ST JOSEPH'S UNIVERSITY
BENGALURU – 560 027

DEPARTMENT OF ENVIRONMENTAL SCIENCE

SYLLABUS FOR POST-GRADUATE COURSE
ENVIRONMENTAL SCIENCE AND SUSTAINABILITY

Syllabus to be followed from 2024-2025 onwards

2022 - 2023 onwards
ST JOSEPH'S UNIVERSITY
BENGALURU - 560 027

DEPARTMENT OF ENVIRONMENTAL SCIENCE

Vision

Empowering and emancipating students through an understanding of the environment, sustainability and related ethical issues.

Mission

Our mission is to develop environmentally conscious citizens who are able to appreciate the environment in its totality. We strive to equip our students with motivation, attitude, sound knowledge, commitment and skills to actively participate, at various levels, in sustainably managing environmental issues.

SYLLABUS – Theory and Practicals

M.Sc. Environmental Science and Sustainability

Semester I

ES 7122 – ATMOSPHERIC SCIENCES

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To provide an integrated understanding of the physical and chemical processes governing the atmosphere.
CSO 2	To develop a scientific understanding and interpretation of global climatic phenomenon.
CSO 3	To provide comprehensive knowledge on approaches to monitor and manage atmospheric pollution.
CSO 4	To provide insights on legal and regulatory aspects of monitoring and controlling atmospheric pollution.

CONTENTS OF ES 7122: ATMOSPHERIC SCIENCES	52 Hours
Unit – 1: Physical Atmosphere	**13**
Atmosphere: Definition - Evolution of atmosphere - Composition of current atmosphere (Permanent and variable gases) - Thermal structure of atmosphere (adiabatic changes). Standard atmosphere. Atmospheric radiation: Concept - laws of radiation, solar radiation, solar spectrum and solar constant. Distribution of solar insolation above the Earth's surface – scattering, absorption and diffusion. Effect of atmospheric gases, aerosols, clouds (surface and planetary albedo) on solar radiation. Solar radiation at the Earth's surface – Atmospheric window, absorbing elements and their spectrum distribution, optical depth - thick and thin objects, aerosol scattering, estimation of radiative heating and cooling. Terrestrial radiation and its passage through the atmosphere, emission and absorption of terrestrial radiation, Raleigh and Mie scattering, radiative transfer, greenhouse effect and net radiation budget. Atmospheric thermodynamics: Distribution of temperature (Atmospheric stability and inversion), density, pressure and water vapour.	

Unit – 2: Chemical Atmosphere	**13**
Chemical constituents: Nitrogen, hydrogen, halogen, sulphur and carbon-containing compounds in the atmosphere. Oxidising, reducing and Neutral atmospheres. Atmospheric aerosols: Concentration and size, sources, and transformation, Chemical composition, transport and sinks, residence times of aerosols, geographical distribution and atmospheric effects. Chemical and photochemical processes - Chemical and dynamical life time of atmospheric constituents. Eddy diffusion and Turbulence. Ozone Chemistry: Evolution of the Ozone layer, sources and sinks of tropospheric and stratospheric Ozone. Ozone depletion and recovery - Influence of Chlorofluorocarbons, free Ozone, UV-radiations and supersonic transport on Ozone layer. Air Pollution: Sources of pollution, pollutants and their classification. Atmospheric effects - Smog, visibility (Global dimming). Peroxyacetyl Nitrate (PAN) and Acid rain: Formation, impacts and control. Atmospheric Boundary Layer and Planetary Boundary Layer. Mixing layer: Prandtl's theory, Turbulence, Convection and Richardson number. Dispersion of air pollutants: Types of Plume behaviour; Gaussian plume model and K models.	
Unit – 3: Meteorology and Climatology	**13**
Meteorology: Physical, Dynamic and Synoptic meteorology. Concept and measurement of weather components: Temperature; Humidity (Absolute, Specific and Relative); Pressure; Wind speed and direction - Beaufort wind scale; Precipitation - Types, Wegener-Bergeron-Findeisen process and Collision-Coalescence process. Illumination and Cloud cover. Clouds: Formation and classification. Artificial rainfall - Cloud seeding, Cloudbuster and Bioprecipitation. Micro & Meso-scale meteorology. Agro and Hydro meteorology. Climatology: Koppen and Geiger Climate Classification. Tropical monsoon climate. Weather extremes and atmospheric disturbances: Heat waves, Cold waves, Dust storms, Depressions, Cyclones (Formation, Vertical and Horizontal structure and landfall), Thunderstorms, Cloudbursts, Floods, Lightening and Droughts.	

Unit – 4: Approaches to monitor and manage atmospheric pollution	**13**
Measures to reduce process emissions at source and fugitive emissions. Identifying and assessing the quantum of emissions. Control of particulates: Settling chambers, Cyclones, Scrubbers, Electrostatic precipitators (ESP) and Fabric filters (FF). Control of gases: Absorption, Wet scrubbers and packed scrubbers, Flue gas desulfurization (FGD), Catalytic Converters, Selective Catalytic Reduction (SCR), Adsorption, Mist collectors, biofilters. Bharat Stage Standards. Hybrid vehicles. Alternative fuels in India. Electric vehicles. Emission inventories - Particulate matter ($PM_{<1\mu m}$, $PM_{<2.5\mu m}$ and $PM_{<10\mu m}$), Sulphur dioxide, Oxides of Nitrogen, Carbon monoxide, 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). Stack monitoring - Particulate matter, Sulphur dioxide, Oxides of Nitrogen and other parameters. Central and State Pollution Control Boards. Air (Prevention and Control of Pollution) Act, 1981. National Clean Air Programme (NCAP).	

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ES 7P1: METEOROLOGY AND AIR QUALITY ANALYSIS

Number of Practical Credits	Number of Practical Hours / Semester
2	52

1. Measurement of Minimum & Maximum Temperature, Relative Humidity and Solar Illuminance.
2. Measurement of Atmospheric Pressure, Wind Speed and Direction.
3. Construction of Wind rose (Primary and secondary data).
4. Measurement of Rain and Rainfall analysis (Secondary data).
5. Study of climatic regions of Karnataka, India and World.
6. Sampling techniques of air.
7. Measurement of Particulate matter using Respirable Dust Sampler.
8. Measurement of Sulphur dioxide and Oxides of Nitrogen using Respirable Dust Sampler.
9. Measurement of Ground Level Ozone using Respirable Dust Sampler.
10. Construction of Pollution rose – Particulate matter, Sulphur dioxide and Oxides of Nitrogen (Secondary data).
11. Measurement of Carbon monoxide and Carbon dioxide concentration using NDIR technology.
12. Study of Automobile emissions using Flue Gas analyser.
13. Study of Air Quality Indices using CPCB AQI Calculator.
14. Construction of Gaussian Plume Dispersion models.

Activity – Depiction of air quality of different locations of Bengaluru on a map
Visit to Indian Meteorological Department (IMD), Regional CPCB and KSPCB laboratories

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M.Sc. Environmental Science and Sustainability

Semester I

ES 7222 – HYDROLOGICAL SCIENCES

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To address the importance of water as a resource along with its consumptive and non-consumptive uses.
CSO 2	To provide knowledge on the concept of virtual waters and integrated water resource management.
CSO 3	To understand the wastewater management strategies.
CSO 4	To create awareness about water quality indices and water governance.

CONTENTS OF ES 7222 – HYDROLOGICAL SCIENCES	52 Hours
Unit – 1: Water resources	**13**
Water as a resource: Classification of water resources – Surface water, Groundwater, Ocean water, Brackish water, Glaciers and Ice caps. Resources properties of water: Universal solvent, Cohesion, Adhesion, High surface tension, High specific heat, Boiling and freezing points, High Heat of vaporization, Amphoteric properties, Capillary action and Occurs as Solid (ice), Liquid and Gas (vapour). Sources and Uses of water (primary, secondary and tertiary sector uses); Concept of virtual water; Health and environmental concerns of availability and quality of water resources. Hydrological cycle: Fluxes, reservoirs, and residence times. Process of heat energy transfer - Radiation, Conduction and Convection; Global Water Balance; Water budget of India. Limnology: Physical, Chemical and Biological limnology. Lotic systems: Springs, Stream profile: Potomon and Rhithron. Lentic systems: Ponds, lakes and estuaries – their types. Photic and thermal stratification of Lentic systems. Marine environment: Zonation, Salinity status of marine environment. Ground water: Zonation; Aquifers; Groundwater flow; Hydraulic head, Conductivity, Permeability, Storativity, and Porosity. Darcy's law. Groundwater flow: Ground water potential; Flow nets; Heterogeneity and Anisotropy. Tracer techniques. Salt water intrusion.	

