

# DEPARTMENT OF ENVIRONMENTAL SCIENCE

## Category-I

### SEMESTER - V

#### BSC (H) ENVIRONMENTAL SCIENCE

#### DISCIPLINE SPECIFIC CORE COURSE – 13 (DSC-EVS-13): BIODIVERSITY AND CONSERVATION

#### 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-EVS-13: BIODIVERSITY AND CONSERVATION	4	2	0	2	Class XII pass	NA

#### Learning objectives

The Learning Objectives of this course are as follows:

- Provide fundamental principles of origin and distribution of biodiversity and its conservation
- Examine major threats to biodiversity and their impacts on ecosystems and human well-being
- Investigate the methods and strategies for conserving biodiversity, including protected areas, and sustainable management practices.
- Develop critical thinking skills and to apply scientific principles to the analysis of biodiversity and conservation issues
- Appreciate the paradigm “think globally, act locally” for a sustainable common future of humankind

#### Learning outcomes

After this course, students will be able to:

- Assess biodiversity and determine its significance for ecological processes
- Explain the underlying factors of generating biodiversity on Earth
- Analyze major threats to biodiversity and its links with human well-being.
- Apply scientific principles to the analysis of biodiversity and conservation issues and evaluate the methods and strategies for conserving biodiversity

- Communicate effectively about biodiversity and conservation issues to both scientific and non-scientific audiences.

## SYLLABUS OF DSC-EVS-13

Theory (02 Credits: 30 lectures)

### **UNIT – I Levels of biological organization and biodiversity patterns (2½ Week)** (5 lectures)

From genes to ecosystems; tree of life; history of character transformation; organic evolution through geographic time scale; species concept – what’s in a name?; how many species are there on earth?; concept and types of speciation.

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

### **UNIT – II Biodiversity estimation (2½ Week)** (5 lectures)

Sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity, biomass estimation; community diversity estimation: alpha, beta and gamma diversity; molecular techniques: RAPD, RFLP, AFLP; NCBI database, BLAST analyses.

### **UNIT – III Importance of biodiversity (2 Week)** (4 lectures)

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

### **UNIT – IV Threats to biodiversity (2½ Week)** (5 lectures)

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

### **UNIT – V Conservation of Biodiversity (3½ Week)** (6 lectures)

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

### **UNIT – VI Biodiversity in India (2½Week)** (5 lectures)

India as a mega diversity nation; phytogeographic and zoogeographic zones of the country; forest types and forest cover in India; fish and fisheries of India; impact of hydropower development on biological diversity; status of protected areas and biosphere reserves in the country; National Biodiversity Action Plan.

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

1. Practice and learn different field survey methods to assess and monitor biodiversity
2. Field trip to a local conservation area to assess the plant and animal diversity
3. Identify threatened and endangered species in a given
4. Assess variations in biodiversity with different types of ecosystems around
5. Estimate biodiversity indices and comparison of biodiversity levels in different locations
6. Determine magnitude of infestation of invasive species and their possible impacts on native species in a given ecosystem
7. Identify and investigate pollinators of selected plant species in a given ecosystem
8. Study the effects of habitat fragmentation or degradation on population of selected species
9. Analyze the conservation strategies and their effectiveness in protecting biodiversity in given natural and restored ecosystems
10. Identify and document economically important species in a given ecosystem
11. Undertake field trip to a local garden/ecosystem to observe different plant species and their adaptations to their environment
12. Analyse the effects of land use change on biodiversity of a given area
13. Investigate the coexistence or competition among species in a given area and based on literature suggest the possible underlying biotic interactions
14. Develop conservation planning for target species and make informed decisions for biodiversity 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.

