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III	Core Course - 5 (CC - 5)	GIS and Remote Sensing	6	4	3	30	70	100
	Core Course - 6 (CC - 6)	Environmental Instrumentation Methods	6	4	3	30	70	100
	Core Practical -3 (CP - 3)	Geoinformatics	6	4	2	40	60	100
	Discipline Centric Elective Course - 3 (DCEC - 3)	Any one from the list	5	4	2	30	70	100
	Generic Elective Course - 3 (GEC - 3)	Any one from the list	5	3	3	30	70	100
	Non-Major Elective Course - 2 (NMEC - 2)	One Course from Outside department	2	2	3	30	70	100
	Internship / Industrial Activity @			2		20	80	100
	Total		30	23	-	-	-	700
IV	Core Course - 7 (CC - 7)	Climate Change Mitigation Adaptation	6	4	3	30	70	100
	Core Course - 8 (CC - 8)	Environmental Toxicology	6	4	3	30	70	100
	Core Course - 9 (CC - 9)	Environmental Ethics, Law & Policy	6	4	3	30	70	100
	Discipline Centric Elective Course - 4 (DCEC - 4)	Any one from the list	4	4	2	30	70	100
	Entrepreneurship / Industry Based Course @	Industry Safety Process	3	3	3	30	70	100
	Project Work @		5	5	-	20	80	100
	Value Added Course - 2 (VAC - 2)*	Waste Entrepreneurship	-	2*		30	70	100*
	Total		30	24	-	-	-	600
Grand Total				91				2600

LIST OF DISCIPLINE CENTRIC ELECTIVE COURSE

Discipline Centric Elective Course - 1 (DCEC - 1)	
1.	Biodiversity and Conservation
2.	Natural Resources
Discipline Centric Elective Course - 2 (DCEC - 2)	
1.	Environmental Microbiology & Biotechnology
2.	Energy Resources
Discipline Centric Elective Course - 3 (DCEC - 3)	
1.	Industrial Safety and Management
2.	Ecotourism
Discipline Centric Elective Course - 4 (DCEC - 4)	
1.	Statistics for Environmental Science
2.	Environmental Informatics

Sl.No	Non-Major Elective Course (NMEC)
1.	Environmental Pollution
2.	Climate Change & Global Warming

LIST OF GENERIC ELECTIVE COURSE (GEC)

GENERIC ELECTIVE COURSE - 1 (GEC - 1)	
1.	Global Environmental Issues
2.	Renewable Energy Resource
3.	Environmental Education & Policy
GENERIC ELECTIVE COURSE - 2 (GEC - 2)	
1.	Green Products
2.	Sustainable Integrate Farming Systems
3.	Environmental Engineering
GENERIC ELECTIVE COURSE - 3 (GEC - 3)	
1.	Research Methodology
2.	Waste Management
3.	Sustainable Development

SUMMARY OF CURRICULUM STRUCTURE OF PG PROGRAMMES: SCIENCE

Sl. No.	Types of the Course	No. of Courses	Credits for each Course	Total Credits	Marks
1.	Core Course	9	4	36	900
2.	Core Practical	3	4	12	300
3.	Discipline Centric Elective Course	4	4	16	400
4.	Generic Elective Course	3	3	9	300
5.	Skill Enhancement Course	2	2	4	200
6.	Non-Major Elective Courses	2	2	4	200
7.	Internship / Industrial Activity @	1	2	2	100
8.	Entrepreneurship/ Industry Based Course @	1	3	3	100
9.	Project @	1	5	5	100
Total		26	-	91	2600
Value Added Courses *		2*	2	4*	200*

*	The value added courses credit will not be included in the total CGPA. These courses are extra-credit courses. Instruction hours for these courses is 30 hours								
@	Summer Internship will be carried out during the summer vacation after the First year. Viva Voce will be conducted by the college and Marks shall be sent to the University and the same will be included in the 3rd semester Mark Statement. Summer Internship / Industrial Activity& Project Scheme of Evaluation: <table border="1" style="width: 100%;"> <tr> <th>Description</th><th>Marks</th></tr> <tr> <td>Report</td><td>80</td></tr> <tr> <td>Viva</td><td>20</td></tr> <tr> <td>Total</td><td>100</td></tr> </table>	Description	Marks	Report	80	Viva	20	Total	100
Description	Marks								
Report	80								
Viva	20								
Total	100								

PROGRAM OUTCOMES	
PO 1	Disciplinary Knowledge: Broad and in-depth knowledge of advanced scientific concepts, principles, and methodologies within the chosen domain. Ability to critically explain, integrate, and apply scientific knowledge to theoretical and practical problems. Opportunities to earn additional credits through specialized and interdisciplinary courses further enhance expertise and broaden disciplinary understanding.
PO 2	Critical Thinking: Field visits, academic interactions, and experiential learning activities will help students develop critical observation, interpretation, and analytical skills. Ability to evaluate and interpret scientific data, formulate hypotheses, and draw logical conclusions. Encourages independent thinking and the ability to assess scientific problems from multiple perspectives.
PO 3	Analytical Reasoning: Through classroom discussions, scientific literature reviews, and interactive learning environments, students will strengthen their analytical reasoning abilities. Ability to critically evaluate scientific texts, identify gaps in existing knowledge, formulate research questions, and synthesize new ideas and concepts. Promotes evidence-based reasoning and logical interpretation of scientific information.
PO 4	Scientific Reasoning: Strong foundation in scientific methods, experimental design, and data interpretation through laboratory-based courses. Enhances practical knowledge of scientific instrumentation, calibration procedures, laboratory safety, and appropriate research techniques. Ability to conduct scientifically sound experiments and interpret results accurately.
PO 5	Self-Directed Learning: Encourages independent and self-directed learning through assignments, field reports, project work, and literature-based studies. Ability to organize, analyze, and present scientific findings in professional formats relevant to academic and industrial settings. Fosters responsibility, time management, and continuous self-improvement in learning.
PO 6	Reflective Thinking: Laboratory-intensive core courses will expose students to a broad range of research methodologies and experimental techniques. Ability to reflect on learning experiences, evaluate the effectiveness of scientific approaches, and understand the broader applications of scientific techniques within the discipline.
PO 7	Problem-Solving Skills: Ability to develop and apply scientific principles, quantitative reasoning, and mathematical concepts to solve discipline-specific problems. Ability to analyze experimental data, interpret scientific observations, and derive meaningful conclusions. Prepares students to address real-world scientific and societal challenges effectively.
PO 8	Research-Related Skills: Internships, dissertation work, and research-oriented projects provide opportunities to design, develop, and execute independent research studies. Students gain hands-on experience in research methodology, experimental techniques, data analysis, scientific writing, and ethical research practices. These experiences strengthen laboratory competence and prepare students for advanced research and professional careers.
PO 9	Lifelong Learning: Cultivates a mindset of continuous learning and professional adaptability. Ability to identify gaps in knowledge and skills, adapt to emerging technologies and scientific advancements, and pursue self-directed learning throughout their careers. Encourages lifelong learning that supports academic growth, employability, and professional excellence.
PO 10	Leadership Readiness: Ability to take initiative, work collaboratively, and manage academic and research responsibilities effectively. Through seminars, group projects, internships, and research activities, students develop decision-making, problem-solving, organizational, and interpersonal skills. Ability to lead scientific teams, communicate effectively in professional environments, and contribute responsibly to academic, industrial, and societal development.

CORE COURSE – 1
ECOLOGY AND ENVIRONMENTAL SCIENCE
(Theory)

Semester I

Code

Credits: 4

COURSE OBJECTIVES

- To provide advanced knowledge on ecological principles, ecosystem processes, and environmental interactions.
- To develop a comprehensive understanding of population, community, and ecosystem ecology.
- To impart knowledge on environmental science concepts, environmental quality, and sustainability issues.
- To familiarize students with contemporary environmental challenges and their management strategies.
- To understand the relationship between biodiversity, ecosystem functioning, and environmental conservation.

UNIT – I: PRINCIPLES OF ECOLOGY

Definition, History, Scope and Branches of Ecology. Ecology as an interdisciplinary science. Levels of Ecological Organization. Evolution of ecological thought. Origin of Life and Evolutionary Processes. Ecological Factors: Abiotic Factors—Light, Temperature, Water, Humidity, Soil, pH, Salinity, Radiation, Wind and Climate. Biotic Factors and Limiting Factors. Ecological Adaptations. Species Interactions: Mutualism, Commensalism, Amensalism, Competition, Predation, Parasitism and Protocooperation. Biogeochemical Cycles: Carbon, Nitrogen, Oxygen, Phosphorus, Sulphur and Hydrological Cycles.

UNIT – II: POPULATION ECOLOGY

Population Ecology: Definition, Attributes and Characteristics. Population Density and Dispersion. Natality, Mortality, Fecundity and Survivorship. Age Structure and Age Pyramids. Population Growth Models – Exponential and Logistic Growth. Population Regulation and Carrying Capacity. r- and K-selection Strategies. Life History Strategies. Metapopulations and Population Dynamics. Population Fluctuations and Cycles. Ecological and Evolutionary Significance of Population Interactions. Keystone Species, Indicator Species and Umbrella Species.

UNIT – III: COMMUNITY ECOLOGY AND SUCCESSION

Community Ecology: Concept, Characteristics and Attributes. Community Structure and Organization. Species Diversity and Community Stability. Dominance, Stratification, Periodicity and Ecotones. Edge Effect and Ecological Niche. Community Interactions: Predation, Herbivory, Competition, Parasitism, Mutualism and Allelopathy. Biological Invasions and Invasive Species Management. Ecological Succession: Concept, Mechanisms and Models. Primary and Secondary Succession. Hydrosere, Xerosere and Lithosere. Climax Theories and Contemporary Concepts of Succession. Community Development and Ecosystem Resilience.

UNIT – IV: ECOSYSTEM ECOLOGY

Concept, Structure and Functions of Ecosystems. Components of Ecosystems: Producers, Consumers and Decomposers. Ecosystem Productivity: Gross Primary Productivity, Net Primary Productivity and Secondary Productivity. Energy Flow in Ecosystems. Food Chains, Food Webs and Ecological Pyramids. Ecosystem Stability, Resistance and Resilience. Ecosystem Services and Valuation. Types of Ecosystems: Forest, Grassland, Desert, Mountain, Freshwater (Lentic and Lotic), Wetlands, Estuaries, Mangroves, Coral Reefs and Marine Ecosystems. Biomes: Distribution, Characteristics and Ecological Significance. Global Biomes and Climatic Determinants.

UNIT – V: ENVIRONMENTAL SCIENCE AND MANAGEMENT

Environmental Science: Scope, Principles and Multidisciplinary Nature. Earth Systems and Environmental Components – Atmosphere, Hydrosphere, Lithosphere and Biosphere. Environmental Pollution: Air, Water, Soil, Noise, Thermal and Radioactive Pollution – Sources, Effects and Control Measures. Environmental Monitoring and Assessment. Climate Change: Causes, Impacts, Adaptation and Mitigation Strategies. Environmental Impact Assessment (EIA). Sustainable Development and Environmental Management. Biodiversity Conservation and Ecosystem Restoration. Environmental Legislation and Policies in India. International Environmental Conventions and Protocols.

UNIT – VI: CURRENT CONTOURS *(For Continuous Internal Assessment Only)*

Recent Trends in Global Climate Change and Carbon Emissions. Air and Water Quality Status at National and Global Levels. Ecosystem Restoration Initiatives. Wetland Conservation and Management in India. Biodiversity Loss and Emerging Threats. Environmental Issues in Tamil Nadu: Coastal Ecosystem Degradation, Wetland Encroachment, Industrial Pollution, Solid Waste Management and Water Resource Challenges. Role of GIS, Remote Sensing and Artificial Intelligence in Ecological and Environmental Studies.

REFERENCES

1. Fundamentals of Ecology, Eugene P. Odum & Gary W. Barrett (2012), Cengage Learning.
2. Ecology: Principles and Applications, J. L. Chapman & M. J. Reiss (2010), Cambridge University Press.
3. Ecology: From Individuals to Ecosystems, Michael Begon, Colin Townsend & John Harper (2021), Wiley-Blackwell.
4. Environmental Science, G. Tyler Miller & Scott E. Spoolman (2023), Cengage Learning.
5. Environmental Science: Earth as a Living Planet, Daniel B. Botkin & Edward A. Keller (2019), Wiley.
6. Environmental Science and Engineering, P. D. Sharma (2021), Rastogi Publications.
7. Principles of Environmental Science, William P. Cunningham & Mary Ann Cunningham (2020), McGraw Hill.
8. Biodiversity and Conservation, K. V. Krishnamurthy (2018), Oxford University Press.
9. Environmental Impact Assessment, Larry W. Canter (2018), McGraw Hill.
10. Ecosystem Ecology, David G. Raffaelli & Christopher L. J. Frid (2019), Cambridge University Press.
11. Climate Change and Society, John Urry (2018), Polity Press.
12. Environmental Management, T. V. Ramachandra (2020), TERI Publications.
13. Conservation Biology, Richard B. Primack (2022), Sinauer Associates.
14. Ecology and Environment, P. D. Sharma (2021), Rastogi Publications.
15. Environmental Studies, Benny Joseph (2020), McGraw Hill Education.
16. <https://moefcc.gov.in>
17. <https://www.unep.org>
18. <https://www.ipcc.ch>

COURSE OUTCOMES (COs)

Upon successful completion of the course, the students will be able to:

CO1: Explain the fundamental principles, concepts, scope, and interdisciplinary nature of ecology and environmental science.

CO2: Analyze the influence of abiotic and biotic factors on organisms, populations, communities, and ecosystems.

CO3: Describe ecological adaptations, species interactions, and the significance of biogeochemical cycles in maintaining ecosystem balance.

- CO4:** Evaluate population attributes, population growth patterns, regulation mechanisms, and ecological significance of population dynamics.
- CO5:** Interpret community structure, species diversity, ecological niches, and the role of ecological interactions in community organization.
- CO6:** Examine ecological succession processes, community development, ecosystem resilience, and management of invasive species.
- CO7:** Assess ecosystem structure, productivity, energy flow, food webs, ecological pyramids, and ecosystem services.
- CO8:** Compare the characteristics, distribution, and ecological importance of major terrestrial and aquatic ecosystems, biomes, and global ecological patterns.
- CO9:** Evaluate environmental issues including pollution, climate change, biodiversity loss, and their impacts on ecological and human systems.
- CO10:** Apply principles of environmental management, conservation, sustainability, environmental legislation, impact assessment, and emerging technologies for addressing contemporary environmental challenges.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	1	1	1	-	-	2	-
CO2	3	3	2	2	1	1	2	-	1	-
CO3	3	2	2	2	1	1	1	-	1	-
CO4	2	3	3	2	1	1	3	1	1	-
CO5	2	3	3	2	1	2	2	1	1	-
CO6	2	3	2	2	1	2	3	1	1	1
CO7	3	2	2	2	1	1	3	1	1	-
CO8	3	2	2	1	1	1	2	1	2	-
CO9	2	3	3	2	1	2	3	2	2	1
CO10	2	2	2	2	2	2	3	3	3	3

CORE COURSE – II
ENVIRONMENTAL CHEMISTRY
(Theory)

Semester I

Code

Credits: 4

COURSE OBJECTIVES

- To provide a comprehensive understanding of the chemical principles governing environmental systems.
- To impart knowledge on the chemistry of air, water, soil and biological environments.
- To understand the sources, transport, transformation and fate of pollutants in the environment.
- To develop analytical skills for environmental monitoring and assessment.
- To enable students to apply chemical principles for solving environmental problems and promoting sustainable development.

UNIT – I: FUNDAMENTALS OF ENVIRONMENTAL CHEMISTRY

Definition, Scope and Importance of Environmental Chemistry. Structure and Composition of Matter. Atomic Structure, Chemical Bonding and Molecular Interactions. Chemical Thermodynamics and Environmental Processes. Chemical Kinetics and Reaction Mechanisms. Acids, Bases and Buffers in Environmental Systems. Oxidation-Reduction Reactions. Environmental Significance of pH, Conductivity, Salinity and Alkalinity. Biogeochemical Cycles of Carbon, Nitrogen, Sulphur and Phosphorus. Chemical Equilibrium in Natural Systems.

UNIT – II: ATMOSPHERIC CHEMISTRY

Structure and Composition of the Atmosphere. Atmospheric Layers and Their Characteristics. Chemistry of Major Atmospheric Constituents. Photochemical Reactions in the Atmosphere. Greenhouse Gases and Global Warming. Ozone Layer Chemistry and Ozone Depletion. Atmospheric Aerosols and Particulate Matter. Smog Formation: Classical and Photochemical Smog. Acid Rain: Causes, Chemistry and Environmental Impacts. Air Pollutants – Sources, Transformation and Fate. Indoor Air Pollution and Emerging Atmospheric Contaminants.

UNIT – III: AQUATIC CHEMISTRY

Physical and Chemical Properties of Water. Hydrological Cycle and Water Chemistry. Dissolved Oxygen, Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC). Water Quality Parameters and Standards. Chemistry of Natural Waters. Nutrient Cycling in Aquatic Systems. Eutrophication and Its Consequences. Heavy Metals and Trace Elements in Water. Organic Pollutants in Aquatic Environments. Water Treatment Processes: Coagulation, Flocculation, Sedimentation, Filtration, Disinfection and Advanced Oxidation Processes. Groundwater Chemistry and Contamination.

UNIT – IV: SOIL AND SEDIMENT CHEMISTRY

Soil Formation and Composition. Physical and Chemical Properties of Soil. Soil pH, Cation Exchange Capacity and Buffering Capacity. Soil Organic Matter and Humic Substances. Nutrient Dynamics in Soils. Soil-Water Interactions. Mobility and Transformation of Pollutants in Soil. Heavy Metal Contamination and Remediation. Pesticides and Agrochemicals in Soil. Sediment Chemistry and Geochemical Processes. Soil Pollution and Management Strategies. Biogeochemical Cycling in Soil Ecosystems.

UNIT – V: ENVIRONMENTAL POLLUTION, TOXICOLOGY AND ANALYTICAL TECHNIQUES

Environmental Pollutants: Classification, Sources and Behaviour. Persistent Organic Pollutants (POPs). Toxic Chemicals in the Environment. Environmental Toxicology: Concepts, Dose-Response Relationships, Bioaccumulation, Biomagnification and Biotransformation. Ecotoxicology and Risk Assessment. Radioactive Pollutants and Environmental Impacts. Instrumental Techniques

in Environmental Analysis: Spectrophotometry, Chromatography (GC, HPLC), Atomic Absorption Spectroscopy (AAS), ICP-MS and Mass Spectrometry. Sampling, Preservation and Quality Assurance in Environmental Analysis. Environmental Monitoring and Pollution Control Technologies.

UNIT – VI: CURRENT CONTOURS (*For Continuous Internal Assessment Only*)

Emerging Contaminants: Microplastics, Pharmaceuticals and Personal Care Products (PPCPs). Environmental Chemistry of Nanomaterials. Carbon Footprint and Green Chemistry Approaches. Air Quality Trends in Indian Metropolitan Cities. Water Quality Challenges in Indian Rivers and Wetlands. Chemical Impacts of Industrialization and Urbanization. Climate Change and Atmospheric Chemistry. Environmental Monitoring Using Advanced Analytical Techniques and Sensor Technologies.

REFERENCES

1. Environmental Chemistry, Colin Baird & Michael Cann (2021), W.H. Freeman and Company.
2. Environmental Chemistry, Stanley E. Manahan (2022), CRC Press.
3. Environmental Chemistry, A.K. De (2021), New Age International Publishers.
4. Principles of Environmental Chemistry, James E. Girard (2020), Jones & Bartlett Learning.
5. Environmental Chemistry: Fundamentals and Applications, John E. Andrews, Peter Brimblecombe, Timothy D. Jickells & Paul S. Liss (2019), Wiley-Blackwell.
6. Environmental Organic Chemistry, René P. Schwarzenbach, Philip M. Gschwend & Dieter M. Imboden (2017), Wiley.
7. Aquatic Chemistry, Werner Stumm & James J. Morgan (2019), Wiley-Interscience.
8. Soil Chemistry, Daniel G. Strawn, Hinrich L. Bohn & George A. O'Connor (2021), Wiley-Blackwell.
9. Environmental Toxicology, David A. Wright & Pamela Welbourn (2017), Cambridge University Press.
10. Environmental Pollution and Control, J. Jeffrey Peirce, P. Aarne Vesilind & Ruth F. Weiner (2019), Butterworth-Heinemann.
11. Analytical Environmental Chemistry, Keith A. Smith (2018), Springer.
12. Instrumental Methods of Chemical Analysis, Gurdeep R. Chatwal & Sham K. Anand (2020), Himalaya Publishing House.
13. Environmental Science and Technology, Stanley E. Manahan (2017), CRC Press.
14. Green Chemistry and Environmental Sustainability, Rashmi Sanghi & M.M. Srivastava (2020), Wiley.
15. Chemistry for Environmental Engineering and Science, Clair N. Sawyer, Perry L. McCarty & Gene F. Parkin (2018), McGraw-Hill.
16. <https://www.epa.gov>
17. <https://www.unep.org>
18. <https://www.cpcb.nic.in>

COURSE OUTCOMES

- CO1:** Explain the fundamental concepts, principles, scope, and significance of environmental chemistry in understanding environmental systems.
- CO2:** Describe the structure, composition, and chemical behavior of matter, including thermodynamic, kinetic, and equilibrium processes in natural environments.
- CO3:** Analyze the role of acids, bases, buffers, oxidation-reduction reactions, and biogeochemical cycles in maintaining environmental balance.
- CO4:** Examine the chemistry of the atmosphere, including photochemical reactions, greenhouse gases, ozone depletion, aerosols, smog formation, and acid rain.
- CO5:** Evaluate the sources, transport, transformation, and environmental fate of atmospheric pollutants and emerging air contaminants.

- CO6:** Assess the physical, chemical, and biological characteristics of aquatic systems using water quality parameters such as DO, BOD, COD, TOC, and nutrient dynamics.
- CO7:** Analyze groundwater and surface water contamination, eutrophication processes, and water treatment technologies for pollution control and management.
- CO8:** Examine soil and sediment chemistry, including nutrient cycling, soil-water interactions, pollutant mobility, heavy metal contamination, and remediation strategies.
- CO9:** Evaluate environmental pollutants, toxic chemicals, ecotoxicological effects, bioaccumulation, biomagnification, and environmental risk assessment.
- CO10:** Apply modern environmental analytical techniques, monitoring methods, quality assurance protocols, and green chemistry approaches to solve environmental problems and support sustainable development.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs \ POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	1	1	1	1	–	–	2	–
CO2	3	2	2	2	1	1	1	–	1	–
CO3	3	3	2	2	1	1	2	–	1	–
CO4	2	3	3	2	1	1	2	1	1	–
CO5	2	3	3	2	1	2	3	1	1	–
CO6	2	3	2	3	1	1	3	1	1	–
CO7	2	3	2	3	1	2	3	2	1	1
CO8	2	3	3	2	1	2	3	2	1	1
CO9	2	3	3	2	1	2	3	2	1	1
CO10	2	2	2	3	2	2	3	3	3	2

CORE PRACTICAL – I
ENVIRONMENTAL CHEMISTRY PRACTICAL
(Practical)

Semester I

Code

Credits: 4

COURSE OBJECTIVES

- To provide practical knowledge on the chemical characteristics of environmental components such as air, water and soil.
- To develop analytical skills in environmental sampling, monitoring and chemical analysis.
- To train students in the use of standard laboratory techniques and instruments used in environmental chemistry.
- To impart hands-on experience in the assessment of environmental quality and pollution.
- To enable students to interpret analytical data for environmental management and decision-making.

EXPERIMENTS

Water Analysis

1. Determination of pH, Electrical Conductivity (EC) and Total Dissolved Solids (TDS) of water samples.
2. Determination of Total Hardness, Calcium Hardness and Magnesium Hardness of water.
3. Estimation of Alkalinity and Acidity in water samples.
4. Determination of Dissolved Oxygen (DO) by Winkler's Method.
5. Determination of Biological Oxygen Demand (BOD).
6. Determination of Chemical Oxygen Demand (COD).
7. Estimation of Chlorides in water by Argentometric Method.
8. Determination of Sulphates and Nitrates in water samples.
9. Estimation of Phosphates in water samples using Spectrophotometric Method.

Soil Analysis

10. Determination of Soil pH and Electrical Conductivity.
11. Estimation of Soil Organic Carbon by Walkley and Black Method.
12. Determination of Available Nitrogen, Phosphorus and Potassium (NPK) in soil.
13. Estimation of Soil Moisture Content and Water Holding Capacity.
14. Determination of Cation Exchange Capacity (CEC) of soil.