Unit – 2: Humans influences on Water Resources and Pollution	**13**
Available water resources and their present Utilization. Water use categories: In-stream and off-stream water use; Anthropogenic and natural water use; Freshwater, brackish water and saltwater use; and Consumptive and non-consumptive water use. Consumptive Use of Water: Agriculture, Industry and Municipal water supply. *Methods of Estimation* - Inflow and outflow studies; Tank and Lysimeter method; Soil moisture studies; Field experimental plots and Integration method. Non-Consumptive Use of Water: Power generation, Navigation, Wildlife habitat and Recreation. The AQUASTAT system. Water quality characteristics: Physical (Temperature, Colour, Taste and Odour, Turbidity, Solids); Chemical (Amphoteric nature, Redox reactions, Hydrolysis reaction, pH, EC, Salinity, Alkalinity, Hardness, Ions, Corrosiveness, DO, BOD, COD); and Biological (Microbial Contamination, Total Coliforms and Faecal Coliforms). Transport of contaminants in water environment: Natural and man-made. Surface water pollution: Thermal pollution; Oil pollution; Pesticide pollution; fertiliser pollution and Eutrophication. Ground water pollution: Fluorides, Nitrates and Arsenic. Radioactive substances – Alpha and Beta emitters. Contamination of Oceans: Nutrient pollution, Plastic pollution, Ocean acidification and oil spills. Water pollutants: Phosphates, Heavy metals, Endocrine disrupting chemicals, Persistent Organic Pollutants (POPs), Perfluorooctane Sulfonate (PFOS), Perfluorooctanoate (PFOA) and Phthalate esters.	
Unit – 3: Water and wastewater treatment	**13**
Water Supply Systems: Water demand, Population demand forecasting methods and Water distribution systems. Water and wastewater standards for specific applications. Water treatment: Preliminary, Primary, Secondary and Tertiary treatments. Aeration, Coagulation, Flocculation, Sedimentation, Filtration (Rapid sand filtration and Slow Sand Filtration) and Disinfection (Chlorination and Ozonation). Water softening; Hardness treatment - Desalination, Membrane Techniques, Removal of Taste and Odour, Miscellaneous Treatment Methods, (Lime, Soda Process, Zeolite Process, Demineralization 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, Reverse Osmosis, and Ion Exchange. Removal of suspended solids: Microscreening, Ultrafiltration, Chemical coagulation and clarification. Removal of organic matter: Adsorption using activated carbon and Biological oxidation. Removal of Phosphorous: Chemical precipitation & clarification; and Chemical coagulation & clarification. Lagoons, Septic tanks, Up-flow Anaerobic Sludge Digesters, Aeration ponds, Advanced Oxidation Processes, Rotatory Biological Contactors, Thermal hydrolysis exelys and Phytoremediation.	
Unit – 4: Approaches to monitor and manage water resources	**13**
Ecological, Economic, Social and Cultural values of water. Water crisis and water stress: Water rights and its legal implications; Politics of water sharing. Inter-basin transfer of water and its implications. Catchment hydrology: Watershed – concept, characteristics and management. Sustainable economic viability. Floods – causes, flood routing, estimation of magnitude and frequency of floods and flood management. Hydrographs. Water Harvesting and Conservation: Water Harvesting Techniques; Micro-catchments; Design of Small Water Harvesting Structures; Farm Ponds and Percolation Tanks. Rain water harvesting methods related to rural and urban areas. Urban water management: Urban water supply – Demand forecast and Urban hydrological cycle. Storm water management: Quantification of urban storm water, storage facilities and Master drainage plans. Interaction between urban drainage and solid waste management. Integrated Water Resources Management: Principles, Stages in IWRM planning and implementation – National goals, Water resources issues assessment, Water resources policy/strategy, Implementation plan, Actions of implementation, monitoring and evaluation. Water governance: Water pricing, legislation and law. Private sector involvement in water management: Types and forms.	

Partnerships for sustainable water governance. Water Quality Indices (WQI): Development of WQI - Selection of parameter, transform the data from a parametric system to a dimensionless system, creation of sub-indices, and computation of the final WQI score using the aggregation of sub-indices.	

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M.Sc. Environmental Science and Sustainability
Semester I
ES 7P2: WATER AND WASTEWATER ANALYSIS

Number of Practical Credits	Number of Practical Hours / Semester
2	52

1. Sampling techniques of water (including planktons) and wastewater.
2. Determination of Colour, Turbidity and Transparency.
3. Determination of pH, Electrical Conductance and Total Solids.
4. Estimation of Oil and grease.
5. Estimation of Calcium Hardness and Total Hardness.
6. Estimation of Chlorides and Fluoride content.
7. Estimation of Sulphates content.
8. Estimation of Nitrates content.
9. Estimation of Phosphates content.
10. Determination of Dissolved Oxygen and Biochemical Oxygen Demand.
11. Estimation of Chemical Oxygen Demand.
12. Determination of Chromium in effluent samples.
13. Determination of Copper in effluent samples.
14. Estimation of Optimum dose of coagulants.
15. Estimation of available Chlorine in the bleaching powder and residual chlorine.
16. Study of Water Quality Indices.

Activity – Depiction of water bodies of Bengaluru on a map
Visit to drinking water treatment plant
Visit to sewage treatment plant

References

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M.Sc. Environmental Science and Sustainability

Semester I

ES 7322 – EARTH SCIENCES AND SOLID WASTE MANAGEMENT

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To provide knowledge on Earth Sciences, pedological processes and soil degradation.
CSO 2	To integrate physical, chemical and biological approaches to manage soil pollution and solid waste.
CSO 3	To disseminate knowledge on various aspects of planning and implementation of waste management strategies.
CSO 4	To provide knowledge on the smart waste management technologies and legal frameworks for sustainable management of solid waste.

CONTENTS OF ES 7322 – EARTH SCIENCES AND SOLID WASTE MANAGEMENT	52 Hours
Unit – 1: Geosphere and its resources	**13**
Earth: Origin, age of the Earth, Internal structure of the Earth, Sea floor spreading and Plate tectonics, Rock cycle, Earth's orbital parameters. Principles of stratigraphy – law of superposition, law of original horizontality, law of cross-cutting relationships and law of lateral continuity. Lithostratigraphy, Biostratigraphy and Chronostratigraphy. Geological Time Scale. Mineralogy: Formation and growth. Classification of minerals – *Elements; Oxides and hydroxides; Silicates; Sulphides; Halides; Nitrates, Carbonates and Borates; Sulphates; Phosphates, Arsenates* and *Vanadates;* Rock-forming minerals – *Feldspars, Quartz, Amphiboles, Micas, Olivine, Garnet, Calcite* and *Pyroxenes*. Accessory minerals – *fluorite, zircon and sulfides.* Biomineralogy and Mineral ecology. Mineraloids and Non-minerals. Petrology: Classification – Igneous, Sedimentary and Metamorphic rocks – their formation – types – uses. Endogenic processes: Diastrophism – Concepts of stress and strain, Behaviour of rocks under stress; Folds, joints and faults. Earthquake and Volcanism – Causes, Effects, and Management. Exogenic processes: Types – Weathering, mass wasting, erosion, and deposition. Earth's surface processes – River, Sand dunes, Glaciation, Avalanches and Landslides.	

Unit – 2: Pedology	**13**
Soils – formation, composition and properties, soil forming processes, soil profile. Indian Standard Soil Classification System. Soil types – *Alluvial; Black; Red and Laterite; Arid and Desert; Saline and Alkaline; Peaty and Marshy; Grassland, Forest and Mountain Soils*. Textural classification of soil. Soil structure. Soil mineralogy and soil maps. Physical classification of soil water: Hygroscopic, capillary and gravitational water. Infiltration, permeability, percolation and surface runoff. Biological classification of soil water: Superfluous, available and unavailable water. Soil moisture and soil moisture stress. Thermal properties of soils: Soil temperature, heat capacity, thermal expansion and thermal conductivity. Soil ecology: Soil biodiversity, soil food webs, soil trophic dynamics, soil organism interactions (*Rhizobium and Mycorrhizae*), soil organic matter, soil decomposition. Soil atmosphere – Carbon cycling and sequestration, nitrogen cycling and fixation, and phosphorous cycling. Soil fertility and Bio-fertilizers.	
Unit – 3: Soil degradation	**13**
Soil erosion: causes, types and control. Soil pollution: Causes of soil pollution (urban areas, industrial areas, agriculture and livestock, landfills, sewage sludge, municipal solid waste dumps and hazardous waste). Classification of soil pollutants: Organic contaminants and inorganic contaminants. Irrigation as a source of soil contamination – Pesticide pollution, fertiliser pollution, water logging, salinity, alkalinity, Sodium Adsorption Ratio (SAR) and soil sickness. Solid waste pollution: Origin and types of solid wastes, characterisation of solid wastes. Segregation, collection, transportation and disposal of municipal solid waste. Plastic wastes: Sources and categories. Micro plastics. Hazardous wastes: Sources, categories and characteristics. Leachate and its impacts. Biomedical wastes: Sources, categories and characteristics. E-waste: Sources, composition and types. Waste audit.	

Unit – 4: Approaches to manage soil pollution and solid wastes	**13**
Soil remediation: In-situ decontamination; Ex-situ decontamination: on-site and off-site; and confinement/isolation of the affected area. Chemical, physical, solidification/stabilization/immobilization, thermal, and biological (Bioaugmentation, biostimulation, bio-volatilisation, bioremediation and phytoremediation) methods. Waste remediation: Waste management hierarchy. Methods of solid, hazardous and biomedical waste treatment: Compositing, vermicomposting bio-methanisation (Bio-methanisation potential), incineration, pyrolysis, secured landfills and Containment technologies, Wet air oxidation, Chemical disinfection, Wet (autoclaving) and dry thermal treatment, Microwave irradiation and Inertization. Leachate management: aerated lagoons and activated sludge, air stripping, pH adjustment, chemical precipitation, oxidation, and reduction. Bioremediation - land farming, biodegradation of recalcitrant and Xenobiotics treatment. E-waste: Recovery for metals and non-metals. Smart waste management: Smart waste bins, waste level sensors, artificial intelligence enabled sorting and recycling robots, garbage truck weighing mechanisms, pneumatic waste pipes, solar-powered trash compactors, E-waste kiosks and recycling apps. Solid Waste Management Rules, 2016 Construction and Demolition Waste Management Rules, 2016 The Plastic Waste Management Rules, 2016 Bio Medical Waste Management Rules, 2016 E-waste (Management) Rules, 2016 Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016.	

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M.Sc. Environmental Science and Sustainability

Semester I

ES 7P3: EARTH RESOURCES, SOIL ANALYSIS AND SOLID WASTE ANALYSIS

Number of Practical Credits	Number of Practical Hours / Semester
2	52

1. Identification properties of minerals and study of rock forming minerals
2. Identification properties of rocks and study of rocks – Igneous, Sedimentary and Metamorphic
3. Sampling techniques of soils, solid waste and leachate
4. Determination of pH and Electrical conductance of soil/leachate
5. Determination of moisture content (soil/solid waste) and water holding capacity of soil
6. Determination of infiltration potential of soil
7. Determination of calcium and magnesium in soil
8. Determination of organic matter and organic carbon in soil
9. Determination of available nitrogen in soil (Agricultural soil/compost/soils from dump sites)
10. Determination of available phosphorous in soil (Agricultural soil/compost/soils from dump sites)
11. Determination of available potassium in soil (Agricultural soil/compost/soils from dump sites)
12. Determination of Sodium Adsorption Ratio (SAR) of soil
13. Study of waste generation pattern of a community – Questionnaire method/Waste audit.
14. Classification of municipal solid waste – segregation method

Activity – Depiction of soil types of India and Karnataka on a map
Composting methods – aerobic /anaerobic/Vermi-composting
Visit to Biogas plant in the campus
Visit to solid waste dumpsite
Visit to E-waste management units

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M.Sc. Environmental Science and Sustainability

Semester I

ES 7422 – ECOSYSTEM DYNAMICS, BIODIVERSITY AND WILDLIFE CONSERVATION

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To gain insights on the key concepts and fundamentals of ecology and ecosystem dynamics.
CSO 2	To develop understanding on ecosystem services and the anthropocentric approach influencing ecosystem stability and resilience.
CSO 3	To perceive the values of biodiversity and the major threats leading over-exploitation of biodiversity.
CSO 4	To comprehend on various strategies and policies related to ecosystem, biodiversity and wildlife conservation.