#### Essential/recommended readings

- Primack, R.B. (2017). *Essentials of Conservation Biology* (Sixth Edition). Sinauer Associates.
- Gaston, K.J. (2016). *Biodiversity: An Introduction* (Third Edition). Wiley-Blackwell.
- Wilson, E.O. (2016). *Half-Earth: Our Planet's Fight for Life*. Liveright Publishing Corporation.
- Kareiva, P., & Marvier, M. (2017). *Conservation Science: Balancing the Needs of People and Nature* (Second Edition). Roberts and Company Publishers.
- Koh, L.P., & Wilcove, D.S. (2016). *Conservation for a New Era: Integrated Conservation Science for the 21st Century*. Oxford University Press.

#### Suggestive readings

- Lovejoy, T.E. (2019). *Biodiversity and Climate Change: Transforming the Biosphere*. Yale University Press.
- Pimm, S.L. (2018). *The Value of Everything: How to Save the World by Making it*

Wealthier. PublicAffairs.

- Simberloff, D. (2013). The Ecology of Invasions by Animals and Plants. University of Chicago Press.
- Tallis, H. (2018). The Nature of Conservation: A Race Against Time. Island Press.
- Wilson, E.O. (2016). Half-Earth: Our Planet's Fight for Life. Liveright Publishing Corporation.

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

**DISCIPLINE SPECIFIC CORE COURSE – 14 (DSC-EVS-14): ORGANISMAL & EVOLUTIONARY 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-EVS-14: ORGANISMAL & EVOLUTIONARY BIOLOGY	4	2	0	2	Class XII pass	NA

**Learning objectives**

The Learning Objectives of this course are as follows:

- Gain insights into principles of evolution and its significance in shaping biological diversity on Earth
- Familiar with classification of organisms from different domains of life and their unique structure and function
- Equip with scientific methods to investigate and understand nuances of organismal and evolutionary biology
- Appreciate the linkages among ecology, conservation biology, and evolutionary biology

**Learning outcomes**

After this course, students will be able to

- Explain the ecological and molecular processes contributing to evolution, including natural selection, genetic drift, gene flow, and mutation
- Identify and characterize organisms belonging to different domains of life based on their major characteristics and functions
- Design and conduct experiments for better understanding on organismal and evolutionary biology
- Evolve better strategies for biodiversity conservation and improving ecosystem health while taking into account their evolutionary biology

**SYLLABUS OF DSC-EVS-14**

Theory (02 Credits: 30 lectures)

**UNIT – I History of life on Earth and theory of evolution (3½ Week) (7 lectures)**

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

including Homo.

Lamarck's concept of evolution; Darwin's Evolutionary Theory: variation, adaptation, struggle, fitness, and natural selection; Mendelism; spontaneity of mutations; The Evolutionary Synthesis.

**UNIT – II Evolution of unicellular life (2½ Week)** (5 lectures)

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

**UNIT – III Evolution of multicellular organisms (2½ Week)** (5 lectures)

Origin of multicellularity, Cellular differentiation and specialization, Developmental biology and body plans, Evolution of cell-to-cell communication, Emergence of tissues and organs, Evolution of organ systems, Evolution of life cycles and reproductive strategies, Evolution of multicellular organisms (protists, plants and animals) and their ecological interactions

**UNIT – IV Geography of evolution (1½ Week)** (3 lectures)

Biogeographic evidence of evolution; patterns of distribution; historical factors affecting geographic distribution; evolution of geographic patterns of diversity.

**UNIT – V Molecular evolution (2 Week)** (4 lectures)

Neutral evolution; molecular divergence and molecular clocks; molecular tools in phylogeny, classification and identification; protein and nucleotide sequence analysis; origin of new genes and proteins; gene duplication and divergence.