Air Quality Analysis

15. Measurement of Ambient Air Quality Parameters: Suspended Particulate Matter (SPM), PM₁₀ and PM_{2.5} (Demonstration/Field Exercise).
16. Determination of Atmospheric Dust Fall and Dust Deposition Rate.
17. Estimation of Carbon Dioxide Concentration in Ambient Air.

Instrumentation and Environmental Monitoring

18. Calibration and use of pH Meter, Conductivity Meter and Dissolved Oxygen Meter.
19. Introduction to UV-Visible Spectrophotometry for Environmental Analysis.

COURSE OUTCOMES

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

- CO1:** Demonstrate proficiency in the collection, preservation, and handling of environmental samples such as water, soil, and air.
- CO2:** Measure and analyze the physico-chemical characteristics of water samples, including pH, Electrical Conductivity (EC), Total Dissolved Solids (TDS), hardness, alkalinity, and acidity.
- CO3:** Evaluate water quality using key pollution indicators such as Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), chlorides, sulphates, nitrates, and phosphates.
- CO4:** Determine the chemical and fertility characteristics of soils through the analysis of soil pH, EC, organic carbon, moisture content, water holding capacity, and nutrient status (NPK).

CO5: Assess soil quality and productivity by estimating cation exchange capacity (CEC) and interpreting soil nutrient availability.

CO6: Perform basic air quality monitoring exercises and assess atmospheric pollution through measurements of particulate matter, dust fall, dust deposition rate, and carbon dioxide concentration.

CO7: Operate, calibrate, and maintain common environmental analytical instruments such as pH meters, conductivity meters, dissolved oxygen meters, and UV-Visible spectrophotometers.

CO8: Apply standard laboratory methods, quality control procedures, and safety practices in environmental chemical analysis.

CO9: Analyze, interpret, and present environmental chemistry data using scientific approaches for environmental quality assessment and pollution monitoring.

CO10: Develop technical competence and problem-solving skills required for environmental research, consultancy services, environmental auditing, regulatory compliance, and environmental management applications.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	3	2	1	1	2	1	1
CO2	3	2	2	3	1	1	2	2	1	
CO3	3	3	2	3	1	1	3	2	1	
CO4	3	2	2	3	1	1	2	2	1	
CO5	3	3	3	2	1	1	3	2	1	
CO6	3	3	2	2	1	1	3	2	1	1
CO7	3	2	2	3	2	2	2	3	1	1
CO8	2	2	2	3	2	2	2	3	2	1
CO9	3	3	3	2	2	2	3	3	2	1
CO10	3	2	2	2	3	2	3	3	3	2

	SKILL ENHANCEMENT COURSE ENVIRONMENTAL AUDITING (Theory/Practical)	Semester I
Code		Credits: 2

COURSE OBJECTIVES

- To introduce the concepts, principles and significance of environmental auditing in industries and institutions.
- To provide knowledge on environmental regulations, compliance requirements and auditing procedures.
- To develop skills in environmental performance assessment and reporting.
- To enable students to conduct basic environmental audits and recommend corrective measures.
- To promote environmental responsibility and sustainable practices in organizations.

UNIT – I: INTRODUCTION TO ENVIRONMENTAL AUDITING

Concept, Definition and Objectives of Environmental Auditing. History and Evolution of Environmental Audits. Scope and Importance of Environmental Auditing. Types of Environmental Audits: Compliance Audit, Management Audit, Functional Audit, Waste Audit, Energy Audit and Sustainability Audit. Benefits and Limitations of Environmental Auditing. Environmental Auditing as a Tool for Sustainable Development.

UNIT – II: ENVIRONMENTAL LEGISLATION AND AUDIT PROCEDURES

Environmental Laws and Regulations in India. Environment (Protection) Act, 1986. Water (Prevention and Control of Pollution) Act, 1974. Air (Prevention and Control of Pollution) Act, 1981. Hazardous Waste Management Rules. Environmental Standards and Compliance Requirements. Environmental Audit Process: Planning, Preparation, Data Collection, Site Inspection, Documentation and Reporting. Audit Checklists and Documentation Methods.

UNIT – III: ENVIRONMENTAL MANAGEMENT SYSTEMS AND PRACTICAL APPLICATIONS

Environmental Management Systems (EMS). Principles of ISO 14001 Environmental Management Standards. Environmental Performance Indicators. Resource Consumption Auditing: Water, Energy and Raw Materials. Waste Management Auditing. Carbon Footprint Assessment and Green Auditing. Environmental Audit Reporting and Corrective Action Plans. Case Studies of Industrial, Institutional and Campus Environmental Audits.

UNIT IV- PRACTICAL / FIELD COMPONENT

1. Preparation of Environmental Audit Checklists.
2. Assessment of Water Consumption in an Institution/Campus.
3. Assessment of Energy Consumption and Energy Efficiency Measures.
4. Solid Waste Quantification and Waste Audit.

UNIT V- PRACTICAL / FIELD COMPONENT

5. Environmental Compliance Review of a Small Industry/Institution.
6. Preparation of a Mini Environmental Audit Report.
7. Campus Green Audit and Sustainability Assessment.
8. Field Visit to an Industry, Environmental Laboratory or Waste Management Facility.

REFERENCES

1. Environmental Auditing, Peter Wathern (2018), Routledge.
2. Environmental Management Systems and ISO 14001, Christopher Sheldon (2017), Routledge.
3. Environmental Audit and Management Handbook, Nicholas P. Cheremisinoff & Madelyn L. Graffia (2019), Butterworth-Heinemann.
4. Environmental Management, T. V. Ramachandra (2020), TERI Press.
5. Environmental Laws in India, P. Leelakrishnan (2021), LexisNexis.
6. ISO 14001: Environmental Management Systems – Requirements with Guidance for Use.
7. Environmental Impact Assessment and Audit, Judith Petts (2019), Wiley.
8. Environmental Performance Evaluation, Robert B. Pojasek (2018), CRC Press.
9. Guidelines for Environmental Audit, Central Pollution Control Board (CPCB), Government of India.
10. Ministry of Environment, Forest and Climate Change (MoEFCC) Publications.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, objectives, scope, and significance of environmental auditing in industries, institutions, and organizations.
- CO2:** Describe the different types of environmental audits, including compliance audits, management audits, waste audits, energy audits, and sustainability audits.
- CO3:** Interpret major environmental legislations, regulations, and standards relevant to environmental auditing and compliance assessment.
- CO4:** Apply environmental audit procedures, including planning, data collection, site inspection, documentation, and reporting.
- CO5:** Develop and utilize environmental audit checklists and assessment tools for evaluating environmental performance.
- CO6:** Assess resource consumption patterns related to water, energy, raw materials, and waste generation within organizations and institutions.
- CO7:** Evaluate Environmental Management Systems (EMS) and the implementation of ISO 14001 standards for environmental performance improvement.
- CO8:** Conduct green audits, carbon footprint assessments, and sustainability evaluations for campuses, industries, and public institutions.
- CO9:** Prepare environmental audit reports, identify non-compliance issues, and recommend appropriate corrective and preventive measures.
- CO10:** Demonstrate professional competence, environmental responsibility, teamwork, and problem-solving skills required for environmental auditing, sustainability management, and environmental consultancy services.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	1	1	1	1	1		1	
CO2	3	2	2	1	1	1	2		1	
CO3	3	3	2	2	1	1	2	1	1	
CO4	2	3	3	2	2	1	3	2	1	1
CO5	2	3	3	2	2	1	3	2	1	1
CO6	2	2	2	2	2	1	3	2	1	1
CO7	3	2	2	3	2	2	2	2	1	1
CO8	2	3	3	2	2	2	3	2	2	1
CO9	2	3	3	2	2	2	3	3	2	2
CO10	2	2	2	2	3	2	3	2	3	3

VALUE ADDED COURSE – I
FOREST AND WILDLIFE MANAGEMENT
(Theory)

Semester I

Code

Credits: 2

COURSE OBJECTIVES

- To introduce students to the principles and practices of forest and wildlife management.
- To provide knowledge on forest ecosystems, biodiversity conservation and sustainable utilization of forest resources.
- To understand wildlife ecology, habitat management and conservation strategies.
- To familiarize students with forest and wildlife policies, legislation and protected area management.
- To develop skills in wildlife monitoring, habitat assessment and conservation planning.

UNIT – I: FOREST ECOSYSTEMS AND FOREST RESOURCES

Definition, Scope and Importance of Forests. Classification of Forests. Forest Ecosystem Structure and Functions. Forest Biodiversity and Ecosystem Services. Types of Forests in India and Tamil Nadu. Forest Resources and Their Utilization. Forest Productivity and Sustainable Forest Management. Role of Forests in Climate Regulation and Carbon Sequestration.

UNIT – II: FOREST CONSERVATION AND MANAGEMENT

Principles of Forest Management. Forest Inventory and Resource Assessment. Afforestation, Reforestation and Social Forestry. Agroforestry and Joint Forest Management (JFM). Forest Degradation and Deforestation: Causes, Impacts and Control Measures. Forest Fire Management. Forest Restoration and Rehabilitation. Community Participation in Forest Conservation.

UNIT – III: WILDLIFE ECOLOGY AND HABITAT MANAGEMENT

Wildlife: Definition, Classification and Importance. Wildlife Ecology and Population Dynamics. Wildlife Habitats and Habitat Requirements. Habitat Fragmentation and Corridor Conservation. Wildlife Behaviour and Adaptations. Human-Wildlife Conflict: Causes, Consequences and Mitigation Measures. Wildlife Census and Monitoring Techniques. Radio Telemetry and Modern Wildlife Tracking Methods.

UNIT – IV: WILDLIFE CONSERVATION AND PROTECTED AREAS

Threats to Wildlife: Habitat Loss, Poaching, Illegal Trade, Invasive Species and Climate Change. Wildlife Conservation Strategies. In-situ and Ex-situ Conservation. Protected Area Network: National Parks, Wildlife Sanctuaries, Biosphere Reserves and Conservation Reserves. Wildlife Protection Act, 1972. Endangered Species Conservation Programmes. Role of Zoos and Botanical Gardens in Conservation.

UNIT – V: FOREST AND WILDLIFE MANAGEMENT IN INDIA

Forest Policy and Wildlife Policy in India. National Forest Policy. National Wildlife Action Plan. Forest Rights Act and Community-Based Conservation. Biodiversity Hotspots of India. Important Forests and Wildlife Areas of Tamil Nadu. Ecotourism and Sustainable Nature-Based Tourism. Role of Technology in Forest and Wildlife Management: GIS, Remote Sensing, Drones and Camera Traps.

UNIT – VI: CURRENT CONTOURS *(For Continuous Internal Assessment Only)*

Recent Trends in Forest Cover and Wildlife Conservation in India. Tiger and Elephant Conservation Programmes. Human-Elephant and Human-Leopard Conflict Management. Mangrove and Coastal Forest Conservation. Forest Landscape Restoration Initiatives. Community-Based Wildlife Conservation Models. Climate Change and Wildlife Adaptation. Recent Wildlife Conservation Success Stories in Tamil Nadu.

REFERENCES

1. Principles of Wildlife Management, James G. Dickson (2020), CRC Press.
2. Wildlife Ecology, Conservation and Management, Anthony R. E. Sinclair, John M. Fryxell & Graeme Caughley (2018), Wiley-Blackwell.
3. Forest Ecology and Management, J. P. Kimmins (2019), Pearson Education.
4. Introduction to Forestry and Natural Resources, Donald L. Grebner, Pete Bettinger & Jacek Siry (2021), Academic Press.
5. Wildlife Management and Conservation, Paul R. Krausman & James W. Cain III (2017), Johns Hopkins University Press.
6. Biodiversity and Conservation, K. V. Krishnamurthy (2018), Oxford University Press.
7. Forests and Forestry in India, K. Manikandan & S. Prabhu (2019), New India Publishing Agency.
8. Handbook of Forestry, Khanna L.S. (2018), Khanna Publishers.
9. Wildlife Ecology, Management and Conservation, J. D. Nichols (2020), Springer.
10. Protected Areas and Wildlife Conservation in India, Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India.
11. <https://fsi.nic.in>
12. <https://wii.gov.in>
13. <https://moefcc.gov.in>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the structure, functions, and ecological significance of forest ecosystems and their role in maintaining environmental balance.
- CO2:** Classify different forest types and evaluate the importance of forest biodiversity, ecosystem services, and forest resources.
- CO3:** Demonstrate an understanding of sustainable forest management practices, including afforestation, reforestation, social forestry, agroforestry, and joint forest management.
- CO4:** Analyze the causes and impacts of deforestation, forest degradation, and forest fires, and recommend appropriate conservation and restoration measures.
- CO5:** Describe the principles of wildlife ecology, population dynamics, habitat requirements, and species interactions in natural ecosystems.
- CO6:** Assess wildlife habitats, habitat fragmentation issues, and the importance of wildlife corridors in biodiversity conservation.
- CO7:** Evaluate the causes and consequences of human–wildlife conflicts and propose suitable mitigation and management strategies.
- CO8:** Apply knowledge of wildlife monitoring techniques, wildlife census methods, radio telemetry, camera trapping, GIS, and remote sensing in wildlife management.
- CO9:** Interpret forest and wildlife policies, legislation, protected area management strategies, and conservation programmes at national and regional levels.
- CO10:** Develop an appreciation for biodiversity conservation, sustainable resource management, ecotourism, and career opportunities in forestry, wildlife conservation, environmental management, and allied sectors.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	1	2	1	1	1		1	
CO2	3	2	2	2	1	1	2	1	1	
CO3	3	2	2	2	1	1	2	1	1	1
CO4	2	3	3	2	1	1	3	2	1	1
CO5	3	2	2	3	1	1	2	1	1	
CO6	2	3	3	2	1	1	3	2	1	1
CO7	2	3	2	2	1	2	3	1	1	2
CO8	2	2	2	3	2	1	2	3	1	1
CO9	3	2	2	2	1	1	2	2	1	1
CO10	2	2	1	1	3	2	2	1	3	3

CORE COURSE – III
POLLUTION CONTROL STRATEGIES
(Theory)

Semester II

Code

Credits: 4

COURSE OBJECTIVES

- To provide an in-depth understanding of environmental pollution and its control strategies.
- To familiarize students with technologies used for the prevention, treatment and management of pollutants.
- To develop knowledge on pollution monitoring, assessment and regulatory frameworks.
- To understand sustainable approaches for pollution prevention and environmental protection.
- To impart practical insights into industrial pollution control and waste management systems.

UNIT – I: INTRODUCTION TO ENVIRONMENTAL POLLUTION

Concept, Sources and Classification of Environmental Pollution. Pollutant Types and Characteristics. Primary and Secondary Pollutants. Environmental Quality Standards. Transport, Transformation and Fate of Pollutants. Pollution Monitoring and Assessment. Environmental Indicators and Indices. Principles of Pollution Prevention and Cleaner Production. Pollution Control Policies and Regulatory Frameworks.

UNIT – II: AIR POLLUTION CONTROL STRATEGIES

Sources and Types of Air Pollutants. Particulate Matter, Sulphur Oxides, Nitrogen Oxides, Carbon Monoxide, Ozone and Volatile Organic Compounds. Indoor Air Pollution. Air Quality Monitoring and Standards. Air Pollution Dispersion Models. Air Pollution Control Technologies: Gravity Settling Chambers, Cyclone Separators, Fabric Filters, Electrostatic Precipitators, Wet Scrubbers and Catalytic Converters. Greenhouse Gas Mitigation Strategies. Urban Air Pollution Management and Clean Air Initiatives.

UNIT – III: WATER POLLUTION CONTROL STRATEGIES

Sources and Characteristics of Water Pollutants. Water Quality Standards and Monitoring. Wastewater Treatment: Preliminary, Primary, Secondary and Tertiary Treatments. Activated Sludge Process, Trickling Filters, Oxidation Ponds and Constructed Wetlands. Industrial Effluent Treatment. Advanced Wastewater Treatment Technologies. Nutrient Removal and Eutrophication Control. Water Recycling and Reuse. Zero Liquid Discharge (ZLD) Concept. River and Lake Restoration Techniques.

UNIT – IV: SOIL POLLUTION AND SOLID WASTE MANAGEMENT

Sources and Impacts of Soil Pollution. Agricultural, Industrial and Municipal Sources of Soil Contamination. Soil Remediation Techniques: Physical, Chemical and Biological Methods. Bioremediation and Phytoremediation. Solid Waste Management: Sources, Characterization and Segregation. Collection, Transportation and Processing of Municipal Solid Waste. Composting, Vermicomposting, Biomethanation and Waste-to-Energy Technologies. Landfill Design and Management. Plastic Waste Management and Circular Economy Approaches.

UNIT – V: INDUSTRIAL POLLUTION CONTROL AND ENVIRONMENTAL MANAGEMENT

Industrial Pollution: Sources, Characteristics and Environmental Impacts. Cleaner Production Technologies. Green Chemistry and Sustainable Industrial Practices. Hazardous Waste Management. Biomedical Waste Management. E-waste Management and Recycling. Noise Pollution Control Measures. Environmental Management Systems (EMS). ISO 14001 Standards. Environmental Audit and Compliance Monitoring. Environmental Risk Assessment and Disaster Management.

UNIT – VI: CURRENT CONTOURS (*For Continuous Internal Assessment Only*)

National Clean Air Programme (NCAP) and Air Quality Improvement Initiatives. River Rejuvenation and Wetland Restoration Programmes in India. Emerging Pollutants: Microplastics, Pharmaceutical Residues and Nanomaterials. Carbon Capture and Storage Technologies. Circular Economy and Zero-Waste Strategies. Pollution Control Challenges in Tamil Nadu. Industrial Pollution in SIPCOT Regions. Smart Cities and Sustainable Waste Management Practices.

REFERENCES

1. Environmental Pollution Control Engineering, C. S. Rao (2018), New Age International Publishers.
2. Environmental Engineering, Howard S. Peavy, Donald R. Rowe & George Tchobanoglous (2017), McGraw-Hill.
3. Environmental Pollution and Control, J. Jeffrey Peirce, P. Aarne Vesilind & Ruth F. Weiner (2019), Butterworth-Heinemann.
4. Air Pollution Control Engineering, Noel de Nevers (2017), Waveland Press.
5. Wastewater Engineering: Treatment and Resource Recovery, Metcalf & Eddy (2018), McGraw-Hill.
6. Solid Waste Management: Principles and Practice, Ramesha Chandrappa & Diganta Das (2019), Springer.
7. Environmental Biotechnology: Principles and Applications, Bruce E. Rittmann & Perry L. McCarty (2020), McGraw-Hill.
8. Hazardous Waste Management, M. N. Rao & H. V. N. Rao (2018), CBS Publishers.
9. Environmental Management, T. V. Ramachandra (2020), TERI Publications.
10. Environmental Science and Engineering, P. D. Sharma (2021), Rastogi Publications.
11. Environmental Chemistry, Stanley E. Manahan (2022), CRC Press.
12. Environmental Pollution, Anubha Kaushik & C. P. Kaushik (2021), New Age International.
13. Principles of Environmental Engineering and Science, Mackenzie L. Davis & Susan J. Masten (2018), McGraw-Hill.
14. Integrated Solid Waste Management, George Tchobanoglous & Frank Kreith (2021), McGraw-Hill.
15. Cleaner Production and Sustainability, Paulo Roberto Leite (2020), Springer.
16. <https://cpcb.nic.in>
17. <https://moefcc.gov.in>
18. <https://www.unep.org>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the sources, types, characteristics, transport, transformation, and environmental impacts of pollutants in air, water, and soil systems.
- CO2:** Interpret environmental quality standards, pollution monitoring techniques, environmental indicators, and regulatory frameworks related to pollution control.
- CO3:** Analyze sources and impacts of air pollution and evaluate air quality monitoring methods and atmospheric pollution assessment techniques.
- CO4:** Assess the effectiveness of air pollution control technologies such as cyclone separators, electrostatic precipitators, scrubbers, catalytic converters, and greenhouse gas mitigation strategies.
- CO5:** Evaluate wastewater treatment systems, including primary, secondary, tertiary, and advanced treatment technologies for pollution control and water resource management.
- CO6:** Analyze water pollution issues and recommend suitable strategies for nutrient removal, eutrophication control, water recycling, reuse, and Zero Liquid Discharge (ZLD) systems.

- CO7:** Assess soil pollution problems and apply appropriate remediation techniques including physical, chemical, biological remediation, bioremediation, and phytoremediation.
- CO8:** Evaluate solid waste, hazardous waste, biomedical waste, plastic waste, and e-waste management systems and recommend sustainable waste management solutions.
- CO9:** Examine industrial pollution control measures, cleaner production technologies, environmental management systems (EMS), environmental auditing, and compliance monitoring procedures.
- CO10:** Develop integrated and sustainable pollution prevention and environmental management strategies for environmental protection, resource conservation, circular economy implementation, and sustainable development.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	1		1	
CO2	3	3	2	2	1	1	2	1	1	
CO3	3	3	3	2	1	1	3	1	1	
CO4	3	3	3	3	1	1	3	2	1	1
CO5	3	3	3	3	1	1	3	2	1	1
CO6	3	3	3	2	1	1	3	2	1	1
CO7	3	3	3	2	1	1	3	2	1	1
CO8	3	3	2	2	1	1	3	2	1	1
CO9	3	3	2	3	2	2	3	3	2	2
CO10	3	3	3	2	2	2	3	3	3	2

	CORE COURSE – IV	Semester II
	ENVIRONMENTAL IMPACT ASSESSMENT	
Code	(Theory)	Credits: 4

COURSE OBJECTIVES

- To provide a comprehensive understanding of the principles, methodologies and significance of Environmental Impact Assessment (EIA) in sustainable development.
- To familiarize students with the procedures, legal frameworks and regulatory requirements governing EIA at national and international levels.
- To develop skills in identifying, predicting and evaluating environmental impacts of developmental projects.
- To impart knowledge on environmental management plans, mitigation measures and monitoring strategies.
- To enable students to prepare, interpret and critically evaluate Environmental Impact Assessment reports for informed decision-making.

UNIT – I: INTRODUCTION TO ENVIRONMENTAL IMPACT ASSESSMENT

Concept, Definition and Need for Environmental Impact Assessment. Evolution and Historical Development of EIA. Objectives, Scope and Principles of EIA. Environmental Planning and Sustainable Development. Environmental Components and Project Activities. Types of Environmental Impacts: Direct, Indirect, Cumulative, Reversible, Irreversible, Short-term and Long-term Impacts. Environmental Clearance Process in India. Role of EIA in Environmental Management and Decision Making.

UNIT – II: EIA PROCESS AND METHODOLOGIES

Stages of Environmental Impact Assessment: Screening, Scoping, Baseline Data Collection, Impact Identification, Impact Prediction, Impact Evaluation and Reporting. Terms of Reference (ToR). Environmental Attributes and Indicators. EIA Methodologies: Ad hoc Methods, Checklists, Matrices, Networks, Overlay Mapping and GIS-based Approaches. Risk Assessment in EIA. Cost-Benefit Analysis. Public Participation and Stakeholder Consultation in Environmental Decision Making.

UNIT – III: ENVIRONMENTAL IMPACT ASSESSMENT OF DEVELOPMENTAL PROJECTS

EIA for Industrial Projects. Mining and Quarrying Projects. Thermal and Hydroelectric Power Projects. Irrigation and River Valley Projects. Transportation Projects: Highways, Railways, Airports and Ports. Urban Development Projects. Tourism and Coastal Development Projects. Ecological and Socio-economic Impact Assessment. Biodiversity Impact Assessment and Ecosystem Service Evaluation.

UNIT – IV: ENVIRONMENTAL MANAGEMENT PLAN AND ENVIRONMENTAL MONITORING

Environmental Management Plan (EMP): Concept, Components and Preparation. Mitigation Measures for Environmental Impacts. Environmental Monitoring Programmes. Compliance Monitoring and Environmental Auditing. Environmental Risk Assessment and Disaster Management Planning. Rehabilitation and Resettlement Issues. Environmental Health Impact Assessment. Post-project Monitoring and Adaptive Management Strategies.

UNIT – V: LEGAL FRAMEWORK, CASE STUDIES AND RECENT ADVANCES IN EIA

Environmental Impact Assessment Notification, 2006 and Subsequent Amendments. Environmental Legislations Relevant to EIA in India. Role of Ministry of Environment, Forest and Climate Change (MoEFCC), State Environmental Impact Assessment Authorities

(SEIAA) and Pollution Control Boards. Strategic Environmental Assessment (SEA). Life Cycle Assessment (LCA). Carrying Capacity Studies. Use of Remote Sensing, GIS and Modelling in EIA. National and International Case Studies on Major Development Projects and Environmental Disasters.

UNIT – VI: CURRENT CONTOURS (*For Continuous Internal Assessment Only*)

Recent Amendments in EIA Regulations in India. Environmental Clearance Procedures for Emerging Infrastructure Projects. Climate Change Considerations in EIA. Strategic Environmental Assessment for Regional Planning. Green Infrastructure and Sustainable Development Projects. Environmental Impact Assessment of Renewable Energy Projects. Role of Artificial Intelligence, Remote Sensing and GIS in Environmental Monitoring and Impact Prediction.