CONTENTS OF ES 7422: ECOSYSTEM DYNAMICS, BIODIVERSITY AND WILDLIFE CONSERVATION	52 Hours
Unit – 1: Ecology and systems dynamics	**13**
Ecology: Levels of organization, Ecology: Divisions of Ecology - approaches in studying Ecology. Significance of space and time (scaling), ecology and natural resources. Ecosystems: Classification of ecosystem. Structure and function of ecosystem. Biogeochemical cycles: Hydrological cycle, sedimentary cycle and gaseous cycles. Energy flow in an ecosystem – productivity - trophic levels; Study of pond and crop land ecosystems. Concept of Standing crop, Standing stock, Mass balance, Material flux rate, Residence time and homeostasis and feedback mechanisms. Community Ecology: Characteristics of a Community – *Species diversity, growth form and structure, dominance, relative abundance, trophic structure*. Population Ecology: Characteristics of Population: *Density, Natality, Mortality, Age distribution, Growth form-Population Equilibrium, Biotic potential, Carrying capacity, Dispersal, Dispersion, Population fluctuations*	

and Population regulation. Ecological Niche: Concept and Types of niches: Spatial, Trophic and Multidimensional. Niche parameters: Form, Position and Width. Niche Partitioning - Realized and Fundamental Niche. Hutchinson's duality: the relationship between geographic and ecological spaces. Niche conservatism. Niche models. Ecological succession: Types – Hydrarch and Xerarch - Climax vegetation and their theories. Biomes: Concept and classification of biomes. Concept of Ecotone and Edge effect; Ecological equivalents; Ecotypes and Ecophenes; Ecological indicators. Systems ecology: Systems thinking, synthesis, and modelling.	
Unit – 2: Ecosystem services	**13**
Ecosystem Services: Concept and Definition. Regulating services: *Purification of water and air; Carbon sequestration and climate regulation; Waste decomposition and detoxification; Regulation of prey populations; Pollination; Biological pest and disease control; Disturbance regulation (Flood protection).* Provisioning services: Food *(crops, wild foods and spices);* Raw materials *(Timber, fuel wood, organic matter, fodder, and fertiliser);* Genetic resources *(crop improvement genes, and health care);* Biogenic minerals; Medicinal resources *(Pharmaceuticals, chemical models, and bioassay organisms)*; Energy *(Hydropower, biomass fuels)*; Ornamental resources *(Fashion, handicrafts, jewellery, pets, worship, decoration, and souvenirs)*. Cultural services: Cultural *(Nature motifs in books, film, painting, folklore, national symbols, advertising); Aesthetics,* spiritual and historical *(Art, religious and heritage value);* Recreational experiences *(Ecotourism, outdoor sports and recreation);* Science and education *(Academic excursions and scientific discovery);* Therapeutic *(Eco-therapy, social forestry and animal assisted therapy).* Supporting services: Nutrient cycling, Soil formation, Primary production and Habitat provision. Valuing ecosystem services: Real market methods of valuation; Surrogate market methods of valuation; Hypothetical market methods of valuation; Non-monetary valuation; Optimization of trade-offs; Types of Decision-Making Analysis (DMA); and Markets & payments for ecosystem services. Millennium Ecosystem Assessment. The future of ecosystem services (Anthropocentric approach).	
Unit – 3: Biodiversity and Wildlife	**13**
Biodiversity: Levels of Biodiversity – (G*enetic diversity, species diversity*	

and ecosystem diversity). Values of Biodiversity – (*Direct uses - 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. Biodiversity profile of India: Forests and Grasslands; Wetlands and Riverine ecosystems; Marine and coastal diversity; Agro-biodiversity; Urban Biodiversity; Invasive Alien species. Threats to biodiversity: Over exploitation, Habitat destruction, fragmentation, urbanisation, agriculture extension, river valley projects, industrialisation, deforestation, invasive species, pollution, acidification of soil and water, mining activities, desertification and climate change. Biodiversity indices: Dominance, Evenness, Simpson, Shannon, Menhinick's richness, Berger-Parker, Margalef's richness, Equitability and Fisher's alpha. Traditional Knowledge and ethics in conservation of biodiversity. Bio-piracy. The Biological Diversity Bill, 2000 and The Biological Diversity (Amendment) Bill, 2021. Convention on Biological Diversity and Agenda 21. National Biodiversity Action Plan (NBAP). **Wildlife**: Wildlife of India. Values of wildlife. Values of wildlife: - *Physical utility, economic/monetary value, recreational value, scientific value, ecological value, existence value.* - *Wildlife damage, human animal conflict, loss of economic productivity, wildlife diseases to man and competition effect*. Importance of wildlife: Ecological, economic, socio-cultural, investigatory, medicinal, conservation of biological diversities, importance in agriculture. Threats to wildlife: Over exploitation, habitat loss, encroachment and fragmentation, disease, pollution, invasive and exotic species, Illegal trapping and poaching, agricultural/unrestricted/ over grazing, urbanisation and climate change. Endangered species – Definition, characteristics and reasons for engendering. *Species with a narrow (or single) geographic range, Species with only one or few populations, Species with a small population size, Species with a declining population size, Species hunted or harvested by people, Species with low reproductive ability and/or germplasm-dispersal-ability, Species that require*	

specialised habitat and niche conditions. Endangered species of India. Endemic species – Concept, types, characteristics, theories of endemism. Endemic Wildlife Species of India. Wildlife (Protection) Act, 1972. The Wildlife Protection Amendment Bill, 2022.	
Unit – 4: Ecosystem conservation	**13**
Conservation (Biodiversity and Wildlife): Definition, need and significance. Conservation vs. Preservation. 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 - Project Tiger and Project Elephant; Ramadevarabetta Vulture Sanctuary. Community Conserved Areas – case studies on Black Buck, Snow leopard, Amur falcon and Sarus crane. 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. International conservation efforts: 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+. UN Environment Programme World Conservation Monitoring Centre (UNEP-WCMC).	

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M.Sc. Environmental Science and Sustainability

Semester I

ES 7P4: ECOSYSTEM ASSESSMENT, BIODIVERSITY AND WILDLIFE STUDIES

Number of Practical Credits	Number of Practical Hours / Semester
2	52

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. Study of plant community – Individual count method/Quadrat method.
8. Study of animal community – Line transect method.
9. Estimation of carbon capture and storage of trees.
10. Identification of ecological indicators.
11. Assessment of regulatory services of terrestrial ecosystems (Green spaces) – Comparison method (air temperature, relative humidity and solar influx).
12. Assessment of provisional services of wetland ecosystems – Questionnaire survey method.
13. Estimation of animal population size – Mark, Release and Recapture method.
14. Hands-on experience with biodiversity assessment software - Paleontological Statistics Software Package for Education and Data Analysis (PAST).

Activity – Mapping of International, National and State-wise biodiversity and wildlife conservation sites – Hotspots, Ramsar convention sites, Biosphere reserves, National parks, Sanctuaries, Protected areas and Ecologically significant zones.

Bird watching

Introduction to global biodiversity databases – Global Biodiversity Information Facility (GBIF), Integrated Biodiversity Assessment Tool (IBAT-alliance)

A locally relevant case study on biodiversity related aspects.

People's Biodiversity Register.

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M.Sc. Environmental Science and Sustainability

Semester I

ES 7522 – ENVIRONMENTAL CHEMISTRY AND ANALYTICAL METHODS

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To provide knowledge about the primary and secondary investigation of the pollutants along with insights on the conventional methods.
CSO 2	To equip students with advanced knowledge on analytical techniques to quantify the concentrations of pollutants in the environment.
CSO 3	To inculcate proficiency in theory and working principles of qualitative and quantitative methods for environmental analysis.
CSO 4	To be able to make informed decision in selecting appropriate tools and techniques towards solving environmental problems.

CONTENTS OF ES 7522: ENVIRONMENTAL CHEMISTRY AND ANALYTICAL METHODS	52 Hours
Unit – 1: Basic aspects of physico-chemical analysis	**13**
Primary investigation: Chemical species responsible for specific colour, odour and texture of common samples encountered in environmental analysis – their role and hazards. Secondary investigation: Confirming the nature of chemical species and separating them and identifying them qualitatively – Elemental analysis, Salt analysis, Spot tests in field investigations. Estimations of selected species encountered in field investigations. Conventional methods: Gravimetry and thermal methods.	
Unit – 2: Volumetric analysis – Aqueous and non-aqueous	**13**
Titrations: Criteria involved in selection of a reaction for a titration. Nature of analyte – Steps involved in extracting the analyte completely in to a solution. Titrants – Selection of titrants – Standard solutions (primary and secondary). Criteria for an effective titrant. Methods of determining completion of reactions (end point) – visual indicators and instrumental signals. Role of sensors in field investigations. Precautions to be taken for retaining the activity of the analyte. Calculations involved: Normality (equivalents), Molarity (moles) and Formality. Principles of volumetric calculations with specific examples to the following titrations. - Acid-base titrations; Precipitation titrations; Complexometric titrations; Redox titrations	

Unit – 3: Spectral investigations	**13**
Regions of electromagnetic spectrum. Interaction of a species with light. Various types of responses – rotation, vibration and electronic transition. Different methods to identify and estimate the species in the samples – Microwave spectra, IR spectra, Electronic spectra (UV-Visible spectra). Additional spectral methods – NMR, ESR.	
Unit – 4: Instrumental methods of analysis	**13**
Electroanalytical methods: Potentiometry, Conductometry, Voltametric methods. Optical methods: Colourimetry, Spectrometry (visible and UV), Fourier Transform Infrared (FTIR), Raman spectroscopy, Flame photometry, Turbidimetry and Nephelometry. Spectral methods: Atomic Absorption Spectroscopy, Inductive Coupled Plasma - Optical Emission Spectroscopy (ICP-OES). Diffraction methods: X-ray diffraction – XRF. Radio-chemical methods: Counters and Dosimetry (gas detection, scintillation detections and photo detectors). Block diagrams/Flow charts for instrumentation and operations to be arrived at appropriately. Gas Chromatography-Mass Spectrometry (GC/MS, MALDI and TOF), Ion chromatography, CHNS Analyser (Instantaneous Oxidation/Flash Combustion-Dumas Method), Gamma radiation. Bomb colorimeter, Scanning Electron Microscopy (SEM), Nuclear Magnetic Resonance (NMR).	

