ST JOSEPH'S UNIVERSITY
BENGALURU, INDIA

Curricular Structure for the Undergraduate Programme

in

ENVIRONMENTAL SCIENCE

(Three major subjects up to IV Semesters and ENVIRONMENTAL SCIENCE in V and VI semesters)

STATE EDUCATION POLICY – 2024

(SEP-2024)

Single Major subject (ENVIRONMENTAL SCIENCE) in V & VI Semesters

DEPARTMENT OF ENVIRONMENTAL SCIENCE

ST JOSEPH'S UNIVERSITY

 # 36, LALBAGH ROAD, BENGALURU – 560 027

DEPARTMENT OF ENVIRONMENTAL SCIENCE

ST JOSEPH'S UNIVERSITY

BENGALURU – 560 027

Curricular Structure for the Undergraduate Programme in ENVIRONMENTAL SCIENCE (Three major subjects up to IV Semesters and ENVIRONMENTAL SCIENCE in V and VI semesters) as per STATE EDUCATION POLICY – 2024 (SEP-2024)

Single MAJOR Subject (ENVIRONMENTAL SCIENCE) in V & VI Semesters

Semester	No. of Theory papers (3 credits each)	No. of practical papers (2 credits each)	No. of credits			
			Theory & Practical	Practical Knowledge / Skill	Research Methodology	Dissertation
I	1	1	3 + 2 = 05	-	-	-
II	1	1	3 + 2 = 05	-	-	-
III	1	1	3 + 2 = 05	-	-	-
IV	1	1	3 + 2 = 05	-	-	-
V	3	3	(3 + 2 = 5) X 3 papers =15	2	2	-
VI	3	3	(3 + 2 = 5) X 3 papers =15	2	-	4
Total	**10**	**10**	**50**	**4**	**2**	**4**

The total credits for the major paper offered by the Department of Environmental Science = 60

DEPARTMENT OF ENVIRONMENTAL SCIENCE
ST JOSEPH'S UNIVERSITY
BENGALURU – 560 027

Curricular Structure for the Undergraduate Programme
in
ENVIRONMENTAL SCIENCE
(Three major subjects up to IV Semesters and ENVIRONMENTAL SCIENCE in V and VI semesters) as per STATE EDUCATION POLICY – 2024 (SEP-2024)

Single Major Subject (ENVIRONMENTAL SCIENCE) in V & VI Semesters

Sem-ester	Paper code	Tentative Paper Title
I	ES 126	Components of the Environment
	ES 1P26	Water Quality Analysis
II	ES 224	Ecosystem Dynamics, Biodiversity and Wildlife
	ES 2P24	Ecological analysis and Biodiversity Assessment
III	ES 324	Natural Resource Management and Environmental Pollution
	ES 3P24	Natural Resource Management and Environmental Pollution
IV	ES 424	Climate Sciences and Disaster Management
	ES 4P24	Meteorology and Climate Change Assessment
V	ES 5126	Air Pollution and Noise Pollution Management
	ES 5P126	Air Quality and Noise Monitoring
	ES 5226	Water Pollution and Radiation Pollution Management
	ES 5P226	Wastewater Analysis and Radiation Studies
	ES 5326	Environment, Health and Safety
	ES 5P326	Environmental Research: From Ideation to Execution
	ES 5S126	Environmental Audit: Concepts and Methods
	ES 5RM126	Research Methods in Environmental Sciences and Biostatistics
VI	ES 6126	Environmental Toxicology and Environmental Forensics
	ES 6P126	Environmental Toxicology and Environmental Forensics
	ES 6226	Environmental Impact Assessment and Environmental Economics
	ES 6P226	Environmental Impact Assessment Tools
	ES 6326	Geospatial Applications in Environmental Management
	ES 6P326	Geospatial Applications in Environmental Management
	ES 6S126	Sustainability Studies, ESG and Entrepreneurship
	ES D126	Dissertation

B. Sc. Semester – I

ES 126: COMPONENTS OF THE ENVIRONMENT

Number of Lecture hours per semester	Number of credits
45	**3**

Course Specific Objectives	
CSO 1	To develop competency in understanding the interrelatedness of the divisions of the Environment.
CSO 2	To instil an introductory knowledge of the divisions of Environment and develop necessary analytical skills to characterise their variations.
CSO 3	To motivate and inspire to acquire contemporary understanding and skills leading to issue identification.
CSO 4	To inculcate creativity and innovative spirit in the domain of human-environment interface.

Course Outcomes	
CO 1	Demonstrate an entry-level competence in understanding the environmental divisions and associated processes.
CO 2	Demonstrate the ability to carry out water quality analysis in the laboratory and interpret the results.
CO 3	Ability to understand and appreciate the role of environmental parameters in specific day-to-day activities.
CO 4	Be able to understand the demands and function in work environment dealing with environmental systems.

ES 124 – COMPONENTS OF THE ENVIRONMENT	45 Hours
Unit – 1	**8**
Environmental Education: Definition, Aim, Objectives and Scope. Environmental Science: Definition, Aim of Study and Scope. Differences between Ecology and Environmental Science; Various approaches to study Environmental Science. **Solar system:** Formation and evolution. **Origin and evolution of Earth:** Theories of origin. **Earth:** Position in the solar system, distance from the Sun, rotation, revolution, tilt, axis and their influences. **Geological time scale:** Geochronologic units – Eon, Era, Period, Epoch, Sub-epoch and Age. **Period and Etymology of eras** – Cenozoic, Mesozoic, Paleozoic, Neoproterozoic, Mesoproterozoic, Paleoproterozoic, Neoarchean, Mesoarchean, Paleoarchean and Eoarchean. **Anthropocene:** Definition and significance.	

Earth as a system - Spheres of Earth - Atmosphere, Hydrosphere, Lithosphere and Biosphere - their complex interactions and significance.	
Unit – 2	**10**
Atmosphere: Definition, Evolution of the atmosphere – Principal components – permanent and variable gases. Chemical composition - Homosphere and Heterosphere. Thermal structure of the atmosphere. **Insolation:** Definition, Factors affecting the distribution. Solar (short-wave) and terrestrial (long-wave) radiations. Laws of Thermodynamics – *Zeroth, First and Second*; and Atmospheric circulation. Earth's Albedo and Heat Budget of the Earth. **Weather:** Definition, parameters – *Temperature, Pressure, Humidity, Precipitation, Wind Speed & Direction*. Differences between weather and climate. **Greenhouse effect:** Factors and significance. **Ozone chemistry:** Significance of stratospheric ozone layer, causes, mechanism and effects of ozone layer depletion. Control measures - Vienna Convention and Montreal Protocol. Recovery of stratospheric ozone. Ozone layer monitoring.	
Unit – 3	**12**
Hydrosphere: Hydrologic cycle - process of heat energy transfer – *Radiation, Conduction and Convection*. Types of lifting and precipitation – Bergeron process – The Collision and Coalescence process. Cloud formation and classification. Forms of condensation; Forms of precipitation; Cloud burst and flash floods. Artificial rainfall – Cloud seeding. **Limnology:** Definition – Lotic and Lentic environment. Differences between Lotic and Lentic systems. **Lotic environment:** Springs, Stream profile: Potomon and Rhithron. **Lentic environment:** Ponds, Lakes and Estuaries – their types. An overview of tanks. Photic and thermal stratification of Lentic systems. **Marine environment:** Zonation, Salinity status of marine environment, biotic communities of oceanic zones, acidification of sea water; Coral bleaching; ocean currents and tides, coastal upwelling and Red tide – significance. **Groundwater:** Definition. Zonation; Aquifers – *Confined and unconfined*. Types of wells. Salinization of groundwater in coastal regions.	
Unit – 4	**15**
Lithosphere: Definition. Internal structure of the Earth. **Endogenic processes:** Plate Tectonics – Earthquake and Volcanism – Causes, effects and management. **Exogenic processes:** River, Sand dunes, Glaciation, Avalanches and Landslides. **Mineralogy:** Definition. Outline classification of minerals. **Petrology:** Definition. Classification – Igneous, Sedimentary and	

Metamorphic rocks – their formation – types – uses. **Pedology:** Soil – definition – formation – soil profile. Soil types – Alluvial; Black; Red and Laterite; Arid and Desert; Saline and Alkaline; Peaty and Marshy; Grassland, Forest and Mountain Soils. **Soil biota:** Definition, characteristics, flora & fauna, and their significance. **Weathering:** Definitions, types and factors. **Soil erosion:** Definitions, types, effects and management.	

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ES 1P26: WATER QUALITY ANALYSIS

Number of practical hours per semester	Number of credits
45	2

1. Sampling techniques of water
2. 2a. Determination of Colour - *Visual/Colorimetric method*

   2b. Determination of Temperature - Thermometer method
3. Determination of Turbidity - Nephelometric method
4. Determination of pH – Electrochemical method
5. Determination of Electrical Conductance - Conductivity meter method
6. 6a. Estimation of Total Solids - Evaporation and Gravimetric method

   6b. Estimation of Total Settleable Solids - Volumetric method
7. 7a. Estimation of Total Dissolved Solids - Filtration and Gravimetric method

   7b. Estimation of Total Suspended Solids - Filtration and Gravimetric method
8. Determination of Alkalinity - Acidimetric method
9. Determination of Total Hardness - EDTA complexometric method
10. Estimation of Dissolved Oxygen – Modified Winkler's method
11. Estimation of Dissolved Carbon dioxide - Titrimetric method
12. Determination of Chlorides - Argentometric method

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B.Sc. Semester – II

ES 224: ECOSYSTEM DYNAMICS, BIODIVERSITY AND WILDLIFE

Number of Lecture hours per semester	Number of credits
45	3

Course Specific Objectives	
CSO 1	To develop competency in understanding the ecological principles governing the biosphere, biodiversity and wildlife.
CSO 2	To develop necessary analytical skills to assess and understand the ecological systems, local biodiversity and regional wildlife.
CSO 3	To motivate and inspire to acquire contemporary understanding and skills leading to issue identification and conservation.
CSO 4	To inculcate creativity and innovative spirit in identifying appropriate conservation tools and their timely implementation.

Course Outcomes	
CO 1	Demonstrate an entry-level competence in understanding the ecological dynamics and the influence of biodiversity/wildlife on social and legal dimensions.
CO 2	Demonstrate the ability to carry-out data collection procedures and analysis in field conditions/laboratories leading to appropriate interpretations.
CO 3	Ability to understand and appreciate the role of ecosystem dynamics in conservation of specific habitats/ agroecosystems.
CO 4	Be able to develop competence and academic skills in contributing towards biodiversity and wildlife conservation.

ES 224 – ECOSYSTEM DYNAMICS, BIODIVERSITY AND WILDLIFE	45 Hours
Unit – 1	**13**
Ecology: Levels of organization, Ecology: Divisions of Ecology - approaches in studying Ecology. **Ecosystems**: Definitions. Classification of ecosystem – Terrestrial and Aquatic with their divisions. Structure of the ecosystem - Function of ecosystem - food chain – food web – bio-magnification. Ecological pyramids – Types. **Ecological Niche:** Concept and Types of niches: Spatial, Trophic and Multidimensional – Niche parameters: Form, Position and Width – Niche Partitioning - Realized and Fundamental Niche. **Biotic and Abiotic factors:** Influence of Temperature, Wind and Water, Edaphic, Topographic on flora and fauna. **Concept of Limiting Factors:** Liebig's Law of Minimum; Shelford's Law of Tolerance and the combined concept.	