REFERENCES

1. Environmental Impact Assessment: A Guide to Best Professional Practices, Charles H. Eccleston (2018), CRC Press.
2. Environmental Impact Assessment, Larry W. Canter (2018), McGraw-Hill Education.
3. Introduction to Environmental Impact Assessment, John Glasson, Riki Therivel and Andrew Chadwick (2020), Routledge.
4. Environmental Impact Assessment Methodologies, Peter Morris and Riki Therivel (2019), Routledge.
5. Environmental Assessment, Environmental Management and Sustainable Development, Vijay Kulkarni, T. V. Ramachandra and others (2021), TERI Press.
6. Strategic Environmental Assessment in Action, Thomas B. Fischer (2017), Routledge.
7. Environmental Management, T. V. Ramachandra (2020), TERI Publications.
8. Environmental Law and Policy in India, Shyam Divan and Armin Rosencranz (2022), Oxford University Press.
9. Environmental Science and Engineering, P. D. Sharma (2021), Rastogi Publications.
10. Environmental Planning and Management, Christian N. Madu (2019), Imperial College Press.
11. Environmental Impact Assessment and Management, David P. Lawrence (2018), Wiley-Blackwell.
12. Principles of Environmental Impact Assessment, N. Carter (2019), Sage Publications.
13. Handbook of Environmental Impact Assessment, Judith Petts (2020), Wiley.
14. Environmental Monitoring and Assessment, P. K. Goel (2018), New Age International Publishers.
15. Environmental Systems Analysis and Modelling, Mike J. Barnsley (2019), Routledge.
16. <https://moefcc.gov.in>
17. <https://environmentclearance.nic.in>
18. <https://www.unep.org>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, principles, objectives, scope, and significance of Environmental Impact Assessment (EIA) in sustainable environmental planning and development.
- CO2:** Describe the legal, institutional, and regulatory frameworks governing Environmental Impact Assessment, including environmental clearance procedures and EIA notifications in India.
- CO3:** Identify, predict, and evaluate the environmental, ecological, social, and economic impacts associated with developmental projects using appropriate assessment techniques.

- CO4:** Apply various Environmental Impact Assessment methodologies, including checklists, matrices, network analysis, overlay mapping, GIS-based approaches, and risk assessment techniques.
- CO5:** Assess the environmental impacts of industrial, mining, transportation, urban development, irrigation, power, tourism, and coastal development projects.
- CO6:** Prepare and evaluate Environmental Management Plans (EMP) by recommending suitable mitigation measures, environmental monitoring programmes, and compliance strategies.
- CO7:** Analyze environmental risk assessment, disaster management planning, rehabilitation and resettlement issues, and post-project environmental monitoring.
- CO8:** Evaluate the role of public participation, stakeholder consultation, cost-benefit analysis, Strategic Environmental Assessment (SEA), Life Cycle Assessment (LCA), and carrying capacity studies in environmental decision-making.
- CO9:** Critically interpret Environmental Impact Assessment reports, environmental policies, legal provisions, and national and international case studies for informed environmental governance.
- CO10:** Integrate modern tools such as Remote Sensing, GIS, modelling, Artificial Intelligence, and sustainable development principles for effective environmental impact prediction, environmental planning, and decision-making.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	1	1	1	
CO2	3	2	2	2	1	1	2	1	1	
CO3	3	3	3	2	1	1	3	2	1	1
CO4	3	3	3	3	1	1	3	2	1	1
CO5	3	3	3	2	1	1	3	2	1	1
CO6	3	3	2	3	2	2	3	2	1	2
CO7	2	3	3	3	2	2	3	3	1	2
CO8	3	3	3	2	2	2	3	3	2	2
CO9	3	3	3	2	2	2	3	3	2	2
CO10	3	3	3	3	2	2	3	3	3	2

CORE PRACTICAL – II
ENVIRONMENTAL MONITORING
(Practical)

Semester II

Code

Credits: 4

COURSE OBJECTIVES

- To provide hands-on training in environmental sampling, monitoring and assessment techniques.
- To develop practical skills in the analysis of air, water, soil and noise quality parameters.
- To familiarize students with environmental monitoring instruments, standards and protocols.
- To enable students to interpret environmental data and assess environmental quality.
- To develop competencies in environmental reporting, monitoring programme design and environmental management.

EXPERIMENTS

WATER QUALITY MONITORING

1. Assessment of Water Quality Index (WQI) using physicochemical parameters.

SOIL QUALITY MONITORING

2. Analysis of Water Holding Capacity of soil.
3. Assessment of heavy metal contamination in soil samples (Demonstration/Instrumental Analysis).

AIR QUALITY MONITORING

4. Determination of dust fall and dust deposition rate.
5. Assessment and interpretation of Air Quality Index (AQI).

NOISE QUALITY MONITORING

6. Measurement of ambient noise levels using Sound Level Meter.
7. Assessment of noise pollution in residential, commercial, industrial and silence zones.
8. Preparation of Noise Pollution Maps using field observations.

ENVIRONMENTAL MONITORING TOOLS AND DATA ANALYSIS

9. Calibration and operation of pH meter, DO meter, Conductivity meter and Turbidity meter.
10. Introduction to GPS and GIS applications in environmental monitoring.
11. Analysis and interpretation of environmental monitoring data using statistical methods.
12. Preparation of Environmental Monitoring Reports based on field and laboratory data.

FIELD EXERCISES

13. Monitoring of water quality in a river, lake, wetland or reservoir.
14. Environmental quality assessment of an industrial, urban or rural ecosystem.
15. Biodiversity and habitat quality assessment using rapid monitoring techniques.
16. Environmental monitoring of a protected area, wetland or forest ecosystem.
17. Preparation and presentation of a comprehensive Environmental Monitoring Project Report.

COURSE OUTCOMES

Upon successful completion of the practical course, the students will be able to:

- CO1:** Demonstrate proficiency in environmental sampling, monitoring, and quality assessment of water, soil, air, and noise using standard protocols.
- CO2:** Analyze physicochemical parameters of environmental samples and determine environmental quality indices such as Water Quality Index (WQI) and Air Quality Index (AQI).
- CO3:** Assess soil quality through the determination of water holding capacity and interpretation of heavy metal contamination using appropriate analytical techniques.

- CO4:** Measure and evaluate ambient air quality and dust deposition using standard environmental monitoring methods.
- CO5:** Monitor and assess environmental noise levels in different land-use zones and prepare noise pollution maps using field observations.
- CO6:** Operate, calibrate, and maintain environmental monitoring instruments including pH meter, DO meter, conductivity meter, turbidity meter, and sound level meter.
- CO7:** Apply GPS, GIS, and other geospatial tools for environmental monitoring, mapping, and spatial analysis of environmental quality.
- CO8:** Analyze, interpret, and present environmental monitoring data using appropriate statistical methods and environmental standards.
- CO9:** Design and implement environmental monitoring programmes for rivers, wetlands, forests, urban ecosystems, industrial areas, and protected landscapes.
- CO10:** Prepare comprehensive environmental monitoring reports and develop professional competencies required for environmental consultancy, regulatory compliance, research, environmental auditing, and environmental management.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	3	2	1	2	2	1	1
CO2	3	3	2	3	1	1	3	2	1	1
CO3	3	3	3	2	1	1	3	2	1	
CO4	3	2	2	3	1	1	3	2	1	
CO5	3	3	2	3	1	1	3	2	1	1
CO6	3	2	2	3	2	2	2	3	1	1
CO7	3	2	2	3	2	2	2	3	2	1
CO8	3	3	3	2	2	2	3	3	2	1
CO9	3	3	3	3	2	2	3	3	2	2
CO10	3	2	2	2	3	2	3	3	3	2

	SKILL ENHANCEMENT COURSE – II	Semester II
	INTELLECTUAL PROPERTY RIGHTS FOR ENVIRONMENTAL SCIENCE	
Code	(Theory)	Credits: 2

COURSE OBJECTIVES

- To introduce the fundamental concepts and significance of Intellectual Property Rights (IPR) in scientific research and innovation.
- To familiarize students with various forms of intellectual property and their legal protection mechanisms.
- To provide knowledge on patents, copyrights, trademarks and geographical indications relevant to environmental sciences.
- To develop skills in identifying, protecting and managing intellectual property generated through environmental research and technological innovations.
- To create awareness about ethical, legal and commercial aspects of intellectual property in environmental conservation and sustainable development.

UNIT – I: INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS

Concept, definition and importance of Intellectual Property Rights. Historical development of IPR and its role in innovation, research and economic development. Overview of national and international IPR frameworks and agreements.

UNIT – II: TYPES OF INTELLECTUAL PROPERTY

Patents, copyrights, trademarks, industrial designs, geographical indications and trade secrets. Scope, features and protection mechanisms of each category. Relevance of IPR in environmental technologies and innovations.

UNIT – III: PATENTS AND ENVIRONMENTAL INNOVATIONS

Patentability criteria, patent application process and patent documentation. Green technologies, renewable energy innovations, waste management technologies and environmental inventions. Patent search and patent information databases.

UNIT – IV: IPR, BIODIVERSITY AND TRADITIONAL KNOWLEDGE

Protection of biodiversity, traditional knowledge and indigenous innovations. Biopiracy, Access and Benefit Sharing (ABS), Convention on Biological Diversity (CBD) and Nagoya Protocol. Intellectual property issues related to biological resources and conservation.

UNIT – V: IPR MANAGEMENT, ETHICS AND COMMERCIALIZATION

Intellectual property management in academic and research institutions. Technology transfer, licensing and commercialization of innovations. Ethical issues in research, plagiarism, scientific misconduct and entrepreneurship opportunities in environmental sciences.

REFERENCES

1. Intellectual Property Rights: Unleashing the Knowledge Economy, Prabuddha Ganguli (2019), McGraw Hill Education.
2. Intellectual Property Rights and Innovation Management, Ramesh Chandra (2020), Himalaya Publishing House.
3. Patent Fundamentals for Scientists and Engineers, N. S. Rathore (2018), PHI Learning.
4. Intellectual Property Rights in India, V. K. Ahuja (2021), LexisNexis.
5. Biodiversity and Intellectual Property Rights, K. R. Gupta (2019), Atlantic Publishers.
6. WIPO Intellectual Property Handbook, World Intellectual Property Organization (WIPO).
7. Intellectual Property: Patents, Copyrights, Trademarks and Allied Rights, B. L. Wadhera (2020), Universal Law Publishing.
8. Research Methodology and Intellectual Property Rights, C. R. Kothari & Gaurav Garg (2019), New Age International.
9. <https://www.wipo.int>
10. <https://ipindia.gov.in>
11. <https://www.cbd.int>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, objectives, significance, and legal framework of Intellectual Property Rights (IPR) and their role in scientific research, innovation, and sustainable development.
- CO2:** Classify the different forms of Intellectual Property, including patents, copyrights, trademarks, industrial designs, geographical indications, and trade secrets, and describe their scope and protection mechanisms.
- CO3:** Analyze the relevance and application of Intellectual Property Rights in environmental science, green technologies, renewable energy, waste management, and environmental innovations.
- CO4:** Demonstrate an understanding of patentability criteria, patent application procedures, patent documentation, and intellectual property protection for environmental inventions.
- CO5:** Perform basic patent searches and retrieve patent information using national and international patent databases for scientific and technological research.
- CO6:** Evaluate issues related to biodiversity conservation, traditional knowledge protection, biopiracy, Access and Benefit Sharing (ABS), the Convention on Biological Diversity (CBD), and the Nagoya Protocol.
- CO7:** Explain the principles of intellectual property management, technology transfer, licensing, and commercialization of environmental technologies and innovations.
- CO8:** Apply ethical principles related to Intellectual Property Rights, including plagiarism prevention, research integrity, scientific misconduct, and responsible innovation.
- CO9:** Assess the legal, ethical, and commercial implications of Intellectual Property Rights in environmental conservation, research institutions, industries, and entrepreneurship.
- CO10:** Develop the ability to identify, protect, manage, and utilize intellectual property for promoting environmental research, innovation, sustainable development, and entrepreneurial opportunities.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	1	1	1	1	1	2	
CO2	3	2	2	1	1	1	2	1	2	
CO3	3	3	2	2	1	1	2	2	2	1
CO4	3	3	3	2	1	1	3	2	2	1
CO5	2	3	3	2	2	1	3	3	2	1
CO6	3	3	3	2	1	2	3	2	2	1
CO7	2	2	2	2	2	2	2	3	2	2
CO8	2	2	2	1	2	3	2	2	3	2
CO9	2	3	3	2	2	2	3	2	3	2
CO10	3	2	2	2	3	2	3	3	3	3

**NON-MAJOR ELECTIVE COURSE – I
ENVIRONMENTAL POLLUTION**

Semester II

Code

(Theory)

Credits: 2

COURSE OBJECTIVES

- To introduce students from various disciplines to the basic concepts of environmental pollution and its impacts on human health and ecosystems.
- To provide knowledge on different types, sources and effects of environmental pollution relevant to everyday life and competitive examinations.
- To create awareness about environmental issues, pollution control measures and sustainable environmental practices.
- To familiarize students with major environmental disasters, environmental policies and current environmental concerns.
- To equip students with fundamental environmental knowledge useful for competitive examinations such as UPSC, TNPSC, SSC, Banking, Railways and other recruitment tests.

UNIT – I: INTRODUCTION TO ENVIRONMENTAL POLLUTION

Environment and its components. Definition, causes and classification of environmental pollution. Natural and anthropogenic sources of pollution. Environmental quality and the need for pollution control in sustainable development.

UNIT – II: AIR AND WATER POLLUTION

Sources, effects and control measures of air pollution and water pollution. Major air pollutants and water contaminants. Acid rain, smog and eutrophication. Air and water quality standards and their significance.

UNIT – III: SOIL, NOISE AND SOLID WASTE POLLUTION

Causes and impacts of soil pollution, noise pollution and solid waste pollution. Municipal solid waste, plastic waste and e-waste. Waste segregation, recycling and scientific waste management practices.

UNIT – IV: ENVIRONMENTAL DISASTERS AND POLLUTION CASE STUDIES

Major environmental disasters and pollution incidents: Bhopal Gas Tragedy, Chernobyl Disaster, Minamata Disease, Love Canal and London Smog. Lessons learned from environmental disasters and their influence on environmental regulations.

UNIT – V: POLLUTION CONTROL, ENVIRONMENTAL LAWS AND CURRENT ISSUES

Pollution prevention and control strategies. Environmental protection laws in India. Climate change, global warming, ozone depletion and sustainable lifestyles. Current environmental issues frequently covered in competitive examinations.

UNIT – VI: CURRENT CONTOURS *(For Continuous Internal Assessment Only)*

National Clean Air Programme (NCAP). Swachh Bharat Mission. Plastic Waste Management Rules. River Conservation Programmes in India. Recent environmental reports, environmental indices and major environmental events relevant to competitive examinations.

REFERENCES

1. Environmental Studies, Erach Bharucha (2021), Universities Press.
2. Environmental Science, G. Tyler Miller and Scott E. Spoolman (2023), Cengage Learning.
3. Environmental Science and Engineering, P. D. Sharma (2021), Rastogi Publications.
4. Environmental Studies, Benny Joseph (2020), McGraw Hill Education.
5. Environmental Pollution, Anubha Kaushik and C. P. Kaushik (2021), New Age International.
6. Objective Environmental Science, S. P. Mishra (2022), Upkar Publications.
7. Textbook of Environmental Studies for Undergraduate Courses by Erach Bharucha (2023) , Fourth Edition
8. Bharat 2026 – A Reference Annual formerly India Year Book – Environment Chapter
9. <https://moefcc.gov.in>
10. <https://cpcb.nic.in>
11. <https://www.unep.org>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the basic concepts, types, sources, and characteristics of environmental pollution and their impacts on ecosystems and human health.
- CO2:** Describe the causes, effects, and control measures of air pollution and water pollution, including major pollutants and environmental quality standards.
- CO3:** Analyze the sources, impacts, and management practices related to soil pollution, noise pollution, municipal solid waste, plastic waste, and e-waste.
- CO4:** Interpret the causes and environmental consequences of major pollution-related phenomena such as acid rain, photochemical smog, and eutrophication.
- CO5:** Examine significant environmental disasters and pollution case studies, including the Bhopal Gas Tragedy, Chernobyl Disaster, Minamata Disease, Love Canal, and London Smog, and evaluate the lessons learned from these events.
- CO6:** Demonstrate knowledge of environmental pollution prevention, pollution control strategies, waste minimization, recycling, and sustainable environmental management practices.
- CO7:** Explain the importance of environmental laws, policies, regulations, and national programmes related to pollution control and environmental protection in India.
- CO8:** Assess current environmental challenges, including climate change, global warming, ozone depletion, plastic pollution, and other emerging environmental issues.
- CO9:** Apply environmental knowledge and awareness to promote environmentally responsible behavior, sustainable lifestyles, and informed decision-making in everyday life.
- CO10:** Develop the fundamental environmental knowledge, analytical ability, and current affairs awareness required for competitive examinations such as UPSC, TNPSC, SSC, Banking, Railways, and other recruitment examinations.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	1	1	1	1	1		2	
CO2	3	2	2	2	1	1	2		2	
CO3	3	3	2	2	1	1	3	1	2	1
CO4	3	3	3	2	1	1	3	1	2	1
CO5	3	3	3	2	1	2	3	1	2	1
CO6	3	2	2	2	1	1	3	1	2	1
CO7	3	2	2	1	1	1	2	1	2	1
CO8	3	3	2	2	1	2	3	1	3	1
CO9	2	2	2	1	2	2	2	1	3	2
CO10	2	2	2	1	3	2	2	1	3	2

CORE COURSE – 5
GIS AND REMOTE SENSING
(Theory)

Semester III

Code

Credits: 4

COURSE OBJECTIVES

- To provide a comprehensive understanding of the principles, concepts and applications of Geographic Information Systems (GIS) and Remote Sensing in environmental studies.
- To familiarize students with satellite data acquisition, image processing techniques and spatial data management.
- To develop skills in the analysis, interpretation and integration of geospatial data for ecological and environmental applications.
- To impart knowledge on the use of GIS and Remote Sensing for natural resource management, environmental monitoring and decision-making.
- To enable students to apply geospatial technologies in research, environmental assessment and sustainable development planning.

UNIT – I: FUNDAMENTALS OF GIS AND REMOTE SENSING

Introduction to Geoinformatics. Concepts, History and Scope of GIS and Remote Sensing. Components of GIS. Spatial and Non-spatial Data. Data Models: Raster and Vector. Coordinate Systems, Map Projections and Datum. Principles of Electromagnetic Radiation. Interaction of Electromagnetic Energy with Atmosphere and Earth Surface Features. Fundamentals of Remote Sensing and Spatial Information Systems.

UNIT – II: SATELLITE SYSTEMS AND DIGITAL IMAGE PROCESSING

Remote Sensing Platforms: Ground-based, Airborne and Spaceborne Sensors. Passive and Active Remote Sensing. Characteristics of Remote Sensing Data: Spatial, Spectral, Radiometric and Temporal Resolution. Indian Remote Sensing Satellites and Global Earth Observation Missions. Digital Image Processing: Image Enhancement, Filtering, Classification and Accuracy Assessment. Visual and Digital Interpretation Techniques.

UNIT – III: GIS DATABASE MANAGEMENT AND SPATIAL ANALYSIS

GIS Data Acquisition and Database Creation. Spatial Data Input and Editing. Topology and Data Quality. Spatial Query and Data Management. Spatial Analysis Techniques: Buffering, Overlay Analysis, Network Analysis and Interpolation. Digital Elevation Models (DEM), Terrain Analysis and Watershed Delineation. GPS and GNSS Applications in Environmental Studies.

UNIT – IV: APPLICATIONS OF GIS AND REMOTE SENSING IN ECOLOGY AND ENVIRONMENT

Land Use and Land Cover Mapping. Vegetation Analysis and Forest Resource Assessment. Biodiversity Mapping and Habitat Suitability Analysis. Wetland Mapping and Monitoring. Watershed and River Basin Management. Environmental Pollution Monitoring. Disaster Risk Assessment and Management. Climate Change Studies and Carbon Stock Assessment. Ecological Modelling and Landscape Ecology Applications.

UNIT – V: ADVANCED GEOSPATIAL TECHNOLOGIES AND ENVIRONMENTAL DECISION SUPPORT

Geospatial Technologies for Sustainable Development. Web GIS and Cloud-based GIS Platforms. Geographic Information System Modelling. Remote Sensing for Environmental Impact Assessment. Drone (UAV)-based Mapping and Monitoring. Artificial Intelligence and Machine Learning in Geospatial Analysis. Geospatial Decision Support Systems. Emerging Trends and Future Prospects of GIS and Remote Sensing in Environmental Sciences.

UNIT – VI: CURRENT CONTOURS *(For Continuous Internal Assessment Only)*

Recent Advances in Earth Observation Technologies. Applications of High-Resolution Satellite Data in Environmental Monitoring. GIS-Based Climate Change Vulnerability Assessment. Drone Applications in Biodiversity and Forest Monitoring. Smart Cities and Geospatial Technologies. National Geospatial Policy and Open-Source GIS Platforms. Role of Artificial Intelligence in Remote Sensing Data Analytics.

REFERENCES

1. Geographic Information Systems and Science, Paul A. Longley, Michael F. Goodchild, David J. Maguire & David W. Rhind (2023), Wiley.
2. Remote Sensing and Image Interpretation, Thomas M. Lillesand, Ralph W. Kiefer & Jonathan W. Chipman (2022), Wiley.
3. Fundamentals of Remote Sensing, George Joseph & C. Jeganathan (2018), Universities Press.
4. Introduction to Geographic Information Systems, Kang-tsung Chang (2021), McGraw-Hill Education.
5. GIS Fundamentals: A First Text on Geographic Information Systems, Paul Bolstad (2022), XanEdu Publishing.
6. Concepts and Techniques of Geographic Information Systems, C. P. Lo & Albert K. W. Yeung (2019), Pearson Education.
7. Remote Sensing of the Environment: An Earth Resource Perspective, John R. Jensen (2018), Pearson.
8. Geospatial Analysis, Michael de Smith, Michael Goodchild & Paul Longley (2021), Troubador Publishing.
9. Principles of Geographic Information Systems, Peter A. Burrough, Rachael A. McDonnell & Christopher D. Lloyd (2019), Oxford University Press.
10. GIS for Environmental Applications, Xuan Zhu (2020), Routledge.
11. Remote Sensing Applications in Environmental Research, Prasad S. Thenkabail (2022), CRC Press.
12. Fundamentals of GPS and GNSS, B. Hofmann-Wellenhof, H. Lichtenegger & E. Wasle (2019), Springer.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the fundamental concepts, principles, components, and applications of Geographic Information Systems (GIS), Remote Sensing, and Geoinformatics in environmental sciences.
- CO2:** Describe the principles of electromagnetic radiation, remote sensing platforms, sensor characteristics, satellite systems, and image acquisition processes used in Earth observation.
- CO3:** Acquire, preprocess, classify, interpret, and evaluate geospatial data using digital image processing techniques and accuracy assessment methods.
- CO4:** Develop and manage GIS databases by applying spatial data models, coordinate systems, map projections, topology, and spatial data quality concepts.
- CO5:** Apply spatial analysis techniques, including buffering, overlay analysis, network analysis, interpolation, Digital Elevation Models (DEM), terrain analysis, and watershed delineation for environmental problem-solving.
- CO6:** Utilize GPS, GNSS, GIS, and Remote Sensing technologies for natural resource assessment, biodiversity mapping, land use and land cover analysis, and environmental monitoring.
- CO7:** Evaluate the applications of geospatial technologies in watershed management, wetland monitoring, pollution assessment, disaster management, climate change studies, and ecological modelling.

CO8: Apply advanced geospatial technologies, including Web GIS, cloud-based GIS, drones (UAVs), Artificial Intelligence (AI), and Machine Learning (ML), for environmental assessment and decision support.

CO9: Analyze and interpret geospatial information to support environmental planning, Environmental Impact Assessment (EIA), natural resource management, and sustainable development initiatives.