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M.Sc. Environmental Science and Sustainability

Semester II

ES 8122 – NATURAL RESOURCES MANAGEMENT

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To develop comprehensive understanding of the dynamics of natural resources and their sustainable utilisation.
CSO 2	To analyse the environmental issues, pressures and conflicts related to Natural resources.
CSO 3	To explore the economy-natural resource interface leading to enhanced and sustainable productivity.
CSO 4	To gain insights into policy and governance framework at national and international levels that shape the management of natural resources.

CONTENTS OF ES 8122: NATURAL RESOURCES MANAGEMENT	52 Hours
Unit – 1: Concept of resources and classification	**13**
Resource: Definition; Resource and wealth. Functional theory of resource and dynamic theory of resource. Classification of resources - Organic and inorganic resources; exhaustible and inexhaustible resources; International, National and Individual resources; Ubiquitous and localised resources. Resources scarcity: Definition; types of resources scarcity - Demand-induced, supply-induced and structural. Resource conflicts: Resource extraction, access and control system. Approaches in resource management: Ecological, economic and ethnological. Integrated resource management strategies. Conservation of resources: Methods of conservation - Refuse, reduce, reuse, recycle and recovery - Methods of waste reduction (Increasing the durability of products, utilising material substitution, recycling and marketability of industrial waste). Natural Resources: Definition, Classification of natural resources based on utility potential. Introduction to Natural Resource Bases: Concept of resource base. Factors influencing resource availability, distribution and utilisation patterns - Nature, Culture and Man. Phantom pile concept. Management of common International resources: Ocean, Climate and Antarctica.	

Unit – 2: Land and Water resources	**13**
Land resources: Land as a resource. Land utilization and land-use pattern of India. Agro-climatic zones of India and Karnataka. Types of agriculture and cropping patterns. Environmental implications of conventional agriculture – Soil degradation, Loss of fertility, Pollution due to fertilisers and pesticides, loss of natural biodiversity, water logging, saline and alkaline soils. Soil sickness (Negative Plant-Soil Feedback). Rangeland: Concept, goals and principles of management. Wasteland: Concept scope, issues and strategies for development. Desertification: Causes, impacts and control measures. Mineral resources: Formation of mineral reserves and deposits. Classification of minerals. Categories of underground, open surface (pit), placer, and in-situ mining. Impacts of mining and quarrying; Mineral exploration in Oceans; Deep sea mining and off shore oil exploration. Ecological conflicts of mineral extraction. Distribution of mineral resources in India and at global level. Case studies on mining and stone quarries. Water Resources: Fresh water - Water budget of India - Dams: Impact on environment – alternatives; Droughts and Floods: Causes and Control Strategies. Rain Water Harvesting and ground water recharge; River linking – pros and cons. Marine water – Ocean as a resource - Fisheries, aquaculture – prawns and oysters - Transportation – Shipping (people, goods and oil) and its impacts - Desalinisation – Importance and impacts Groundwater: Impacts of extraction: uplifting and seismic activities, land subsidence, vegetation degradation and food security implications. Water and agriculture: Irrigated and rain-fed cultivation; Types of irrigation. Irrigation and drainage. Nutrient delivery through irrigation. Hydroponics. National Lake and River Conservation Programmes. Wetland management - Ramsar Convention Sites. Seawater intrusion, Coastal erosion and reclamation. Coastal zone management - concept, scope, issues and strategies. Watershed Management as participatory soil-water conservation practice.	
Unit – 3: Forest resources	**13**
Forest resources: Concept and its significance. Contribution as resource: Major and minor (NTFPs) forest products. Forest ecosystem concept, stand dynamics-forest succession, competition and tolerance, classification of World's forest vegetation. Status and	

distribution of forests in India. Forest genetics resources of India. Documentation and evaluation of Forests Genetic Resources (FGR), in-situ and ex-situ conservation of gene resources. Forest based industries and Indian economy - paper and pulp, furniture, bamboo, sports goods, pencil making, match box, medicinal and pharmaceutical industries. Forest capital theory. Forest Resource Accounting (FRA) - methods and implications. Significance of Farm forestry, Agroforestry, Plantations, Industrial plantation, urban forestry, Avenue trees, and Social forestry in reducing resource demands on forests. Forests and people: Forest societies, tribal economic security and forests, interactions between forests and people, importance of forests in traditional farming systems, forests and food security, livestock economy and forests, social and cultural significance of forests - eco-philosophy. Eco-tourism – Pros and cons. Forest conflicts: Land use change and forests - wildlife and human conflicts, forest fires and weeds, developmental projects, global warming and forests. Inter-regional and international trade in forest products. Forest policy – National Forest Policy, 1988; Indian Forest Act, Forest Conservation Act, 1980; Forest Conservation Rules *(Vana samrakshana Adhiniyam – 2023),* Forest Survey Report. Forest rights, customary rights of people - *Scheduled Tribes and other Traditional Forest Dwellers (Recognition of Forest Right) Act, 2006*; Community participation, Ethnobotany, Joint Forest Management (JFM), Common Property Resources (CPRs) and open access resources. Role of Non-Governmental and community-based organisations in forest management.	
Unit – 4: Energy resources	**13**
Energy resources: Concept and its significance. Forms of energy, primary energy sources, Energy and power. Classification of energy resources – Conventional and non-conventional. Renewable and non-renewable. Commercial and non-commercial. Fossil fuel reserves in India: Coal, petroleum, natural gas and lignite. Renewable energy resources: Solar energy - Flat plate collectors, evacuated tube collectors and photovoltaic cells; Wind energy and wind farms; Hydropower – Magnetohydrodynamic power (MHD) and micro-hydel Power; Geo-thermal energy; Tidal energy; Ocean Thermal Energy Conversion (OTEC) Technology; Hydrogen as an alternate fuel. Nuclear energy: Fission energy, fusion energy, nuclear power generation and nuclear reactors.	

Bioenergy: Biomass energy, Bioconversion technologies, bioethanol and biohydrogen. Biomass (wood) gasification - Fuel wood production and consumption, agro residues as source of energy, pollution free improved biomass cooking stoves. Biogas digesters. Bio-energy plantations: Power generation from energy plantations - producer gas, High Density Energy Plantations (HDEP) and Petro-crops. Recent advances in bio-fuels. Environmental impacts of bio-energy production and usage. Energy from waste: Concept, types and significance. Indian scenario. Energy production and consumption trends in India. Factors affecting India's energy development - Economy and demographics policy and institutional framework. Energy prices and affordability. Social and environmental aspects. Investments in energy production and trade. Energy storage systems: Energy storage methods - mechanical, chemical, biological, magnetic and thermal. Energy management: Principles, energy demand estimation and energy pricing. Conservation of energy: Importance, methods of conservation, barriers to energy conservation, measures for promoting energy conservation and eco-friendly energy sources. Energy audit: Purpose, methodology with respect to residential, commercial and process industries. Energy saving practices. Energy policies in India. Bureau of Energy Efficiency - Energy Efficiency Standards. The Energy Conservation Building Code. ISO 50001 – Energy Management Systems.	

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Content of Practical Course

ES 8P1: MAPPING AND NATURAL RESOURCES STUDIES

Number of Practical Credits	Number of Practical Hours / Semester
2	52

1. Introduction to survey and use of surveying instruments (Total station, Handheld GPS) for mapping. Type of maps and their utilities.
2. Cartographic concept; Essential of cartographic process (scale, projection, direction, elevation).
3. Conventional signs, plan and profile and representation of relief and map numbering system.
4. Thematic map and map reading (latitude, longitude and MSL of any point), area measurements, slope measurements.
5. Aerial photographs and satellite imageries- its usage in 2d/3d data capturing.
6. Delineation of entity like forest, settlements, water bodies, etc using topographical maps.
7. Watershed characteristics and delineation using a topographical map.
8. Geotagging of Environmental assets (field activities).
9. Mapping of Forest fire risk zone, Biosphere reserves, National Park, etc.
10. Characteristics of agro-climatic zones of Karnataka state and mapping of local agricultural Diversity.
11. Identification and documentation of medicinal plants and NTFPs.
12. Bhuvan- Indian Geo-platform of ISRO – geographic services (display, editing, interpretation, etc.)

Activity – Visit to nearby forest and document the floral and faunal species

Visit to Institute of Wood Science and Technology

Visit to medicinal garden at Foundation for Revitalisation of Local Health Traditions (FRLHT)

Visit to nearby agricultural area – cropping pattern

Visit to power generation plant

Visit to Biofuel facility

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M.Sc. Environmental Science and Sustainability

Semester II

ES 8222 – ENVIRONMENTAL MICROBIOLOGY AND ENVIRONMENTAL BIOTECHNOLOGY

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To acquaint the learners with key concepts on microbiology, microbial sampling and biochemistry.
CSO 2	To understand the fundamentals of genetic engineering along with case studies to encourage critical thinking.
CSO 3	To comprehend the advancements in bioinformatics, metagenomics and metabarcoding to provide sustainable alternatives.
CSO 4	To explore the possibilities of biotechnology in wastewater management and its application as an alternative energy source as biofuels.