**UNIT – VI Fundamentals of population genetics (3 Week)** (6 lectures)

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

**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 effects of pH on the toxicity of heavy metals on model organism, such as Daphnia
- 2-3. Determine toxicity of varying concentration of industrial effluent on common

- alga and measure its growth and survival rates
- 4-5. Effects of heavy metal toxicity on plant growth, focussing on different plant parts and physiological characteristics
  6. Analyze effects of climate change on diversity of pollinators
  7. Determine the impacts of environmental chemicals on the abundance and diversity of nematodes (e.g., *Caenorhabditis elegans*)
  8. Ascertain the possible impacts of herbicides on weed populations
  9. Test the effects of a target organic contaminant on behaviour and mortality of earthworm
  - 10-11. Measure developmental abnormalities in zebrafish embryos due to toxicity of target environmental chemicals
  - 12-13. Prepare and characterize nanoparticles of selected heavy metal and assess effect of nanoparticles on plant growth
  15. Effects of various concentrations of road salt on freshwater organisms (e.g., zooplankton) and measure changes in their behavior and survival

#### 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

- Futuyma, D. J., & Kirkpatrick, M. (2017). *Evolution* (4th ed.). Sunderland, MA: Sinauer Associates.
- Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W. M., & Stahl, D. A. (2018). *Brock Biology of Microorganisms* (15th ed.). London, UK: Pearson.
- Primack, R. B., & Rodricks, R. V. (2021). *Essentials of Conservation Biology* (7th ed.). Sunderland, MA: Sinauer Associates.
- Raven, P. H., Evert, R. F., & Eichhorn, S. E. (2022). *Biology of Plants* (9th ed.). New York, NY: W. H. Freeman.
- Sodhi, N. S., Gibson, L., & Raven, P. H. (2021). *Conservation Biology for All*. Oxford, UK: Oxford University Press.
- Stearns, S. C., & Hoekstra, R. F. (2021). *Evolution: An Introduction* (3rd ed.). Oxford, UK: Oxford University Press.
- Zimmer, C., & Emlen, D. J. (2021). *Evolution: Making Sense of Life*. New York, NY: Macmillan Learning.

#### Suggestive readings

- Deacon, J. (2019). *Fungal Biology* (5th ed.). Hoboken, NJ: John Wiley & Sons.
- Haveland, W. A., Prins, H. E. L., Walrath, D., & McBride, B. (2021). *Evolution and Prehistory: The Human Challenge* (11th ed.). Boston, MA: Cengage Learning.
- Herron, J. C., & Freeman, S. (2020). *Evolutionary Analysis* (6th ed.). Hoboken, NJ: Pearson.

- Pough, F. H., Janis, C. M., & Heiser, J. B. (2018). *Vertebrate Life* (10th ed.). London, UK: Pearson.
- Raven, P. H., Johnson, G. B., Mason, K. A., Losos, J. B., & Singer, S. R. (2021). *Biology* (12th ed.). New York, NY: McGraw-Hill Education.
- Ruppert, E. E., Fox, R. S., & Barnes, R. D. (2021). *Invertebrate Zoology: A Functional Evolutionary Approach*. Boston, MA: Cengage Learning.

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

**DISCIPLINE SPECIFIC CORE COURSE – 15 (DSC-EVS-15): NATURAL RESOURCES  
MANAGEMENT & 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-EVS-15: NATURAL RESOURCES MANAGEMENT & SUSTAINABILITY	4	2	0	2	Class XII pass	NA

**Learning objectives**

The Learning Objectives of this course are as follows:

- Gain insights into the principles and practices of natural resources management and sustainability
- Understand critical linkages among social, economic, and environmental issues related to natural resources management and sustainability
- Impart analytical and critical thinking skills related to natural resources management and sustainability
- Equip students with the knowledge and skills necessary to develop and implement sustainable solutions to natural resource management challenges
- Prepare students for careers in natural resource management, environmental policy, sustainability, and related fields

**Learning outcomes**

After this course, students will be able to

- Analyze the socio-economic, and environmental issues related to natural resource management
- Explain the key principles and practices of natural resource management and sustainability.
- Evaluate the effectiveness of natural resource management and sustainability policies and practices and develop sustainable solutions
- Communicate effectively about natural resource management and sustainability issues to a variety of audiences.
- Assess the environmental impacts of natural resource management and sustainability practices and apply ecological, economic and ethical principle to natural resource management and sustainability issues

- Pursue careers in natural resource management, environmental policy, sustainability, and related fields.