CO10: Develop integrated geospatial solutions using GIS, Remote Sensing, GPS, and emerging technologies for environmental research, conservation planning, climate resilience, and evidence-based environmental decision-making.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	1	1	1	
CO2	3	2	2	3	1	1	2	2	1	
CO3	3	3	3	3	1	1	3	2	1	1
CO4	3	3	3	3	2	2	3	3	1	1
CO5	3	3	3	3	2	2	3	3	1	1
CO6	3	3	2	3	2	2	3	3	2	1
CO7	3	3	3	3	2	2	3	3	2	2
CO8	3	3	3	2	2	2	3	3	2	2
CO9	3	3	3	2	2	2	3	3	2	2
CO10	3	3	3	3	3	2	3	3	3	2

	CORE COURSE – 6	Semester III
	ENVIRONMENTAL INSTRUMENTATION METHODS	
Code	(Theory)	Credits: 4

COURSE OBJECTIVES

- To provide a comprehensive understanding of the principles and applications of analytical instruments used in environmental monitoring and research.
- To familiarize students with modern instrumentation techniques for the qualitative and quantitative analysis of environmental samples.
- To develop knowledge on sampling, calibration, quality assurance and quality control procedures in environmental analysis.
- To impart skills in selecting appropriate analytical methods for assessing environmental pollutants and ecosystem health.
- To enable students to interpret analytical data and apply instrumental techniques in environmental management, research and consultancy.

UNIT – I: FUNDAMENTALS OF ENVIRONMENTAL INSTRUMENTATION

Principles of Environmental Analysis. Environmental Sampling and Sample Preservation. Accuracy, Precision, Sensitivity and Detection Limits. Calibration Methods and Standardization. Quality Assurance (QA) and Quality Control (QC). Errors in Environmental Measurements. Instrument Validation and Laboratory Safety Practices. Good Laboratory Practices (GLP). Data Recording and Interpretation.

UNIT – II: SPECTROSCOPIC METHODS IN ENVIRONMENTAL ANALYSIS

Principles and Applications of Spectroscopy. Electromagnetic Spectrum and Radiation-Matter Interaction. UV-Visible Spectrophotometry: Instrumentation and Applications. Infrared (IR) Spectroscopy and Fourier Transform Infrared (FTIR) Spectroscopy. Atomic Absorption Spectroscopy (AAS). Atomic Emission Spectroscopy (AES). Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES). Environmental Applications of Spectroscopic Techniques.

UNIT – III: CHROMATOGRAPHIC AND MASS SPECTROMETRIC TECHNIQUES

Principles of Chromatography. Paper Chromatography and Thin Layer Chromatography (TLC). Gas Chromatography (GC): Instrumentation and Environmental Applications. High Performance Liquid Chromatography (HPLC). Ion Chromatography. Gas Chromatography-Mass Spectrometry (GC-MS). Liquid Chromatography-Mass Spectrometry (LC-MS). Applications in the Analysis of Organic Pollutants, Pesticides and Emerging Contaminants.

UNIT – IV: ENVIRONMENTAL MONITORING INSTRUMENTS

Water Quality Monitoring Instruments: pH Meter, Conductivity Meter, Dissolved Oxygen Meter, Turbidity Meter and Multiparameter Probes. Air Quality Monitoring Instruments: High Volume Air Sampler, PM_{2.5} and PM₁₀ Monitors, Gas Analyzers and Stack Monitoring Instruments. Soil Analysis Instruments. Noise Monitoring Instruments and Sound Level Meters. Meteorological Instruments for Environmental Monitoring.

UNIT – V: ADVANCED ANALYTICAL TECHNIQUES AND ENVIRONMENTAL APPLICATIONS

Inductively Coupled Plasma Mass Spectrometry (ICP-MS). X-Ray Fluorescence Spectroscopy (XRF). X-Ray Diffraction (XRD). Thermal Analysis Techniques (TGA and DTA). Environmental Biosensors and Sensor Networks. Remote Sensing-Based Monitoring Instruments. Automation and Digital Data Acquisition Systems. Applications of Instrumental Techniques in Environmental

Impact Assessment, Pollution Monitoring, Biodiversity Conservation and Climate Change Studies.

UNIT – VI: CURRENT CONTOURS (*For Continuous Internal Assessment Only*)

Emerging Sensor Technologies for Real-Time Environmental Monitoring. Internet of Things (IoT) in Environmental Monitoring. Artificial Intelligence and Machine Learning in Instrumental Data Analysis. Portable Environmental Monitoring Devices. Microplastics Detection Techniques. Advances in Air and Water Quality Monitoring Systems. Smart Environmental Monitoring and Citizen Science Initiatives.

REFERENCES

1. Principles of Instrumental Analysis, Douglas A. Skoog, F. James Holler & Stanley R. Crouch (2020), Cengage Learning.
2. Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, J. A. Dean & F. A. Settle (2019), CBS Publishers.
3. Environmental Instrumentation and Analysis Handbook, Randy D. Down & Jay H. Lehr (2018), Wiley-Interscience.
4. Environmental Chemistry and Instrumental Methods, S. M. Khopkar (2021), New Age International Publishers.
5. Environmental Monitoring and Characterization, Janick Artiola, Ian L. Pepper & Mark Brusseau (2019), Academic Press.
6. Instrumental Analysis, R. D. Braun (2018), McGraw-Hill Education.
7. Environmental Sampling and Analysis, Maria Csuros (2018), CRC Press.
8. Modern Environmental Analysis Techniques, P. N. Cheremisinoff (2021), Elsevier.
9. Environmental Monitoring Technologies, M. Subramanian (2022), Springer.
10. Analytical Techniques in Environmental Science, Alok Mittal (2020), CBS Publishers.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the principles, components, calibration procedures, and operational characteristics of analytical instruments used in environmental monitoring and analysis.
- CO2:** Demonstrate knowledge of environmental sampling methods, sample preservation techniques, quality assurance (QA), quality control (QC), Good Laboratory Practices (GLP), and laboratory safety protocols.
- CO3:** Describe the principles, instrumentation, and environmental applications of spectroscopic techniques including UV-Visible Spectrophotometry, FTIR, AAS, AES, and ICP-OES.
- CO4:** Explain the principles and applications of chromatographic and mass spectrometric techniques such as TLC, GC, HPLC, Ion Chromatography, GC-MS, and LC-MS for environmental analysis.
- CO5:** Select appropriate analytical instruments and methods for the qualitative and quantitative analysis of environmental samples, including water, air, soil, sediments, and biological materials.
- CO6:** Operate and interpret data from environmental monitoring instruments, including pH meters, conductivity meters, dissolved oxygen meters, turbidity meters, air quality monitoring instruments, gas analyzers, sound level meters, and meteorological instruments.
- CO7:** Analyze and interpret instrumental data for environmental quality assessment, pollution monitoring, contaminant identification, and ecosystem health evaluation.
- CO8:** Evaluate advanced analytical techniques such as ICP-MS, XRF, XRD, thermal analysis (TGA and DTA), biosensors, and remote sensing-based monitoring systems for environmental applications.
- CO9:** Apply modern technologies including IoT, Artificial Intelligence (AI), Machine Learning (ML), portable monitoring devices, and automated data acquisition systems in real-time environmental monitoring and decision-making.

CO10: Develop technical competence in selecting, operating, and interpreting advanced environmental instrumentation for research, environmental consultancy, regulatory compliance, environmental impact assessment, and sustainable environmental management.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	3	1	1	2	2	1	
CO2	3	2	2	3	2	2	2	2	1	1
CO3	3	3	3	3	1	1	3	2	1	1
CO4	3	3	3	3	1	1	3	2	1	1
CO5	3	3	3	3	2	1	3	3	1	1
CO6	3	3	2	3	2	2	3	3	1	1
CO7	3	3	3	3	2	2	3	3	2	1
CO8	3	3	3	3	2	2	3	3	2	2
CO9	3	3	3	2	2	2	3	3	3	2
CO10	3	3	3	3	3	2	3	3	3	2

CORE PRACTICAL – 3
GEOINFORMATICS PRACTICAL
(Practical)

Semester III

Code

Credits: 4

COURSE OBJECTIVES

- To introduce students to the basic concepts and practical applications of GIS, GPS and Remote Sensing.
- To develop simple skills in handling spatial data, maps and satellite imagery for environmental studies.
- To familiarize students with freely available geospatial software and online mapping tools.
- To enable students to prepare basic thematic maps and perform simple spatial analyses.
- To provide hands-on experience in applying geoinformatics for environmental monitoring and natural resource management.

EXPERIMENTS

GIS BASICS

1. Introduction to GIS software (QGIS/Open-source GIS environment).
2. Identification and understanding of map components: Scale, Legend, North Arrow and Coordinates.
3. Downloading and viewing satellite imagery using Google Earth and Bhuvan Portal.
4. Georeferencing of scanned maps using simple control points.
6. Digitization of village boundary, roads, water bodies and land-use features from satellite imagery.
7. Preparation of attribute tables and entry of basic field data.
8. Preparation of simple thematic maps using GIS.
9. Measurement of area, distance and perimeter using GIS tools.

GPS AND FIELD DATA COLLECTION

10. Collection of geographic coordinates of selected locations using smartphones or handheld GPS.
11. Importing GPS coordinates into GIS software.

REMOTE SENSING APPLICATIONS

12. Visual interpretation of satellite images for identifying forests, agricultural land, water bodies and settlements.
13. Preparation of simple Land Use/Land Cover (LULC) maps (Demonstration Only).

SOFTWARE AND TOOLS

- QGIS (Open Source GIS Software)
- Google Earth Pro
- ISRO Bhuvan Portal
- GPS-enabled Smartphone Applications
- OpenStreetMap (OSM)

COURSE OUTCOMES

Upon successful completion of the practical course, the students will be able to:

- CO1:** Demonstrate proficiency in the use of basic GIS, GPS, and Remote Sensing tools for environmental mapping and spatial analysis.
- CO2:** Identify and interpret essential map components, including scale, coordinates, legends, north arrow, and projection systems for geospatial applications.

- CO3:** Acquire, download, and visualize satellite imagery from freely available platforms such as Google Earth, ISRO Bhuvan, and OpenStreetMap for environmental studies.
- CO4:** Perform georeferencing of scanned maps and digitize spatial features such as administrative boundaries, roads, water bodies, and land-use categories using GIS software.
- CO5:** Create, manage, and edit spatial databases, attribute tables, and geospatial information for environmental resource mapping.
- CO6:** Prepare thematic maps and perform basic spatial analyses, including measurement of area, distance, perimeter, and spatial relationships using GIS tools.
- CO7:** Collect, import, and integrate field-based geographic coordinates using GPS-enabled smartphones or handheld GPS devices into GIS environments.
- CO8:** Interpret satellite imagery for identifying major land use/land cover classes, natural resources, environmental features, and ecosystem characteristics.
- CO9:** Apply GIS, GPS, and Remote Sensing techniques for environmental monitoring, natural resource management, and basic geospatial investigations.
- CO10:** Develop technical competency in using open-source geospatial software and digital mapping tools for environmental planning, research, and decision-making in environmental sciences.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	3	2	1	2	2	1	1
CO2	3	2	2	3	1	1	2	1	1	
CO3	3	2	2	3	2	1	2	2	1	
CO4	3	3	3	3	2	2	3	3	1	1
CO5	3	3	3	3	2	2	3	3	1	1
CO6	3	3	3	3	2	2	3	3	2	1
CO7	3	2	2	3	2	2	2	3	2	1
CO8	3	3	3	2	2	2	3	3	2	1
CO9	3	3	3	3	2	2	3	3	2	2
CO10	3	3	3	3	3	2	3	3	3	2

NON-MAJOR ELECTIVE COURSE – II
CLIMATE CHANGE AND GLOBAL WARMING

Semester III

Code

(Theory)

Credits: 2

COURSE OBJECTIVES

- To introduce students from various disciplines to the concepts of climate change and global warming and their environmental significance.
- To provide knowledge on the causes, impacts and consequences of climate change at local, national and global levels.
- To create awareness about climate-related challenges affecting ecosystems, biodiversity, agriculture and human societies.
- To familiarize students with climate change mitigation and adaptation strategies.
- To equip students with fundamental knowledge useful for competitive examinations and informed environmental decision-making.

UNIT – I: INTRODUCTION TO CLIMATE CHANGE

Weather and Climate: Concepts and Differences. Climate System and Climate Variability. Definition and Causes of Climate Change. Natural and Anthropogenic Factors Influencing Climate. Greenhouse Effect and Greenhouse Gases.

UNIT – II: GLOBAL WARMING AND ITS CAUSES

Global Warming: Concept and Scientific Basis. Sources of Greenhouse Gas Emissions. Fossil Fuel Consumption, Deforestation and Industrial Activities. Carbon Cycle and Carbon Footprint. Evidence of Global Climate Change.

UNIT – III: IMPACTS OF CLIMATE CHANGE

Effects of Climate Change on Atmosphere, Hydrosphere and Biosphere. Sea Level Rise, Extreme Weather Events, Droughts and Floods. Impacts on Agriculture, Water Resources, Biodiversity and Human Health. Climate Change and Sustainable Development.

UNIT – IV: CLIMATE CHANGE MITIGATION AND ADAPTATION

Mitigation Strategies: Renewable Energy, Energy Efficiency, Afforestation and Carbon Sequestration. Climate Change Adaptation Measures in Agriculture, Water Management and Urban Planning. Role of Individuals and Communities in Climate Action.

UNIT – V: CLIMATE POLICIES, AGREEMENTS AND CURRENT ISSUES

International Climate Agreements: United Nations Framework Convention on Climate Change (UNFCCC), Kyoto Protocol and Paris Agreement. Climate Action in India. National Action Plan on Climate Change (NAPCC). Sustainable Development Goals (SDGs) and Contemporary Climate Challenges.

UNIT – VI: CURRENT CONTOURS *(For Continuous Internal Assessment Only)*

Recent IPCC Assessment Reports. Global Carbon Emission Trends. Climate Change and Extreme Weather Events in India. India's Net-Zero Commitments and Renewable Energy Initiatives. Climate Resilience and Nature-Based Solutions. Climate Change Issues Frequently Covered in Competitive Examinations.

REFERENCES

1. Climate Change: The Science of Global Warming and Our Energy Future, Edmond A. Mathez & Jason E. Smerdon (2018), Columbia University Press.
2. Climate Change and Society, John Urry (2018), Polity Press.
3. Global Warming and Climate Change, S. K. Dash (2020), Cambridge University Press.
4. Introduction to Climate Change, Timothy O'Riordan & Jill Jäger (2019), Routledge.

5. Climate Change and Sustainable Development, D. Munasinghe (2020), Springer.
6. Environmental Studies, Erach Bharucha (2021), Universities Press.
7. Environmental Science, G. Tyler Miller & Scott E. Spoolman (2023), Cengage Learning.
8. Climate Change: Impacts, Adaptation and Mitigation, Intergovernmental Panel on Climate Change (IPCC Reports).

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the fundamental concepts of weather, climate, climate variability, climate change, global warming, and the greenhouse effect.
- CO2:** Describe the natural and anthropogenic causes of climate change, including greenhouse gas emissions, fossil fuel consumption, deforestation, and industrial activities.
- CO3:** Analyze the carbon cycle, carbon footprint, and scientific evidence supporting global climate change and global warming.
- CO4:** Evaluate the impacts of climate change on the atmosphere, hydrosphere, biosphere, biodiversity, agriculture, water resources, human health, and sustainable development.
- CO5:** Interpret the causes and consequences of climate-related hazards such as sea level rise, extreme weather events, droughts, floods, and ecosystem degradation.
- CO6:** Explain climate change mitigation strategies, including renewable energy, energy efficiency, afforestation, carbon sequestration, and sustainable resource management.
- CO7:** Assess climate change adaptation measures for agriculture, water resources, urban planning, disaster risk reduction, and community resilience.
- CO8:** Describe international climate agreements, national climate policies, the National Action Plan on Climate Change (NAPCC), Sustainable Development Goals (SDGs), and India's climate initiatives.
- CO9:** Demonstrate environmental awareness and promote climate-resilient lifestyles, sustainable practices, and informed environmental decision-making at individual and community levels.
- CO10:** Develop the fundamental knowledge, analytical ability, and current affairs awareness required for competitive examinations such as UPSC, TNPSC, SSC, Banking, Railways, and other recruitment examinations, with special reference to climate change and global environmental issues.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	1	1	1	1	1		2	
CO2	3	2	2	2	1	1	2		2	
CO3	3	3	2	2	1	1	2	1	2	
CO4	3	3	3	2	1	2	3	1	2	1
CO5	3	3	3	2	1	2	3	1	2	1
CO6	3	2	2	2	1	1	3	1	2	1
CO7	3	3	2	2	1	2	3	1	2	1
CO8	3	2	2	1	1	1	2	1	2	1
CO9	2	2	2	1	2	2	2	1	3	2
CO10	2	2	2	1	3	2	2	1	3	2

CORE COURSE – 7
CLIMATE CHANGE MITIGATION AND
ADAPTATION
(Theory)

Semester IV

Code

Credits: 4

COURSE OBJECTIVES

- To provide a comprehensive understanding of the science, impacts and challenges of climate change at global, national and regional scales.
- To familiarize students with climate change mitigation strategies for reducing greenhouse gas emissions and enhancing carbon sequestration.
- To develop knowledge on climate change adaptation approaches for ecosystems, communities and economic sectors.
- To impart skills in climate vulnerability assessment, risk management and resilience planning.
- To enable students to evaluate climate policies, international agreements and sustainable development strategies for addressing climate change.

UNIT – I: CLIMATE CHANGE SCIENCE AND IMPACTS

Climate System and Climate Variability. Weather and Climate. Causes of Climate Change: Natural and Anthropogenic Factors. Greenhouse Effect and Greenhouse Gases. Evidence of Climate Change. Global Warming and Climate Feedback Mechanisms. Impacts of Climate Change on Ecosystems, Biodiversity, Water Resources, Agriculture, Human Health and Livelihoods. Climate Change Scenarios and Projections.

UNIT – II: CLIMATE CHANGE MITIGATION STRATEGIES

Concept and Importance of Climate Change Mitigation. Greenhouse Gas Emission Sources and Inventories. Carbon Cycle and Carbon Budget. Renewable Energy Technologies: Solar, Wind, Biomass and Hydropower. Energy Efficiency and Sustainable Transportation. Carbon Capture, Utilization and Storage (CCUS). Afforestation, Reforestation and Ecosystem-Based Carbon Sequestration. Green Buildings and Low-Carbon Development Pathways.

UNIT – III: CLIMATE CHANGE ADAPTATION STRATEGIES

Concept, Principles and Types of Adaptation. Climate Vulnerability and Risk Assessment. Adaptation in Agriculture, Forestry and Fisheries. Climate-Resilient Water Resource Management. Adaptation for Coastal and Urban Ecosystems. Ecosystem-Based Adaptation (EbA). Community-Based Adaptation Approaches. Indigenous Knowledge and Climate Adaptation. Disaster Risk Reduction and Climate Resilience.

UNIT – IV: CLIMATE POLICY, GOVERNANCE AND SUSTAINABLE DEVELOPMENT

International Climate Governance. United Nations Framework Convention on Climate Change (UNFCCC). Kyoto Protocol and Paris Agreement. Intergovernmental Panel on Climate Change (IPCC). National Action Plan on Climate Change (NAPCC). State Action Plans on Climate Change. Climate Finance and Carbon Markets. Sustainable Development Goals (SDGs) and Climate Action. Environmental Justice and Climate Equity.

UNIT – V: TOOLS, TECHNOLOGIES AND APPLICATIONS FOR CLIMATE ACTION

Climate Change Monitoring and Assessment Tools. Role of GIS, Remote Sensing and Climate Modelling in Climate Studies. Carbon Footprint Assessment and Life Cycle Assessment. Nature-Based Solutions for Climate Mitigation and Adaptation. Climate-Smart Agriculture.

Blue Carbon and Ecosystem Restoration. Artificial Intelligence and Emerging Technologies in Climate Change Research and Management. Climate Communication and Public Awareness.

UNIT – VI: CURRENT CONTOURS (*For Continuous Internal Assessment Only*)

Recent IPCC Assessment Reports and Global Climate Trends. Net-Zero Emission Targets and Climate Commitments. Climate-Induced Extreme Weather Events. Carbon Neutrality Initiatives. Climate-Smart Cities and Sustainable Infrastructure. India's Climate Action Programmes. Climate Adaptation Challenges in Tamil Nadu. Emerging Innovations in Climate Change Mitigation and Adaptation.

REFERENCES

1. Climate Change 2023: Synthesis Report, Intergovernmental Panel on Climate Change (IPCC).
2. Climate Change: The Science of Global Warming and Our Energy Future, Edmond A. Mathez & Jason E. Smerdon (2018), Columbia University Press.
3. Climate Change and Society, John Urry (2018), Polity Press.
4. Climate Change Adaptation, Resilience and Hazards, Walter Leal Filho (2021), Springer.
5. Climate Change and Sustainable Development, D. Munasinghe (2020), Springer.
6. The Economics of Climate Change, Nicholas Stern (2017), Cambridge University Press.
7. Climate-Smart Agriculture, Leslie Lipper et al. (2018), Springer.
8. Environmental Science and Policy for Sustainable Development, Robert V. Percival (2021), Routledge.
9. Climate Governance and Policy, J. Gupta (2020), Cambridge University Press.
10. Climate Change and Biodiversity, Thomas E. Lovejoy & Lee Hannah (2019), Yale University Press.
11. Adaptation to Climate Change, Mark Pelling (2018), Routledge.
12. Environmental Management, T. V. Ramachandra (2020), TERI Publications.
13. Climate Change and Ecosystems, David A. Coomes (2021), Oxford University Press.
14. Nature-Based Solutions to Climate Change, Nathalie Seddon (2022), Oxford University Press.
15. Climate Change and Water Resources, P. C. D. Milly (2019), Elsevier.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the scientific basis of climate change, including climate systems, greenhouse gases, climate variability, global warming, and climate feedback mechanisms.
- CO2:** Analyze the environmental, ecological, economic, and social impacts of climate change on biodiversity, ecosystems, agriculture, water resources, human health, and livelihoods.
- CO3:** Evaluate greenhouse gas emission sources, carbon budgets, and various climate change mitigation strategies, including renewable energy, carbon sequestration, energy efficiency, and low-carbon development pathways.
- CO4:** Assess climate vulnerability, climate risks, and adaptation needs for ecosystems, communities, agriculture, forestry, fisheries, coastal regions, urban systems, and water resources.
- CO5:** Apply ecosystem-based adaptation (EbA), community-based adaptation, indigenous knowledge, disaster risk reduction, and resilience planning approaches for climate change adaptation.
- CO6:** Interpret international climate agreements, climate governance mechanisms, national climate policies, carbon markets, climate finance, Sustainable Development Goals (SDGs), and environmental justice principles.
- CO7:** Utilize climate assessment tools, including GIS, Remote Sensing, climate modelling, carbon footprint assessment, and Life Cycle Assessment (LCA), for climate change studies and environmental planning.

- CO8:** Evaluate the role of climate-smart agriculture, nature-based solutions, blue carbon ecosystems, ecosystem restoration, Artificial Intelligence (AI), and emerging technologies in climate change mitigation and adaptation.
- CO9:** Analyze recent climate change trends, IPCC assessment reports, India's climate action programmes, net-zero commitments, climate resilience initiatives, and sustainable development strategies.
- CO10:** Develop integrated climate change mitigation and adaptation strategies for environmental management, policy formulation, research, climate resilience planning, and sustainable development at local, national, and global levels.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	1	
CO2	3	3	3	2	1	1	3	2	1	1
CO3	3	3	3	3	1	1	3	2	1	1
CO4	3	3	3	3	2	2	3	2	1	1
CO5	3	3	3	3	2	2	3	2	2	2
CO6	3	3	2	2	2	2	3	2	2	2
CO7	3	3	3	3	2	2	3	3	2	2
CO8	3	3	3	3	2	2	3	3	2	2
CO9	3	3	3	2	2	2	3	3	3	2
CO10	3	3	3	3	3	2	3	3	3	3

CORE COURSE – 8
ENVIRONMENTAL TOXICOLOGY

Semester IV

Code

(Theory)

Credits: 5

COURSE OBJECTIVES

- To provide a comprehensive understanding of the principles and concepts of environmental toxicology and their relevance to environmental health.
- To familiarize students with the sources, fate, transport and effects of toxic substances in environmental systems.
- To develop knowledge on toxicological mechanisms, dose-response relationships and risk assessment methodologies.
- To impart understanding of the impacts of environmental contaminants on humans, wildlife and ecosystems.
- To enable students to evaluate environmental hazards and formulate strategies for pollution prevention, toxic substance management and environmental protection.

UNIT – I: FUNDAMENTALS OF ENVIRONMENTAL TOXICOLOGY

Definition, Scope and Importance of Environmental Toxicology. History and Development of Toxicology. Concepts of Toxicity, Hazard and Risk. Types of Toxicants and Toxic Substances. Sources of Environmental Contaminants. Exposure Pathways and Routes of Entry. Dose-Response Relationships. Toxicokinetics: Absorption, Distribution, Metabolism and Excretion (ADME). Toxicodynamics and Mechanisms of Toxic Action.