Biogeochemical cycles: Classification. Carbon and Phosphorus cycles – anthropogenic influences on these cycles. **Energy flow in an ecosystem**: Productivity - trophic levels; Study of pond and crop land ecosystems; homeostasis and feedback mechanisms.	
Unit – 2	**12**
Population Ecology: Definition, Characteristics of Population: Density – Natality – Mortality – Age distribution – Growth form – Population Equilibrium – Biotic potential – Carrying capacity – Dispersal – Dispersion – Population fluctuations – Population regulation. **Community Ecology:** Definition, Characteristics of a Community – Species diversity, growth form and structure, dominance, relative abundance, trophic structure. **Ecological succession**: Primary and Secondary succession – Natural and man-influenced succession, – Hydrarch and Xerarch - Climax vegetation and their theories; Ecotone and Edge effect; Ecological equivalents; Ecotypes and Ecophenes; Ecological indicators. **Biomes:** Definition and concept. Classification of biomes. **Evolution:** Definition – Darwin's postulates - Natural selection – Types – Industrial Melanism – Pesticide resistance. Co-evolution; Mimicry – Batesian and Mullerian mimicry, warning colouration.	
Unit – 3	**10**
Biodiversity: Definition: Levels of Biodiversity - genetic diversity, species diversity and ecosystem diversity. Values of Biodiversity: *Consumptive use value, productive use value; Non-consumptive values - social value, ethical value, aesthetic value, option values and ecosystem service value.* **Biodiversity Hotspots:** Global and Indian centres. Biogeography of India. Concept of Eco-Sensitive Areas (ESA). Biodiversity profile of India: Forests and Grasslands; Wetlands and Riverine ecosystems; Marine and coastal diversity; Agrobiodiversity; Urban Biodiversity; Invasive Alien species. **Wildlife:** Definition. Wildlife of India. Values of wildlife. Importance of wildlife: Ecological, economic, socio-cultural, investigatory, medicinal, conservation of biological diversities, importance in agriculture. Endangered species: Definition, characteristics and reasons for endangering. Endangered species of India. Endemic species – Concept, types, characteristics, theories of endemism. Endemic Wildlife Species of India. Wildlife (Protection) Act, 1972, Concept of Eco-Sensitive Zones (ESZ). Threats to biodiversity and wildlife: *Over exploitation, Habitat destruction, fragmentation, urbanisation, agriculture extension, Illegal trapping and poaching, diseases, deforestation, invasive species, pollution, acidification of soil and water, desertification, tourism and climate change.*	

Unit – 4	**10**
Conservation (Biodiversity and Wildlife): Definition, need and significance. Conservation goals - *Habitat conservation, Prevention of deforestation, Preventing species from extinction, Sustainable harvest of biological resources and climate change mitigation.* Terminologies of conservation significance: *Keystone species, Foundation species, Umbrella Species and Flagship species, Edge species, Critical link species, Indicator species, Priority species and Rare species.* **IUCN Red Listed species:** *Data Deficient, Least Concern, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild and Extinct.* **In-situ conservation:** Protected areas – Sanctuaries - National Parks – Biosphere Reserves – Sacred groves. Case studies Project Tiger and Project Elephant, Project Crocodile; Vulture (Ramadevarabetta Vulture Sanctuary), Black Buck, Snow Leopard, Amur falcon, Sarus Crane, Great Indian Bustard, King Cobra and Mahseer Fish; Translocation of Cheetah in Kuno National Park, M.P. ***(One Case study to be taught in the class; Others are to be given as assignments)*.** **Ex-situ conservation:** Captive breeding (Botanical gardens, zoological parks, seed banks). Case study of *Ailuropoda melanoleuca* (Giant panda), *Ramosmania heterophylla* and *Madhuca insignis*. Cryopreservation, pollen storage, tissue culture, genetic engineering, field gene banks. Case study of Indian rhinoceros and black rhinoceros. ***(One Case study to be taught in the class; Others are to be given as assignments)****.* Traditional Knowledge and ethics in conservation of biodiversity. A locally relevant case study on biodiversity related aspects. People's Biodiversity Register. Bio-piracy. **Communication on Wildlife:** Journalism and Wildlife Photography. **Overview of International and National conservation efforts -** *Convention on Biological Diversity and Agenda 21. Ramsar Convention, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention on the Conservation of Migratory Species of Wild Animals (CMS), Trade Records Analysis of Flora and Fauna in Commerce (TRAFFIC). Reducing Emissions from Deforestation and Forest Degradation (REDD) and REDD+. National Biodiversity Action Plan (NBAP).*	

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ES 2P24: ECOLOGICAL ANALYSIS AND BIODIVERSITY ASSESSMENT

Number of practical hours/semesters	Number of credits
45	2

1. Sampling technique of plankton
2. Quantitative estimation of phytoplankton – Sedgwick-Rafter method
3. Quantitative estimation of zooplankton – Sedgwick-Rafter method
4. Determination of organic pollution – Palmer's Algal Pollution index
5. Estimation of primary productivity of a pond – Light and Dark bottle method
6. Estimation of primary productivity of terrestrial vegetation – Chlorophyll method
7. Identification of ecological indicators and Identification of endangered flora and fauna of India
8. Documentation and assessment of vegetation diversity – Census method/quadrat method
9. Documentation and assessment of faunal diversity – Line transect method
10. Documentation and assessment of winged insect fauna (Entomology) – Light trap/Sticky trap method / Visual encounter /Photographic survey
11. Documentation and assessment of soil fauna – Pitfall trap method
12. Determination of species diversity indices – Simpson's Index and Shannon-Weiner Index

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B. Sc. Semester – III

ES 325: NATURAL RESOURCE MANAGEMENT AND ENVIRONMENTAL POLLUTION

Number of Lecture hours per semester	Number of credits
45	3

Course Specific Objectives	
CSO 1	To develop a comprehensive understanding of the distribution, management, and sustainability challenges of India's water, land and marine resources.
CSO 2	To impart knowledge on forest, energy and mineral resources, including their classification, environmental impacts and sustainable management practices.
CSO 3	To enable students to understand the sources, effects and control measures of air, water and noise pollution, focusing on treatment technologies and environmental standards.
CSO 4	To provide insights into the management of various waste types – solid, hazardous, e-waste, biomedical, plastic and construction – with emphasis on their impacts and sustainable disposal/recycling methods.

Course Outcomes	
CO 1	Analyse the distribution, utilization, and sustainability issues of natural resources in India and propose management strategies for water, land and marine resources.
CO 2	Assess the impacts of forest, energy and mineral resource use, and recommend sustainable practices for environmental conservation.
CO 3	Identify sources and effects of air, water, and noise pollution, and apply suitable control and treatment methods.
CO 4	Evaluate various waste types and implement sustainable management and disposal practices for environmental protection.

ES 325: NATURAL RESOURCE MANAGEMENT AND ENVIRONMENTAL POLLUTION	45 Hours
Unit – 1	**7**
Natural resource: Definition, Characteristics and Classification of natural resources based on utility potential. Availability and distribution of natural resources in India. **Surface water resources:** Water budget of India – Watershed Management; Dams: Impact on environment – alternatives. Conflicts over water. **Groundwater resources:** Impacts of urbanization, industrialisation and agriculture on groundwater. Rainwater harvesting. **Marine water resources**: Ocean as a resource – Marine ranching: fisheries, aquaculture; Transportation – Shipping (people, goods and oil) and its impacts. Desalination of marine water. **Water resource management:** Judicious use, Conjunctive use, reuse, recharge and recycle.	

Land resources: Land-use patterns in India. Ownership patterns and conflicts. Desertification: causes, impacts and control measures.	
Unit – 2	**12**
Forest resources: Importance of forestry – Types of forests of India and Karnataka – Pressures on forest areas – NTFPs. Forest diversions for infrastructure development. Impacts of deforestation; Forest fires and their control; Forest conservation: Sacred groves; Chipko and Appiko Movements; Forest based industries (Plywood, Pulp and Paper and Cottage industries) and Energy plantations. **Energy resources:** Definition - Classification of energy resources; Conventional sources and their impacts (fossil fuels and electricity), non-conventional sources and their impacts (Fuelwood, Agriculture residue, Cow dung, Geothermal, Solar - Thermal and Photovoltaic, Wind, Tidal, Briquettes, Wood gas, Energy from waste - Pyrolysis and Biogas, Agrofuels, Bioenergy and Hydrogen fuels) and emerging energy resources. **Mineral resources:** Mining and Quarrying and their impacts; Deep-sea mining – Polymetallic nodules. Reclamation of mines. Ecological conflicts of mineral extraction **Sustainable Resource Management Strategies:** Integrated resource management, community-based management and green technologies.	
Unit – 3	**16**
Air pollution: Definition. Sources of air pollution (Point and non-point). Classification of air pollutants – Particulates ($PM_{<10\mu m}$, $PM_{<2.5\mu m}$, $PM_{<1\mu m}$), gaseous (CO, CO_2, SO_2, NO_X) and aerosols (PAN and Ground level Ozone). **Air pollution episodes:** Acid rain, Los Angeles Smog, London Smog and Delhi Smog. - *Effect on Humans:* Respiratory and cardiovascular diseases, neuropsychiatric complications, the eyes irritation, skin diseases and long-term chronic diseases. Pneumoconiosis. - *Effect on plants:* Necrosis, Chlorosis and Senescence. - *Effect on materials:* Corrosion, discolouration and structural failure. **Indoor air pollution:** Causes- Radon, VOCs – Control measures. **Indicators of air pollution:** Physical, chemical and biological. **Control of air pollution:** - *Gaseous pollutants* – Absorption, Adsorption and Condensation. - *Particulate matter* – Gravity settling chambers, Cyclonic separators, Filters (Baghouse), Electrostatic precipitators and Scrubbers. National Ambient Air Quality Standards (NAAQS), 2009. Air Quality Indices. Bharat Stage Standards. **Water pollution:** Definition, Sources (Point and non-point). Classification of Water pollutants. **Surface water pollution:** Self-purification potential of water bodies - Oxygen sag curve and cultural eutrophication. **Heavy metal pollution:** Sources/Causes, Effects and control measures with	

reference to Mercury and Chromium. Sources/causes, effects and control measures with special reference to Organo-chlorine pesticides, thermal pollution, oil pollution and groundwater pollution (Nitrate, Fluoride and Arsenic). **Domestic and industrial wastewater:** Physical, chemical and biological characteristics. **Treatment of wastewater:** Primary (Intake, screening, grit removal, pre-aeration, equalisation, neutralisation, coagulation, sedimentation and filtration), secondary (Activated Sludge process and Trickling filters) and tertiary (Chlorination; Reverse Osmosis, Activated Carbon). **Water Quality Standards**: IS 10500; 2012 for drinking water and Central Pollution Control Board (CPCB) classification for surface water – Class A, Class B, Class C, Class D and Class E and Water Quality Indices. **Noise Pollution:** Definitions of sound and noise. Sources of noise – Transport, neighbourhood, industrial and indoor. Decibel scale. Effects of noise on human beings: Auditory and Non-auditory effects - Control measures. Noise standards.	
Unit – 4	**10**
Solid Waste Management: Definition, Types, Sources and Characteristics of solid waste. Impacts of Solid Waste on Environment - Methods of Solid Waste Management - S*ource reduction, Reuse, Source and plant sorting, Recycling, Composting, Recovery of energy & materials and Final disposal of residual waste*. **Hazardous Waste Management**: Definition, sources, classification and Characteristics of Hazardous Waste - *Ignitability, Corrosivity, Reactivity and Toxicity*. Hazardous Waste Treatment, Storage and Disposal Facilities (TSDF). **E-waste Management**: Definition, sources and composition. Effects of E-waste on human health and Environment. Steps in E-waste management - *Collection, Sorting, Repair, Refurbishing and Dismantling of disused Electrical and Electronic products*. **Biomedical Waste Management:** Definition, sources, generation, classification, storage, transportation and disposal. Biomedical Waste Treatment: *Disinfection, Irradiation and Incineration*. **Plastic (Polymer) Waste Management:** Definition, Sources and Types of plastics (Recyclability) and Disposal. Microplastics. Bioplastics. **Construction and Demolition (C&D) Waste Management:** Definition, Sources and Types of C&D wastes. Sanitary landfill. Recycling of C&D waste - *sorting, crushing and sieving of aggregates.*	