## **SYLLABUS OF DSC-EVS-15**

Theory (02 Credits: 30 lectures)

### **UNIT – I Natural resources and reserves and their management**

**(3½ Weeks)** (7 lectures)

Classification of natural resources, Renewable and non-renewable resources, Land resources; Soil resources, Forest resources, food resources, Water resources; Fisheries and other marine resources; energy resources; mineral resources; resource availability and factors influencing its availability; human impact on natural resources; Resource degradation; Resource conservation; Concept of natural resource management, Relationship between natural resource management and sustainability, Stakeholders and natural resource management, Social and economic dimension of resource management, Role of science and technology in natural resource management, Sustainable Development Goals (SDGs) and natural resources.

### **UNIT –II Land Use and Management**

**(2 Weeks)** (4 lectures)

Land use and land cover change, Land use planning and management, Land degradation and desertification, Soil conservation and management, Agroforestry and sustainable agriculture, Urbanization and land use, Land rights, Land use conflict and resolution

### **UNIT – III Mineral resources**

**(3 Weeks)** (6 lectures)

Mineral resources: definition, types, rock cycle, significance in society and importance economic development, Mineral extraction and processing: types of mining, techniques, methods, waste management, and social and environmental impacts, Global consumption patterns of mineral resources, techniques to increase mineral resource supplies; ocean mining for mineral resources, Mineral markets and economics, Mineral governance and policy, Sustainable mineral resource management, Future of mineral resources

### **UNIT – IV Non-renewable and renewable energy resources (3½ Weeks)** (7 lectures)

Oil, coal natural gas liquified natural gas: formation, reserve, exploration, extraction and processing, and consumption; Environmental and economic impacts of non-renewable energy consumption;

Solar energy, hydropower, geothermal energy, tidal energy, wave energy, ocean thermal energy, nuclear power, biomass and biofuel: technology, potential, operational costs, advantages, challenges, innovation and future; Radioactive contamination; Application of green technology; India's efforts and its global impacts on solar mission, Indian renewable energy programme, Future energy options and challenges.

### **UNIT – V Resource management for sustainability (3 Weeks)** (6 lectures)

Approaches in Resource Management: ecological, economic, and ethnological, Implications of integrated resource management; Climate Change and Energy Management: energy sources, efficiency and conservation, carbon capture and storage;

Urban Ecosystems: energy efficiency, transportation, industry, and reduction in greenhouse gas emissions; Energy policy and governance.

### 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, classify and assess the status of different tree species in a given ecosystems and recommend appropriate management strategies
2. Investigate the effects of different land management practices on soil erosion to understand how to prevent soil degradation and protect natural resources
3. Test the water quality of given water samples collected from two water bodies and suggest appropriate management practices
4. Survey and document the socio-economic and ecological importance of plant species sampled from a local ecosystem
5. Assess the current status of plant species prioritized in practical 4 and recommend the appropriate conservation and management practices
6. Calculate and interpret the ecological footprint of a community or organization using the Ecological Footprint Standards.
7. Conduct energy audits of buildings or facilities using standard methods such as the ASHRAE Level I, II, or III Energy Audits.
8. Analyze stakeholders to identify and engage with key stakeholders in natural resources management and sustainability.
9. Conduct life cycle assessment of products or processes using standard methods such as the ISO 14040/14044 standards
10. Document agricultural research priorities of India and comment on its importance as sustainable agricultural practices for natural resource management and food security
11. Develop and implement a sustainable plan for water resource management of your institute
12. Assess the environmental impacts of mining activities in India during past 10 years and identify the shift in trend, if any
13. Analyze mineral/energy resource policies in a national or global context to understand the importance of sustainable mineral resource management.
14. Extract bioenergy from organic waste or crops to understand the importance of renewable energy sources and their management.