UNIT – II: TOXICANTS IN THE ENVIRONMENT

Heavy Metals and Metalloids: Lead, Mercury, Cadmium, Arsenic and Chromium. Pesticides and Agrochemicals. Industrial Chemicals and Persistent Organic Pollutants (POPs). Polycyclic Aromatic Hydrocarbons (PAHs). Endocrine Disrupting Chemicals (EDCs). Pharmaceuticals and Personal Care Products (PPCPs). Radioactive Substances and Environmental Toxicity. Emerging Environmental Contaminants and Microplastics.

UNIT – III: ECOTOXICOLOGY AND BIOLOGICAL EFFECTS OF TOXICANTS

Principles of Ecotoxicology. Toxic Effects on Microorganisms, Plants, Animals and Aquatic Organisms. Acute and Chronic Toxicity. Bioaccumulation, Bioconcentration and Biomagnification. Ecological Consequences of Environmental Contamination. Biomarkers of Toxic Exposure and Effect. Environmental Stress and Ecosystem Responses. Toxicity Testing and Ecotoxicological Assessment.

UNIT – IV: HUMAN HEALTH TOXICOLOGY AND RISK ASSESSMENT

Human Exposure to Environmental Pollutants. Occupational and Environmental Health Hazards. Toxic Effects on Major Organ Systems. Carcinogenicity, Mutagenicity and Teratogenicity. Environmental Epidemiology. Toxicological Risk Assessment: Hazard Identification, Dose-Response Assessment, Exposure Assessment and Risk Characterization. Health Risk Assessment Models and Regulatory Standards.

UNIT – V: TOXICANT MANAGEMENT, REMEDIATION AND ENVIRONMENTAL SAFETY

Environmental Monitoring of Toxic Substances. Pollution Prevention and Toxic Substance Management. Bioremediation, Phytoremediation and Other Remediation Technologies. Environmental Regulations and Toxic Chemical Control. International Conventions on Hazardous Chemicals and Wastes. Chemical Safety Assessment. Environmental Health Management. Sustainable Approaches for Reducing Toxicological Risks.

UNIT – VI: CURRENT CONTOURS *(For Continuous Internal Assessment Only)*

Microplastics and Nanotoxicology. Emerging Contaminants in Aquatic Ecosystems. Environmental Toxicity of Electronic Waste. Climate Change and Toxicological Risks. Pharmaceutical Residues in the Environment. Advances in Ecotoxicological Monitoring and Biomarker Studies. Recent Environmental Toxicology Case Studies and Global Toxicological Issues.

REFERENCES

1. Casarett and Doull's Toxicology: The Basic Science of Poisons, Curtis D. Klaassen (2022), McGraw-Hill Education.
2. Environmental Toxicology: Biological and Health Effects of Pollutants, Ming-Ho Yu (2019), CRC Press.
3. Principles of Ecotoxicology, C. H. Walker, R. M. Sibly, S. P. Hopkin & D. B. Peakall (2021), CRC Press.
4. Environmental Toxicology and Chemistry, Donald G. Crosby (2018), Oxford University Press.
5. Ecotoxicology: Effects of Pollutants on the Natural Environment, F. Moriarty (2019), Academic Press.
6. Fundamentals of Ecotoxicology, Michael C. Newman (2020), CRC Press.
7. Environmental Health: From Global to Local, Howard Frumkin (2021), Jossey-Bass.
8. Environmental Chemistry and Toxicology, H. K. Chopra (2020), CBS Publishers.
9. Risk Assessment for Environmental Health, Mark J. Nieuwenhuijsen (2018), Oxford University Press.
10. Environmental Pollution and Toxicology, J. Rose (2021), Scientific Publishers.
11. Toxicology and Risk Assessment: A Comprehensive Introduction, Anna M. Fan & George Alexeeff (2019), Springer.
12. Environmental Monitoring and Characterization, Janick Artiola, Ian L. Pepper & Mark Brusseau (2019), Academic Press.
13. Principles and Methods of Toxicology, A. Wallace Hayes (2020), CRC Press.
14. Handbook of Environmental Toxicology, Michael J. Derelanko (2018), CRC Press.
15. Environmental Toxicants: Human Exposures and Their Health Effects, Morton Lippmann (2021), Wiley.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the fundamental concepts, principles, and mechanisms of environmental toxicology, including toxicity, hazard, risk, toxicokinetics, and toxicodynamics.
- CO2:** Identify and classify major environmental toxicants, including heavy metals, pesticides, persistent organic pollutants (POPs), endocrine-disrupting chemicals (EDCs), pharmaceuticals, radioactive substances, microplastics, and emerging contaminants.
- CO3:** Analyze the sources, environmental fate, transport, exposure pathways, and dose-response relationships of toxic substances in air, water, soil, and biological systems.
- CO4:** Evaluate the toxicological effects of environmental contaminants on microorganisms, plants, animals, aquatic organisms, wildlife, and ecosystems using ecotoxicological principles.
- CO5:** Assess bioaccumulation, bioconcentration, biomagnification, biomarkers, acute and chronic toxicity, and ecosystem responses associated with environmental contamination.
- CO6:** Examine the impacts of environmental toxicants on human health, including carcinogenicity, mutagenicity, teratogenicity, occupational health hazards, and environmental epidemiology.
- CO7:** Apply environmental and human health risk assessment methodologies, including hazard identification, dose-response assessment, exposure assessment, and risk characterization.

CO8: Evaluate environmental monitoring methods, pollution prevention strategies, remediation technologies such as bioremediation and phytoremediation, and chemical safety management practices.

CO9: Interpret national and international regulations, conventions, and policies related to hazardous chemicals, toxic substances, environmental safety, and sustainable toxicant management.

CO10: Develop integrated strategies for toxic substance monitoring, environmental risk reduction, ecosystem protection, environmental health management, and sustainable environmental management using modern toxicological approaches.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	3	1	1	2	1	1	
CO2	3	3	2	2	1	1	3	2	1	
CO3	3	3	3	3	1	1	3	2	1	1
CO4	3	3	3	3	1	1	3	2	1	1
CO5	3	3	3	3	2	2	3	2	1	1
CO6	3	3	3	3	2	2	3	2	2	1
CO7	3	3	3	3	2	2	3	3	2	2
CO8	3	3	2	3	2	2	3	3	2	2
CO9	3	2	2	2	2	2	2	2	2	2
CO10	3	3	3	3	3	2	3	3	3	2

**CORE COURSE – IX
ENVIRONMENTAL ETHICS, LAW AND POLICY**

Semester IV

Code

(Theory)

Credits: 4

COURSE OBJECTIVES

- To provide a comprehensive understanding of environmental ethics and their role in promoting environmental stewardship and sustainable development.
- To familiarize students with national and international environmental laws, policies and regulatory frameworks.
- To develop knowledge of environmental governance, environmental justice and public participation in environmental decision-making.
- To impart understanding of legal mechanisms for environmental protection, conservation and pollution control.
- To enable students to critically analyze environmental policies and legal instruments for addressing contemporary environmental challenges.

UNIT – I: ENVIRONMENTAL ETHICS AND SUSTAINABILITY

Concept, Definition and Scope of Environmental Ethics. Human-Nature Relationship. Anthropocentrism, Biocentrism and Ecocentrism. Environmental Values and Moral Responsibility. Ethics of Natural Resource Utilization. Sustainable Development and Intergenerational Equity. Environmental Stewardship and Ecological Citizenship. Traditional Ecological Knowledge and Indigenous Environmental Ethics.

UNIT – II: FOUNDATIONS OF ENVIRONMENTAL LAW

Introduction to Environmental Law. Constitutional Provisions for Environmental Protection in India. Fundamental Rights, Directive Principles of State Policy and Fundamental Duties related to Environment. Principles of Environmental Law: Precautionary Principle, Polluter Pays Principle, Public Trust Doctrine and Sustainable Development Principle. Environmental Governance and Institutional Framework in India.

UNIT – III: ENVIRONMENTAL LEGISLATION IN INDIA

Environment (Protection) Act, 1986. Water (Prevention and Control of Pollution) Act, 1974. Air (Prevention and Control of Pollution) Act, 1981. Wildlife (Protection) Act, 1972. Forest (Conservation) Act, 1980. Biological Diversity Act, 2002. National Green Tribunal (NGT) Act, 2010. Environmental Impact Assessment (EIA) Notification and Environmental Clearance Procedures.

UNIT – IV: INTERNATIONAL ENVIRONMENTAL LAW AND POLICY

Evolution of International Environmental Law. Major International Environmental Agreements and Conventions. Stockholm Conference (1972). Rio Earth Summit (1992). Convention on Biological Diversity (CBD). United Nations Framework Convention on Climate Change (UNFCCC). Kyoto Protocol. Paris Agreement. Ramsar Convention on Wetlands. Convention on International Trade in Endangered Species (CITES). Sustainable Development Goals (SDGs) and Global Environmental Governance.

UNIT – V: ENVIRONMENTAL POLICY, JUSTICE AND CONTEMPORARY ISSUES

Environmental Policy Formulation and Implementation. National Environmental Policy of India. Environmental Justice and Equity. Public Participation in Environmental Decision-Making. Role of Judiciary in Environmental Protection. Public Interest Litigation (PIL) and Environmental Activism. Corporate Environmental Responsibility and Environmental Auditing. Emerging Environmental Challenges and Policy Responses. Climate Change Governance and Green Economy Initiatives.

UNIT – VI: CURRENT CONTOURS *(For Continuous Internal Assessment Only)*

Recent Judgments of the National Green Tribunal and Supreme Court on Environmental Issues. Climate Change Policies and Net-Zero Commitments. Biodiversity Conservation Policies in India. Plastic Waste Management Rules and Circular Economy Initiatives. Environmental Governance in Tamil Nadu. Community-Based Conservation and Environmental Movements. Emerging Legal Challenges in Environmental Protection and Sustainable Development.

REFERENCES

1. Environmental Law and Policy in India, Shyam Divan & Armin Rosencranz (2022), Oxford University Press.
2. Environmental Ethics: An Introduction to Environmental Philosophy, Joseph R. DesJardins (2021), Cengage Learning.
3. Environmental Governance, Policy and Law, Nicholas A. Robinson (2020), IUCN Publications.
4. Principles of Environmental Law, Philippe Sands & Jacqueline Peel (2018), Cambridge University Press.
5. Environmental Studies: From Crisis to Cure, R. Rajagopalan (2020), Oxford University Press.
6. Environmental Law, P. Leelakrishnan (2021), LexisNexis Butterworths.
7. Environmental Ethics and Sustainable Development, M. Karpagam (2019), PHI Learning.
8. International Environmental Law and Policy, David Hunter, James Salzman & Durwood Zaelke (2020), Foundation Press.
9. Environmental Policy and Politics, Michael E. Kraft (2021), Routledge.
10. Biodiversity, Environmental Governance and Sustainable Development, P. S. Ramakrishnan (2019), Oxford University Press.
11. Environmental Justice and Sustainability, Julian Agyeman (2020), MIT Press.
12. Environmental Law and Human Rights, Alan Boyle (2018), Oxford University Press.
13. National Environmental Policy Documents, Government of India.
14. Environmental Governance in India, S. Chatterjee (2021), Springer.
15. Environmental Protection and Sustainable Development, S. C. Kalwar (2020), Pointer Publishers.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the fundamental concepts, principles, and philosophical foundations of environmental ethics, sustainability, ecological citizenship, and environmental stewardship.
- CO2:** Interpret the constitutional provisions, legal principles, and institutional frameworks governing environmental protection and sustainable development in India.
- CO3:** Analyze the major environmental legislations in India, including the Environment (Protection) Act, Water Act, Air Act, Wildlife (Protection) Act, Forest (Conservation) Act, Biological Diversity Act, National Green Tribunal (NGT) Act, and Environmental Impact Assessment (EIA) framework.
- CO4:** Evaluate the principles of environmental law, including the Precautionary Principle, Polluter Pays Principle, Public Trust Doctrine, and Sustainable Development Principle, in environmental decision-making.
- CO5:** Examine the evolution and significance of international environmental agreements, conventions, and global governance mechanisms related to biodiversity conservation, climate change, wetlands, wildlife protection, and sustainable development.
- CO6:** Assess the role of environmental governance, environmental policy, public participation, environmental justice, judicial interventions, Public Interest Litigation (PIL), and environmental activism in environmental management.

- CO7:**Analyze contemporary environmental policies, corporate environmental responsibility, environmental auditing, green economy initiatives, and climate change governance at national and international levels.
- CO8:** Critically evaluate recent environmental legal cases, National Green Tribunal (NGT) judgments, Supreme Court decisions, and policy responses to emerging environmental challenges.
- CO9:** Apply ethical, legal, and policy principles to address environmental conflicts, resource conservation, biodiversity protection, pollution control, and sustainable environmental governance.
- CO10:** Develop informed and responsible decision-making skills by integrating environmental ethics, law, governance, policy frameworks, and sustainability principles for effective environmental management and public welfare.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	1	1	2	2	1	2	1
CO2	3	3	2	2	1	1	3	1	2	1
CO3	3	3	3	2	1	1	3	2	2	1
CO4	3	3	3	2	2	2	3	2	2	2
CO5	3	3	3	2	1	2	3	2	2	2
CO6	3	3	3	2	2	2	3	2	2	3
CO7	3	3	2	2	2	2	3	2	3	3
CO8	3	3	3	2	2	2	3	3	3	3
CO9	3	3	3	2	2	2	3	2	3	3
CO10	3	3	3	2	3	3	3	3	3	3

**ENTREPRENEURSHIP / INDUSTRY-BASED
COURSE**

Semester IV

INDUSTRIAL SAFETY PROCESSES

Code

(Theory)

Credits: 3

COURSE OBJECTIVES

- To provide fundamental knowledge of industrial safety principles, occupational health and workplace hazard management.
- To familiarize students with industrial safety regulations, standards and compliance requirements applicable to various industries.
- To develop skills in hazard identification, risk assessment and accident prevention strategies.
- To impart knowledge on emergency preparedness, disaster management and safety auditing procedures.
- To enhance employability and entrepreneurial competencies in industrial safety, environmental compliance and occupational health sectors.

UNIT – I: INTRODUCTION TO INDUSTRIAL SAFETY

Concept, importance and scope of industrial safety. Occupational health and workplace safety culture. Types of industrial hazards and their impacts on workers, industries and the environment. Role of safety management in sustainable industrial development.

UNIT – II: HAZARD IDENTIFICATION AND RISK ASSESSMENT

Physical, chemical, biological, mechanical and ergonomic hazards in industries. Hazard identification techniques and workplace inspections. Principles of risk assessment, risk analysis and risk mitigation. Safety signs, symbols and hazard communication systems.

UNIT – III: ACCIDENT PREVENTION AND OCCUPATIONAL HEALTH

Causes and consequences of industrial accidents. Accident investigation and reporting procedures. Occupational diseases and health monitoring. Personal Protective Equipment (PPE), safety training and employee awareness programmes for accident prevention.

UNIT – IV: INDUSTRIAL SAFETY MANAGEMENT AND EMERGENCY RESPONSE

Safety management systems and industrial safety standards. Fire prevention and firefighting techniques. Emergency preparedness, evacuation procedures and disaster management planning. First aid, rescue operations and crisis management in industrial settings.

UNIT – V: SAFETY LEGISLATION, AUDITING AND ENTREPRENEURSHIP OPPORTUNITIES

Factories Act, Occupational Safety, Health and Working Conditions Code, environmental and industrial safety regulations. Safety audits and compliance assessment. Industrial safety consultancy services, environmental compliance auditing, safety training enterprises and career opportunities in industrial safety management.

REFERENCES

1. Industrial Safety Management, L. M. Deshmukh (2021), McGraw Hill Education.
2. Industrial Safety, Health and Environment Management Systems, R. K. Jain and Sunil S. Rao (2020), Khanna Publishers.
3. Safety and Accident Prevention in Chemical Operations, Frank P. Lees (2019), Butterworth-Heinemann.
4. Occupational Health and Safety Management, Charles D. Reese (2022), CRC Press.
5. Industrial Safety and Environment, Amit Gupta (2021), Laxmi Publications.
6. Safety Management: A Human Approach, Dan Petersen (2019), ASSE Publications.

7. Occupational Safety and Health Standards, Government of India Publications.
8. Industrial Hazard and Safety Handbook, B. K. Mishra (2020), CBS Publishers.
9. Fire Safety Engineering, John A. Purkiss (2021), Routledge.
10. Industrial Safety and Risk Management, P. S. Rajan (2020), New Age International.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, principles, scope, and importance of industrial safety, occupational health, and workplace safety management in industrial sectors.
- CO2:** Identify and classify physical, chemical, biological, mechanical, ergonomic, and environmental hazards present in different industrial workplaces.
- CO3:** Apply hazard identification techniques, workplace inspection methods, and risk assessment procedures to evaluate industrial safety risks and recommend appropriate control measures.
- CO4:** Demonstrate knowledge of accident causation, accident investigation, reporting procedures, and preventive strategies for minimizing workplace incidents.
- CO5:** Evaluate occupational health hazards, occupational diseases, health surveillance programmes, and the effective use of Personal Protective Equipment (PPE) for worker safety.
- CO6:** Analyze industrial safety management systems, fire prevention techniques, emergency preparedness, evacuation procedures, disaster management planning, first aid, and rescue operations.
- CO7:** Interpret the provisions of industrial safety legislation, including the Factories Act, Occupational Safety, Health and Working Conditions (OSHC) Code, environmental regulations, and industrial safety standards.
- CO8:** Conduct basic industrial safety audits, compliance assessments, and recommend corrective measures for improving workplace safety and environmental compliance.
- CO9:** Assess entrepreneurial opportunities in industrial safety consultancy, environmental compliance auditing, occupational health services, safety training, and industrial risk management.
- CO10:** Develop professional competencies in industrial safety, hazard management, regulatory compliance, emergency response, occupational health, and sustainable industrial practices to enhance employability and entrepreneurship.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	1	1
CO2	3	3	2	2	1	1	3	1	1	1
CO3	3	3	3	3	2	2	3	2	1	1
CO4	3	3	3	2	2	2	3	2	1	2
CO5	3	3	2	2	2	2	3	2	1	2
CO6	3	3	3	3	2	2	3	2	2	3
CO7	3	3	2	2	2	2	3	2	2	2
CO8	3	3	3	2	2	2	3	3	2	3
CO9	2	2	2	1	3	2	2	2	3	3
CO10	3	3	3	2	3	2	3	3	3	3

VALUE ADDED COURSE – II
WASTE ENTREPRENEURSHIP
(Theory)

Semester IV

Code

Credits: 2

COURSE OBJECTIVES

- To introduce students to the concepts of waste management and entrepreneurship based on resource recovery and circular economy principles.
- To provide knowledge on business opportunities arising from waste recycling, reuse and value addition.
- To develop entrepreneurial skills for establishing waste-based enterprises and sustainable livelihood opportunities.
- To familiarize students with waste processing technologies, market potential and business planning.
- To promote innovation and sustainable solutions for waste minimization and environmental management.

UNIT – I: INTRODUCTION TO WASTE ENTREPRENEURSHIP

Concept of waste and resource recovery. Types of waste: municipal solid waste, plastic waste, e-waste, agricultural waste, biomedical waste and industrial waste. Principles of circular economy and sustainable entrepreneurship. Opportunities in waste-based businesses.

UNIT – II: WASTE PROCESSING AND VALUE ADDITION

Waste segregation, collection and processing techniques. Composting, vermicomposting, recycling and upcycling. Conversion of waste into value-added products. Technologies for waste utilization and resource recovery.

UNIT – III: ENTREPRENEURIAL OPPORTUNITIES IN WASTE MANAGEMENT

Business opportunities in recycling industries, organic manure production, plastic recycling, paper recycling, e-waste management and handicrafts from waste materials. Start-up models and success stories in waste entrepreneurship. Green jobs and employment generation.

UNIT – IV: BUSINESS PLANNING AND MARKETING

Basics of entrepreneurship and enterprise development. Preparation of business plans for waste-based enterprises. Financial planning, funding sources and government support schemes. Marketing strategies for recycled and eco-friendly products.

UNIT – V: POLICIES, REGULATIONS AND SUSTAINABLE WASTE ENTERPRISES

Waste management rules and regulations in India. Extended Producer Responsibility (EPR). Environmental compliance and certification. Sustainable business practices, social entrepreneurship and future prospects of waste-based enterprises.

UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)

Start-up India and green entrepreneurship initiatives. Circular economy practices in India. Plastic-free campaigns and waste-to-wealth programmes. Emerging technologies in waste management. Success stories of waste entrepreneurs and innovative recycling enterprises.

REFERENCES

1. Integrated Solid Waste Management, George Tchobanoglous & Frank Kreith (2021), McGraw-Hill.
2. Solid Waste Management: Principles and Practice, Ramesha Chandrappa & Diganta Das (2019), Springer.
3. Waste to Wealth: The Circular Economy Advantage, Peter Lacy & Jakob Rutqvist (2018), Palgrave Macmillan.
4. Entrepreneurship Development, S. S. Khanka (2020), S. Chand Publications.
5. Environmental Entrepreneurship, Richard P. Wells (2019), Routledge.
6. Waste Management and Resource Recovery, M. N. Rao (2021), CBS Publishers.
7. Handbook of Recycling, Ernst Worrell & M. A. Reuter (2022), Elsevier.
8. Green Entrepreneurship and Sustainable Development, Rajeev Roy (2021), Springer.
9. Ministry of Housing and Urban Affairs – Waste Management Guidelines.
10. Central Pollution Control Board (CPCB) Publications.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts of waste management, resource recovery, circular economy, and sustainable entrepreneurship in the context of environmental conservation.
- CO2:** Classify different types of waste, including municipal solid waste, plastic waste, e-waste, agricultural waste, biomedical waste, and industrial waste, and evaluate their resource recovery potential.
- CO3:** Demonstrate knowledge of waste segregation, collection, recycling, composting, vermicomposting, upcycling, and value-addition technologies for sustainable waste management.
- CO4:** Identify entrepreneurial opportunities in waste recycling, organic manure production, plastic recycling, paper recycling, e-waste management, handicrafts, and other waste-based enterprises.
- CO5:** Analyze successful waste entrepreneurship models, green business initiatives, and emerging employment opportunities in the circular economy sector.
- CO6:** Prepare basic business plans for waste-based enterprises, including feasibility assessment, financial planning, funding opportunities, and marketing strategies.
- CO7:** Evaluate government policies, waste management regulations, Extended Producer Responsibility (EPR), environmental compliance, and certification systems relevant to waste-based businesses.
- CO8:** Apply principles of sustainable business management, social entrepreneurship, and circular economy to develop environmentally responsible and economically viable waste enterprises.
- CO9:** Assess emerging technologies, waste-to-wealth initiatives, and innovative recycling approaches for promoting sustainable waste management and green entrepreneurship.
- CO10:** Develop entrepreneurial competencies, innovation skills, leadership qualities, and decision-making abilities for establishing and managing sustainable waste-based enterprises that contribute to environmental protection and livelihood generation.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	1	1	1	2	1	2	1
CO2	3	2	2	2	1	1	2	1	2	1
CO3	3	3	2	2	2	2	3	2	2	1
CO4	3	3	3	2	2	2	3	2	2	3
CO5	2	3	3	2	2	2	3	2	2	3
CO6	2	2	2	1	3	2	3	2	2	3
CO7	3	2	2	2	2	2	3	2	2	2
CO8	3	3	3	2	3	2	3	2	3	3
CO9	3	3	3	2	2	2	3	3	3	2
CO10	3	3	3	2	3	3	3	3	3	3

DISCIPLINE CENTRIC ELECTIVE COURSE – I
BIODIVERSITY AND CONSERVATION

Semester I

Code

(Theory)

Credits: 2

COURSE OBJECTIVES

- To understand the concept, values and significance of biodiversity.
- To provide knowledge on different levels and patterns of biodiversity.
- To familiarize students with threats to biodiversity and conservation challenges.
- To develop understanding of biodiversity conservation strategies and policies.
- To create awareness about sustainable utilization and management of biological resources.

UNIT – I: Concept and Values of Biodiversity

Biodiversity refers to the variety of life forms present on Earth and includes diversity at genetic, species, and ecosystem levels. It plays a vital role in maintaining ecological balance and supporting life-support systems. Biodiversity provides economic, cultural, social, and ethical benefits to human societies. Understanding biodiversity is essential for sustainable development and natural resource management.

UNIT – II: Biogeographical Distribution of Biodiversity

India is one of the world's megadiverse countries with rich biological resources distributed across various ecosystems. The unit explains biogeographical regions, biodiversity hotspots, and the ecological significance of forests, wetlands, grasslands, and marine ecosystems. Special emphasis is given to endemic and endangered species and their conservation importance. Students gain knowledge about global and national biodiversity patterns.

UNIT – III: Threats to Biodiversity

Biodiversity is increasingly threatened by habitat destruction, fragmentation, overexploitation of resources, pollution, invasive species, and climate change. These threats result in species extinction and ecosystem degradation. The unit examines the ecological consequences of biodiversity loss and introduces the IUCN Red List categories and Red Data Book. Students understand the urgency of biodiversity protection and sustainable management.