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ES 3P25: NATURAL RESOURCE MANAGEMENT AND ENVIRONMENTAL POLLUTION

Number of practical hours per semester	Number of credits
45	2

1. Identification properties of minerals and rocks
2. Description of major rock forming minerals
3. Description of rocks
4. Identification of NTFPs and medicinal plants of Karnataka
5. Quantification of particulate matter in ambient air
6. Quantification of oxides of nitrogen in ambient air
7. Determination of Biochemical Oxygen Demand in wastewater
8. Determination of Chemical Oxygen Demand in wastewater
9. Measurement of Noise - Noise Level Meter
10. Determination of Calcium and Magnesium in solid waste / compost
11. Determination of moisture content and bulk density in solid waste / compost
12. Determination of organic matter in agricultural residue / compost

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B.Sc. Semester – IV

ES 425: CLIMATE SCIENCES AND DISASTER MANAGEMENT

Number of Lecture hours per semester	Number of credits
45	3

Course Specific Objectives	
CSO 1	To develop an understanding of climate systems, meteorological parameters, climate zones, and global phenomena and their influence on weather and the environment.
CSO 2	To explain the causes, evidence, and impacts of climate change and introduce key concepts in mitigation and adaptation.
CSO 3	To explore climate change mitigation and adaptation strategies across sectors, highlighting policies, technologies and local/global solutions.
CSO 4	To provide knowledge of disaster types, their impacts, and strategies for disaster risk reduction, preparedness and management at all governance levels.

Course Outcomes	
CO 1	Understand and analyse climate systems, classify climate zones, and assess the impact of global climatic phenomena on weather and the environment.
CO 2	Analyse the causes and evidence of climate change, evaluate its impacts, and assess mitigation and adaptation strategies.
CO 3	Apply sector-wise climate change mitigation and adaptation strategies, understand policy frameworks and evaluate technological solutions.
CO 4	Identify various disasters, assess their impacts and apply disaster management strategies across different governance levels.

ES 425: CLIMATE SCIENCES AND DISASTER MANAGEMENT	45 Hours
Unit – 1	**10**
Climate: Definition - Meteorological parameters. **Key concepts:** Elliptical orbit, Axial tilt, Ecliptic plane, Longitude and Latitude, Equator, Tropic of Cancer, Tropic of Capricorn, Zodiac, Perihelion, Aphelion, Equinox, Solstice, Polar day, Polar night and Sunspot. Coriolis force. Weather - short-term weather patterns; Climate - long-term climate trends. Significance of studying climate. **Energy balance:** Solar Energy and Influences of Sun on Earth's climate. Incoming solar radiation vs. outgoing heat. Earths Albedo. Role of latitude and the Earth's tilt (seasons). Köppen-Geiger climate classification. **Climate zones of the World:** Tropical, Dry, Temperate, Continental and Polar. **Microclimates:** Definition, Influence of topography on climate (mountains, valleys). Urban heat islands and their influence on local climate. **Monsoons:** Definition, Indian monsoons – seasons; Cold weather season, the hot weather season, season of advancing monsoon and season of retreating	

monsoon. Cyclones of the Indian region. **Global climatic phenomena:** El Niño and La Niña and their impacts.	
Unit – 2	**13**
Climate change: Definition, scope, history and facts of climate change. **Greenhouse gases:** Definition, sources and sinks of greenhouse gases. **Greenhouse effect:** Natural and human-induced (global warming) and global warming potential of greenhouse gases. **Natural climate variability:** Volcanic activity and sunspot cycles. **Human-induced climate variability:** Heat waves, cold waves and variations in precipitation. **Evidence of climate change:** Ice cores, tree rings, temperature records, sea-level rise, glacier retreat and warmer oceans. **Impacts of global climate change:** - *Ecosystems disruptions:* Ocean acidification and coral bleach, biodiversity loss and desertification. - *Social impacts:* Social inequality, food and water security, conflict and displacement, loss of cultural heritage and displacement, climate refugees and heat-related illnesses. - *Economic impacts:* Agricultural disruption, damage to infrastructure, loss of livelihoods, increased insurance costs, impact on energy production, migration and displacement. **Sector-wise climate change impact data:** Energy; Industrial Production and Product Use; Agriculture, Forestry and Other land use; and Waste sectors. Climate change and food security. India's climate change vulnerability. **Key concepts:** Footprints and handprints, carbon budget, carbon credits, carbon tax, carbon pricing, carbon offset, carbon neutrality, net-zero emissions, carbon positive and carbon negative.	
Unit – 3	**14**
Climate change mitigation and adaptation Urgency of climate change mitigation: Addressing the climate crisis to limit future damage. **Mitigation strategies** - *Energy sector:* Energy efficiency measures, advanced energy as a mitigation option, renewable energy technologies and Carbon Capture and Storage (CCS) – *Bioenergy plantations*. - *Transportation sector:* Sustainable transport solutions, low-carbon fuels, reducing emissions in aviation and shipping, urban planning and transport. - *Land-use and agriculture sector:* Sustainable agriculture practices, methane emissions from livestock, forest conservation and reforestation, soil carbon sequestration. - *Policy and financial approaches:* International Climate Agreements - Paris agreement. National Action Plan for Climate Change (NAPCC), India's NDC. - *Social and behavioural aspects:* Public Awareness & Education and Behavioural change strategies, Role of Climate Activism and Advocacy	

Case studies of successful mitigation initiatives: Global case studies, local and community-based mitigation efforts and private sector initiatives (one each). **Climate change adaptation:** Definitions and principles of adaptation. **Urgency of adaptation**: Understanding the impacts of climate change – need for immediate and long-term adaptation efforts – Identifying vulnerable communities and ecosystems. - *Water sector:* Water efficiency and conservation. - *Agriculture and food security:* Climate-smart agriculture – crop diversification, strategies to protect rural and farming communities from climate impacts. - *Coastal zones and ecosystems:* Coastal erosion and flooding – sea walls, mangrove restoration. - *Urban infrastructure:* Designing climate-resilient cities, buildings, green spaces and sustainable transportation, integrating adaptation into development planning. - *Disaster Risk Reduction (DRR):* Integrating disaster resilience into climate adaptation. - *Climate-related health risks:* Public health - heat-related illnesses, vector-borne diseases, climate-induced malnutrition and respiratory diseases. - *Policy for climate change adaptation:* Frameworks for integrating climate change adaptation into International, National and local levels. - *Climate finance:* Adaptation fund and Green Climate Fund. **Case studies of successful climate change adaptation:** Global case studies, local and community-based adaptation and private sector initiatives (one each). **Technological innovations for mitigation and adaptation:** Artificial intelligence (AI), Internet of Things (IoT), big data and supply chain management.	
Unit – 4	**8**
Disaster management **Key concepts:** Event, Risk, Hazard, Exposure, Vulnerability, Response, Mitigation, Preparedness and Prevention. **Disasters:** Definition, History of disasters; Components of disasters. **Types of disasters:** Natural disasters and Man-made disasters. **Natural disasters:** Definitions and introduction to Earthquakes, Tropical cyclones, Cloud bursts, Floods, Drought, Land subsidence, Landslides, Mudslides, Volcanoes, Tsunami, Avalanches, Heat waves, Cold waves, Dust storms and Locust attacks. **Man-made disasters:** Definitions and introduction to Gas leaks, Toxic and Hazardous wastes, Nuclear and radiation accidents, Oil spills, Forest fires, Weather Extremes & Climate Change, Pandemics and Wars. **Mitigation and Management techniques of disaster:** Basic principles of disaster management, Disaster Management Cycle and Plan, Disaster Management Policy. Disaster Management Authority at National, State and District levels; Roles and responsibilities of Government authorities including Local Self-Government at various levels. **Case studies:** Uttarakhand floods; Cyclone Dana; Vizag gas leak.	

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ES 4P24: METEOROLOGY AND CLIMATE CHANGE ASSESSMENT

Number of practical hours per semester	Number of credits
45	2

1. Measurement of minimum & maximum temperature and solar illuminance
2. Measurement of relative humidity and atmospheric pressure
3. Measurement of rainfall, wind speed and direction
4. Construction of windrose
5. Mapping Earth's climate zones – Global and India
6. Study of agroclimatic zones of India and Karnataka
7. Sector-wise climate change impact analysis – energy and agriculture sectors
8. Calculate the carbon footprint of an Individual / Institution / organisation
9. Development of hydrograph for a region
10. Carbon stock assessment of trees
11. Development of community-based disaster management plan
12. Development of community perception on climate change issues in a region using questionnaire / Focal group discussion

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B.Sc. Semester – V

ES 5126: AIR POLLUTION AND NOISE POLLUTION MANAGEMENT

Number of Lecture hours per semester	Number of credits
45	3

Course Specific Objectives	
CSO 1	To build a strong understanding of the scientific principles underlying air and noise pollution; their sources, transport and impacts.
CSO 2	To assess the health, ecological and economic impacts of air and noise pollution on communities and ecosystems.
CSO 3	To understand the process of monitoring and explore the online tools, AI & IoT applications in mitigating air pollution.
CSO 4	To understand the fundamentals of noise pollution, its measurement, health impacts and apply control strategies as per regulatory standards.

Course Outcomes	
CO 1	Comprehensive understanding of the concepts, sources, types and effects of air and noise pollution.
CO 2	To comprehend plume behaviour, dispersion models and physical/chemical transformation processes of air pollutants.
CO 3	Examine vehicular and indoor air pollution sources, their health impacts and mitigation techniques.
CO 4	Be able to interpret air quality data using relevant standards and in understand India's air pollution regulatory framework.

ES 5126: AIR POLLUTION AND NOISE POLLUTION MANAGEMENT	45 Hours
Unit – 1: Air pollution	**15**
Air pollution: Definition and historical perspective; Types of air pollution: primary vs secondary pollutants; Natural vs Anthropogenic sources; **Airshed:** Local, Regional and Global scales of pollution. **Air pollutant behaviour:** Transport, transformation and fate of pollutants in the atmosphere. **Meteorology of air pollution:** Overview of Solar radiation (Photic and Thermal), Pressure, Wind, Humidity, Precipitation, Atmospheric stability & Mixing height. **Plume behaviour:** Types of plume behaviour; Gaussian plume model and K-Nearest Neighbours (KNN) regression models. **Physical processes:** Diffusion, Advection, Deposition (Wet and Dry). **Physical transformations of air pollutants** - *Phase changes and partitioning:* Gas to particle conversion (condensation, evaporation). - *Aerosol dynamics:* Coagulation, agglomeration and sedimentation.	