### 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

- Cleveland, C. J. (2018). *Biophysical economics: From physiocracy to ecological economics and industrial ecology*. Routledge.
- Folke, C., Österblom, H., Jouffray, J. B., Lambin, E. F., & Adger, W. N. (Eds.). (2020). *For ocean sustainability: Challenges, opportunities, and the role of science-policy interaction*. Cambridge University Press.
- Mitchell, B. (2019). *Resource efficiency and sustainable production: A handbook for achieving sustainability in manufacturing*. Springer.
- Reed, M. G. (2021). *Environmental and natural resource economics: A contemporary approach*. Routledge.
- Varghese, J. (2019). *Resource management for sustainable development*. Springer.

### Suggestive readings

- Agyeman, J. (Ed.). (2020). *Sustainability: A handbook for management and leadership*. Routledge.
- Daly, H. E. (Ed.). (2017). *Valuing the Earth: Economics, ecology, ethics*. MIT Press.
- Norton, B. G. (2018). *Sustainability: A philosophy of adaptive ecosystem management*. University of Chicago Press.
- Westman, W. E. (Ed.). (2018). *How much is enough? Shaping the defense program, 1961-1969*. Routledge.
- Wright, T. (2020). *Sustainable communities and urban housing: A comparative analysis of self-help housing practices in the United States and Mexico*. Routledge.

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

## DISCIPLINE SPECIFIC ELECTIVE (DSE-EVS-05): WATERSHED 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		
DSE-EVS-05: WATERSHED MANAGEMENT	4	2	0	2	Class XII pass	NA

#### Learning objectives

The Learning Objectives of this course are as follows:

- Familiarize with the concepts of watershed management and its relevance in ecological balance
- Gain insights into various physico-chemical, and biological processes related to watersheds and its impact on water quality and quantity
- Empower with tools and methods widely used in watershed management, such as remote sensing and GIS
- Understand the legal and regulatory frameworks governing watershed management at different levels (local, state, and national)

#### Learning outcomes

After the course, the students will be able to

- Explain the concept of a watershed and its importance in maintaining ecological balance
- Describe the various physical, chemical, and biological processes occurring in watersheds and their impact on water quality and quantity
- Use remote sensing, GIS, and modeling tools to analyze and manage watersheds.
- Identify and explain the legal and regulatory frameworks governing watershed management at the local, state, and national levels
- Evaluate the effectiveness of a watershed management plan through critical analysis of case studies and practical exercises
- Critically evaluate case studies in watershed management to understand challenges and opportunities in the field

## **SYLLABUS OF DSE-EVS-05**

Theory (02 Credits: 30 lectures)

### **UNIT – I Watershed Management Basics (2½ Weeks) (05 lectures)**

Watershed: definition, and characteristics: Watershed Management: approaches, principles, planning, importance, institutional and legal framework, role in sustainable development, and challenges and opportunities

### **UNIT – II Watershed Hydrology (2 Weeks) (04 lectures)**

Precipitation and its measurement, Evaporation and transpiration, Infiltration and percolation, Runoff generation and calculation, Streamflow and stream gauging, Watershed models and simulations, Hydrologic design of watershed management practices, Impacts of climate change on watershed hydrology

### **UNIT – III Water Quality in Watershed (1½ Weeks) (03 lectures)**

Water quality parameters and standards, Sources of water pollution, Point and non-point source pollution, Water quality monitoring and sampling, Water quality modeling

Eutrophication and harmful algal blooms, Water quality management practices, Watershed management for drinking water supply

### **UNIT – IV Land Use in Watersheds (2½ Weeks) (05 lectures)**

land use and land cover change, Land use planning and zoning, Soil erosion and sedimentation, Agricultural management practices for soil and water conservation, Forest management for watershed protection, Urbanization and watershed management, Wetland conservation and management, Mining and watershed management