UNIT – IV: Biodiversity Conservation Approaches

Conservation strategies include both in-situ and ex-situ methods for protecting species and ecosystems. Protected areas such as national parks, wildlife sanctuaries, and biosphere reserves play a major role in conservation. Ex-situ approaches include seed banks, gene banks, botanical gardens, and zoological parks. The unit highlights the significance of integrated conservation measures for preserving biodiversity.

UNIT – V: Biodiversity Policies and Community Participation

The unit introduces international and national initiatives for biodiversity conservation, including the Convention on Biological Diversity and the Biodiversity Act, 2002. It discusses Access and Benefit Sharing (ABS) mechanisms and the role of traditional knowledge in resource conservation. Community participation and sustainable utilization of biological resources are emphasized. Students learn about participatory approaches to biodiversity management.

UNIT – VI: CURRENT CONTOURS (For Continuous Internal Assessment Only)

Global Biodiversity Framework. Biodiversity Conservation Initiatives in India. Ecosystem Restoration Programmes. Citizen Science in Biodiversity Monitoring. Emerging Threats to Biodiversity under Climate Change.

REFERENCES

1. Primack, R.B. (2022). *Essentials of Conservation Biology*. Sinauer Associates.
2. Krishnamurthy, K.V. (2018). *Biodiversity and Conservation*. Oxford University Press.
3. Groom, M.J., Meffe, G.K. & Carroll, C.R. (2021). *Principles of Conservation Biology*. Sinauer Associates.
4. Hunter, M.L. (2019). *Fundamentals of Conservation Biology*. Wiley.
5. Singh, J.S., Singh, S.P. & Gupta, S.R. (2020). *Ecology, Environment and Resource Conservation*. Anamaya Publishers.
6. Biodiversity Act, 2002 – Government of India.
7. <https://www.cbd.int> ; <https://www.iucn.org>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, levels, values, and significance of biodiversity and its role in maintaining ecological balance and sustainable development.
- CO2:** Classify biodiversity at the genetic, species, and ecosystem levels and describe the patterns of biodiversity distribution at global, national, and regional scales.
- CO3:** Identify India's major biogeographical regions, biodiversity hotspots, endemic species, endangered species, and ecologically significant ecosystems.
- CO4:** Analyze the major threats to biodiversity, including habitat destruction, fragmentation, pollution, overexploitation, invasive alien species, and climate change.
- CO5:** Evaluate the ecological, environmental, economic, social, and cultural consequences of biodiversity loss and ecosystem degradation.
- CO6:** Compare and assess in-situ and ex-situ biodiversity conservation strategies, including protected areas, biosphere reserves, botanical gardens, zoological parks, seed banks, and gene banks.
- CO7:** Interpret national and international biodiversity policies, including the Convention on Biological Diversity (CBD), the Biological Diversity Act, 2002, Access and Benefit Sharing (ABS), and related conservation frameworks.
- CO8:** Assess the importance of traditional ecological knowledge, community participation, citizen science, and ecosystem restoration in biodiversity conservation and sustainable resource management.
- CO9:** Evaluate emerging biodiversity conservation challenges, including climate change impacts, biodiversity monitoring, ecosystem restoration initiatives, and global biodiversity frameworks.
- CO10:** Apply biodiversity conservation principles, sustainable resource management practices, and environmental stewardship approaches to promote conservation, ecological restoration, and sustainable development.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	2	1
CO2	3	2	2	2	1	1	2	1	2	1
CO3	3	3	2	2	1	1	3	2	2	1
CO4	3	3	3	2	1	2	3	2	2	1
CO5	3	3	3	2	2	2	3	2	2	2
CO6	3	3	3	2	2	2	3	2	2	2
CO7	3	3	2	2	2	2	3	2	2	2
CO8	3	3	2	2	2	2	3	2	3	2
CO9	3	3	3	2	2	2	3	3	3	2
CO10	3	3	3	2	3	3	3	3	3	3

DISCIPLINE CENTRIC ELECTIVE COURSE – II
NATURAL RESOURCES

Semester I

Code

(Theory)

Credits: 2

COURSE OBJECTIVES

- To understand the classification and importance of natural resources.
- To provide knowledge on sustainable utilization and conservation of natural resources.
- To familiarize students with resource management practices and environmental challenges.
- To understand resource depletion and conservation strategies.
- To promote sustainable resource stewardship.

UNIT – I: Introduction to Natural Resources

Natural resources are materials and energy sources obtained from nature that support human survival and development. This unit explains the classification of resources into renewable and non-renewable categories. It discusses resource distribution, utilization patterns, and their significance for economic growth. The relationship between natural resources and sustainable development is also explored.

UNIT – II: Forest Resources

Forests are valuable renewable resources that provide ecological, economic, and social benefits. The unit covers different forest types, their utilization, and their role in maintaining environmental stability. Causes and consequences of deforestation are discussed along with forest conservation measures. Community forestry, agroforestry, and social forestry approaches are highlighted.

UNIT – III: Water Resources

Water is a critical natural resource essential for all forms of life and economic activities. This unit examines surface and groundwater resources, causes of water scarcity, and challenges in water management. Various conservation methods, including rainwater harvesting and watershed management, are discussed. Sustainable water use practices are emphasized for long-term resource security.

UNIT – IV: Land and Mineral Resources

Land and minerals form the foundation of agricultural and industrial development. The unit addresses issues such as soil erosion, land degradation, and desertification resulting from unsustainable practices. It also discusses mineral extraction, environmental impacts of mining, and sustainable mining techniques. Land reclamation and restoration measures are highlighted for resource conservation.

UNIT – V: Energy and Resource Management

Efficient management of natural resources is essential for environmental sustainability and economic development. This unit focuses on energy resources, conservation strategies, and environmental impacts associated with resource exploitation. Sustainable resource planning and management techniques are discussed. Students learn approaches to minimize resource depletion while meeting societal needs.

UNIT – VI: CURRENT CONTOURS*(For Continuous Internal Assessment Only)*

Water Security, Resource Conflicts, Circular Economy, Natural Resource Accounting and Climate Change Impacts on Resources.

REFERENCES

1. Singh, J.S. et al. (2020). Ecology, Environment and Resource Conservation.
2. Cunningham & Cunningham (2020). Principles of Environmental Science.
3. Sharma, P.D. (2021). Ecology and Environment.

4. Miller & Spoolman (2023). Environmental Science.
5. Bharucha, E. (2021). Environmental Studies.
6. <https://moefcc.gov.in>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concept, classification, distribution, and significance of natural resources and their role in environmental sustainability and socio-economic development.
- CO2:** Classify natural resources into renewable and non-renewable categories and evaluate their patterns of utilization, availability, and conservation.
- CO3:** Analyze the ecological, economic, and social importance of forest resources, causes and impacts of deforestation, and the role of community forestry, agroforestry, and social forestry in sustainable forest management.
- CO4:** Assess the importance of water resources, identify causes of water scarcity, and evaluate sustainable water conservation practices, including rainwater harvesting and watershed management.
- CO5:** Examine issues related to land degradation, soil erosion, desertification, mineral resource extraction, and the environmental impacts of mining activities.
- CO6:** Evaluate sustainable land reclamation, ecological restoration, and environmentally responsible mining and land management practices.
- CO7:** Analyze different conventional and non-conventional energy resources, resource conservation techniques, and sustainable energy management strategies.
- CO8:** Interpret the principles of sustainable natural resource management, circular economy, natural resource accounting, and resource efficiency for long-term environmental sustainability.
- CO9:** Assess emerging challenges affecting natural resources, including climate change, water security, resource conflicts, and environmental degradation, and recommend appropriate conservation strategies.
- CO10:** Apply the principles of sustainable natural resource management and environmental stewardship to promote responsible resource utilization, conservation, and sustainable development at local, regional, and global levels.

CO-PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	2	1
CO2	3	2	2	2	1	1	2	1	2	1
CO3	3	3	3	2	1	2	3	2	2	1
CO4	3	3	3	2	2	2	3	2	2	1
CO5	3	3	3	2	2	2	3	2	2	2
CO6	3	3	2	2	2	2	3	2	2	2
CO7	3	3	2	2	2	2	3	2	2	2
CO8	3	3	3	2	2	2	3	2	3	2
CO9	3	3	3	2	2	2	3	3	3	2
CO10	3	3	3	2	3	3	3	3	3	3

DISCIPLINE CENTRIC ELECTIVE COURSE – III
ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY

Semester II

Code

(Theory)

Credits: 2

COURSE OBJECTIVES

- To understand the role of microorganisms in environmental processes.
- To familiarize students with microbial applications in environmental management.
- To provide knowledge on environmental biotechnology.
- To understand bioremediation and waste treatment technologies.
- To explore modern microbial tools for environmental sustainability.

UNIT – I: Introduction to Environmental Microbiology

Environmental microbiology studies microorganisms and their interactions with the environment. The unit introduces microbial diversity and ecological roles in soil, water, and air ecosystems. It explains how microorganisms influence nutrient cycling and ecosystem stability. Students gain an understanding of microbial ecology and environmental functions.

UNIT – II: Microbial Processes in Ecosystems

Microorganisms play a key role in maintaining biogeochemical cycles and ecosystem productivity. This unit examines microbial involvement in carbon, nitrogen, sulphur, and phosphorus cycling. It highlights the significance of microbial interactions in nutrient transformation and ecosystem functioning. The importance of microbes in sustaining environmental health is emphasized.

UNIT – III: Environmental Biotechnology

Environmental biotechnology applies biological systems and organisms to solve environmental problems. The unit introduces genetic engineering, recombinant DNA technology, biofertilizers, and biopesticides. It explains how biotechnology enhances agricultural productivity and environmental sustainability. Students learn the principles and practical applications of environmental biotechnology.

UNIT – IV: Bioremediation and Waste Management

Bioremediation utilizes microorganisms and plants to remove environmental pollutants from contaminated sites. The unit discusses microbial degradation of pollutants and phytoremediation techniques. Applications of microorganisms in wastewater treatment and solid waste management are explained. Students understand eco-friendly technologies for pollution control and environmental restoration.

UNIT – V: Industrial and Environmental Applications

Biotechnology has extensive applications in environmental monitoring and sustainable development. This unit explores biosensors, bioenergy production, and industrial applications of microorganisms. Emerging biotechnological innovations for environmental management are discussed. The role of biotechnology in addressing future environmental challenges is emphasized.

UNIT – VI: CURRENT CONTOURS*(For Continuous Internal Assessment Only)*

Microbial Solutions for Plastic Degradation, Biofuels, Synthetic Biology and Environmental Biotechnology Innovations.

REFERENCES

1. Atlas & Bartha (2019). Microbial Ecology.
2. Maier et al. (2020). Environmental Microbiology.
3. Rittmann & McCarty (2020). Environmental Biotechnology.

4. Pelczar et al. (2019). Microbiology.
5. Alexander (2018). Biodegradation and Bioremediation.
6. <https://www.asm.org>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, scope, and significance of environmental microbiology and the ecological roles of microorganisms in maintaining environmental quality.
- CO2:** Identify the diversity of microorganisms and describe their distribution, characteristics, and functions in soil, water, air, and other environmental ecosystems.
- CO3:** Analyze the role of microorganisms in biogeochemical cycles, including carbon, nitrogen, sulphur, and phosphorus cycles, and their contribution to ecosystem productivity and stability.
- CO4:** Describe the principles and applications of environmental biotechnology, including genetic engineering, recombinant DNA technology, biofertilizers, and biopesticides for sustainable environmental management.
- CO5:** Evaluate the role of microorganisms in bioremediation, phytoremediation, biodegradation, wastewater treatment, and solid waste management for pollution control and ecosystem restoration.
- CO6:** Assess the applications of microbial technologies in environmental monitoring, biosensors, bioenergy production, and industrial biotechnology for sustainable development.
- CO7:** Analyze emerging environmental biotechnological innovations, including microbial degradation of plastics, synthetic biology, biofuels, and other green technologies for environmental protection.
- CO8:** Interpret the environmental, ecological, and socio-economic benefits of microbial processes and biotechnology in addressing contemporary environmental challenges.
- CO9:** Apply microbiological and biotechnological principles to develop sustainable solutions for environmental conservation, pollution prevention, waste management, and natural resource management.
- CO10:** Demonstrate scientific knowledge and problem-solving skills by evaluating modern microbial technologies and environmental biotechnology applications for sustainable environmental management, research, and entrepreneurship.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	2	1
CO2	3	2	2	3	1	1	2	2	1	1
CO3	3	3	3	3	1	2	3	2	1	1
CO4	3	3	3	3	2	2	3	2	1	1
CO5	3	3	3	3	2	2	3	3	2	2
CO6	3	3	2	3	2	2	3	3	2	2
CO7	3	3	3	2	2	2	3	3	2	2
CO8	3	3	3	2	2	2	3	2	2	2
CO9	3	3	3	3	2	2	3	3	2	2
CO10	3	3	3	3	3	2	3	3	3	3

DISCIPLINE CENTRIC ELECTIVE COURSE – IV
ENERGY RESOURCES

Semester II

Code

(Theory)

Credits: 2

COURSE OBJECTIVES

- To understand different energy resources and their significance.
- To provide knowledge on conventional and renewable energy sources.
- To familiarize students with energy conservation practices.
- To understand environmental impacts of energy production.
- To promote sustainable energy utilization.

UNIT – I: Energy Concepts and Consumption

Energy is fundamental for economic development and societal progress. This unit introduces different forms and sources of energy, patterns of energy consumption, and factors influencing energy demand and supply. It also examines global and Indian energy scenarios. Students gain an understanding of energy challenges and opportunities.

UNIT – II: Conventional Energy Resources

Conventional energy sources such as coal, petroleum, natural gas, and nuclear energy have been the primary drivers of industrial development. The unit discusses their availability, utilization, and environmental impacts. Issues related to resource depletion and pollution are examined. Students learn the advantages and limitations of conventional energy systems.

UNIT – III: Renewable Energy Resources

Renewable energy resources provide sustainable alternatives to fossil fuels. This unit covers solar, wind, hydropower, biomass, geothermal, and ocean energy technologies. Their applications, benefits, and limitations are discussed. Emphasis is placed on the role of renewable energy in achieving energy security and environmental sustainability.

UNIT – IV: Energy Conservation and Efficiency

Energy conservation is an essential strategy for reducing environmental impacts and improving resource efficiency. The unit examines energy-efficient technologies, green buildings, sustainable transportation, and low-carbon development approaches. It highlights methods to minimize energy wastage in various sectors. Students understand the importance of efficient energy utilization.

UNIT – V: Sustainable Energy Management

This unit focuses on energy policies, planning, and management strategies for sustainable development. It explores future energy technologies and their role in climate change mitigation. National and international energy initiatives are discussed. Students gain insights into transitioning towards sustainable and resilient energy systems.

UNIT – VI: CURRENT CONTOURS*(For Continuous Internal Assessment Only)*

Green Hydrogen, Net-Zero Energy Systems, Smart Grids and Renewable Energy Missions in India.

REFERENCES

1. Boyle, G. (2020). Renewable Energy.
2. Twidell & Weir (2021). Renewable Energy Resources.
3. Rai, G.D. (2020). Non-Conventional Energy Sources.
4. Miller & Spoolman (2023). Environmental Science.
5. Sharma, P.D. (2021). Environmental Science.
6. <https://mnre.gov.in>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the fundamental concepts of energy, various forms of energy, patterns of energy consumption, and the significance of energy resources in economic development and environmental sustainability.
- CO2:** Classify and compare conventional and non-conventional (renewable) energy resources based on their availability, efficiency, environmental impacts, and sustainability.
- CO3:** Analyze the characteristics, applications, advantages, limitations, and environmental implications of conventional energy sources such as coal, petroleum, natural gas, and nuclear energy.
- CO4:** Evaluate renewable energy technologies including solar, wind, hydropower, biomass, geothermal, and ocean energy, and assess their role in achieving energy security and sustainable development.
- CO5:** Assess the environmental impacts of energy production and utilization, including greenhouse gas emissions, air pollution, resource depletion, and climate change.
- CO6:** Apply principles of energy conservation, energy efficiency, green buildings, sustainable transportation, and low-carbon technologies to minimize energy consumption and environmental degradation.
- CO7:** Interpret national and international energy policies, renewable energy programmes, and sustainable energy management strategies for achieving long-term energy security.
- CO8:** Analyze emerging energy technologies such as green hydrogen, smart grids, net-zero energy systems, and renewable energy missions, and evaluate their potential in climate change mitigation.
- CO9:** Evaluate sustainable energy planning, resource management, and policy interventions for promoting clean energy transitions and environmental sustainability.
- CO10:** Develop scientifically sound and environmentally responsible approaches for sustainable energy utilization, energy management, climate action, and resource conservation in support of sustainable development goals.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	2	1
CO2	3	3	2	2	1	1	2	1	2	1
CO3	3	3	3	2	1	2	3	2	2	1
CO4	3	3	3	2	2	2	3	2	2	2
CO5	3	3	3	2	2	2	3	2	2	2
CO6	3	3	3	2	2	2	3	2	2	2
CO7	3	3	2	2	2	2	3	2	2	2
CO8	3	3	3	2	2	2	3	3	3	2
CO9	3	3	3	2	2	2	3	3	3	2
CO10	3	3	3	2	3	3	3	3	3	3

DISCIPLINE CENTRIC ELECTIVE COURSE – V
INDUSTRIAL SAFETY AND MANAGEMENT

Semester III

Code

(Theory)

Credits: 2

COURSE OBJECTIVES

- To understand industrial safety principles.
- To familiarize students with hazard identification and risk management.
- To develop awareness on occupational health and safety.
- To understand industrial safety regulations.
- To enhance employability in safety management sectors.

UNIT – I: Fundamentals of Industrial Safety

Industrial safety focuses on protecting workers, equipment, and the environment from workplace hazards. This unit introduces the concepts, importance, and scope of industrial safety in various industries. Occupational health and safety practices are discussed along with the development of a positive safety culture. Students gain an understanding of safe work practices and accident prevention measures.

UNIT – II: Industrial Hazards and Risk Assessment

Industries are exposed to various hazards, including physical, chemical, biological, and mechanical risks. This unit explains the identification, evaluation, and control of workplace hazards. Risk assessment techniques and hazard analysis methods are discussed to minimize accidents and injuries. Students learn systematic approaches to workplace safety management.

UNIT – III: Accident Prevention and Emergency Response

Preventing workplace accidents is essential for ensuring employee well-being and organizational productivity. This unit covers accident causation, prevention strategies, safety training, and the use of personal protective equipment (PPE). Emergency response procedures and first-aid measures are also discussed. Students develop skills necessary for handling workplace emergencies effectively.

UNIT – IV: Safety Management Systems

Safety management systems provide structured approaches to maintaining workplace safety. The unit focuses on industrial safety management practices, fire safety measures, disaster management, and emergency preparedness plans. It highlights the importance of planning and monitoring safety performance. Students learn methods for creating safer and more resilient workplaces.

UNIT – V: Safety Regulations and Compliance

Industrial safety is governed by various laws, standards, and regulatory frameworks. This unit discusses safety auditing, compliance monitoring, environmental health and safety (EHS) management, and legal responsibilities. It emphasizes the importance of regulatory compliance in reducing workplace risks. Students gain knowledge of industrial safety governance and best practices.

UNIT – VI: CURRENT CONTOURS*(For Continuous Internal Assessment Only)*

Industry 4.0 Safety Systems, Smart Monitoring Devices and Modern Occupational Safety Challenges.

REFERENCES

1. Deshmukh (2021). Industrial Safety Management.
2. Reese (2022). Occupational Health and Safety.
3. Jain & Rao (2020). Industrial Safety.

4. Petersen (2019). Safety Management.
5. Gupta (2021). Industrial Safety and Environment.
6. <https://dgfasli.gov.in>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, principles, scope, and significance of industrial safety, occupational health, and safety culture in industrial organizations.
- CO2:** Identify and classify various industrial hazards, including physical, chemical, biological, mechanical, electrical, and ergonomic hazards encountered in workplaces.
- CO3:** Apply hazard identification techniques, workplace inspections, and risk assessment methods to evaluate industrial safety risks and recommend appropriate control measures.
- CO4:** Analyze the causes of industrial accidents and apply accident prevention strategies, safety training programmes, and Personal Protective Equipment (PPE) for ensuring workplace safety.
- CO5:** Evaluate industrial safety management systems, fire prevention methods, emergency preparedness plans, disaster management strategies, and first-aid procedures for effective emergency response.
- CO6:** Interpret industrial safety legislation, occupational health regulations, Environmental Health and Safety (EHS) standards, and compliance requirements applicable to industrial operations.
- CO7:** Assess safety auditing procedures, compliance monitoring systems, and industrial safety performance indicators for improving workplace safety and organizational efficiency.
- CO8:** Evaluate the applications of Industry 4.0 technologies, smart monitoring systems, digital safety devices, and emerging technologies in modern industrial safety management.
- CO9:** Apply industrial safety principles, occupational health practices, and environmental management strategies to promote safe, healthy, and sustainable industrial workplaces.
- CO10:** Develop professional competencies in industrial safety management, hazard control, regulatory compliance, leadership, and decision-making for careers in occupational safety, environmental management, and industrial consultancy.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	1	1
CO2	3	3	2	2	1	1	3	1	1	1
CO3	3	3	3	3	2	2	3	2	1	1
CO4	3	3	3	2	2	2	3	2	1	2
CO5	3	3	3	3	2	2	3	2	2	2
CO6	3	3	2	2	2	2	3	2	2	2
CO7	3	3	3	2	2	2	3	3	2	2
CO8	3	3	3	2	2	2	3	3	2	2
CO9	3	3	3	2	2	2	3	2	2	2
CO10	3	3	3	2	3	2	3	3	3	3

DISCIPLINE CENTRIC ELECTIVE COURSE – VI
ECOTOURISM

Semester III

Code

(Theory)

Credits: 2

COURSE OBJECTIVES

- To understand the principles of ecotourism.
- To familiarize students with sustainable tourism practices.
- To understand biodiversity conservation through ecotourism.
- To explore ecotourism opportunities and challenges.
- To promote community participation in ecotourism.

UNIT – I: Principles of Ecotourism

Ecotourism is a responsible form of tourism that promotes environmental conservation and community well-being. This unit introduces the concepts, principles, scope, and ethics of ecotourism. It explains the relationship between sustainable tourism and nature-based tourism. Students gain an understanding of how tourism can contribute to conservation and sustainable development.

UNIT – II: Ecotourism Resources

Natural ecosystems such as forests, wildlife sanctuaries, national parks, wetlands, and coastal regions serve as major ecotourism destinations. This unit explores the ecological and economic importance of these resources. It highlights biodiversity conservation through tourism activities. Students learn about the sustainable utilization of natural attractions.

UNIT – III: Ecotourism Planning and Management

Effective planning and management are essential for sustainable ecotourism development. This unit focuses on visitor management, interpretation services, environmental education, and tourism infrastructure. It discusses strategies to minimize ecological impacts while enhancing visitor experiences. Students gain knowledge of sustainable tourism management practices.

UNIT – IV: Community-Based Ecotourism

Local communities play a vital role in the success of ecotourism initiatives. This unit examines community participation, livelihood opportunities, and the socio-economic benefits of ecotourism. It emphasizes inclusive development and conservation-oriented tourism practices. Students understand the importance of empowering local stakeholders in tourism planning.

UNIT – V: Ecotourism Policies and Best Practices

This unit discusses ecotourism policies, environmental impacts of tourism activities, and sustainable management approaches. It examines successful ecotourism models in India and Tamil Nadu. Best practices for balancing conservation and tourism development are highlighted. Students learn policy frameworks that support responsible tourism.

UNIT – VI: CURRENT CONTOURS*(For Continuous Internal Assessment Only)*

Responsible Tourism, Green Tourism Certification and Digital Ecotourism Platforms.