CONTENTS OF ES 8222: ENVIRONMENTAL MICROBIOLOGY AND ENVIRONMENTAL BIOTECHNOLOGY	52 Hours
Unit – 1: Microbiological concepts, sampling and biochemistry	**13**
Structure and morphology of bacterial, fungal and viral cells. Microbial growth media and the factors that impact the growth. Stages of bacterial growth curve. Sampling from air, water and soil sources. Sample dilution techniques and microbial culture techniques. Pure culture isolation from a mixed microbial culture. Concepts of pH, buffers and chemical bonds (hydrogen, ionic, covalent). Classification and structure of carbohydrates, lipids, amino acids. Structure of biomolecules (DNA, RNA, protein and plasma membrane).	
Unit 2: Environmental omics, Bioremediation	**13**
Environmental omics: Bioindicator species. e-DNA, metagenomics, metabarcoding. Bioinformatics tools for environmental analysis. Bioremediation: Definition, Types with examples. Techniques in bioremediation. Examples of organisms used in Bioremediation (microbial and plants). Case studies on bioremediation of heavy metals, pesticides, textile dyes, nitrogen compounds, oil spills.	
Unit 3: Genetic engineering, Biocontrol and Biosafety	**13**
Genetic engineering: Concepts of recombinant DNA technology, Enzymes in genetic engineering (restriction enzymes, ligases, DNA/RNA	

polymerases), vectors for cloning (plasmid and bacteriophage). Concepts of crop improvement using genetic engineering. Case study: Bt cotton. Biocontrol: Biological insecticides (*B. thuringiensis*, *B. sphaericus* and *Baculovirus*), Biofertilisers. Biosafety: Biosafety levels (BSL), Organisms in various BSL.	
Unit 4: Bioprocess and Production of Biofuels	**13**
Concepts of cleaner bioprocess. Sustainable alternatives with positive impact on environment: energy sources, alternate and efficient industrial processes, alternate biomaterials etc. Application of nanotechnology to improve efficiency. Overview of wastewater treatment process. Microbes involved in different levels of waste treatment. Improving the design of bioreactors involved in the process. GMOs for improving the treatment efficiency. Biofuels: Sources for biofuel, Biochemical Conversion Process, bioethanol production from different sources, biomethanol production, biogas and syngas. Algae for biofuels. Biodiesel production. Challenges in biofuel business. Plant based materials for energy harvesting. New avenues using nanobiotechnology.	

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ES 8P2: ENVIRONMENTAL MICROBIOLOGY AND ENVIRONMENTAL BIOTECHNOLOGY

Number of Practical Credits	Number of Practical Hours / Semester
2	52

1. Good Lab Practises (GLP) and introduction to various instruments and their function: pH meter, Incubator, Laminar air flow unit, autoclave, hot air oven, light microscope.
2. Sterilization techniques and preparation of bacterial and fungal growth media, pH adjustment, plugging and sterilization.
3. Open air culture/Serial dilution of bacteria and fungi.
4. Colony characterization and cell counting using Haemocytometer.
5. Gram's staining of bacterial culture and fungal staining and observation.
6. Plate culturing techniques (pour, spread and streak) and slant cultures.
7. Biochemical tests: (Starch hydrolysis, Gelatin liquefaction, MPN, Catalase and IMViC tests).
8. Antibiotic susceptibility testing of bacteria.
9. Isolation of textile dye degrading bacteria.
10. Transesterification of oil samples.
11. Growth curve of bacteria in nutrient agar and its comparison with media enriched with toxic contaminants.
12. Toxicity impact on bacterial growth.

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Aneja, K. R. 1996. Experiments in Microbiology, Plant Pathology, Tissue Culture and Mushroom Cultivation. Wishwa Prakashan.

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M.Sc. Environmental Science and Sustainability

Semester II

ES 8322 – ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL AUDIT

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To provide insights on the basic principles, objectives, core values and pillars of Environmental Impact Assessment.
CSO 2	To provide knowledge on the EIA methodologies, impact identification, impact prediction and impact mitigation strategies.
CSO 3	To comprehend the environmental impacts and mitigation measures of various developmental projects with case studies.
CSO 4	To gain insights on the environmental audit procedures and accreditation bodies of India.

CONTENTS OF ES 8322: ENVIRONMENTAL IMPACT ASSESSMENT AND ENVIRONMENTAL AUDIT	**52 Hours**
Unit – 1: Concept of an EIA	**13**
Environmental Impact Assessment: Definition, history and evolution. Initial Environmental Examination and Full-scale Environmental Impact Assessment. Basic principles of an EIA: *Prevention is better than repair*, *System dynamics and Black-box approach*. Objectives, Salient features and Core values of an EIA. Stakeholders of an EIA: *Proponent, Decision maker, Review commission, Legal advisors, Public interest groups and Consultancy companies*. Analytical functions associated with EIA: *Defining scope of an EIA, Identification and description of the existing environmental system, prediction and impact evaluation and analysis*. Steps in an EIA: *Screening, Scoping & consideration of alternatives, Baseline data collection, Impact prediction, Assessment of alternatives, Delineation of mitigation measures, preparation of environmental impact statement, Public hearing, Environment Management Plan, Decision making and Monitoring the clearance conditions*. Components to be considered in an EIA: *Air, Water, Nosie, Land, Biological environment, Socio-economic and Health Environment, Risk*	

Assessment. Pillars of an EIA: *Transparency, certainty, participation and inclusion, practicability, flexibility, cost-effectiveness, credibility and accountability*.	
Unit – 2: Impacts and their methods of identification	**13**
Impact: Definition, Types - *Direct, Indirect and Cumulative; Primary secondary, Tertiary and chain impacts; Positive and negative; local and widespread impacts; random and predictable impacts; and short and long term impacts*. Methods of impact evaluation: Characteristics, Criteria for the selection of EIA methodology: *General, impact identification, impact measurement, impact interpretation and evaluation and impact communication*. Types of EIA: *Strategic EIA, regional EIA, sectoral EIA, project level EIA and life cycle assessment*. EIA Methodologies: Rapid and Comprehensive EIA. Characteristics of methods of Impact Identification. Methods of Impact Identification: *Ad-hoc methods, Checklist methods, Matrices methods, Networks methods, Overlay methods, Environmental index using factor analysis, Cost-benefit analysis, Predictive or Simulation methods*. Methods of Impact Prediction: *Explorative and Normative; Field and laboratory methods; Physical models; statistical models; mathematical models; Geographic Information System and Expert judgements*. Impact Mitigation: Concept, Hierarchy in impact mitigation: *Avoid, Reduce, Remedy, Compensate and Enhance*.	
Unit – 3: Prediction & Assessment of Impacts and Case Studies	**13**
Prediction & Assessment of Impacts on 1. *Soil and ground water environment* 2. *Surface Water Environment* 3. *Biological Environment* 4. *Air Environment* 5. *Noise Environment* 6. *Socio-economic and human health impacts* 7. *Environmental Risk Assessment and Risk Management* List of projects requiring Prior Environment Clearance or Prior Environment Permission - Category A, B1 & B2 projects.	

Case Studies (*Assignments are to be assigned after an Overview and discussing the structure*): 1. *Industrial projects* 2. *Sugar, Distilleries and molasses-based manufacturing units* 3. *Pulp & Paper Industry* 4. *Power projects – Hydel, Thermal and Nuclear Power* 5. *River Valley projects* 6. *Mining projects* 7. *Infrastructural projects/Industrial Estates - Building Construction and Area Development projects, Special Economic Zones (SEZs)* 8. *Common Effluent Treatment Plants (CETP)/Treatment, Storage and Disposal Facilities (TSDFs)* 9. *Common Municipal Solid Waste Management Facility (CMSWMF) involving land filling and / or incineration* 10. *Highways or Expressways or Multi-modal corridors or Ring Roads* 11. Textile industries with reference to MSME 12. IT industries with reference to National Building Code related to Energy/Urban Heat Islands.	
Unit – 4: Environmental audit and Accreditation bodies	**13**
Environmental Management System – Concept, principles and objectives. Overview of ISO 14001. **Environmental Audit** Concept, Objectives and advantages. Internal and External audit. Types of Environmental Audit: Environmental Compliance Audits, Environmental Management Audits and Functional Environmental Audits. Water audit, Energy audit, Health & Safety audit and Waste & Waste Minimisation audit. Audit procedure: Pre-audit activities, On-site activities and Post-audit activites. Evaluation of Audit data and Preparation of audit report. Auditor profile. Salient features of Environment (Protection) Act, 1986. **Accreditation bodies** National Productivity Council (NPC)	

Quality Control of India (QCI) National Accreditation Board for Certification Bodies (NABCB) National Accreditation Board for Education and Training (NABET) National Accreditation Board for Testing and Calibration Laboratories (NABL) International Accreditation Forum (IAF) International Laboratory Accreditation Cooperation (ILAC)	

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ES 8P3: ENVIRONMENTAL IMPACT IDENTIFICATION AND AUDIT METHODS

Number of Practical Credits	Number of Practical Hours / Semester
2	52

1. Study of recent EIA notification and guidelines.
2. A review of various EIA reports.
3. Development of data sheet and analysis - Ad-hoc methods for EIA.
4. Development of data sheet and analysis - Checklist methods for EIA.
5. Development of data sheet and analysis - Matrices methods for EIA.
6. Development of data sheet and analysis - Networks methods for EIA.
7. Development of data sheet and analysis - Overlay methods for EIA.
8. Development of questionnaire and data collection - Socio-economic dimensions of a project.
9. Development of questionnaire and data collection - Health impacts of a project.
10. Development of datasheet to analysis the Environmental Risk Assessment and Risk Management in an industry.
11. Cost-benefit analysis of development projects.
12. Water audit – Clean water, grey water and black water.
13. Energy audit – Electricity and fossil fuel.
14. Waste audit – Solid and Liquid.

(Any relevant open source software to be used for Sl. No. 12 – 14).

Activity – Visit to Environmental consultancy companies

Participation in public hearings

Preparation of EIA for some typical developmental activity

References

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M.Sc. Environmental Science and Sustainability

Semester II

ES 8422 – GEOSPATIAL AND WEB-GIS APPLICATIONS

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To provide a comprehensive understanding of fundamentals of mapping and various elements of a map.
CSO 2	To equip learners with the processes of remote sensing and utilization of different satellites and sensors for data acquisition.
CSO 3	To articulate the role of GNSS satellites to enable the positioning of objects and explore new ways of GPS data collection using mobile based apps.
CSO 4	To develop skills in spatial analysis techniques including interpolation methods, overlay analysis, buffer analysis and network operations.