### **UNIT – V Management Practices for Sustainable Watershed Management (2 Weeks) (04 lectures)**

Best management practices (BMPs), Conservation tillage and crop rotation, Agroforestry and silvopasture, Riparian buffer management, Grassland management, Land treatment and land application, Green infrastructure and low-impact development (lid), Restoration of degraded watersheds

### **UNIT – VI Watershed Economics (2½ Weeks) (05 lectures)**

Economic valuation of watershed services, Benefit-cost analysis of watershed management projects, Water pricing and market-based mechanisms for watershed management, Environmental economics and watershed management, Cost-effective watershed management, Watershed financing and investment, Economic instruments for watershed conservation, Watershed management and rural livelihoods

### **UNIT –VII Stakeholder Participation and Governance in Watershed Management**

**(2 Weeks) (04 lectures)**

Community-based watershed management, Public participation and stakeholder engagement, Social equity and environmental justice, Governance structures and watershed management, Water user associations (WUAs), Decentralization and devolution of watershed management, Indigenous knowledge and watershed management, Gender and watershed management

**UNIT – VIII Case Studies in Watershed Management (1½ Weeks) (03 lectures)**

Case studies on: success and failures of watershed management, from developing countries, influence by and adaptation to climate change conflicts and resolution, and ecological restoration; Watershed management and sustainable development goals

**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. Delineate and categorize watershed boundary using digital elevation data and GIS software
2. Calibrate and validate the model by collecting data on climate, land use, soil properties, and topography of the watershed
3. Set up the model in the chosen software by defining the watershed boundary, hydrological processes, and inputs and outputs of the model
4. Conduct a sensitivity analysis to identify the most important model parameters that affect the model's output
5. Document prevalence of invasive species in two most significant watershed regions of India
6. Design and suggest best management practices (BMPs) of world's most notable watershed region and compare it with any watershed region of India
7. Analyze different types of satellite imagery and their use in watershed management
8. Determine the impact of changes in land use and land cover on water quality and watershed management
9. Create a hydrological model of a watershed using remote sensing and GIS, simulating runoff, soil erosion, and other hydrological processes
10. Map wetlands in a watershed using remote sensing and GIS and analyze their functions, such as water storage, nutrient cycling, and biodiversity conservation
11. Determine soil erosion rates in a watershed using remote sensing and GIS and analyze their impact on water quality, sedimentation, and flooding

**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

- Anderson, C. W., & Miller, W. W. (2021). *Watershed management: Planning for the 21st century*. John Wiley & Sons.
- Bruijnzeel, L.A., Hamilton, L.S., and Asdak, C. (2011). *Rainforest Hydrology, Ecology and Management*. Springer.
- Dupigny-Giroux, L. A., McCabe, G. J., & Hirsch, R. M. (2017). *State of the art in watershed modeling*. John Wiley & Sons.
- King, K.W., Balogh, J.C., and Harmel, R.D. (2010). *Watershed Management for Potable Water Supply: Assessing the New York City Strategy*. American Society of Agricultural and Biological Engineers.
- National Research Council. (2008). *Urban Stormwater Management in the United States*. National Academies Press.
- Tindall, J.A., Keren, R.A., and Stone, J.J. (2016). *Watershed Management: Planning for the 21st Century*. American Society of Civil Engineers.

### Suggestive readings

- Ma, J., Su, C., and Liu, W. (Eds.). (2018). *River basin management in the twenty-first century: Understanding people and place*. CRC Press.
- Miao, S. L., Zhang, C., Cai, Y., & Zhou, J. (Eds.). (2022). *Sustainable watershed management in China*. Springer.
- Water Environment Federation. (2012). *Urban Watersheds: Geology, Contamination, and Sustainable Development*. Wiley.
- Wilcock, R.J., and Iverson, R.M. (2013). *Surface Water-Quality Modeling*. Waveland Press.
- Yang, H. (2010). *Integrated Watershed Management in the Global Ecosystem*. Nova Science Publishers.

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