REFERENCES

1. Fennell (2020). Ecotourism.
2. Weaver (2019). Ecotourism Management.
3. Honey (2018). Ecotourism and Sustainable Development.
4. Newsome et al. (2020). Natural Area Tourism.
5. Wearing & Neil (2021). Ecotourism.
6. <https://wii.gov.in>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, principles, scope, ethics, and significance of ecotourism and its role in environmental conservation and sustainable development.
- CO2:** Identify and evaluate various ecotourism resources, including forests, wildlife sanctuaries, national parks, wetlands, coastal ecosystems, and other biodiversity-rich landscapes.
- CO3:** Analyze the ecological, economic, cultural, and social benefits of ecotourism and its contribution to biodiversity conservation and sustainable livelihoods.
- CO4:** Apply principles of ecotourism planning, visitor management, environmental interpretation, tourism infrastructure development, and sustainable destination management.
- CO5:** Assess the environmental, socio-economic, and cultural impacts of tourism activities and recommend appropriate mitigation measures for sustainable ecotourism development.
- CO6:** Evaluate the role of community participation, indigenous knowledge, local entrepreneurship, and stakeholder engagement in community-based ecotourism initiatives.
- CO7:** Interpret national and state ecotourism policies, environmental regulations, green tourism certification systems, and best management practices for responsible tourism.
- CO8:** Examine successful ecotourism models, conservation programmes, and sustainable tourism initiatives in India, Tamil Nadu, and other ecologically significant regions.
- CO9:** Analyze emerging trends in ecotourism, including responsible tourism, digital ecotourism platforms, eco-certification, nature interpretation, and sustainable tourism technologies.
- CO10:** Develop environmentally responsible tourism strategies that integrate biodiversity conservation, sustainable resource management, community welfare, and ecotourism entrepreneurship.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	1	1	1	2	1	2	1
CO2	3	2	2	2	1	1	2	1	2	1
CO3	3	3	3	2	1	2	3	2	2	2
CO4	3	3	3	2	2	2	3	2	2	2
CO5	3	3	3	2	2	2	3	2	2	2
CO6	3	3	2	2	2	2	3	2	3	3
CO7	3	3	2	2	2	2	3	2	2	2
CO8	3	3	3	2	2	2	3	2	2	2
CO9	3	3	3	2	2	2	3	2	3	2
CO10	3	3	3	2	3	3	3	3	3	3

	DISCIPLINE CENTRIC ELECTIVE COURSE – VII	Semester IV
	STATISTICS FOR ENVIRONMENTAL SCIENCE	
Code	(Theory)	Credits: 2

COURSE OBJECTIVES

- To introduce statistical methods used in environmental studies.
- To develop skills in data analysis and interpretation.
- To understand sampling techniques and hypothesis testing.
- To familiarize students with environmental data management.
- To enhance research and analytical skills.

UNIT – I: Basics of Statistics

Statistics provides scientific methods for collecting, organizing, analyzing, and interpreting data. This unit introduces different types of data, measures of central tendency, and measures of dispersion. Various methods of data presentation are discussed for effective communication of information. Students develop fundamental skills for environmental data analysis.

UNIT – II: Sampling and Probability

Sampling techniques are important for obtaining representative environmental data. This unit explains probability concepts, sampling methods, frequency distributions, and normal distribution. Applications of probability in environmental studies are emphasized. Students learn methods for designing reliable environmental investigations.

UNIT – III: Hypothesis Testing

Hypothesis testing is a statistical tool used to evaluate scientific assumptions and research findings. This unit introduces t-tests, Chi-square tests, and Analysis of Variance (ANOVA). The significance of statistical testing in environmental research is discussed. Students gain practical knowledge of testing relationships and differences in environmental datasets.

UNIT – IV: Correlation and Regression Analysis

Environmental variables often exhibit relationships that require quantitative analysis. This unit explains correlation and regression techniques used to study environmental data. Trend analysis and interpretation of statistical relationships are also covered. Students learn how statistical models support environmental decision-making and prediction.

UNIT – V: Statistical Software and Applications

Modern environmental research relies heavily on statistical software for data analysis and interpretation. This unit introduces software tools and their applications in environmental monitoring and research. Students learn methods for managing, analyzing, and presenting environmental datasets. The role of statistics in evidence-based environmental management is emphasized.

UNIT – VI: CURRENT CONTOURS(For Continuous Internal Assessment Only)

Big Data Analytics, Environmental Modelling and Data Visualization Techniques.

REFERENCES

1. Zar (2019). Biostatistical Analysis.
2. Kothari & Garg (2019). Research Methodology.
3. Gupta, S.P. (2020). Statistical Methods.

4. Daniel (2020). Biostatistics.
5. Sokal & Rohlf (2018). Biometry.
6. <https://www.r-project.org>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the fundamental concepts of statistics, including types of data, measures of central tendency, measures of dispersion, and graphical presentation techniques used in environmental studies.
- CO2:** Apply probability concepts, sampling techniques, frequency distributions, and normal distribution for designing and conducting reliable environmental investigations.
- CO3:** Analyze environmental datasets using appropriate statistical methods and interpret descriptive statistical measures for scientific decision-making.
- CO4:** Apply hypothesis testing techniques, including t-tests, Chi-square tests, and Analysis of Variance (ANOVA), to evaluate environmental research questions and scientific hypotheses.
- CO5:** Evaluate relationships among environmental variables using correlation, regression, and trend analysis techniques for environmental prediction and assessment.
- CO6:** Utilize statistical software and computational tools for environmental data management, statistical analysis, visualization, and interpretation.
- CO7:** Interpret statistical outputs and communicate environmental research findings using appropriate tables, graphs, charts, and scientific reports.
- CO8:** Analyze environmental monitoring data using statistical methods to support evidence-based environmental management and policy formulation.
- CO9:** Assess emerging applications of statistics, including big data analytics, environmental modelling, and data visualization techniques for solving environmental problems.
- CO10:** Apply statistical reasoning, quantitative analysis, and data interpretation skills in environmental research, consultancy, environmental impact assessment, and scientific decision-making.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	2	1
CO2	3	3	2	3	1	1	3	2	1	1
CO3	3	3	3	3	2	2	3	2	1	1
CO4	3	3	3	3	2	2	3	3	1	1
CO5	3	3	3	3	2	2	3	3	2	1
CO6	3	3	2	3	2	2	3	3	2	1
CO7	3	3	3	2	2	2	3	2	2	2
CO8	3	3	3	3	2	2	3	3	2	2
CO9	3	3	3	2	2	2	3	3	3	2
CO10	3	3	3	3	3	2	3	3	3	2

DISCIPLINE CENTRIC ELECTIVE COURSE – VIII

**Semester
IV**

ENVIRONMENTAL INFORMATICS

Code

(Theory)

Credits: 2

COURSE OBJECTIVES

- To introduce information technology applications in environmental sciences.
- To familiarize students with environmental databases and information systems.
- To understand digital tools used in environmental monitoring and management.
- To develop skills in environmental data handling and analysis.
- To explore emerging technologies for environmental decision-making.

UNIT – I: Introduction to Environmental Informatics

Environmental informatics integrates information technology with environmental science for efficient data management and decision-making. This unit introduces environmental information systems, databases, and data management concepts. The importance of digital information in environmental monitoring is discussed. Students gain foundational knowledge of environmental data systems.

UNIT – II: Computer Applications in Environmental Science

Computers play a crucial role in collecting, storing, retrieving, and processing environmental information. This unit examines environmental information networks and data management techniques. Various software applications used in environmental studies are introduced. Students learn the significance of information technology in environmental problem-solving.

UNIT – III: GIS, Remote Sensing and Spatial Databases

Geospatial technologies provide powerful tools for environmental analysis and resource management. This unit covers Geographic Information Systems (GIS), Remote Sensing, spatial databases, and environmental modelling. Applications in land use planning, resource assessment, and environmental monitoring are discussed. Students gain practical understanding of spatial data analysis techniques.

UNIT – IV: Digital Technologies for Environmental Monitoring

Advanced digital technologies have transformed environmental monitoring and management. This unit introduces sensors, Internet of Things (IoT), cloud computing, and web-based environmental information systems. Their applications in real-time environmental monitoring are highlighted. Students learn how digital innovations improve environmental data collection and analysis.

UNIT – V: Artificial Intelligence and Environmental Management

Artificial Intelligence (AI), Machine Learning, and Big Data analytics are increasingly used in environmental decision-making. This unit explores their applications in environmental modelling, resource management, and sustainability planning. Environmental communication and digital reporting tools are also discussed. Students understand the potential of emerging technologies in addressing complex environmental challenges.

UNIT – VI: CURRENT CONTOURS*(For Continuous Internal Assessment Only)*

Smart Environmental Monitoring, Citizen Science Platforms, Environmental Apps and AI-Based Environmental Analytics.

REFERENCES

1. Goodchild et al. (2021). GIS and Environmental Modelling.
2. Longley et al. (2023). Geographic Information Systems and Science.
3. Burrough & McDonnell (2019). Principles of GIS.
4. Jensen (2018). Remote Sensing of the Environment.

5. Roy, P.S. (2021). Geoinformatics for Environmental Management.
6. <https://www.isro.gov.in>

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, scope, and significance of Environmental Informatics and the role of information technology in environmental management and sustainable development.
- CO2:** Demonstrate knowledge of environmental databases, environmental information systems, and digital data management techniques used for environmental monitoring and research.
- CO3:** Apply computer applications, environmental information networks, database management systems, and software tools for the collection, storage, retrieval, processing, and analysis of environmental data.
- CO4:** Utilize Geographic Information Systems (GIS), Remote Sensing, spatial databases, and environmental modelling techniques for environmental assessment, resource management, and decision-making.
- CO5:** Evaluate the applications of sensors, Internet of Things (IoT), cloud computing, and web-based environmental information systems in real-time environmental monitoring and management.
- CO6:** Analyze the role of Artificial Intelligence (AI), Machine Learning (ML), and Big Data analytics in environmental modelling, natural resource management, climate studies, and sustainability planning.
- CO7:** Interpret environmental datasets using digital tools and geospatial technologies to support evidence-based environmental management and policy formulation.
- CO8:** Assess emerging digital technologies, smart environmental monitoring systems, citizen science platforms, environmental mobile applications, and AI-based environmental analytics for addressing environmental challenges.
- CO9:** Apply environmental informatics tools for environmental communication, digital reporting, environmental monitoring, and sustainable resource management.
- CO10:** Develop professional competencies in environmental data management, digital technologies, geospatial analysis, environmental decision support systems, and emerging informatics applications for research, consultancy, and environmental governance.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	2	1
CO2	3	2	2	3	2	1	2	2	1	1
CO3	3	3	3	3	2	2	3	2	1	1
CO4	3	3	3	3	2	2	3	3	2	2
CO5	3	3	2	3	2	2	3	3	2	2
CO6	3	3	3	3	2	2	3	3	2	2
CO7	3	3	3	3	2	2	3	3	2	2
CO8	3	3	3	2	2	2	3	3	3	2
CO9	3	3	3	2	2	2	3	2	3	2
CO10	3	3	3	3	3	2	3	3	3	3

GENERIC ELECTIVE COURSE – 1
GLOBAL ENVIRONMENTAL ISSUES
(Theory)

Semester I

Code

Credits: 3

COURSE OBJECTIVES

- To provide an understanding of major global environmental issues and their causes.
- To familiarize students with environmental challenges affecting ecosystems and society.
- To understand the relationship between human activities and environmental degradation.
- To create awareness about international efforts for environmental protection.
- To develop informed perspectives on environmental sustainability.

UNIT – I: INTRODUCTION TO GLOBAL ENVIRONMENTAL ISSUES

Concept and scope of global environmental issues. Human population growth, urbanization, industrialization and technological development as drivers of environmental change. Human-environment interactions and their consequences on natural systems. Global environmental concerns and the need for sustainable resource management. Overview of major environmental challenges facing the world.

UNIT – II: CLIMATE CHANGE AND GLOBAL WARMING

Climate change and global warming: concepts, causes and scientific basis. Greenhouse gases and the greenhouse effect. Impacts of climate change on biodiversity, agriculture, water resources and human health. Extreme weather events, sea-level rise and climate-induced disasters. Climate mitigation and adaptation strategies at global and regional levels.

UNIT – III: BIODIVERSITY LOSS AND ECOSYSTEM DEGRADATION

Biodiversity and ecosystem services. Causes of biodiversity loss including habitat destruction, invasive species, overexploitation and pollution. Species extinction and ecosystem degradation. Conservation strategies such as protected areas, habitat restoration and community participation. International efforts for biodiversity conservation.

UNIT – IV: ENVIRONMENTAL POLLUTION AND RESOURCE DEPLETION

Air, water, soil and marine pollution: sources, impacts and control measures. Plastic pollution and hazardous waste issues. Resource depletion due to unsustainable extraction and consumption patterns. Environmental health concerns arising from pollution. Strategies for pollution prevention and sustainable resource utilization.

UNIT – V: GLOBAL ENVIRONMENTAL GOVERNANCE AND SUSTAINABLE FUTURES

International environmental agreements and conventions. Sustainable Development Goals (SDGs) and environmental governance. Green economy, circular economy and sustainable lifestyles. Role of governments, industries, NGOs and citizens in environmental protection. Future challenges and opportunities for achieving environmental sustainability.

UNIT – VI: CURRENT CONTOURS *(For Continuous Internal Assessment Only)*

Recent global climate reports and environmental assessments. Biodiversity conservation initiatives and ecosystem restoration programmes. Emerging environmental concerns such as microplastics and electronic waste. International environmental negotiations and climate commitments. Environmental issues frequently discussed in competitive examinations.

REFERENCES

1. Miller, G.T. & Spoolman, S.E. (2023). *Environmental Science*. Cengage Learning.
2. Cunningham, W.P. & Cunningham, M.A. (2020). *Principles of Environmental Science*. McGraw-Hill.

3. Botkin, D.B. & Keller, E.A. (2019). *Environmental Science: Earth as a Living Planet*. Wiley.
4. Bharucha, E. (2021). *Environmental Studies*. Universities Press.
5. UNEP. *Global Environment Outlook Reports*.
6. IPCC. *Assessment Reports*.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

CO1: Explain the concepts, causes, scope, and significance of major global environmental issues and their implications for sustainable development.

CO2: Describe the scientific basis, causes, and impacts of climate change, global warming, greenhouse gases, and extreme weather events on natural and human systems.

CO3: Analyze the causes and consequences of biodiversity loss, ecosystem degradation, habitat destruction, invasive species, and species extinction, and evaluate appropriate conservation measures.

CO4: Assess the sources, impacts, and control measures of air, water, soil, marine, plastic, and hazardous waste pollution, along with issues related to resource depletion and environmental health.

CO5: Evaluate international environmental agreements, conventions, Sustainable Development Goals (SDGs), and global environmental governance mechanisms for addressing environmental challenges.

CO6: Analyze the roles of governments, industries, non-governmental organizations, local communities, and citizens in promoting environmental protection and sustainable resource management.

CO7: Apply concepts of green economy, circular economy, sustainable lifestyles, and resource conservation for addressing global environmental issues.

CO8: Assess emerging global environmental challenges, including climate change, microplastics, electronic waste, ecosystem restoration, and international climate commitments.

CO9: Interpret environmental information, global assessment reports, and policy initiatives to support informed environmental decision-making and environmental awareness.

CO10: Develop environmentally responsible attitudes and apply environmental knowledge to sustainable development, public awareness, competitive examinations, and responsible citizenship.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	2	1
CO2	3	3	2	2	1	2	3	2	2	1
CO3	3	3	3	2	2	2	3	2	2	2
CO4	3	3	3	2	2	2	3	2	2	2
CO5	3	3	3	2	2	2	3	2	2	2
CO6	3	3	2	2	2	2	3	2	2	3
CO7	3	3	3	2	2	2	3	2	3	2
CO8	3	3	3	2	2	2	3	3	3	2
CO9	3	3	3	2	2	2	3	3	3	2
CO10	3	3	3	2	3	3	3	2	3	3

GENERIC ELECTIVE COURSE – 2
RENEWABLE ENERGY RESOURCES
(Theory)

Semester I

Code

Credits: 3

COURSE OBJECTIVES

- To introduce various renewable energy resources and their significance in sustainable development.
- To understand the principles and applications of renewable energy technologies.
- To familiarize students with environmental and economic benefits of renewable energy.
- To evaluate the role of renewable energy in climate change mitigation.
- To promote awareness of sustainable energy utilization and conservation.

UNIT – I: ENERGY RESOURCES AND SUSTAINABILITY

Energy: concept, forms and importance in human development. Global and Indian energy demand and consumption patterns. Conventional and non-conventional energy resources. Energy security and sustainability challenges. Environmental impacts associated with energy production and utilization.

UNIT – II: SOLAR AND WIND ENERGY

Solar energy resources and solar radiation. Solar photovoltaic and solar thermal technologies. Wind energy generation, wind turbines and site selection. Applications of solar and wind energy in domestic, agricultural and industrial sectors. Advantages, limitations and future prospects.

UNIT – III: HYDROPOWER, BIOMASS AND BIOENERGY

Hydropower generation and classification of hydroelectric projects. Biomass resources and biomass conversion technologies. Biogas production, biofuels and biomass gasification. Waste-to-energy technologies and their environmental significance. Economic feasibility and sustainability aspects.

UNIT – IV: EMERGING RENEWABLE ENERGY TECHNOLOGIES

Geothermal energy, tidal energy, wave energy and ocean thermal energy conversion. Hydrogen energy and fuel cells. Hybrid renewable energy systems. Energy storage technologies and smart grids. Challenges in large-scale adoption of renewable energy systems.

UNIT – V: ENERGY POLICY AND FUTURE ENERGY SCENARIOS

National and international renewable energy policies. Renewable energy programmes in India. Energy efficiency and conservation measures. Role of renewable energy in achieving carbon neutrality and climate goals. Future trends and innovations in sustainable energy systems.

UNIT – VI: CURRENT CONTOURS*(For Continuous Internal Assessment Only)*

Green Hydrogen Mission, Solar Parks, Offshore Wind Farms, Net-Zero Targets and Renewable Energy Transitions.

REFERENCES

1. Boyle, G. (2020). *Renewable Energy*.
2. Twidell, J. & Weir, T. (2021). *Renewable Energy Resources*.
3. Rai, G.D. (2020). *Non-Conventional Energy Sources*.
4. Kaltschmitt et al. (2021). *Renewable Energy Systems*.

5. Sharma, P.D. (2021). *Environmental Science and Engineering*.
6. Ministry of New and Renewable Energy Publications.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts of energy, energy resources, sustainability, and the importance of renewable energy in meeting future global and national energy demands.
- CO2:** Compare conventional and renewable energy resources based on their availability, efficiency, environmental impacts, economic feasibility, and sustainability.
- CO3:** Describe the principles, components, applications, advantages, and limitations of solar and wind energy technologies for domestic, agricultural, and industrial applications.
- CO4:** Evaluate hydropower, biomass, bioenergy, biogas, biofuels, and waste-to-energy technologies as sustainable alternatives to fossil fuels.
- CO5:** Assess emerging renewable energy technologies including geothermal, tidal, wave, ocean thermal energy, hydrogen energy, fuel cells, hybrid energy systems, energy storage technologies, and smart grids.
- CO6:** Analyze the environmental, economic, and social benefits of renewable energy technologies in reducing greenhouse gas emissions, conserving natural resources, and promoting sustainable development.
- CO7:** Interpret national and international renewable energy policies, government programmes, energy conservation strategies, and carbon neutrality initiatives.
- CO8:** Evaluate the role of renewable energy technologies in climate change mitigation, energy security, sustainable development, and environmental protection.
- CO9:** Assess recent developments in renewable energy, including the Green Hydrogen Mission, offshore wind energy, solar parks, net-zero targets, and renewable energy transitions.
- CO10:** Apply knowledge of renewable energy technologies and sustainable energy management principles to promote clean energy adoption, environmental sustainability, and informed decision-making.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	2	1
CO2	3	3	2	2	1	1	2	1	2	1
CO3	3	3	3	2	2	2	3	2	2	1
CO4	3	3	3	2	2	2	3	2	2	2
CO5	3	3	3	2	2	2	3	2	2	2
CO6	3	3	3	2	2	2	3	2	2	2
CO7	3	3	2	2	2	2	3	2	2	2
CO8	3	3	3	2	2	2	3	2	3	2
CO9	3	3	3	2	2	2	3	3	3	2
CO10	3	3	3	2	3	3	3	2	3	3

GENERIC ELECTIVE COURSE – 3
ENVIRONMENTAL EDUCATION AND POLICY

Semester II

Code

(Theory)

Credits: 3

COURSE OBJECTIVES

- To introduce the concepts, principles and significance of environmental education in promoting environmental awareness and sustainable development.
- To familiarize students with various approaches, methods and tools used in environmental education and communication.
- To provide knowledge on environmental policies, governance systems and institutional frameworks at national and international levels.
- To develop an understanding of environmental ethics, public participation and community engagement in environmental management.
- To enable students to evaluate environmental policies and contribute to environmental awareness and sustainability initiatives.

UNIT – I: FOUNDATIONS OF ENVIRONMENTAL EDUCATION

Concept, objectives and scope of environmental education. Historical development and global perspectives. Environmental awareness and environmental literacy. Role of environmental education in sustainable development. Environmental ethics and values.

UNIT – II: APPROACHES AND METHODS

Formal, informal and non-formal environmental education. Teaching-learning methods and environmental communication. Environmental interpretation and awareness campaigns. Community participation and environmental outreach programmes. Use of media and technology in environmental education.

UNIT – III: ENVIRONMENTAL POLICY AND GOVERNANCE

Environmental policy: concept and significance. Environmental governance and institutional frameworks. National Environmental Policy and environmental planning. Stakeholder participation in policy implementation. Role of NGOs and civil society organizations.

UNIT – IV: ENVIRONMENTAL LEGISLATION AND PUBLIC PARTICIPATION

Major environmental laws and regulations. Public participation in environmental decision-making. Environmental movements and public awareness initiatives. Environmental justice and equity. Community-based environmental management.

UNIT – V: EDUCATION FOR SUSTAINABLE DEVELOPMENT

Concept of Education for Sustainable Development (ESD). Sustainable lifestyles and responsible citizenship. Integration of environmental education into development programmes. Environmental leadership and capacity building. Future directions in environmental education.

UNIT – VI: CURRENT CONTOURS*(For Continuous Internal Assessment Only)*

National Education Policy and environmental education, Green Campus Initiatives, Climate Education and SDGs.

REFERENCES

1. Palmer, J. (2018). *Environmental Education in the 21st Century*.
2. Bharucha, E. (2021). *Environmental Studies*.
3. UNESCO Environmental Education Guidelines.
4. Sharma, P.D. (2021). *Ecology and Environment*.
5. Miller & Spoolman (2023). *Environmental Science*.
6. National Environmental Policy Documents.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, principles, objectives, and scope of environmental education and its role in promoting environmental awareness and sustainable development.
- CO2:** Describe the historical development, approaches, methods, and communication strategies used in formal, informal, and non-formal environmental education.
- CO3:** Analyze environmental governance systems, institutional frameworks, environmental policies, and stakeholder participation at national and international levels.
- CO4:** Interpret major environmental laws, public participation mechanisms, environmental justice, and community-based approaches for environmental management.
- CO5:** Evaluate environmental education programmes, awareness campaigns, outreach activities, and environmental communication tools for promoting environmental literacy.
- CO6:** Assess the role of environmental ethics, values, responsible citizenship, and community engagement in achieving sustainable environmental management.
- CO7:** Analyze the concept and significance of Education for Sustainable Development (ESD), sustainable lifestyles, environmental leadership, and capacity-building programmes.
- CO8:** Evaluate emerging environmental education initiatives such as Green Campus Programmes, climate education, SDGs, and environmental policy reforms.
- CO9:** Apply environmental education principles, communication techniques, and policy knowledge to support environmental awareness, conservation, and sustainable development initiatives.
- CO10:** Demonstrate responsible environmental citizenship by integrating environmental education, policy, ethics, and sustainability principles into professional practice and community engagement.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	1	1	2	2	1	2	1
CO2	3	2	2	2	2	2	2	1	2	2
CO3	3	3	3	2	2	2	3	2	2	2
CO4	3	3	3	2	2	2	3	2	2	2
CO5	3	3	3	2	2	2	3	2	2	2
CO6	3	3	2	2	2	3	3	2	3	3
CO7	3	3	3	2	2	3	3	2	3	3
CO8	3	3	3	2	2	2	3	3	3	2
CO9	3	3	3	2	3	3	3	2	3	3
CO10	3	3	3	2	3	3	3	2	3	3

**GENERIC ELECTIVE COURSE – 4
GREEN PRODUCTS**

Semester II

Code

(Theory)

Credits: 3

COURSE OBJECTIVES

- To introduce the concept, characteristics and importance of green products in sustainable development.
- To provide knowledge on eco-friendly materials, green technologies and environmentally responsible production systems.
- To familiarize students with eco-labelling, environmental certification and product life cycle assessment.
- To develop an understanding of green marketing, sustainable consumption and green entrepreneurship opportunities.
- To promote awareness of environmentally responsible consumer behaviour and sustainable product development.

UNIT – I: INTRODUCTION TO GREEN PRODUCTS

Concept and characteristics of green products. Sustainable consumption and production patterns. Environmental impacts of conventional products. Green economy and circular economy principles. Importance of eco-friendly products in sustainable development.

UNIT – II: GREEN MATERIALS AND TECHNOLOGIES

Biodegradable materials and eco-friendly alternatives. Green packaging technologies. Sustainable manufacturing processes. Resource-efficient product design. Environmental benefits of green technologies.

UNIT – III: ECO-LABELLING AND CERTIFICATION

Environmental certification systems and eco-labels. Green product standards and environmental compliance. Life Cycle Assessment (LCA) and environmental footprint analysis. Consumer awareness and green purchasing behaviour. International and national certification schemes.