CONTENTS OF ES 8422: GEOSPATIAL AND WEB-GIS APPLICATIONS	52 Hours
Unit - 1: Basic MAP and GIS Concepts	**13**
Definition of map, fundamental aspects of a map- point, lines and polygons ,map scale and types of scales GIS definitions, Advantages of GIS - Paper maps over digital maps, Type of GIS software – Open sources vs proprietary. Spatial & Non-spatial Data: Data vs information, data type, data sources, characteristics of spatial and non-spatial data. Data models - raster and vector. Map elements.	
Unit - 2: Remote Sensing	13
Introduction to remote sensing, process of remote sensing, Types of remote sensing. Concept of pixel, satellite and sensors used in remote sensing, types of resolutions -spatial, temporal, radiometric and spectral, examples of remote sensed data. Downloading satellite imagery and DEM from online sources.	
Unit - 3: Data Collection and GNSS basics	13
Sources of spatial data, sources of non-spatial data. GNSS**:** Concept, Components-Space segment, Control segment, User segment. GPS Observations, Errors in GPS Observations, mobile-based apps for collecting location data, importing GPS data into GIS software.	
Unit - 4: Manipulation and Analysis of Data	13
Measurement of lengths, perimeter and areas, queries, buffer analysis, topology, neighborhood operations, network operations, overlay analysis,	

and surface analysis. Interpolation and its methods. Role of GIS in developmental projects. Multi-criteria decision making using GIS.	

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Anji Reddy, M. (2001). Textbook of remote sensing and geographical information systems. *S. Publications, Hyderabad*.

Anji, R. (2010). Textbook of Geographical Information Systems. *BS Publication, third edition, Hyderabad*.

Collier, P. (2007). Geographical Information Systems: An introduction. *Geography*, *92*(3), 303.

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https://www.qgis.org/en/site/

https://www.surveyofindia.gov.in/

ES 8P4: GEOSPATIAL AND WEB-GIS APPLICATIONS

Number of Practical Credits	Number of Practical Hours / Semester
2	52

1. Introduction to GIS and its components. Concepts and theory.
2. Understanding Google Earth Pro - hands on exercise (spatial data capturing and analysis).
3. QGIS (3 practical classes).
    a. Georeferencing
    b. Digitization
    c. Labelling, styling, print composer and map generation
4. Q GIS - Data views, attribute data visualization spatial join.
5. QGIS- Spatial analysis-buffer, union, intersection.
6. Land use land cover digitization from aerial photographs, satellite images.
7. Elevation data (DTM and DEM) downloading using Bhuvan portal (2 practical classes).
    a. Slope
    b. Aspect
    c. Viewshed
    d. Hillside analysis
8. Field data collection using GPS for Environmental Monitoring.
9. Field data collection using mobile applications for Environmental Monitoring.
10. Introduction to drone technology and demonstrations.

Activity- Project presentation on Environment and review.

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https://www.isro.gov.in/update/01-sep-2008/national-remote-sensing-agency-becomes-isro-centre

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M.Sc. Environmental Science and Sustainability

Semester II

ES 8522 – ENVIRONMENTAL ECONOMICS

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To provide understanding of economics, the cost-benefit analysis and link between environment and economics.
CSO 2	To examine the market failures and externalities.
CSO 3	To conceptualise the methods of valuing environmental assets.
CSO 4	To address International trade and transboundary environmental issues.

CONTENTS OF ES 8422: ENVIRONMENTAL ECONOMICS	52 Hours
Unit - 1: Introduction to economics	**12**
Economics-definitions; approaches- Microeconomics, production possibility curve -choice making (concepts). Macroeconomics - circular flow, national income, aggregate demand and supply Determination of Output, Employment, and Prices. Positive and normative economics, static and dynamic (concepts). Link between economics and the environment	
Unit - 2: Consumption, Production and Welfare	**10**
Utility, the law of demand. Supply -Laws of production, cost of production, Marginal cost and marginal revenue (benefit); the concept of opportunity cost; Cost-benefit analysis, neo-classical framework. Welfare -Pareto optimality	
Unit - 3: Market failure and externalities	**12**
Competitive markets, price mechanism and market failure- Incomplete and missing markets. Externalities-divergence between private and social -costs and benefits, negative and positive externality - – production and consumption externalities. Type of goods, goods, asymmetric information, property rights; Hardin's tragedy of commons, Coase theorem, Elinor Ostrom's logic of collective action.	
Unit - 4: Instruments for environmental protection	**8**
Economic incentives - Price rationing - Emission charges, ambient charges, product charges, subsidies, imposing taxes. Liability rules- non-compliance fees, performance bonds and deposit refunds. Quantity rationing- tradable pollution permits. Technological restrictions and abatement methods; cooperative institutions -sharing information.	

Unit - 5: Economic valuation	**8**
Concept of measuring values, measures of non-economic value – preferences, utility and consumer surplus, valuing risk. Total value-use and non-use values. Methods of valuing environmental assets-cost and benefits- willingness to pay and willingness to accept- Direct methods of valuation-contingent valuation method. Indirect methods of valuation-travel cost model, Hedonic pricing, Dose-response, averting expenditure and avoided cost methods.	
Unit - 6: International trade and transboundary environmental issues	**2**
Basis of international trade-comparative cost and resource endowment, problem of international externalities, differential environmental standards – NIMBY, international protocols	

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M.Sc. Environmental Science and Sustainability

Semester III

Title of the Course: **ES 9123 – CLIMATE CHANGE AND DISASTER MANAGEMENT**

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To provide thorough understanding on climate change science with impacts of climate change on various sectors
CSO 2	To create awareness on the sources of meteorological data and GHG protocols of climate change.
CSO 3	To explore the legal, scientific, biological and market-based mechanisms to mitigate climate change.
CSO 4	To develop deep understanding on relationship of climate change and disasters and profound mitigation measures for disaster management.

Title of the Course: **ES 9123 – CLIMATE CHANGE AND DISASTER MANAGEMENT**	**52 Hours**
Unit – 1: Climate Change Science	**13**
Climate Change Science: Concept, significance and causes. History of climate change. Greenhouse gases and greenhouse effect. Increase in atmospheric carbon dioxide concentration, increase in surface mean temperature, variability in precipitation, sea level rise, melting of ice and glaciers. Impacts of Climate Change on Various Sectors: Health, agriculture, forestry, water resources, coastal areas, species & natural areas, industry, settlements and society – climate refugees. Anthropogenic Drivers of Climate Change: Energy sector; Industrial process and product use sector; Agriculture, forestry & other land use sectors; and Waste sector. Trends and Impacts of Climate Change: Observed and projected impacts for different regions. Uncertainties in the projected impacts of climate change and risk of irreversible changes.	
Unit – 2: Scientific Data, Legal and Policy Framework	**13**
Sources of Scientific Data: The World Meteorological Organization (WMO), The National Oceanic and Atmospheric Administration (NOAA), Scripps Institution of Oceanography (SIO), The Intergovernmental Panel on Climate Change (IPCC), World Resources Institute (WRI), The India Meteorological Department (IMD), National Disaster Management	

Authority (NDMA) and Karnataka State Natural Disaster Monitoring Centres (KSNDMC). GHG Protocols: ISO 14064 - International standard for GHG emissions inventories and verification. IPCC guidelines for national greenhouse gas inventories. GreenCo Rating System. Efforts towards climate change: UN Conference on the Human Environment 1972, Rio Earth Summit 1992, Agenda 21, Kyoto Protocol 1997, Rio+20, Conference of Parties (CoPs) and Paris Agreement - Nationally Determined Contributions (NDCs) towards climate justice. National Action Plan on Climate Change (NAPCC), India's NDCs.	
Unit – 3: Climate Change Mitigation and Adaptation	**13**
Climate change mitigation: Definition, Factors to be considered for climate change mitigation - renewable energy; energy efficiency; sustainable transportation; carbon capture & storage; afforestation & reforestation; low carbon development; waste reduction & management; sustainable agricultural practices; low carbon tech; building codes & standards; education and awareness. Alternative development models. Mission LiFE. The United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation (UN-REDD and REDD+ Programmes). Climate change adaptation: Definition, Vulnerability Assessment and climate justice. Factors to be considered for Climate Change Adaptation - Coastal Protection; Water Management; Land-Use planning; Ecosystem Restoration; Infrastructure Upgrades; Heat wave preparedness; Urban Heat Islands; Health Management; Disaster Risk Reduction; Sustainable Agriculture, Education and awareness. Biological capacity and Ecological footprints: Definitions, Carbon footprint, water footprint, Global Footprint Network. Earth Overshoot Day. Market-based mechanisms for managing climate change: Clean Development Mechanism, Carbon emission trading, Carbon pricing, Carbon credits, Carbon offsets and Carbon markets. Climate finance – Green Climate Fund and Adaptation Fund. Calculation of Social Cost of Carbon.	
Unit – 4: Disaster Management 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.	**13**

Man-made disasters: Definitions and introduction to Gas leaks, Toxic and Hazardous wastes, Nuclear and radiation accidents, Oil spills, Forest fires, Pandemics, Weather Extremes & Climate Change and Wars. Definitions of Risk, Hazard, Exposure, Vulnerability, Response, Mitigation, Preparedness and Prevention. Mitigation and Management techniques of disaster: Basic principles of disaster management, Disaster Management Cycle, 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. Dam Safety: Issues, emergencies preparedness and mitigative measures. National Dam Safety Bill.	

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Content of Practical Course

ES 9P1: CLIMATE CHANGE ASSESSMENT AND SUSTAINABILITY TOOLS

Number of Practical Credits	Number of Practical Hours / Semester
2	52

1. Study of Guidelines - ISO 14064, IPCC, GRI, WRI and CEA
2. Collection of Scientific Data for Climate Change Studies - Real-time and Published data
3. Study of Emission Factor Databases for Greenhouse Gas Inventory
4. Inventorisation of GHG emissions from the Energy sector – Petrol, Diesel and Electricity sources
5. Inventorisation of GHG emissions from Agricultural sector - Livestock and Fertiliser sources
6. Inventorisation of GHG emissions from Waste sector - Municipal solid waste, Domestic and Industrial wastewater
7. Quantification of Carbon footprint and Water footprint of an Institution/Organisation
8. Calculation of Human Development index / Sustainable Development Index
9. Calculation of Sustainable Value of an Organisation – SV calculator
10. Quantification of Handprint of an Institution/Organisation
11. Introduction to ESG Reporting/Life Cycle Assessment Software
12. Rating of Buildings - GRIHA standards
13. Mapping and analysis of the supply chain of a product

Activity – Visit to consultancy companies offer ESG service

Visit to a green building

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M.Sc. Environmental Science and Sustainability

Semester III

Title of the Course: **ES 9223 – SUSTAINABLE DEVELOPMENT**

Number of Theory Credits	Number of Lecture Hours / Semester
4	**52**

Course Specific Objectives	
CSO 1	To provide in-depth knowledge on concepts and approaches to attain sustainable development.
CSO 2	To give insights on sustainable development goals along with tools to assess sustainable development.
CSO 3	To analyse the life cycle assessment methodology to be able to calculate footprint and handprints.
CSO 4	To develop skillsets on sustainable building and infrastructure rating systems for planning of sustainable cities.