Chemical transformations of air pollutants - *Gas-phase reactions:* Oxidation, Reduction, Photolysis. - *Photochemical smog formation:* Role of Volatile Organic Compounds (VOCs), Oxides of Nitrogen (NOx) and Sunlight. - *Secondary pollutant formation:* Ground Level Ozone (GLO), Peroxyacetyl Nitrate (PAN), Secondary Organic Aerosols (SOA), Acid rain precursors (*SO_2 to H_2SO_4, NOx to HNO_3*). **Mechanism of secondary pollutant formation (heterogenous reactions)** - *Surface adsorption:* Physisorption (Weak van der Waals forces) and Chemisorption (Strong chemical bonding). - *Surface reaction mechanisms:* Post adsorption Oxidation, hydrolysis and photochemical reactions on the particle surface. - *Desorption and product formation:* Thermal desorption, Photo-desorption and Electron stimulated desorption. Role of desorption in secondary pollutant formation. **Examples of heterogenous reactions:** Dinitrogen Pentoxide (N_2O_5) hydrolysis on aerosols; Sulphur dioxide (SO_2) oxidation on particle surfaces and reaction of chlorine compounds on sea salt aerosols. Concept of Atmospheric lifetime and persistence. Sinks of air pollutants. **Long-range transport of air pollutants:** Bioaccumulation and re-emission.	
Unit – 2: Vehicular and Indoor Pollution	**10**
Vehicular pollution: Definition. Sources – Internal combustion engines - Exhaust emissions, Evaporative emissions and Crankcase blow-by. **Vehicles with alternative fuels:** **Hybrid vehicles:** Mild hybrid; full Hybrid & Plug-in Hybrid. Liquefied Petroleum Gas vehicles; Compressed Natural Gas vehicles; Hydrogen Fuel Cell vehicles. **Biofuel-Powered Vehicles:** Ethanol blends – E20, E85; Biodiesel; Flexible-fuel vehicles; Synthetic fuels. Battery Electric Vehicles (BEVs) – Issues. **Indoor pollution:** Definition and significance. **Sources of indoor pollutants and their health effects** - *Combustion sources:* Tobacco, incense, camphor and insect repellent smoke, heating appliances. - *Biological contaminants:* Mold, dust mites, pet dander, bacteria (endotoxins), viruses. - *Chemical pollutants:* VOCs from paints, cleaning products, building materials, formaldehyde. - *Emerging pollutants:* Nanoparticles, flame-retardants, phthalates. - *Overview of Sick building syndrome* **Mitigation and control strategies for indoor air pollution:** Air filtration technologies - HEPA filters, Ultraviolet Germicidal Irradiation (UVGI); Use of low-	

emission building materials and household products; Behavioural interventions (smoking bans, cooking practices); Role of indoor plants and bioremediation; Smart ventilation systems and real-time IAQ feedback.	
Unit – 3: Air Pollution Control Engineering	**14**
Particulate pollution control devices: Working principle and applications of Settling chambers; Cyclones; Wet scrubbers and spray towers; Electrostatic Precipitators (ESP); Fabric filters (baghouses). **Gaseous pollution control devices:** Absorption and wet scrubbers; Packed bed scrubbers; Flue Gas Desulphurisation (FGD); Catalytic converters; Selective Catalytic Reduction (SCR); Adsorption methods and Mist collectors and Biofilters. **Air quality monitoring and standards:** An overview of Air (Prevention and Control of Pollution) Act, including recent amendments. National Clean Air Programme (NCAP). **Effects and Control of pollutants:** Particulate matter ($PM_{<10\mu m}$, $PM_{<2.5\mu m}$, $PM_{<1\mu m}$), Sulphur dioxide, Oxides of Nitrogen, Oxides of Carbon, Hydrocarbons and other parameters as per National Ambient Air Quality Standards - NAMP programme. Air Pollution information - IQAir. Air Quality Index (AQI) and Air Quality Life Index (AQLI). **Real-time air quality monitoring system:** SPCB and CPCB dashboards. Data analytics – Role of AI & IoT in air pollution forecasting. Stack monitoring - Particulate matter, Sulphur dioxide, Oxides of Nitrogen and other parameters. Euro Norms and Bharat Stage Standards.	
Unit – 4: Noise Pollution	**06**
Noise Pollution: Definitions of sound and noise. Sources of noise – Transport, neighbourhood, industrial and indoor. Noise, Vibration and Harshness. Decibel scale. **Metrics of Noise:** Pressure, intensity and frequency. Sound Pressure Level (SPL). Energy average equivalent level of the A-weighted sound - LAeq; Day-time level - LAeqD or Lday; Night-time level - LAeqN or Lnight; Maximum level, LAmax; Sound Exposure Level of A-weighted sound; Percentile-derived measurements (L10, L50, L90). **Special noise environments:** Infrasound, ultrasound, impulsive sound and sonic boom. **Effects of noise on human beings:** Auditory and Non-auditory effects. **Control measures:** At source, in the transmission path and protection at the receiver end. Engineering and administrative controls. Noise Level standards. An overview of The Noise Pollution (Regulation and Control) Rules.	

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ES 5P126: AIR QUALITY AND NOISE MONITORING

Number of practical hours per semester	Number of credits
45	2

1. Sampling techniques of air
2. Determination of Particulate matter ($PM_{<10\mu m\ \&\ <2.5\mu m}$)
3. Determination of oxides of Nitrogen in ambient air
4. Determination of Sulphur-di-Oxide in ambient air
5. Measurement of Ground Level Ozone
6. Construction of Particulate matter pollution rose (Secondary data) using open-source software.
7. Construction of gaseous pollution rose – Sulphur dioxide and Oxides of Nitrogen (Secondary data) using open-source software.
8. Measurement and mapping of Carbon monoxide and Carbon dioxide concentration in multiple locations
9. Study of automobile emissions using Flue Gas analyser
10. Study of Air Quality Indices using CPCB AQI calculator
11. Measurement of Noise - Noise Level Meter

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B.Sc. Semester – V

ES 5226: WATER POLLUTION AND RADIATION POLLUTION MANAGEMENT

Number of Lecture hours per semester	Number of credits
45	3

Course Specific Objectives	
CSO 1	To understand global water resources, their usage patterns, quality parameters and associated challenges
CSO 2	To analyse various types, sources and impacts of surface water, groundwater and oceanic water.
CSO 3	To utilise solutions for water and wastewater treatment and evaluate the efficiency of conventional and advanced technologies.
CSO 4	To assess sources, health impacts and safe disposal methods of radiation pollution and radioactive waste.

Course Outcomes	
CO 1	Explore global water resource availability, usage trends and water quality parameters.
CO 2	Analyse causes, effects and control strategies of water pollution, including emerging contaminants.
CO 3	Apply physical, chemical and biological methods in water and wastewater treatment systems.
CO 4	Explore the sources, effects and disposal methods of radiation pollution, in line with the safety standards.

ES 5226: WATER POLLUTION AND RADIATION POLLUTION MANAGEMENT	45 Hours
Unit – 1: Water Resources	**10**
Available water resources and their present utilization: Global freshwater availability trends considering climate change impacts; Emerging water scarcity issues, virtual water trade. **Water use categories:** In-stream and Off-stream water use; Natural and Anthropogenic use; Freshwater, brackish water and saltwater use. **Consumptive water use and management** - Agriculture: Adoption of precision irrigation, drought-resistant crops, and water footprint accounting. - Industry: Trends towards water recycling, Zero Liquid Discharge (ZLD) and sustainable manufacturing - Municipal supply: Smart metering, leakage control and decentralized water systems (rainwater harvesting, greywater reuse). **Non-consumptive use of water and management** - *Power generation:* Impact of shifting from thermal to renewable energy on water use.	

- *Navigation:* Effects of climate variability on inland waterways. - *Wildlife habitat and recreation:* Ecosystem services valuation and blue-green infrastructure role. **The AQUASTAT System:** Climate-resilience indicators, water stress indices and SDG 6 metrics. **Water supply systems:** Water demand, Population demand forecasting methods and Water distribution systems. Water and wastewater standards for specific applications. **Water quality characteristics** - Physical (Temperature, Colour, Taste and Odour, Turbidity, Solids); - Chemical (Amphoteric nature, Redox reactions, Hydrolysis reaction, pH, EC, cations and anions, corrosiveness, DO, BOD, COD) - Bacteriological contamination – *E. coli* and Total coliforms. **Transport of contaminants in water environment:** Natural and Anthropogenic.	
Unit – 2: Water pollution	**10**
Surface water pollution: Causes, effects and management of Thermal pollution; Oil pollution; Fertiliser pollution; Pesticide pollution and Eutrophication. **Ground water pollution:** Fluorides, Nitrates and Arsenic. **Contamination of Oceans:** Nutrient pollution and Oil spills. **Significant water pollutants:** Phosphates, Heavy metals (Chromium, Mercury, Cadmium, Lead), Endocrine disrupting chemicals, Persistent Organic Pollutants (POPs), Perfluorooctane Sulphonate (PFOS), Perfluorooctanoate (PFOA) and Phthalate esters. **Microparticles and Nanoparticles:** Source, transport, effects and removal. **Microplastics:** Source, transport, effects and removal. **Environmental impacts:** Persistence, Transport, Toxicity, Bioaccumulation and biotransformation – *Colonization; enzymatic action; depolymerization and mineralization*. Factors influencing biotransformation. **Detection and measurement:** Spectroscopy (*UV, FTIR, Raman*), X-ray Diffraction (XRD), Microscopy (SEM, TEM) and Dynamic Light Scattering (DLS) techniques; Fluorescent tagging and nanoparticle tracking analysis.	
Unit – 3: Water Pollution Control Engineering	**15**
Water treatment: Preliminary, Primary, Secondary and Tertiary treatments. Aeration, Coagulation, Flocculation, Sedimentation, Hydraulic jump, Filtration (Rapid sand filtration and Slow sand filtration), Dissolved Air Flotation (DAF) and Disinfection (Chlorination and Ozonation). Water softening; Hardness treatment - Desalination, Membrane Techniques (Reverse Osmosis) and Zeolite Process. **Wastewater treatment:** **Primary** – Screening, Grit removal and Sedimentation. **Secondary** – Aeration/Activated Sludge Processes and Filtration/ Trickling Filters). Disinfection of treated wastewater and disposal methods. Sludge	

management – Drying, Dewatering and Sludge digestion. **Tertiary** – Air Stripping, Chemical Coagulation, Flocculation, Biofiltration, Advanced Oxidation Process, Reverse Osmosis and Ion Exchange. **Removal of suspended solids:** Micro screening, Ultrafiltration, Chemical Coagulation and Clarification. **Removal of organic matter and colour:** Adsorption using activated carbon and biological oxidation. **Removal of phosphorous:** Chemical precipitation & clarification; and Chemical coagulation & clarification. Aeration and anaerobic ponds, Septic tanks, Up-flow anaerobic sludge digesters, Rotatory biological contactors, Multi-Effect Evaporation, Exelys and Phytoremediation.	
Unit – 4: Radiation Pollution	**10**
Radiation Pollution and Management: Definition and types of radiation (ionizing vs non-ionizing); Low-Level Waste (LLW), Intermediate-Level Waste (ILW) and High-Level Waste (HLW). Sources of radiation pollution (natural and artificial) - ***Natural:*** Cosmic rays, Radon gas, Terrestrial radiation. ***Artificial:*** Nuclear power plants, medical equipment and Industrial sources. Alpha and Beta emitters. **Effects of radiation pollution:** Biological effects of radiation exposure (acute and chronic); Health impacts: *Cancer, genetic mutations, radiation sickness*. **Management of radiation pollution:** Radiation exposure limits and safety standards (ICRP, NCRP, WHO); Radiation detection and monitoring techniques (Geiger counters, dosimeters). **Principles of radioactive waste disposal:** Isolation, Containment, Decay storage and minimisation. **Methods of disposal:** Near-surface disposal; deep geological disposal; intermediate storage and ocean disposal. **Waste treatment before disposal** - Volume reduction: *Compaction, incineration (for combustible waste)* - Solidification: *Cementation, vitrification (glass immobilization of HLW)* - Encapsulation: *Encasing waste in stable materials to prevent leakage* **Safety and monitoring** - Long-term monitoring of disposal sites to detect leaks. - Regulatory oversight to ensure compliance with safety standards. - Emergency preparedness for potential contamination.	

