conflict*. Routledge.

Suggestive readings

- Roberts, L., Georgiou, N. and Hassan, A.M., 2022. Investigating biodiversity and circular economy disclosure practices: Insights from global firms. *Corporate Social Responsibility and Environmental Management*. DOI: 10.1002/csr.2402
- Ringham, K., 2017. CSR and Sustainability: From the Margins to the Mainstream: A Textbook, Routledge
- Rendtorff, J.D., 2019. *Philosophy of Management and Sustainability: Rethinking Business Ethics and Social Responsibility in Sustainable Sevelopment*. Emerald Group Publishing.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-EVS-8): E-WASTES: LEGISLATION, TRADE AND 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
		Lecture	Tutorial	Practical/ Practice		
E-WASTES: LEGISLATION, TRADE AND MANAGEMENT	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Define and explain e-waste and its category
- Learn effective mechanisms to regulate the generation, collection, storage, transport, import, and export,
- Empower with methods of recycling, treatment, and disposal of e-waste
- Current legislative rules for managing e-waste in the environment

Learning outcomes:

After the course, students will be able to

- Apply various concepts for e-waste management hierarchy with a holistic understanding of the environmental impacts of e-waste
- Decipher the roles of the various national and internal acts and laws applicable for e-waste management
- Evolve plans for handling e-waste to comply with its management proposed under national and global legislation
- Develop a holistic understanding of environmental impacts of e-waste, application of

SYLLABUS OF GE-EVS-8

Theory (02 Credits: 30 lectures)

UNIT – I E-waste Composition, Generation and Management (4 Weeks) (8 lectures)
Definition, Composition and generation, Global and national perspective, Co-pollutants, Hazardous properties, Effects on human health and environment, Domestic e-waste disposal, E-waste Management: Basic principles, Components, Resource recovery potential, Technologies for recovery of resources, Steps in recycling and recovery of materials-mechanical processing, Occupational and environmental health effects (8 Lectures)

UNIT – II Global trade of E-waste (3½ Weeks) (7 lectures)
Factors in global waste trade economy, Waste trading and electronic recycling, Free trade agreements as a means of waste trading. Import of hazardous e-waste in India; India's stand on liberalizing import rules, E-waste economy in the organized and unorganized sector, Production and recycling of e-wastes in Indian metro cities. (7 Lectures)

UNIT – III Control measures (3½ Weeks) (7 lectures)
Need for stringent health safeguards and environmental protection laws in India, Extended Producers Responsibility (EPR), Import of e-waste permissions, Producer-Public-Government cooperation, Administrative Controls & Engineering controls, monitoring of compliance of Rules, Effective regulatory mechanism strengthened by manpower and technical expertise, Reduction of waste at source
(7 Lectures)

UNIT – IV Relevant legislation (4 Weeks) (8 lectures)
Hazardous Waste Rules, 2008, E-waste (Management and Handling) Rules, 2011; and E-Waste (Management) Rules, 2016 - Salient Features and its likely implication. Government assistance for TSDFs. The international legislation: The Basel Convention; The Bamako Convention. The Rotterdam Convention. Waste Electrical and Electronic Equipment (WEEE) Directive in the European Union, Restrictions of Hazardous Substances (RoHS) Directive. (8 Lectures)

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Prepare inventory and estimate the magnitude of electrical and electronic waste from the home, college, or the selected site (hospitals/company/manufacturing facilities) (example, air conditioners, heaters, microwaves, batteries, digital cameras, calculators, circuit boards, monitors, VCRs/DVD players, telephone equipment, etc.)
2. Categorize e-waste into different types as per international and national guidelines
3. Prepare a list of certified electronics recyclers in your city and transport e-waste to it, and have an interactive session to learn from the processes being followed.
4. Find out the composition of e-waste and segregate it from the given materials. Recommend the internationally acceptable shredding processes for each type of e-waste.
5. Prepare a poster showing salient features of the e-waste management act of India
6. Sort electronics and prepare a list of valuables that can be extracted from electronics, such as fluorescent light and toner cartridges (metals, plastics, glass,

compounds, and other elements). Identify and remove e-waste that may carry hazardous materials (like cathode ray tubes) before sending the objects for recycling.

7. Visit a nearby e-waste handling facility and learn about the dismantling of e-waste and the handling process
8. Discuss with students in groups the plausible ways and implementation of e-waste reduction at the source and how regulatory mechanisms can be utilized in the management of e-waste in educational institutions.
9. Evaluate the status of e-waste handling at your institution. Suggest potential solutions as per the existing norms of E-Waste (Management) Rules, 2016 and beyond.
10. Decipher the methods of dust extractions, magnetic and water separation, purification, and preparation for sale. Identify the material that can be repurposed.
11. Study the evolutionary history of e-waste management rules and their implementation- Hazardous Waste Rules, 2008; E-waste (Management and Handling) Rules, 2011; and E-Waste (Management) Rules, 2016
12. Compare and analyze international laws on e-waste management- the international legislations: The Basel Convention; The Bamako Convention; The Rotterdam Convention; Waste Electrical and Electronic Equipment (WEEE) Directive in the European Union; Restrictions of Hazardous Substances (RoHS) Directive
13. Develop an understanding and itinerary of the process for procuring e-waste import permissions and inventory of the e-waste disposal mechanisms.

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratory practicals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Hester, R.E. and Harrison, R.M., 2009. Electronic Waste Management: Design. Analysis and Application. Royal Society of Chemistry Publishing. Cambridge, UK.
- Fowler, B.A., 2017. Electronic Waste: Toxicology and Public Health Issues. Academic Press.
- Eduljee, G.H. and Harrison, R.M. eds., 2019. Electronic Waste Management. Royal Society of Chemistry.

Suggested readings

- Janyasuthiwong, S., 2020. Metal Removal and Recovery from Mining Wastewater and E-waste Leachate. CRC Press.
- Gaidajis, G., Angelakoglou, K. and Aktsoglou, D., 2010. E-waste: environmental problems and current management. Journal of Engineering Science and Technology Review, 3(1), pp.193-199.

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