Title of the Course: **ES 9223 – SUSTAINABLE DEVELOPMENT**	**52 Hours**
Unit – 1: Sustainable Development	**14**
Sustainable Development: Definition. Conventional development model and its criticisms. Sustainability vs Sustainable Development. Approaches to sustainable development: Hartwick-Solow or Weak sustainability approach; London school or Strong sustainability approach and safe minimum standards approach – Anthropocene and Planetary boundaries. The concept of finitude, fragility and fairness in sustainable development. Components of sustainable development: Environment, Social, Economic and Cultural. Synergies, trade-offs and conflicts in Sustainable Development. Geographic Perspectives and Sustainable Development: The role of Spatial Scale in Sustainable Development and Interaction between different Spatial Levels. Linking Local and Global Sustainability. Evolution of Sustainable Development perspectives: Brundtland Commission, 1987, Agenda 21, MDGs and SDGs; United Nations summits and their outcomes. Transboundary issues, Multilateral Environmental Agreements, Conventions and Protocols. Key Concepts for Sustainable Development: *Factor 4 and Factor 10. The goals of sustainability (Ehrlich and Holdren's IPAT equation); Systems Thinking; Life Cycle Thinking; The Circular Economy; Industrial Ecology; Green Economy and Low Carbon Economy; The Natural Step; Resource Efficiency and Decoupling; Eco-efficiency and Triple Bottom Line.*	

Unit – 2: Sustainable Development Goals	**8**
Sustainable Development Goals: Introduction, Objectives and Significance. An overview of Sustainable Development Goals and Targets: Global and Indian perspective. Sustainable Development Goals Integration: Indian Model of SDG localisation. Sustainable Development indices. Sustainable Development Goals India index.	
Unit – 3: Indicators of Sustainable Development and Sustainability Assessment	**8**
Indicators of Sustainable Development: *Pressure indicators, State indicators, Response indicators, Impact indicators, Efficiency indicators, Sustainable indicators, Environmental performance indicators*. Uses of Indicators. Characteristics of a good indicator - SMART - *Specific, Measurable, Achievable, Realistic and Time-Bound*. Sustainability Assessment: Introduction and need. Tools of sustainability assessment - *Environmental Management Systems; Environmental Auditing; Cleaner Production Assessment; Environmental Impact Assessment; Strategic Environmental Assessment; Design for Sustainability and Stakeholder Engagement.*	
Unit – 4: Life Cycle Assessment	**14**
Life Cycle Assessment: Definition, Goal and Scope. Sustainable consumption and production policy frameworks. Instruments for sustainable extraction, use and management of raw materials - Sustainable Procurement. Instruments for cleaner production. Instruments for better products, services and the marketplace. Instruments for smarter consumption. Instruments for end-of-life management. Life Cycle Assessment Methodology: *Life Cycle Inventory; Life Cycle Impact Assessment*; Interpretation and Presentation of Results; The Iterative Nature of LCA; Methodological Choices; LCI Databases and LCA Software; Strengths and Limitations of LCA. Environmental Life Cycle Costing, Social Life Cycle Assessment, and Life Cycle Sustainability Assessment: LCA Applications; Eco-labelling and Environmental Product Declarations and Product Category Rules. Footprints: Ecological Footprint; Carbon Footprint; Water Footprint; Energy Footprint; Waste Footprint including E-waste; Foodprint; Industrial Footprint, Agricultural Footprint – Case studies. Handprints: Concept and significance.	
Unit - 5: Sustainable Cities and Communities	**8**
Sustainable Cities (Urbanisation and its impact of growth on Water, Energy, Non-motorised and motorised transport, Waste generation).	

Building Resilience in Cities; Planning for Sustainable Cities. Significance of green spaces. Comprehensive Sustainable Development Plan (CSDP). Case studies. Sustainable Buildings and Infrastructure Rating Systems: Indian Green Building Council (IGBC), Green Rating for Integrated Habitat Assessment (GRIHA), Leadership in Energy and Environmental Design (LEED), Excellence in Design for Greater Efficiencies (EDGE); Sustainable Energy/Energy Sustainability (BEE) and Urban Agriculture. Principles of Sustainable Lifestyle.	

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M.Sc. Environmental Science and Sustainability

Semester III

Title of the Course: **ES 9323 – CORPORATE SUSTAINABILITY AND ENVIRONMENT, SOCIAL & GOVERNANCE**

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To explore the key concepts on corporate sustainability and corporate social responsibility.
CSO 2	To develop standards and attitudes in understanding ESG and complex environmental issues.
CSO 3	To comprehend on the relationship between business activities and environmental issues along with impact of climate risks on financial systems.
CSO 4	To highlight the ESG disclosures, frameworks and collaborative initiatives to attain sustainable development goals.

Title of the Course: **ES 9323 – CORPORATE SUSTAINABILITY AND ENVIRONMENT, SOCIAL & GOVERNANCE**	**52 Hours**
Unit – 1: Corporate Sustainability	**8**
Corporate Sustainability: Overview, Debates surrounding corporate sustainability. Triple Bottom Line – meaning and components. Responsible Investing: Impact Investing, Social Impact Investing, ESG Investing. Corporate Social Responsibility (CSR): Meaning, history and evolution, drivers of CSR, Sustainable development and CSR. Moral and economic arguments for CSR. CSR in India – Overview, Provisions of the Companies Act, 2013. Corporate Environmental Responsibility. CER Frame work.	
Unit – 2: Environment, Social and Governance	**20**
Environment, Social and Governance: Meaning, Importance and Components. Environment Factors – Concepts of climate change, climate change mitigation, climate change adaptation and other environmental issues; Relationship between business activities and environmental issues, impact of climate risks on the financial system; climate related physical and transition risks to business; Circular economy; Clean and technological innovation, green and ESG-related products; the Blue Economy. Environmental reporting: Significance, methods for measuring and reporting on environmental impacts - *Ecological footprints*. ……..	

Social Factors – Stakeholders, key social concepts including human capital, development, employment standards, health and safety; product liability/consumer protection: safety, quality, health and demographic risks, and data privacy and security; stakeholder opposition/controversial sourcing. Social reporting: Significance, methods for measuring and reporting on social impacts. Social impact assessment tools - *Social Return on Investment (SROI)*. …… Governance Factors - Board structure, diversity, effectiveness, and independence; executive remuneration, performance metrics, and Key Performance Indicators (KPIs); Reporting and Transparency; financial integrity and capital allocation; Business ethics. Role of auditors in corporate governance. Governance reporting: Significance, methods for measuring and reporting on governance performance. Corporate governance frameworks and codes - *The Organisation for Economic Co-operation and Development (OECD) Principles of Corporate Governance.*	
Unit 3: Integrated reporting, Assurance and Verification	**10**
Integrated reporting: Overview of integrated reporting and its benefits. Key components of an integrated report. Examples of integrated reports and best practices for preparing them. Assurance and verification: Overview of assurance and verification in sustainability reporting. Types of assurance and verification (internal audit, external assurance). Best practices for selecting and working with assurance providers.	
Unit – 4: ESG Disclosures	**14**
Drivers for sustainability disclosures: Investor interest, consumer interest and regulatory bodies. Engaging with stakeholders - *Customers, suppliers, employees and investors.* Collaborative initiatives - *Industry associations and multi-stakeholder partnerships.* ESG Frameworks: Meaning, need for ESG reporting, principle of materiality – International Frameworks: Environmental Performance Index (EPI); Global Reporting Initiative (GRI); Carbon Disclosure Project (CDP); Sustainability Accounting Standards Board (SASB); United Nations Global Compact; Task Force on Climate related Financial Disclosures (TCFD), The Taskforce on Nature-related Financial Disclosures (TNFD), International Sustainability Standards Board (ISSB) and Science Based Targets (SBT). Securities Exchange Board of India (SEBI) - Business Responsibility and Sustainability Report (BRSR). Sustainability leadership: Case studies of different industries.	

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M.Sc. Environmental Science and Sustainability
Semester III

Title of the Course: **ES 9423 – SAFETY, HEALTH & ENVIRONMENT**

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To understand interrelatedness of environmental science and safety at work place.
CSO 2	To be able to identify hazards at workplace and to carry out risk assessment.
CSO 3	To understand fire accidents, their management and to familiarise with the concepts of Occupational Safety and Health (OSH)
CSO 4	To familiarise with the safety rules, guidelines and protocols at workplace.

Title of the Course: **ES 9423 – SAFETY, HEALTH & ENVIRONMENT**	**52 Hours**
Unit – 1: Safety, Health and Environment (SHE)	**14**
Safety, Health and Environment (SHE): 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 NSD Pledge. Industrial accident: Introduction, meaning, Near miss, industrial accidents - types, Causes - Unsafe Act, Unsafe condition, Difference between Unsafe acts and unsafe conditions, Examples, 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. Hazop Studies - Introduction, Risk based Decision-making, ALARP – As. Low As Reasonably Practical (LARP), So Far As Is Reasonably Practicable (SFAIRP), Risk and Risk Matrix. Five E's for Accident Prevention at the workplace. Housekeeping: Introduction, Meaning. Advantages, Profits.	