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ES 5P226: WASTEWATER ANALYSIS AND RADIATION STUDIES

Number of practical hours per semester	Number of credits
45	2

1. Sampling techniques of wastewater
2. Estimation of Oil and Grease in wastewater
3. Estimation of Sodium and Potassium in wastewater
4. Estimation of Sulphates content in wastewater
5. Estimation of Nitrates content in wastewater
6. Estimation of Phosphates content in wastewater
7. Determination of Chromium in wastewater
8. Determination of Iron in wastewater
9. Determination of Copper in wastewater
10. Determination of Anionic Detergents (as MBAS) in wastewater
11. Determination of Sodium Adsorption Ratio (SAR) in wastewater
12. Study of Wastewater Quality Indices (WWQI)
13. Detection and documentation of background radiation

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B.Sc. Semester – V

ES 5326: ENVIRONMENT, HEALTH AND SAFETY

Number of Lecture hours per semester	Number of credits
45	3

Course Specific Objectives	
CSO 1	To develop an understanding of Environment, Health and Safety (EHS) principles, policies and practices at workplace and industrial settings.
CSO 2	To analyse workplace hazards, risk factors, accidents and safety performance using structured methodologies and tools.
CSO 3	To understand fire safety and management principles – fire risk assessments, fire prevention strategies and fire safety technologies.
CSO 4	To evaluate and implement an effective EHS management system, ensuring compliance.

Course Outcomes	
CO 1	Understand the core concepts and significance of EHS, industrial safety principles, ergonomics, personal protection and first aid.
CO 2	Identify, assess and document workplace hazards and risks using qualitative and quantitative methods.
CO 3	Apply fire safety measures, conduct fire risk assessments and interpret tools used in fire safety audits.
CO 4	Explore the components of an effective EHS management framework.

ES 5326: ENVIRONMENT, HEALTH AND SAFETY	45 Hours
Unit – 1: Environment, Health and Safety	**10**
Environment, Health and Safety (EHS): Definitions and significance. History and development. Environment, Health and Safety Policy. **Characteristics of work-related illness** - hypertension, affective disorders, alcohol dependence and musculoskeletal disorders associated with fatigue, absenteeism and loss of productivity. **Industrial safety** – Objectives and goals, Principles of safety management. **National Safety Council (India)** – Objectives, roles and National Safety Day (NSD) Pledge. **Industrial accident:** Introduction, meaning, near miss, industrial accidents - types, Causes - Unsafe Act, Unsafe condition, Difference between Unsafe acts and unsafe conditions with examples and Consequences. 5W and 1H investigation theory and documentation. **Investigation of accidents:** Methodology, outcomes, reports, benefits. Measurement of safety performance. **Accident prevention:** Introduction, principles, Domino's theory of Accident	

causation, Frank Bird's Domino theory. Hazard and Operability study (HAZOP) - Introduction, Risk based decision-making, As Low As Reasonably Practical (ALARP), So Far As Is Reasonably Practicable (SFAIRP), Risk and Risk Matrix. 5E's *(Education, Engineering, Enforcement, Encouragement and Evaluation)* for accident prevention at the workplace. **Housekeeping:** Introduction, meaning, advantages, profits. Introduction to 5S principle – *Sort, Set in Order, Shine, Standardise and Sustain*. Advantages, roles of employees. **Ergonomics:** Introduction, meaning, application, objectives, safety program. Musculo-Skeletal Disorders (MSDs) - signs and symptoms, engineering controls. **Personal Protective Equipment's (PPEs):** Introduction, requirements, selection, types based on hazards and maintenance. Benefits & limitations of PPE's. Indian standards of PPE's - Specification of safety PPE's based on Indian standard. **First aid and emergency response:** Definition and importance, Principles of first aid, Importance of training and awareness. **Key first aid procedures:** Electrical shock, Poisoning, Open wounds and bleeding control, Snakebites, Emergency Cardio Pulmonary Resuscitation (CPR).	
Unit – 2: Hazard Identification and Risk Assessment	**13**
Hazard analysis: Introduction, need and importance in safety management systems. **Hazard Identification and Risk Assessment (HIRA):** Concepts, Terms and Definitions, Purpose and Scope. Planning and Conducting HIRA. Process and Flowchart for HIRA. **Hazard identification:** Health hazards, Safety hazards and Environmental hazards. Techniques for hazard identification. Methodology for hazard identification and assessment. **Risk assessment:** Definition, Exposure assessment, Comparative risk analysis, Risk matrix and Risk rating, Risk communication. **Risk analysis:** Definition and Process – Identification, Analysis, Evaluation, Treatment and Review. **Risk estimation and control:** Likelihood and severity. Risk matrix and Risk assessment. Control measures - Engineering controls, Monitoring controls, Safe work procedures and Administrative controls. Documentation of HIRA. **Key techniques in Hazard and Risk analysis** ***Qualitative methods:*** *Bow Tie Analysis, The Delphi Technique, SWIFT Analysis (Structured What-If Technique), FLY Analysis (Focused Learning Yields).* ***Quantitative methods:*** *Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis (FTA), Event Tree Analysis (ETA).*	
Unit – 3: Fire Safety and Management	**15**
Fire safety: Definition, Workplace fire, fire hazard, fire risk. Fire Risk	

Assessment (FRA). **Causes of fire:** Electrical faults (overloads, short circuits), Flammable materials stored improperly, Smoking and open flames, Hot work (welding, grinding) without permits, Static discharge in explosive atmospheres, Fire from batteries, EV-related fire risks, fire in green buildings (solar panels, insulation materials). Human error or arson. **Fire science parameters:** Flash point, fire point, ignition temperature, spontaneous combustion. **Anatomy of fire:** Fire triangle - *Fuel, Oxygen, Heat*. Fire tetrahedron: Chemical chain reaction. **Heat transfer modes in fire spread:** Convection, Conduction, Radiation. **Classification of fire:** Class A, Class B, Class C, Class D, Class E, Class F/K. **Fire development stages:** Incipient stage, growth stage, fully developed fire, decay stage. **Factors affecting fire severity:** Type and amount of fuel, Ventilation (Oxygen availability), Building materials, Enclosure effect (flashover risk). **Need for early detection:** Prevent flashover, enable safe evacuation, minimize asset loss. **Classification of fire extinguishing methods:** Starvation, Smothering, Cooling, Inhibition. Uses of FM-200, NOVEC 1230, Argon, CO_2 systems. **Types of fire extinguishers:** Water, Foam, CO_2, Dry powder, Wet chemical (for Class F/K), Smart extinguishers with IoT tracking. **Fire Risk Control Systems (FRCS):** Alarm systems, fire doors, sprinklers, training, egress paths, emergency lighting. **Risk assessment process:** Identify fire hazards, Identify people at risk, Evaluate and control risks, Record findings and action plans, Review and update assessment. **Emergency plans:** Evacuation maps, assembly points, fire drills, emergency contacts. Inclusion of vulnerable individuals (PWDs, pregnant workers). **Fire safety audit *(Assignments only)*:** General fire safety audit, Industrial fire safety audit, Hospital & healthcare facility fire safety audit, Educational institution fire safety audit, Commercial complex fire audit, High-rise building fire safety audit, Data centre and IT facility fire audit, Airport, Metro and Transport hub fire safety audit, Oil & gas sector fire safety audit. **Tools used in modern fire safety audits:** Thermal imaging cameras, Smoke detectors with IoT, Digital compliance audit tools, Building Information Modelling (BIM) for fire zone mapping, Fire Dynamics Simulator Software (FDS).	
Unit – 4: EHS management framework	**7**
Definition and concept. Quality, Environment, Health & Safety (QEHS). **EHS policy and leadership commitment –** Policy statement, top management commitment, Communicate the policy to all stakeholders. PDCA Model. **Key elements of planning:** Risk and hazard identification; Legal and regulatory compliance – *Local, National and International standards (OSHA, EPA, ISO 14001, ISO 45001)*. EHS Objectives and targets: *SMART goals (Specific,*	

Measurable, Achievable, Relevant, Time-bound); Resource allocation: *Budget, staff, tools*. **Components of implementation and operation:** Roles and Responsibilities; Training and competency; Communication - *Internal (employees) and external (public, regulators)*; Documentation and control: *SOPs, work instructions, permits*; Emergency preparedness and response: *Plans for fire, chemical spills, medical emergencies*. **Key tools of monitoring and measurement:** EHS Key Performance Indicators (KPIs), EHS audits and inspections, Incident reporting and investigation and Health surveillance and exposure monitoring. **Evaluation and corrective action:** Non-conformance tracking; Corrective and Preventive Actions (CAPA); Management reviews. **Continuous improvement:** Use data, audit results and feedback to improve EHS performance. Incorporate new technologies, methods and regulations. Employee participation.	

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B.Sc. Semester – V

ES 5P326: ENVIRONMENTAL RESEARCH: FROM IDEATION TO EXECUTION

Number of practical hours per semester	Number of credits
30	2

Research in Environmental Science is inherently complex, as it demands a multidisciplinary understanding of socio-cultural contexts, economic factors and analytical tools necessary to identify and address pressing environmental challenges. A strategic and systematic approach to visualising environmental parameters and developmental processes is therefore essential.

To facilitate this, students must be meaningfully engaged with the current environmental landscape – its issues, dynamics and diverse perspectives. This can be achieved by forming interest-based student groups focused on specific environmental problems and guiding them through a structured scientific inquiry process. Such efforts may culminate in an in-depth research experience (Dissertation), to be undertaken in the VI semester.

B. Sc. Semester – V

ES 5S126: ENVIRONMENTAL AUDIT: CONCEPTS AND METHODS

Number of Lecture hours per semester	Number of credits
30	2

Course Specific Objectives	
CSO 1	To understand the fundamental concepts and types of environmental auditing, in accordance with relevant legal and regulatory frameworks.
CSO 2	To apply and analyse environmental audit processes and procedures to identify non-compliances and suggest corrective actions.
CSO 3	To generate audit checklists and data collection sheets for environmental audits integrating ISO standards and EMS principles.