UNIT – IV: GREEN MARKETING AND ENTREPRENEURSHIP

Green marketing concepts and strategies. Consumer preferences and sustainable markets. Entrepreneurship opportunities in green products. Green business models and start-up opportunities. Case studies of successful green enterprises.

UNIT – V: FUTURE TRENDS IN GREEN PRODUCTS

Innovations in sustainable product development. Circular economy and resource recovery. Smart materials and sustainable packaging solutions. Challenges and opportunities in green product markets. Future prospects of sustainable industries.

UNIT – VI: CURRENT CONTOURS*(For Continuous Internal Assessment Only)*

Plastic Alternatives, Sustainable Packaging, Green Certifications and Carbon-Neutral Products.

REFERENCES

1. Ottman, J. (2020). *The New Rules of Green Marketing*.
2. Roy, R. (2021). *Green Entrepreneurship*.
3. Lacy & Rutqvist (2018). *Waste to Wealth*.
4. UNEP Sustainable Consumption Publications.
5. Sharma, P.D. (2021). *Environmental Science*.
6. CPCB Environmental Guidelines.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, characteristics, principles, and significance of green products, sustainable production, and sustainable consumption in environmental protection.
- CO2:** Describe eco-friendly materials, biodegradable alternatives, green packaging technologies, sustainable manufacturing processes, and resource-efficient product design.
- CO3:** Evaluate environmental certification systems, eco-labelling schemes, environmental standards, and compliance requirements for green products.
- CO4:** Apply Life Cycle Assessment (LCA), environmental footprint analysis, and sustainability assessment tools to evaluate the environmental performance of products.
- CO5:** Analyze consumer behaviour, green purchasing patterns, sustainable consumption practices, and the role of environmental awareness in promoting green markets.
- CO6:** Evaluate green marketing strategies, sustainable business models, and entrepreneurship opportunities related to environmentally friendly products and services.
- CO7:** Assess innovations in sustainable product development, circular economy principles, resource recovery technologies, smart materials, and sustainable packaging solutions.
- CO8:** Interpret emerging trends in green products, including plastic alternatives, carbon-neutral products, green certifications, and eco-innovation for sustainable industrial development.
- CO9:** Apply principles of sustainable product development, environmental management, and green entrepreneurship for promoting environmentally responsible business practices.
- CO10:** Demonstrate responsible consumer behaviour, environmental stewardship, and entrepreneurial skills for supporting sustainable development through green product innovation and commercialization.

CO-PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	2	1
CO2	3	2	2	2	1	1	2	1	2	1
CO3	3	3	3	2	2	2	3	2	2	1
CO4	3	3	3	2	2	2	3	2	2	2
CO5	3	3	3	2	2	2	3	2	2	2
CO6	3	3	3	2	2	2	3	2	2	3
CO7	3	3	3	2	2	2	3	2	3	2
CO8	3	3	3	2	2	2	3	3	3	2
CO9	3	3	3	2	2	2	3	2	3	3
CO10	3	3	3	2	3	3	3	2	3	3

**GENERIC ELECTIVE COURSE – 5
SUSTAINABLE INTEGRATED FARMING SYSTEMS**

Semester III

Code

(Theory)

Credits: 3

COURSE OBJECTIVES

- To provide an understanding of the principles, components and benefits of sustainable integrated farming systems.
- To familiarize students with sustainable agricultural practices, resource conservation and ecosystem-based farming approaches.
- To develop knowledge on crop-livestock-fishery integration and efficient farm resource management.
- To understand climate-smart agriculture, water management and sustainable food production systems.
- To promote sustainable rural livelihoods, agricultural entrepreneurship and environmentally sound farming practices.

UNIT – I: PRINCIPLES OF INTEGRATED FARMING

Integrated farming systems: concept, principles and objectives. Components of farming systems and resource integration. Sustainable agriculture and ecosystem services. Nutrient recycling and farm productivity. Benefits of integrated farming approaches.

UNIT – II: CROP AND SOIL MANAGEMENT

Crop diversification and cropping systems. Organic farming and conservation agriculture. Soil health management and nutrient cycling. Biofertilizers and organic manures. Sustainable soil and water conservation practices.

UNIT – III: LIVESTOCK, FISHERIES AND POULTRY INTEGRATION

Integration of livestock, poultry and fisheries with crop production. Waste recycling and nutrient recovery. Farm resource optimization and income diversification. Livelihood benefits and sustainability. Role of indigenous farming practices.

UNIT – IV: CLIMATE-SMART AGRICULTURE

Climate change impacts on agriculture. Water-efficient irrigation systems and rainwater harvesting. Climate-resilient crops and farming practices. Agroforestry and sustainable land management. Adaptation and mitigation strategies.

UNIT – V: FARM ECONOMICS AND RURAL DEVELOPMENT

Economic analysis of integrated farming systems. Entrepreneurship opportunities in agriculture. Rural livelihoods and food security. Government schemes and support systems. Future prospects of sustainable farming.

UNIT – VI: CURRENT CONTOURS *(For Continuous Internal Assessment Only)*

Natural Farming, Precision Agriculture, Climate-Smart Villages and Agri-Entrepreneurship.

REFERENCES

1. Altieri, M. (2019). *Agroecology*.
2. Palaniappan & Annadurai (2018). *Organic Farming*.
3. ICAR Publications on Farming Systems.
4. FAO Sustainable Agriculture Reports.
5. Singh et al. (2020). *Resource Conservation*.
6. Sustainable Agriculture Manuals.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, principles, components, and significance of sustainable integrated farming systems for improving agricultural productivity and environmental sustainability.
- CO2:** Describe sustainable crop production systems, organic farming, conservation agriculture, soil health management, nutrient cycling, and resource conservation practices.
- CO3:** Apply integrated crop-livestock-fishery-poultry farming approaches for efficient resource utilization, nutrient recycling, waste management, and income diversification.
- CO4:** Evaluate climate-smart agriculture practices, water-efficient irrigation systems, rainwater harvesting, agroforestry, and climate-resilient farming technologies for sustainable agricultural development.
- CO5:** Assess the role of biofertilizers, organic manures, indigenous farming practices, and ecosystem-based agricultural approaches in maintaining soil fertility and environmental quality.
- CO6:** Analyze farm resource management strategies, agricultural economics, livelihood diversification, food security, and government support programmes for sustainable rural development.
- CO7:** Evaluate entrepreneurship opportunities in integrated farming systems, value-added agricultural products, and sustainable agri-business models.
- CO8:** Assess emerging agricultural innovations such as natural farming, precision agriculture, climate-smart villages, and digital farming technologies for improving farm productivity and sustainability.
- CO9:** Apply sustainable farming principles to address climate change adaptation, resource conservation, environmental protection, and resilient agricultural production systems.
- CO10:** Develop environmentally responsible, economically viable, and socially sustainable farming strategies that promote rural development, agricultural entrepreneurship, and long-term food security.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	2	1
CO2	3	3	2	2	2	2	3	2	2	1
CO3	3	3	3	2	2	2	3	2	2	2
CO4	3	3	3	2	2	2	3	2	2	2
CO5	3	3	3	2	2	2	3	2	2	2
CO6	3	3	3	2	2	2	3	2	2	2
CO7	3	3	3	2	2	2	3	2	3	3
CO8	3	3	3	2	2	2	3	3	3	2
CO9	3	3	3	2	2	2	3	2	3	2
CO10	3	3	3	2	3	3	3	2	3	3

GENERIC ELECTIVE COURSE – 6
ENVIRONMENTAL ENGINEERING
(Theory)

Semester III

Code

Credits: 3

COURSE OBJECTIVES

- To introduce the fundamental principles and scope of environmental engineering in environmental protection and resource management.
- To provide knowledge on water treatment, wastewater treatment and pollution control technologies.
- To familiarize students with solid waste management systems and environmental engineering infrastructure.
- To develop an understanding of engineering approaches for addressing environmental pollution and public health issues.
- To enable students to evaluate and apply environmental engineering solutions for sustainable environmental management and development.

UNIT – I: INTRODUCTION TO ENVIRONMENTAL ENGINEERING

Environmental engineering concepts and scope. Environmental quality standards and regulations. Role of engineering in pollution control and environmental protection. Sustainable infrastructure development. Environmental engineering challenges.

UNIT – II: WATER SUPPLY AND TREATMENT

Water sources and quality parameters. Water treatment processes including coagulation, sedimentation, filtration and disinfection. Drinking water standards and distribution systems. Water conservation practices. Emerging water treatment technologies.

UNIT – III: WASTEWATER MANAGEMENT

Characteristics of wastewater. Primary, secondary and tertiary treatment systems. Industrial effluent treatment technologies. Water recycling and reuse. Environmental impacts of untreated wastewater.

UNIT – IV: SOLID WASTE MANAGEMENT

Municipal solid waste generation and management. Waste collection, transportation and disposal systems. Composting, recycling and waste-to-energy technologies. Landfill design and management. Integrated waste management approaches.

UNIT – V: AIR POLLUTION CONTROL ENGINEERING

Air pollutants and emission sources. Air pollution control devices and technologies. Stack monitoring and emission standards. Noise pollution control measures. Sustainable engineering solutions for pollution prevention.

UNIT – VI: CURRENT CONTOURS*(For Continuous Internal Assessment Only)*

Smart Water Systems, Green Infrastructure, Zero Liquid Discharge and Circular Economy Approaches.

REFERENCES

1. Peavy et al. (2017). *Environmental Engineering*.
2. Metcalf & Eddy (2018). *Wastewater Engineering*.
3. Rao, C.S. (2018). *Environmental Pollution Control Engineering*.
4. Davis & Masten (2018). *Principles of Environmental Engineering*.
5. Tchobanoglous (2021). *Solid Waste Management*.
6. Sharma, P.D. (2021). *Environmental Science*.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, principles, scope, and significance of environmental engineering in environmental protection, pollution control, and sustainable development.
- CO2:** Describe water sources, water quality parameters, drinking water standards, and conventional and advanced water treatment technologies.
- CO3:** Apply principles of wastewater characterization, primary, secondary, tertiary, and industrial effluent treatment technologies for pollution prevention and water resource management.
- CO4:** Evaluate municipal solid waste management systems, including waste collection, transportation, recycling, composting, waste-to-energy technologies, landfill design, and integrated waste management approaches.
- CO5:** Analyze air pollution sources, emission characteristics, air pollution control devices, stack monitoring systems, emission standards, and noise pollution control measures.
- CO6:** Assess environmental engineering approaches for water conservation, wastewater recycling and reuse, resource recovery, and sustainable infrastructure development.
- CO7:** Evaluate environmental quality standards, environmental regulations, engineering design principles, and pollution control strategies for environmental compliance.
- CO8:** Assess emerging environmental engineering technologies such as smart water systems, Zero Liquid Discharge (ZLD), green infrastructure, circular economy approaches, and sustainable urban environmental management.
- CO9:** Apply environmental engineering concepts to solve practical environmental problems related to water supply, wastewater treatment, solid waste management, and air pollution control.
- CO10:** Demonstrate the ability to recommend sustainable environmental engineering solutions for environmental protection, public health improvement, resource conservation, and sustainable development.

CO-PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

[illegible]

GENERIC ELECTIVE COURSE – 7
RESEARCH METHODOLOGY

Semester IV

Code

(Theory)

Credits: 3

COURSE OBJECTIVES

- To introduce the fundamental concepts and principles of scientific research.
- To develop skills in research planning, data collection and analysis.
- To familiarize students with quantitative and qualitative research methods.
- To impart knowledge on scientific writing, publication and research ethics.
- To prepare students for conducting independent research in environmental sciences and allied disciplines.

UNIT – I: INTRODUCTION TO RESEARCH

Research: Meaning, Objectives and Importance. Types of Research: Basic, Applied, Experimental and Descriptive Research. Scientific Method and Research Process. Identification and Formulation of Research Problems. Development of Research Objectives, Hypotheses and Research Questions.

UNIT – II: RESEARCH DESIGN AND DATA COLLECTION

Research Design and Its Components. Sampling Techniques: Probability and Non-Probability Sampling Methods. Primary and Secondary Data Sources. Questionnaire Design, Interviews, Surveys and Field Investigations. Experimental Design and Observational Studies in Environmental Research.

UNIT – III: DATA ANALYSIS AND INTERPRETATION

Data Processing, Classification and Tabulation. Descriptive and Inferential Statistics. Measures of Central Tendency and Dispersion. Hypothesis Testing, Correlation and Regression Analysis. Interpretation and Presentation of Research Findings using Tables, Graphs and Charts.

UNIT – IV: SCIENTIFIC WRITING AND COMMUNICATION

Literature Review and Reference Management. Structure of Research Reports, Thesis and Dissertation. Preparation of Research Papers and Scientific Articles. Oral and Poster Presentation Techniques. Use of Digital Tools and Software for Scientific Communication.

UNIT – V: RESEARCH ETHICS AND INTELLECTUAL PROPERTY RIGHTS

Research Ethics and Professional Conduct. Plagiarism and Academic Integrity. Intellectual Property Rights (IPR) and Copyright Issues. Patent Basics and Research Commercialization. Ethical Considerations in Environmental and Social Research.

UNIT – VI: CURRENT CONTOURS (*For Continuous Internal Assessment Only*)

Artificial Intelligence in Research. Open Access Publishing. Research Data Management. Predatory Journals and Publication Ethics. Emerging Trends in Environmental Research and Scientific Communication.

REFERENCES

1. Kothari, C.R. & Garg, G. (2019). *Research Methodology: Methods and Techniques*. New Age International.
2. Creswell, J.W. & Creswell, J.D. (2021). *Research Design*. Sage Publications.
3. Daniel, W.W. (2020). *Biostatistics: A Foundation for Analysis in the Health Sciences*. Wiley.

4. Gupta, S.P. (2020). *Statistical Methods*. Sultan Chand & Sons.
5. Kumar, R. (2021). *Research Methodology: A Step-by-Step Guide for Beginners*. Sage Publications.
6. Singh, Y.K. (2021). *Fundamentals of Research Methodology and Statistics*. New Age International.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, objectives, principles, types, and significance of scientific research and the scientific method in environmental sciences.
- CO2:** Identify research problems, formulate research objectives, hypotheses, and research questions, and develop appropriate research designs for scientific investigations.
- CO3:** Apply appropriate sampling techniques, data collection methods, questionnaires, surveys, field investigations, and experimental designs in environmental research.
- CO4:** Analyze qualitative and quantitative data using descriptive and inferential statistical methods, including hypothesis testing, correlation, and regression analysis.
- CO5:** Interpret research findings and present scientific data effectively using tables, graphs, charts, and appropriate statistical tools.
- CO6:** Prepare literature reviews, research reports, dissertations, scientific papers, and technical documents following accepted scientific writing standards.
- CO7:** Demonstrate effective scientific communication through oral presentations, poster presentations, digital tools, and reference management software.
- CO8:** Evaluate research ethics, academic integrity, plagiarism issues, intellectual property rights (IPR), copyright regulations, and ethical considerations in scientific research.
- CO9:** Assess emerging trends in research, including artificial intelligence applications, open-access publishing, research data management, publication ethics, and responsible research practices.
- CO10:** Design and conduct independent research projects by integrating scientific methodology, ethical principles, statistical analysis, and scientific communication skills to address environmental problems.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

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GENERIC ELECTIVE COURSE – 8
WASTE MANAGEMENT

Semester IV

Code

(Theory)

Credits: 3

COURSE OBJECTIVES

- To provide knowledge on various types of waste and their environmental impacts.
- To familiarize students with waste management principles and technologies.
- To develop understanding of waste minimization, recycling and resource recovery.
- To impart knowledge on waste management regulations and policies.
- To promote sustainable waste management practices and circular economy approaches.

UNIT – I: INTRODUCTION TO WASTE MANAGEMENT

Waste: Definition, Sources and Classification. Municipal Solid Waste, Industrial Waste, Agricultural Waste and Hazardous Waste. Waste Generation Trends and Environmental Impacts. Principles of Waste Management and Integrated Waste Management Systems.

UNIT – II: SOLID WASTE MANAGEMENT

Collection, Segregation, Storage and Transportation of Solid Waste. Waste Characterization and Quantification. Composting, Vermicomposting and Biomethanation. Recycling and Resource Recovery from Solid Waste. Role of Public Participation in Waste Management.

UNIT – III: HAZARDOUS, BIOMEDICAL AND E-WASTE MANAGEMENT

Characteristics and Classification of Hazardous Waste. Biomedical Waste Handling and Treatment Methods. E-Waste Generation and Recycling Technologies. Health and Environmental Risks Associated with Improper Disposal. Regulatory Frameworks and Management Practices.

UNIT – IV: WASTE TREATMENT AND DISPOSAL TECHNOLOGIES

Physical, Chemical and Biological Waste Treatment Methods. Incineration, Pyrolysis and Gasification Technologies. Sanitary Landfill Design and Management. Waste-to-Energy Technologies and Their Applications. Environmental Monitoring of Waste Disposal Sites.

UNIT – V: CIRCULAR ECONOMY AND SUSTAINABLE WASTE MANAGEMENT

Concept of Circular Economy and Resource Efficiency. Waste Auditing and Cleaner Production. Extended Producer Responsibility (EPR). Zero Waste Concepts and Sustainable Consumption. Innovations and Entrepreneurship Opportunities in Waste Management.

UNIT – VI: CURRENT CONTOURS (*For Continuous Internal Assessment Only*)

Plastic Waste Management Rules. Circular Economy Initiatives in India. Microplastics and Emerging Waste Challenges. Smart Waste Management Systems. Waste-to-Wealth Programmes and Green Entrepreneurship.

REFERENCES

1. Tchobanoglous, G. & Kreith, F. (2021). *Integrated Solid Waste Management*. McGraw-Hill.
2. Chandrappa, R. & Das, D. (2019). *Solid Waste Management: Principles and Practice*. Springer.
3. Rao, M.N. & Rao, H.V.N. (2018). *Hazardous Waste Management*. CBS Publishers.
4. Lacy, P. & Rutqvist, J. (2018). *Waste to Wealth*. Palgrave Macmillan.
5. CPCB Guidelines on Waste Management.
6. Sharma, P.D. (2021). *Environmental Science and Engineering*. Rastogi Publications.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, principles, classifications, sources, and environmental significance of waste management and integrated waste management systems.
- CO2:** Classify municipal solid waste, industrial waste, agricultural waste, hazardous waste, biomedical waste, and electronic waste based on their characteristics, sources, and environmental impacts.
- CO3:** Apply appropriate techniques for waste segregation, collection, storage, transportation, characterization, and quantification in accordance with scientific waste management practices.
- CO4:** Evaluate biological, physical, and chemical waste treatment technologies including composting, vermicomposting, biomethanation, recycling, resource recovery, incineration, pyrolysis, gasification, sanitary landfills, and waste-to-energy systems.
- CO5:** Assess the environmental and public health impacts associated with improper waste management and recommend suitable pollution prevention and environmental protection measures.
- CO6:** Interpret waste management regulations, environmental policies, Extended Producer Responsibility (EPR), and regulatory frameworks governing hazardous, biomedical, plastic, and electronic wastes.
- CO7:** Analyze the principles of circular economy, resource efficiency, cleaner production, zero-waste strategies, and sustainable consumption for achieving environmental sustainability.
- CO8:** Evaluate emerging waste management technologies, smart waste management systems, waste auditing, waste-to-wealth initiatives, green entrepreneurship, and innovations in resource recovery.
- CO9:** Apply scientific knowledge and environmental management principles to develop sustainable waste management strategies for industries, institutions, municipalities, and communities.
- CO10:** Demonstrate professional competence in planning environmentally sound waste management systems that support circular economy principles, environmental protection, public health, and sustainable development.

CO-PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

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**SUSTAINABLE DEVELOPMENT
GENERIC ELECTIVE COURSE – 9**

Semester IV

Code

(Theory)

Credits: 3

COURSE OBJECTIVES

- To introduce the concepts, principles and dimensions of sustainable development.
- To provide knowledge on environmental, social and economic aspects of sustainability.
- To familiarize students with sustainable resource management and environmental governance.
- To understand global sustainability challenges and development goals.
- To develop skills for integrating sustainability principles into planning and decision-making.

UNIT – I: CONCEPTS AND PRINCIPLES OF SUSTAINABLE DEVELOPMENT

Definition, Evolution and Importance of Sustainable Development. Historical Development of Sustainability Concepts. Environmental, Economic and Social Dimensions of Sustainability. Principles of Intergenerational Equity and Resource Conservation. Sustainability Indicators and Assessment Frameworks.

UNIT – II: NATURAL RESOURCES AND SUSTAINABLE MANAGEMENT

Sustainable Management of Land, Water, Forest and Energy Resources. Resource Efficiency and Conservation Strategies. Biodiversity Conservation and Ecosystem Services. Sustainable Agriculture and Resource Utilization. Environmental Challenges Associated with Resource Exploitation.

UNIT – III: SUSTAINABLE DEVELOPMENT GOALS (SDGs) AND GLOBAL INITIATIVES

United Nations Sustainable Development Goals (SDGs). International Environmental Agreements and Sustainability Frameworks. Climate Change and Sustainable Development. Poverty Alleviation, Food Security and Social Equity. Global and National Sustainability Initiatives.

UNIT – IV: SUSTAINABLE URBANIZATION AND GREEN ECONOMY

Urban Sustainability and Smart Cities. Sustainable Transportation and Green Infrastructure. Circular Economy and Green Technologies. Sustainable Production and Consumption. Environmental Accounting and Green Growth Strategies.

UNIT – V: GOVERNANCE, POLICY AND COMMUNITY PARTICIPATION

Environmental Governance and Sustainable Development Policies. Role of Government, Industry and Civil Society. Environmental Education and Public Participation. Corporate Social Responsibility (CSR) and Sustainability Reporting. Community-Based Sustainable Development Approaches.

UNIT – VI: CURRENT CONTOURS *(For Continuous Internal Assessment Only)*

Net-Zero Development Pathways. Climate Resilience and Nature-Based Solutions. Green Finance and Carbon Markets. Sustainable Lifestyles and Consumption Patterns. Emerging Sustainability Challenges and Innovations.

REFERENCES

1. Rogers, P.P., Jalal, K.F. & Boyd, J.A. (2020). *An Introduction to Sustainable Development*. Routledge.
2. Dresner, S. (2018). *The Principles of Sustainability*. Earthscan.
3. Strange, T. & Bayley, A. (2019). *Sustainable Development: Linking Economy, Society and Environment*. OECD Publications.
4. Sachs, J.D. (2022). *The Age of Sustainable Development*. Columbia University Press.
5. United Nations Sustainable Development Goals Reports.
6. Sharma, P.D. (2021). *Ecology and Environment*. Rastogi Publications.

COURSE OUTCOMES

Upon successful completion of the course, the students will be able to:

- CO1:** Explain the concepts, principles, evolution, dimensions, and significance of sustainable development and their relevance to environmental protection and societal well-being.
- CO2:** Analyze the interrelationships among environmental, economic, and social dimensions of sustainability and evaluate their role in achieving balanced development.
- CO3:** Assess sustainable management practices for land, water, forests, biodiversity, energy resources, and ecosystem services to promote long-term resource conservation.
- CO4:** Evaluate the United Nations Sustainable Development Goals (SDGs), international environmental agreements, climate action frameworks, and national sustainability initiatives.
- CO5:** Analyze sustainable urbanization, green infrastructure, circular economy, sustainable production and consumption, and green growth strategies for environmental sustainability.
- CO6:** Interpret environmental governance systems, sustainable development policies, corporate social responsibility (CSR), environmental education, and community participation in sustainable development.
- CO7:** Assess the role of climate resilience, nature-based solutions, resource efficiency, environmental accounting, and green finance in promoting sustainable development.
- CO8:** Evaluate emerging sustainability concepts including net-zero development pathways, carbon markets, sustainable lifestyles, climate adaptation, and innovative environmental solutions.
- CO9:** Apply sustainability principles, environmental planning approaches, policy analysis, and resource management strategies for addressing environmental and developmental challenges.
- CO10:** Demonstrate the ability to integrate sustainability concepts into professional practice, environmental decision-making, policy formulation, community development, and responsible environmental stewardship.

CO–PO Mapping Matrix (3 = High, 2 = Medium, 1 = Low)

COs / POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	3	2	2	2	1	1	2	1	2	1
CO2	3	3	3	2	2	2	3	2	2	1
CO3	3	3	3	2	2	2	3	2	2	2
CO4	3	3	3	2	2	2	3	2	3	2
CO5	3	3	3	2	2	2	3	2	3	2
CO6	3	3	3	2	2	2	3	2	3	3
CO7	3	3	3	2	2	2	3	2	3	2
CO8	3	3	3	2	2	2	3	3	3	2
CO9	3	3	3	2	3	3	3	2	3	3
CO10	3	3	3	2	3	3	3	2	3	3