Introduction to 5S principle, Advantages, Roles of employees. Ergonomics: Introduction, meaning, Application, Objectives, safety program. Musculoskeletal disorders (MSDs) - Signs and symptoms, Engineering controls. Personal Protective Equipment's (PPEs): Introduction, Requirements, points to be considered when selecting, types based on hazards, maintenance. Benefits & Limitations of PPE's. Indian standards of PPE's - Specification of safety PPE's based on Indian standard. Best practice indicators - Plan, Do, Check and Act (PDCA).	
Unit – 2: Hazard Identification and Risk Assessment	**14**
Hazard Analysis Techniques: Introduction, Requirements for Hazard Analysis, Various Hazard Analysis Techniques. Fault Tree Analysis (FTA) - Application of FTA with a Typical Example, Symbols used Construction, Advantages and Disadvantages, Summary. Event Tree Analysis (ETA), Failure Mode and Effects Analysis (FMEA), Health Hazard Analysis (HHA) –Methodology. Hazard Identification and Risk Assessment (HIRA): Term and Definitions, Basic Concepts, Planning and Conducting of HIRA, Process of HIRA, Flow chart for HIRA process, Hazard identification - Health hazards, Safety hazards, Environmental hazards, Hazard identification technique, The hazard identification and assessment methodology, Analyse and estimate risk - Likelihood of an occurrence, Severity of hazard, Risk assessment, Control- Selecting a suitable control, Types of Control - Engineering control, Administrative controls, Monitoring controls - Safe work procedures, Documenting HIRA. Work Permit System: Introduction, Definition and Meaning, Purpose, Type of work Requiring work Permit, List of Safety Documents, Type of Work Permits – Hot Work Permits, Cold Work Permits, Confined Spaces / Vessel Entry Work Permits, Chemical Work Permits, Height Work Permit, Electrical Isolation Permit, Excavation Permit, Blasting work Permits and Industrial Radiography Permits. Limited Work Permit, Contributing Factors for Work Permit, Application of Work Permit System, Permit Issue, Review, Validation, Cancellation, and Completion of Work, Administration Process for Work Permit System, Benefits and Limitations of Work Permit System. Risk assessment: Definition of Risk, Exposure assessment, Comparative risk analysis, Risk matrix, Risk rating and Risk communication. Risk analysis: Definition. Process of risk analysis - Identification, Analysis, Evaluation, Treatment and Review. Qualitative Risk Analysis Methods - Bow Tie analysis, The Delphi Technique, The SWIFT Analysis and The Fly Analysis.	

Quantitative Risk Analysis Methods - Failure Mode & Effect Analysis (FMEA), Fault Tree Analysis (FTA) and Event Tree Analysis (ETA). First aid: Introduction, principles, training in first aid, Cardio Pulmonary Resuscitation-CPR, First aid procedures - electrical shocks, poisons, open wounds, Control of bleeding and Snakebites.	
Unit – 3: Fire Safety and Management	**14**
Fire at work place: Definition and causes of fire. Fire development and its severity, effect of enclosure, need for early detection of fire. Fire safety foundation: Definitions- Occupational health and safety, Safety, Ill health, Accident. Incident, Environmental protection, Hazard, Risk. Scope and nature, the moral, legal and financial reasons for promoting good standards of safety within an organisation, The business case for managing fire safety, The nature and sources of safety information, The basis of a system for managing safety. Anatomy of Fire: Introduction, Elements of Combustion - The fire triangle, the fire tetrahedron, Products of Combustion, Heat of reaction and calorific value, Flash point, Fire point, Ignition temperature and spontaneous combustion. Stages of combustion. Principles of fire spread – Convection, Conduction and Radiation. Classification of Fire & Extinguishers: Classification of Fire. Techniques of fire extinction - starvation, smothering, cooling, and Inhibition. Extinguishing agents. Halon and its detrimental effects on environment. Alternatives of Halon. Types of extinguishers, method of operation, maintenance. Selection of fire extinguishers. Fire risk assessment: Introduction, Definitions relating to fire risk assessment - Fire hazard, Fire risk, Fire risk assessment, Fire risk controls Risk control systems (RCS). Risk assessment process - Practical steps, recording the assessment, the emergency plan, Fire Safety Audit, Case study of a fire risk assessment record and action plan.	
Unit – 4: Occupational Safety and Health (OSH)	**10**
Major OSH Laws & Regulations - Salient features of the Factories Act, 1948, the Mines Act, 1952 and Mines Rules, 1955, the Dock Workers (Safety, Health and Welfare) Act, 1986, the Building & Other Construction Workers (Regulations of Employment and Conditions of Service) Act, 1996 (BOCW Act), National Policy on Safety, Health and Environment at Workplace (NPSHEW). International Labour Organization (ILO) – ILO member states, Governing Body, International Labour Conference and Code, Conventions and Recommendations, Fundamental Conventions. World Health Organization (WHO) – Constitution and History, Work,	

Activities. Process Safety Management (PSM) – Meaning, 14 elements, Performance Measurements to Determine Effectiveness of PSM Programme. International Organization for Standardization (ISO) - Salient Features, ISO- 14001 – Purpose, Features, Application, Overview of Requirements for ISO 14001, Environmental Performance Improvement, Benefits. ISO 45001 – Introduction, Purpose, Requirements and structure, Benefits. Emergency Management: Introduction, Need, Definition - Emergency, Emergency Management, Causes of Emergency, Types of Emergencies, On-Site Emergency - Objectives, Main Elements. Off-Site Emergency Plan – Mock drills. Application of software in risk analysis – ALOHA.	

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M.Sc. Environmental Science and Sustainability

Semester III

Title of the Course: **ES 9523 – ENVIRONMENTAL STATISTICS AND RESEARCH METHODS**

Number of Theory Credits	Number of Lecture Hours / Semester
4	52

Course Specific Objectives	
CSO 1	To develop research orientation by imparting knowledge on research framework, design of experiments, analysis, interpretation and presentation.
CSO 2	To analyse wide range of applications of statistics in environmental management and decision-making.
CSO 3	To impart technical skills by utilizing statistical tools and software in environmental data analysis.
CSO 4	To equip the learners with critical skills needed to conceptualise, write and present their work.

Title of the Course**: ES 9523 – RESEARCH METHODOLOGY AND ENVIRONMENTAL STATISTICS**	**52 Hours**
Unit – 1: Research Framework - Design, Data collection and analysis	**13**
Aim and Objectives of Research: Significance of Research in Environmental Science; Motivation in Research; Types of research; Research approaches. Research methods *vs.* Methodology. Research Process. Criteria of Good Research. Purpose and Formulation of Research: Defining research problem. Selecting the problem. Literature review in defining a problem - Primary and secondary sources – reviews, monographs - patents – web as a source - Identifying gap areas from literature review. Setting up of Hypothesis. Research design: Basic Principles, Need and features of research design, Important concepts relating to research design – Observation and Facts, Prediction and Explanation, Orientation, Reasoning, Development of Models. Research plan - Exploration, Description, Experimentation and Determining experimental and sample designs. Data Collection and analysis: Observation, Interviews, Schedules and Questionnaire. Tabulation, Processing and Interpretation of Data. Principles of experimental design, Randomization, Blocking, Replication and Extraneous Variables. Completely Randomized Design and Randomized Block Design.	

Unit 2: Sampling and Descriptive statistics	**13**
Statistics and Biostatistics: Definition, Functions and limitations of Statistics. Significance of Statistics in Environmental Sciences. Sampling and Census: Definitions. Sample and Population. Need for sampling. Random Sampling methods – Simple Random Sampling, Stratified Random Sampling, Systematic Random Sampling and Cluster sampling. Non-Random Sampling methods: Quota Sampling and Judgement Sampling and snow-ball sampling. Sampling errors and non-sampling errors. Measures of Central Tendency: Mean, Median and Mode; Measures of Dispersion: Range, Percentile, Standard Deviation, coefficient of variation, Kurtosis and Skewness. Organisation and representation of data: Histograms, Stem-and Leaf Plots and Box Plots.	
Unit – 3: Probability Theory; Correlation & Regression and Inferential Statistics	**13**
Probability: Definition, Rules for Calculating Probabilities. Discrete random variables: Binomial and Poisson Probability distributions. Continuous random variables: Normal and Standard normal distributions. Correlation and Regression Correlation: Definition and Significance. Karl Pearson's Coefficient of Correlation and Spearman's Rank Correlation; Likert scale. Regression: Definition and Significance. Regression analysis - Simple linear regression. Significance testing of correlation and regression coefficients. Single and Double-blind Experiments. Point and Interval estimates. Sampling distributions: t, Chi-square, F-distributions. Hypothesis testing: Null and alternative hypotheses, decision criteria, critical values, type I and type II errors, the meaning of statistical significance, power of a test, Student's t-test – independent and dependent tests, Least Significant Difference, Chi-square test – test of goodness of fit.	
Unit – 4: Hypothesis Testing, R Programming and Report Writing	**13**
Analysis of Variance: One-way ANOVA and Two- way ANOVA. F-test, Signed rank test, Rank sum test, Kruskal-Wallis test, Post ANOVA tests:	

Tukey's test and Dunnett's Test. R Programming: Features, Variables, Constants and Operators in R, Input and Output Option in R. Report Writing: Preparation of report: Organization and Significance of reports/thesis - Different steps in the preparation – Layout, structure and Language of typical reports – Illustrations and tables - Bibliography, referencing and footnotes. Presentation: Oral presentation, Planning, Preparation, Practice, Making presentations, Use of audio-visual aids. Ethical issues: Ethical committees, Copyright, Royalty, Intellectual Property Rights and Patent Law. Reproduction of published material: Plagiarism, Citation and Acknowledgements. Reproducibility and Accountability. Publications: Significance and types.	

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IV SEMESTER

The Fourth Semester of M.Sc. Environmental Science and Sustainability is dedicated to internship programme with the industry.

Internship with an institution is an integral part of the M. Sc. Environmental Science and Sustainability course. This is carried out by individual students in association with Environmental Consultancies, Environmental Auditors, Production and Processing Industries, Certified Laboratories, Certification and/or Assurance Bodies, Pollution Control Boards, Research Institutions, Non-Governmental Organisations involved in assessing environment assessment/ acting as public interest representatives related to EIA, Quasi-government bodies and other relevant institutions with the formal approval of the Department of Environmental Science, St Joseph's University.

To enable the process of selecting the relevant industry specific to a particular student, students are encouraged to initiate the interaction with industries towards the end of second semester.

An option of working with the collaborating industry is enabled in the form of dissertation in the third semester. As there is only one practical to be taught in the laboratories, students will be provided with an option of interacting with their chosen industry and work for the dissertation with the industry.

This will be a win-win situation for the student and industry as the student gains an exposure to the industry by the interaction; and the industry will benefit by offering an internship (in the Fourth Semester) to a student who is aware of the scope of the industry and its work culture.

NOTE:

- If there is no option for a student to work outside the University, such student may take up a dissertation work equivalent to 14 credits.
- A teacher guide is to be allotted for the same.
- Evaluation criteria will remain same as described for the internship.

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