Course Outcomes	
CO 1	Understand the environmental audits and legal frameworks to ensure effective environmental management.
CO 2	Implement environmental audits towards identifying environmental risks and to recommend improvements.
CO 3	Develop comprehensive audit checklists supporting organisational sustainability goals.

ES 5S 126: ENVIRONMENTAL AUDIT: CONCEPTS AND METHODS	30 Hours
Unit – 1: Environmental auditing	**6**
Environmental audit: Definition and importance. Role of environmental audit in environmental management and compliance. **Types of Environmental audits**: Environmental compliance audits, Environmental management audits, Functional environmental audits, Environmental risk audits and Waste audits. Internal and External audits. **Legal and regulatory framework in India**: An overview of Environment Protection Act (EPA), 1986; Environmental Impact Assessment Notification, 2006 and amendments. An overview of Environmental Audit and ISO Standards. Role of CPCB, SPCBs and MoEF&CC in enforcing environmental laws.	
Unit – 2: Environmental audit process	**12**
Salient features of Environmental Audit Rules, 2025. **Auditor profile**: Qualifications, skills, role and responsibilities and core competencies. **Audit procedure:** Pre-audit activities, On-site activities and Post-audit activities. **Environmental audit themes:** Water audit, Energy audit, Biodiversity audit, Health & Safety audit and Waste and Waste Minimisation audit. **Environmental audit process:** Need and significance.	

- **Audit planning:** *Objectives, scope, criteria, steps and resources.* - **Audit team and responsibilities:** *Role of auditors and stakeholders.* - **Data collection methods:** *Primary and secondary data collection tools. Document review, interviews, observation and sampling.* - **Site inspection techniques:** *Conducting field visits, sample collection and monitoring environmental parameters (air, water, soil).* - **Audit checklist preparation:** *Developing checklists based on applicable standards and regulations.* - **Audit reporting:** *Documenting findings, non-compliances, recommendations.* - **Follow-up and corrective actions:** *Ensuring implementation of recommendations.* **Environmental Management Systems (EMS):** Definition, benefits and components. Key principles and requirements of ISO 14001 EMS. Role of EMS in Environmental Audits: Continuous monitoring, internal audits and improvement. Linkage between EMS and Sustainability. **Accreditation bodies** An overview of QCI, NABCB, NABET, NABL, IAF, ILAC.	
Unit 3: Environmental audit methods	**12**
1. Study of various data collection tools - observation checklists, structured questionnaires and surveys, Interview schedules, Field data sheets / logs 2. Study of various sampling tools and kits, laboratory analytical instruments, digital data collection platforms, document review tools, Stakeholder feedback tools 3. Preparation of checklists and data collection sheets for Water audit 4. Preparation of checklists and data collection sheets for Energy audit 5. Preparation of checklists and data collection sheets for Health and Safety audit 6. Preparation of checklists and data collection sheets for Waste and Waste Minimisation audit 7. Analysis and interpretation of the accrued data (Sl. 3 – 6) 8. Analysis of biodiversity indices using PAST software 9. Study of ISO 14064 – GHG inventory and reporting 10. Study of ISO 14067 – Product carbon footprint 11. Study of ISO 20400 – Sustainable procurement (Green supply chains)	

Reference

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B. Sc. Semester – V

ES 5RM126: RESEARCH METHODS IN ENVIRONMENTAL SCIENCES AND BIOSTATISTICS

Number of Lecture hours per semester	Number of credits
30	2

Course Specific Objectives	
CSO 1	To comprehend types of research, research designs and data collection methods specific to environmental sciences.
CSO 2	To apply statistical tools and software towards precise analysis of environmental data and data interpretation.
CSO 3	To develop scientific reports and project proposals following standard formats and ethical guidelines.

Course Outcomes	
CO 1	Explain key concepts of research methodology, their types and significance of literature review and research ethics.
CO 2	Design, analyse and implement research studies – data collection plans using appropriate sampling techniques and digital tools.
CO 3	Prepare clear, coherent and well-structured scientific reports and project proposals adhering to academic standards.

ES 5RM126: RESEARCH METHODS IN ENVIRONMENTAL SCIENCES AND BIOSTATISTICS	30 Hours
Unit – 1: Research methodology in Environmental Sciences	**6**
Research: Meaning, significance and objectives. Characteristics of scientific research. **Types of research:** *Conceptual vs. Empirical, Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative.* Research Methods vs. Methodology. Criteria of good research. **Research problem:** Definition, scope and role of literature review in research problem selection. Identifying research gaps. **Research in Environmental Sciences:** *Complexity and interdisciplinarity, Scale and variability, Data limitations and uncertainty, Research reproducibility and transparency, Funding and policy constraints, Ethical, socio-economic considerations, Communication and public engagement*.	
Unit – 2: Research design, data collection and analysis	**16**
Research design: Definition and purpose. Types and features of research designs – *Exploratory, descriptive, experimental and diagnostic research*. Formulating research questions, hypotheses characteristics and types (null and alternate).	

Data collection – Methods **Sources of data:** Primary and secondary. Types of data – Categorical (*Nominal and ordinal*) and Numerical (*Discrete, continuous, ratio and interval*). **Primary data:** Survey, Questionnaire types and their design. Types of questions (*Open-ended, close-ended, Likert scale*). **Digital data collection tools:** *Google forms, Open Data Kit (ODK), KoboToolbox, iNaturalist, EpiCollect5* and their uses. **Secondary data:** Reports, satellite data, climate databases, journals. **Sampling techniques**: Census vs. sampling. **Probability sampling:** Simple random sampling, Stratified sampling, Systematic sampling, Cluster sampling and Multistage sampling. **Non-probability sampling:** Judgemental sampling; Convenience sampling and Quota sampling. Sampling errors - Type I and II. **Quality of data:** Accuracy and precision. **Measures of central tendency**: Mean, Median and Mode. **Frequency distributions** – types. **Measures of dispersion:** Range, Quartile, Percentile, Standard deviation, Coefficient of variation, Skewness and Kurtosis. Correlation and Regression. **Testing of hypotheses:** Parametric or Standard tests of hypotheses. Introduction to software (Excel/SPSS/R) for data analysis. **Diagrammatic representation of data:** Bar diagram and types, Pie diagram, Pictogram (Pictograph), Cartogram. **Graphical representation of data:** Histogram, Frequency polygon, Ogive, Scatter plot (Scatter diagram), Box plot (Box-and-Whisker plot), Dotplots, Stem-and-leaf plot, Time series graph and Area graph.	
Unit – 3: Scientific writing and project proposal preparation	**8**
Scientific writing: Importance of scientific writing in environmental research. Principles of clarity, precision, objectivity and coherence. **Types of scientific reports:** Research articles, technical reports, field study reports, dissertations and thesis. **Structure and components of scientific reports:** Title, Abstract, Introduction, Materials and Methods / Methodology, Results, Discussion, Conclusion, References, Annexure (if any). **Report preparation** - **Layout and format:** Consistency in font, spacing, margins and headings. - **Structure and organisation:** Logical flow and standardized sectioning. - **Language and style:** Use of formal, concise and scientific language. - **Use of visuals:** Effective incorporation of illustrations, graphs, charts and tables. - **Referencing and Bibliography:** Use of standardized referencing styles - American Psychological Association (APA), Modern Language	

Association (MLA), Chicago, Harward. **Technical reports, thesis writing and publishing** - Purpose and audience of reports - Specific format for thesis or dissertation writing - Guidelines from academic or institutional frameworks - Plagiarism and AI generated data - Abstracting, indexing databases and metrices for journals: Scopus, Web of Science, PubMed, ResearchGate and Google Scholar **Preparation of the project proposal:** Title, abstract, introduction, rationale, objectives, methodology – timeframe and work plan. Budget and justification – references.	

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B.Sc. Semester – VI

ES 6126: ENVIRONMENTAL TOXICOLOGY AND ENVIRONMENTAL FORENSICS

Number of Lecture hours per semester	Number of credits
45	3

Course Specific Objectives	
CSO 1	Understand the principles of environmental toxicology, including toxicants, mechanisms, dose-response and ecological impacts.
CSO 2	Develop skills in environmental forensic investigations using sampling, pollutant tracing and analytical techniques.
CSO 3	Explore biotechnological solutions, biosafety and regulatory frameworks to mitigate environmental pollution.

Course Outcomes	
CO 1	Identify and evaluate toxicants and their effects on health and ecosystems.
CO 2	Apply forensic and analytical tools for pollution source identification and evidence interpretation.
CO 3	Integrate bioremediation, biotechnology and regulations to propose environmentally safe solutions.

ES 6126: ENVIRONMENTAL TOXICOLOGY AND ENVIRONMENTAL FORENSICS	45 Hours
Unit – 1: Fundamentals of toxicology and environmental forensics	**15**
Environmental toxicology: Definitions, scope, brief history and development. **An overview of key concepts:** - Pollutants, contaminants, poison, toxins, toxicants, xenobiotics - Dose, dosage, LD, ED, TLV, therapeutic index - Risk, hazard, safety, virtual safety, ADI, exposure pathways - Carcinogens, mutagens, teratogens, endocrine disruptors - Hyposensitivity and hypersensitivity **Toxicity:** Physical, chemical, biological toxicants and radiation. Factors affecting toxicity - biological factors, chemical factors and genetic factors. **Toxicokinetics:** Absorption, Distribution, Metabolism, Excretion (ADME). Case study: Methyl mercury. **Dose–response relationships:** Principles and bioassay methods. Acute, sub-acute and chronic toxicity studies. **Ecotoxicology:** Concepts, principles. Community and trophic-level effects - Bioconcentration, Bioaccumulation, Biotransformation (Detoxification and activation), Biomagnification.	
Unit – 2: Environmental forensic investigations and analytical tools	**15**
Environmental forensics: Definitions, scope and applications. **Environmental contaminants:** Organic, inorganic and emerging contaminants. **Principles of environmental forensics:** Site characterization; Sampling and evidence collection (Soil, water, air, biological and waste); Evidence tracing;	

Chain of custody; Pollution fingerprinting and timeline reconstruction; Waste profiling. **Pollution source identification:** Stable isotope analysis; Chemical fingerprinting; Molecular markers and biomarkers; Environmental Deoxyribonucleic Acid (eDNA); Microbial DNA fingerprinting; Polymerase Chain Reaction (PCR), 16S rRNA sequencing; Microbial communities as forensic evidence. **Analytical tools:** Electrophoresis; Thin Layer Chromatography (TLC); Gas Chromatography–Mass Spectrometry (GC-MS); High Performance Liquid Chromatography (HPLC); Inductively Coupled Plasma–Mass Spectrometry (ICP–MS). **Data analysis:** Interpretation, statistical analysis and reporting. Expert testimony and legal relevance.	
Unit – 3: Biotechnology, regulatory frameworks and case studies	**15**
Genetic engineering and environmental applications: Recombinant DNA technology; Enzymes and vectors; Crop improvement and Biofertilisers; Biological insecticides; Genetic modification for environmental solutions. **Bioremediation:** Definition, concepts, types and techniques. Bioaugmentation and biostimulation. **Phytoremediation:** Definition. Mechanisms of phytoextraction, phytostabilisation, phytovolatilisation, phytodegradation, rhizofiltration. **Microbial ecology and biodegradation:** Microbial indicators of ecosystem health; Degradation of DDT, PCBs and plastics; Monitoring bioremediation processes. **Biosafety:** Definitions, concepts and applications. Biosafety levels: BSL-1, BSL-2, BSL-3 and BSL-4. **Regulatory frameworks** **National:** NGT Act, Bio-Medical Waste Management Rules, Food Safety and Standards Act. **International:** Stockholm Convention on POPs; REACH Regulation – Registration, Evaluation, Authorisation and Restriction of Chemicals; Classification, Labelling and Packaging (CLP) Regulation – Hazard communication and chemical classification. **Indicative case studies:** Hazardous waste dumping — Okhla industrial area, Delhi, India; Litchi-associated acute toxicity – Bihar, India; Forensic confirmation of fungicide poisoning in Peacocks – Tumakuru, Karnataka.	

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ES 6P126: ENVIRONMENTAL TOXICOLOGY AND ENVIRONMENTAL FORENSICS

Number of practical hours per semester	Number of credits
45	2

1. Good Lab Practices (GLP) and introduction to various instruments and their function: incubator, laminar airflow unit, autoclave, hot air oven, light microscope.
2. Isolation of bacteria in air / water / soil.
3. Colony characteristics and identification of bacteria - Gram staining technique.
4. Microbiological methods for coliform detection in water – MPN and MF technique.
5. Plant-Microbe Symbiosis – Rhizobium and Mycorrhizal (VAM) associations.
6. Isolation of fungus in air / water / soil.
7. Identification of fungi – Lactophenol cotton blue staining technique.
8. Microbial growth inhibition test – heavy metals and pesticide analysis.
9. Bioassay for toxicity testing – LC 10, 50, 90.
10. Isolation and separation of DNA by Gel electrophoresis.
11. Chemical fingerprinting and tracing the sources of sediments – TLC.
12. Biodegradation of dye from contaminated sites.

Activity – 1. Visit to polluted sites

2. Visit to State Forensic Science Laboratory

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B.Sc. Semester – VI
ES 6226: ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL ECONOMICS

Number of Lecture hours per semester	Number of credits
45	3

Course Specific Objectives	
CSO 1	To impart fundamental knowledge of Environmental Impact Assessment (EIA) including its principles, processes, regulatory framework and stakeholder roles.
CSO 2	To develop competency in identifying, predicting and mitigating environmental impacts using scientific, technical and economic assessment tools.
CSO 3	To introduce environmental economics concepts relevant to environmental valuation, policy instruments and sustainable decision-making.

Course Outcomes	
CO 1	Explain and interpret EIA concepts, procedures and clearance mechanisms for different categories of development projects.
CO 2	Apply appropriate EIA methodologies to assess environmental impacts and recommend effective mitigation and management measures.
CO 3	Analyse environmental problems using economic principles such as externalities, valuation techniques and policy instruments to support sustainable development.

ES 6226: ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL ECONOMICS	45 Hours
Unit – 1: Fundamentals of Environmental Impact Assessment	**07**
Concept and evolution of EIA: Definition, history and evolution of EIA. Initial Environmental Examination (IEE) vs Full-scale EIA. EIA, EIS and ESMP. **Classification of EIA projects based on potential environmental impacts:** Category A, B1 and B2 projects. Clearance and consent requirements. **Principles, objectives and framework**: Basic principles: prevention, system dynamics, black-box approach. Objectives, salient features and core values. Pillars of EIA: transparency, participation, accountability, flexibility, cost-effectiveness. **EIA stakeholders and process:** *Stakeholders*: proponent, decision-maker, review agencies, public interest groups, legal experts and consultants. *Steps in EIA*: screening, scoping, baseline studies, impact prediction, mitigation, EIS, public hearing, EMP, decision-making and monitoring. **Environmental components:** Air, water, noise, land, biological, socio-economic and health environment. Introduction to risk assessment. **EIA types and methodologies:** Strategic, regional, sectoral and project-level EIA. Rapid vs comprehensive EIA. Life Cycle Assessment (LCA) – overview. **Impacts and classification:** Definition and types of impacts: Direct-indirect, Discrete-cumulative, Primary and Secondary, Positive-negative, short-long term, local-widespread.	

Unit – 2: Methods of impact identification, prediction and mitigation	**23**
Key parameters to consider in EIA *(to be taught with reference to 12 functional areas of expertise).* **Physical environment:** Air quality, Water resources, Soil and Land, Noise and Vibration, Climate and Meteorology. **Biological environment:** Local and regional biodiversity, Protected areas – National parks, sanctuaries, eco-sensitive zones. **Socio-economic environment:** Population and demography: *density, growth, migration*; Livelihood and employment: *agriculture, fisheries, industry, income levels*; Land acquisition and resettlement (Urban and Rural): *displacement, rehabilitation issues*; Cultural and archaeological sites: *heritage structures, religious sites*. **Human health environment:** Public health: *disease patterns, health infrastructure;* Occupational health and safety: *worker exposure, accident risks;* Community health impacts: *health effects related pollution and stress*. **Environmental risk and safety:** Hazard identification: *chemical, fire, explosion risks;* Risk assessment: *probability and consequence analysis;* Disaster management: *on-site and off-site emergency plans*. **Resource and energy aspects:** Water consumption and conservation; energy use and efficiency; raw material and natural resource utilization. **Waste and pollution management:** Solid waste: *hazardous and non-hazardous*; Liquid waste: *effluent quantity and quality*; Air emissions: *source and control measures*; Noise and heat emissions. **Methods of impact identification:** Ad-hoc, checklists, matrices, networks, overlays. **Prediction methods:** Field/lab methods, physical and mathematical models. GIS as a tool of visualisation and expert judgement. **Impact evaluation:** Impact evaluation criteria and communication. **Rationale and approach to impact mitigation in EIA:** Anticipation over reaction; mitigation hierarchy; source–pathway–receptor concept; integration with project design; alternatives analysis; proportionality and practicality; adaptive management; stakeholder involvement. **Introduction to PARIVESH (MoEF&CC) –** Environmental clearance forms. **Overview of select case studies** - Industrial and manufacturing projects - Power projects (thermal, hydel, nuclear) - River valley and mining projects - Infrastructure projects (roads, SEZs, buildings) - Waste management facilities (CETP, TSDF, MSW) - Textile and IT industries (MSME & National Building Codes of India) *(Assignments based on case study structure and EIS report components)*	

Unit – 3: Fundamentals of Environmental Economics	**15**
Environmental economics: Meaning and scope. Micro and macroeconomics – basic concepts. Production Possibility Curve and choice. Circular flow of income. National income and aggregate demand and supply (overview). Positive vs normative economics; static vs dynamic concepts. Link between economics and the environment. **Consumption, production and welfare:** Utility and law of demand. Supply and laws of production. Cost of production: marginal cost and marginal revenue. Opportunity cost. Cost–benefit analysis (Neo-classical framework). Welfare economics and Pareto optimality. **Market failure and externalities:** Competitive markets and price mechanism; Market failure: incomplete and missing markets; Externalities: private vs social costs and benefits; Positive and negative externalities in production and consumption; Types of goods and asymmetric information; Property rights; Tragedy of the Commons; Coase theorem and Ostrom's collective action approach. **Environmental valuation and global issues:** Concept of environmental valuation; Use and non-use values; Willingness to pay and willingness to accept; Direct valuation: contingent valuation method; Indirect valuation: travel cost, hedonic pricing, dose-response, avoided cost; International trade: comparative advantage and resource endowment; Transboundary environmental problems; Differential environmental standards, NIMBY (Not In My Back Yard); International environmental protocols.	

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ES 6P226: ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL ECONOMICS

Number of practical hours per semester	Number of credits
45	2

1. Introduction to PARIVESH portal – Functional areas and clearance forms
2. Development of data sheet and analysis – Ad-hoc methods for EIA
3. Development of data sheet and analysis – Checklist methods for EIA
4. Development of data sheet and analysis – Matrices methods for EIA
5. Development of data sheet and analysis – Networks methods for EIA
6. Development of data sheet and analysis – Overlay methods for EIA
7. Development of questionnaire and data collection – Socio-economic dimensions of a project
8. Development of questionnaire and data collection – Health impacts of a project
9. Cost-benefit analysis of development projects
10. Comparative economic evaluation of areas of environmental significance
11. Identification and evaluation of ecosystem services of an ecological area – a park.

Activity – 1. Participating in public hearing / Mock public hearing
2. Socio-economic data collection from a local area

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B.Sc. Semester – VI

ES 6326: GEOSPATIAL APPLICATIONS IN ENVIRONMENTAL MANAGEMENT

Number of Lecture hours per semester	Number of credits
45	3

Course Specific Objectives	
CSO 1	Understand the fundamental principles of remote sensing, including EMR, sensors, satellite platforms and Earth observation programmes.
CSO 2	Develop knowledge of GIS, geospatial data models, coordinate systems, spatial analysis and positioning technologies.
CSO 3	Apply remote sensing and geospatial technologies to real-world applications such as natural resource management, urban planning, disaster management and climate monitoring.

Course Outcomes	
CO 1	Explain remote sensing concepts, EMR interactions, sensor features, and satellite orbits, and evaluate their applications.
CO 2	Analyse and manage geospatial data using GIS, coordinate systems, GPS/GNSS, and spatial analysis techniques.
CO 3	Interpret satellite imagery and geospatial data for environmental assessment, disaster management, urban planning, and emerging geospatial technologies.

ES 6326: GEOSPATIAL APPLICATIONS IN ENVIRONMENTAL MANAGEMENT	45 Hours
Unit – 1: Fundamentals of geospatial technologies	**16**
Overview of geospatial technologies: Definition, scope and significance. **Introduction to remote sensing:** Definition and scope. Historical development of remote sensing. Advantages and limitations of remote sensing. Applications in agriculture, forestry, urban planning, disaster management, climate studies. **Electromagnetic Radiation (EMR):** Nature and properties of EMR. Electromagnetic spectrum. Atmospheric windows. Interaction of EMR with atmosphere – scattering, absorption, transmission. **Interaction of EMR with Earth's surface:** Energy interaction with vegetation, soil, water, and built-up areas. Spectral reflectance curves. Factors affecting spectral signatures. **Platforms and sensors:** Remote sensing platforms: Ground-based sensors, Airborne – aircrafts, Unmanned Aerial Vehicle (UAVs)/drones, Spaceborne – Low Earth Orbit (LEO), Medium Earth Orbit (MEO), Geostationary Earth Orbit (GEO) satellites. Types of sensors: *Passive and Active sensors*; *Imaging vs Non-imaging sensors*. Sensor characteristics: *Spatial resolution, Spectral resolution, Radiometric resolution, Temporal resolution*. **Types of remote sensing:** Optical remote sensing, Thermal remote sensing, Microwave remote sensing, Radar and LiDAR – basic concepts. **Indian and International Remote Sensing Programme:** Indian Remote Sensing Satellites (IRS, Cartosat, Resourcesat, Oceansat); International satellite systems (Landsat, Sentinel, MODIS); Role of ISRO, NRSC and NASA in Earth	

observation. NISAR Mission. Visual and digital interpretation techniques. **Image processing and interpretation:** Digital image processing steps: *Image restoration; Image enhancement; Image classification (supervised and unsupervised).* Accuracy assessment.	
Unit – 2: Geographic Information Systems and Geospatial Data	**16**
Introduction to GIS: Definition and components of GIS. GIS *vs* Remote Sensing. GIS as a decision-support system. **Geospatial data models:** Spatial data types: Vector data (point, line, polygon); Raster data; Attribute data and databases; Scale, resolution and accuracy. **Coordinate systems and map projections:** Geographic and projected coordinate systems; Datum and ellipsoid; Common map projections (UTM, Lambert, Mercator); Errors and distortions in map projections. **Data sources for GIS:** Remote sensing data; GNSS data (NavIC - Navigation with Indian Constellation); Survey data; Secondary data (census, toposheets). **GIS data processing and analysis:** Data input and editing; Spatial analysis: *Buffering, Overlay analysis, Terrain analysis (slope, aspect, DEM)*; Attribute query and spatial query. **Global Positioning System (GPS):** Principles of GPS, GPS segments (space, control, user), Accuracy and errors in GPS, Applications of GPS in mapping and navigation. **Frontiers in geospatial technologies:** Web GIS and cloud-based GIS; Artificial Intelligence and Machine Learning in geospatial analysis; UAVs (Drones) and high-resolution mapping; Big data and geospatial analytics; Open-source geospatial tools (QGIS, Google Earth Engine, Bhuvan).	
Unit – 3: Applications of geospatial technologies	**13**
Applications in natural resource management: Land use and land cover mapping; Plantation management; Agriculture and crop assessment; Forest monitoring and biodiversity conservation; Water resource management and watershed analysis. **Urban and regional planning:** Urban growth analysis, Urban Heat Islands, Infrastructure planning, Smart cities and spatial planning, Transportation and utility mapping. **Disaster management:** Hazard zonation mapping, Flood, cyclone, earthquake and landslide monitoring; Disaster preparedness, response and recovery; Role of remote sensing and GIS in early warning systems. **Climate change and environmental monitoring:** Climate variables monitoring; Environmental Impact Assessment; Pollution monitoring; Carbon mapping and ecosystem services.	

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ES 6P326: GEOSPATIAL APPLICATIONS IN ENVIRONMENTAL MANAGEMENT

Number of practical hours per semester	Number of credits
45	2

1. Study of toposheets: Direction and scale; Latitude and longitude; Grid references; Conventional signs, symbols, spatial positioning using toposheet
2. Delineation of contours and representation of relief using toposheet
3. Mapping a watershed – Delineation and drainage patterns
4. Vector and Raster data models: Point, Line and Polygon
5. a. Introduction to QGIS – Visualization, Analysis and Geospatial Data Management
   b. Understanding Google Earth Pro - hands on exercise (spatial data capturing and analysis)
6. Georeferencing spatial data using QGIS
7. Digitisation of spatial data using QGIS – Point, Line, Polygon
8. Buffering, overlay analysis, attribute queries of vector data model
9. Downloading and pre-processing of satellite imagery for GIS applications
10. DEM-based slope, aspect and viewshed analysis using Bhuvan Data
11. Land-use Land-cover (LULC) classification using remote sensing
12. Field data collection using GPS / mobile applications for environmental monitoring

    Activity – Introduction to drone technology and demonstrations

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B.Sc. Semester – VI
ES 6S126: SUSTAINABILITY STUDIES, ESG AND ENTREPRENEURSHIP

Number of Lecture hours per semester	Number of credits
45	3

Course Specific Objectives	
CSO 1	Understand the concepts, principles and frameworks of sustainability, including SDGs, circular economy, planetary boundaries, life cycle assessment and sustainability reporting.
CSO 2	Analyse Environmental, Social and Governance (ESG) dimensions, metrics, risks, compliance requirements, stakeholder engagement practices and National and International sustainability frameworks.
CSO 3	Develop knowledge and skills related to sustainable entrepreneurship, including business models, financing, marketing, scaling strategies and impact measurement in the Indian context.

Course Outcomes	
CO 1	Explain key sustainability concepts, SDGs, circular economy models, resource management strategies, and sustainability reporting systems applicable to organizations and communities.
CO 2	Evaluate ESG performance using appropriate indicators, metrics, ratings, and reporting frameworks, and assess ESG risks, compliance and stakeholder engagement strategies.
CO 3	Design and evaluate sustainable enterprises using the triple bottom line, government initiatives, green financing, impact measurement and ESG reporting through case studies and practical exercises.

ES 6S 126: SUSTAINABILITY STUDIES, ESG AND ENTREPRENEURSHIP	45 Hours
Unit – 1: Concepts and principles of sustainability	**15**
Sustainable Development Goals (SDGs): Definitions – Sustainable Development and Sustainable Development Goals, Evolution of SDGs. Overview of 17 goals, their targets and relevance. **Planetary boundaries:** Understanding limits to resource use, ecological thresholds and environmental carrying capacity. **Circular economy principles:** Rethink, Refuse, Reduce, Reuse and Recycle. Design for sustainability in production and consumption. **Sustainable resource management:** Efficient use of water, energy and materials in households, industries and communities. Strategies for resource conservation, recycling and waste reduction. **System-level sustainability strategies:** Cradle-to-Cradle (C2C), Business-to-Consumer (B2C), Consumer-to-Consumer (C2C), Business-to-Business (B2B), Business-to-Government (B2G), Product-as-a-Service (PaaS), Circular economy model, Sharing economy, Industrial symbiosis, Extended Producer Responsibility (EPR).	

Life Cycle Assessment (LCA): Concept, stages (raw material extraction, production, use, end-of-life) and interpretation of LCA results. **Concept of sustainability reporting:** Core idea, key features, objectives and scope. **Types sustainability reporting:** Environmental – Social – Economic – Integrated Reporting; Voluntary vs Mandatory reporting.	
Unit – 2: Environmental, Social and Governance (ESG)	**15**
Introduction to ESG: Definition, significance and Government mandate. Evolution of ESG – CSR vs ESG. ESG-1 = Efforts / Actions / Policies *('What we did')*; ESG-2 = Outcomes / Impact / Results *('What difference it made')*. **Pillars of ESG:** Environmental, Social and Governance. - Environmental: *Resource use, carbon footprint, emissions, pollution, climate impact.* - Social: *Gender Equity Social Inclusion (GESI), Labour practices, health and safety, community engagement.* - Governance: *Board structure, ethics, compliance, transparency, risk management.* **Significance:** Regulatory compliance; Financial performance and Investor attraction; Reputation and brand value; Sustainability and long-term value creation; Alignment with global goals, Competitive advantage and Risk management. **ESG risk factors:** - Environmental: *Climate change exposure, pollution, resource scarcity, energy inefficiency*. - Social: *Labor disputes, human rights issues, public health concerns, community conflicts.* - Governance: *Corruption, weak oversight, non-compliance, cybersecurity risks.* **ESG metrics and data sources:** Data collection methods, KPIs, internal reports, audits, regulatory filings and stakeholder feedback. **Key Performance Indicators (KPIs):** - Environmental: *CO_2 emissions, water consumption, waste generation*. - Social: *Employee turnover, workplace injuries, community initiatives*. - Governance: *Board diversity, compliance incidents, ethics training*. **Sustainability indices and benchmarking:** Dow Jones Sustainability Index (DJSI), ESG ratings, FTSE4Good, CRISIL, NSE. **Integrating ESG into strategy and operations:** ESG due diligence for investment decisions. Sustainable supply chain management. **Stakeholder engagement:** Definition, Key stockholders - Internal: *Employees, management, board of directors*. External: *Investors, customers, suppliers, regulators, local communities, NGOs, media*. **Methods of stakeholder engagement:** Surveys and feedback mechanisms; investor briefings and ESG disclosures; stakeholder advisory panels; Public	

consultations and workshops. **Compliance:** Definition, Types - Legal compliance: *Environmental laws, labour laws, corporate governance regulations*. Regulatory compliance: *SEBI ESG/BRSR requirements, mandatory disclosures*. Internal compliance: *Company policies, codes of conduct, anti-corruption programs*. Voluntary compliance: *ISO standards, GRI guidelines, CDP, TCFD*. **International Sustainability reporting frameworks:** An overview of Global Reporting Initiative (GRI), Carbon Disclosure Project (CDP), Sustainability Accounting Standards Board (SASB), Task Force on Climate-related Financial Disclosures (TCFD). **National Sustainability reporting frameworks:** An overview of Business Responsibility and Sustainability Report (BRSR), NITI Aayog guidelines, India's greenhouse gas protocols. **Rating systems:** IGBC, GRIHA, LEED, EDGE, BEE.	
Unit – 3: Sustainable entrepreneurship	**15**
Sustainable entrepreneurship: Definition, significance and scope. Triple Bottom Line: People-Planet-Profit. Differences between conventional and sustainable entrepreneurship. **Characteristics of a Sustainable Entrepreneur:** Triple bottom line mindset; Innovative and creative; Visionary; Environmentally responsible; Socially responsible; Ethical and transparent; Stakeholder-oriented; Resource-efficient and circular thinking; Resilient and adaptable: impact-focused. **An overview of major India Government initiatives for entrepreneurship development:** Make in India, Start-up India, Atmanirbhar Bharat Abhiyan, Digital India, Skill India, National Green Hydrogen Mission, Swachh Bharat Mission, Stand-Up India and NITI Aayog guidelines. **Incentives:** Tax breaks and subsidies. **Financing sustainable ventures:** Green finance and impact investing; Venture capital, crowdfunding, government grants; ESG-linked loans and green bonds. **Marketing sustainable ventures:** Identify target audience; Develop a Unique Value Proposition (UVP); Leverage storytelling; Green branding and certification; multi-channel promotion; Engage stakeholders. **Scaling sustainable ventures:** Develop a scalable business model; Secure financing; Strengthen operations; Build partnerships; Focus on impact measurement; Adapt and Innovate. **Measuring impact:** Definition of impact measurement; Select KPIs; Data Collection & Monitoring; Evaluation of outcomes. **Communicating impact:** Definition of impact communication; Identify stakeholders; Choose the right format; Focus on transparency and credibility; Storytelling; Align with standards. **Tools and methods:** Data Analytics; Impact Assessment Tools; ESG Dashboards; Certification Programmes. **Case studies and group exercise** *(including all the three units)* –Environmental audits and preparation of a sustainability/ESG report. **CIA Activity - Opportunities in sustainable entrepreneurship:** examples -	

Renewable energy, clean technology, waste management, water solutions. Organic and sustainable agriculture. Circular economy and sustainable supply chains. Green building and construction.	

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B.Sc. Semester – VI

ES 6P326: DISSERTATION

Number of practical hours per semester	Number of credits
30	2

Dissertation work in Environmental Science holds significant importance as it provides students with an opportunity to conduct in-depth research on critical environmental issues, contributing to the understanding and advancement of sustainable practices.

This project carried out in groups of students allows them to explore a specific area of their interest under the guidance of a mentor. The group size is at the discretion of the department / project supervisor. The topics for the dissertation are chosen in consultation with the guide to ensure alignment with both academic goals and real-world relevance. The process of developing a dissertation enhances research skills, critical thinking and problem-solving abilities, equipping students with the knowledge and expertise to address complex environmental challenges. Moreover, it fosters a deeper understanding of the interconnectedness of natural and human systems, preparing graduates to make meaningful contributions to the field of environment.

The dissertation is prescribed to be initiated in the V semester of the course and will be completed in the VI semester. An interim evaluation will be carried out in the V Semester with the report submission and final evaluation being carried out in the VI semester (Evaluation formats attached).

The dissertation reports, are to be submitted to the department by each student, individually towards the end of the semester VI for evaluation. A copy of the report from each group is to be submitted to the department for future reference.