



Deccan Education Society's
FERGUSSON COLLEGE (AUTONOMOUS), PUNE

Deccan Education Society's
Fergusson College (Autonomous)
Pune

Learning Outcomes-Based Curriculum
M. Sc. Programme as per guidelines of

NEP-2020

for

S. Y. M. Sc. (Environmental Science)

With effect from Academic Year

2024-2025

Program Outcomes (POs) for M. Sc.

PO1	Disciplinary Knowledge: Demonstrate comprehensive knowledge of the discipline that form a part of a postgraduate programme. Execute strong theoretical and practical understanding generated from the specific programme in the area of work
PO2	Critical Thinking and Problem solving: Exhibit the skill of critical thinking and understand scientific texts and place scientific statements and themes in contexts and also evaluate them in terms of generic conventions. Identify the problem by observing the situation closely, take actions and apply lateral thinking and analytical skills to design the solutions.
PO3	Social competence: Exhibit thoughts and ideas effectively in writing and orally; communicate with others using appropriate media, build effective interactive and presenting skills to meet global competencies. Elicit views of others, present complex information in a clear and concise and help reach conclusion in-group settings.
PO4	Research-related skills and Scientific temper: Infer scientific literature, build sense of enquiry and able to formulate, test, analyse, interpret and establish hypothesis and research questions; and to identify and consult relevant sources to find answers. Plan and write a research paper/project while emphasizing on academics and research ethics, scientific conduct and creating awareness about intellectual property rights and issues of plagiarism.
PO5	Trans-disciplinary knowledge: Create new conceptual, theoretical and methodological understanding that integrates and transcends beyond discipline-specific approaches to address a common problem.
PO6	Personal and professional competence: Perform independently and also collaboratively as a part of team to meet defined objectives and carry out work across interdisciplinary fields. Execute interpersonal relationships, self-motivation and adaptability skills and commit to professional ethics.
PO7	Effective Citizenship and Ethics: Demonstrate empathetic social concern and equity centered national development, and ability to act with an informed awareness of moral and ethical issues and commit to professional ethics and responsibility.
PO8	Environment and Sustainability: Understand the impact of the scientific solutions in societal and environmental contexts and demonstrate the knowledge of and need for sustainable development.
PO9	Self-directed and Life-long learning: Acquire the ability to engage in independent and life-long learning in the broadest context of socio-technological changes

PSO No.	Program Specific Outcomes(PSOs) Upon completion of this programme the student will be able to
PSO1	Academic competence: (i) Understand fundamental concepts, principles and processes underlying the field of Environmental Science, its interdisciplinary nature and create and disseminate knowledge to the students about environmental problems at local, regional and global scale.(ii) Demonstrate an understanding of a wide range of Environmental techniques (e.g. basic water and soil analysis, microbiological methods, spectrophotometry, GIS based analysis, Ecological data analysis, Bio- assays, statistical data analysis and its applications, mathematical modelling
PSO2	Personal and Professional Competence: (i) Carry out laboratory-orientated numerical calculations and be capable in data visualization and interpretation. related to Environmental Science, atmospheric science, Climatology, GIS and Remote sensing (ii) Analyse Environmental data (e.g. in Natural Resource Management, Habitat analysis and biological databases, watershed Management, Environmental pollution and its control. (iii) Formulate ideas, write scientific reports, demonstrate effective presentation, communication skill and standard practices of environmental protection.
PSO3	Research Competence: (i) Apply environmental data analysis methodology in order to conduct research and demonstrate appropriate skill to seek innovative solutions to problems that emerge in various fields of Ecology and Environmental Science and interdisciplinary fields like Green Technology, Biotechnology etc. (ii) Integrate (L-6- Create) informatics and statistical skills to explore and authenticate biological data for experimental and research purpose
PSO4	Entrepreneurial and Social competence: (i) Employ skills in specific areas related to Environmental Science such as industrial pollution, Green technology development, Ecological, health, agriculture and ensure multilevel commitment to health and well-being of the society at large (ii) Exhibit awareness of environmental and ethical issues: emphasizing on academic and research ethics, scientific misconduct, intellectual property rights and issues of plagiarism. (iii) Demonstrate capability for developing sustainable societies and understand national and international environmental policies and programmes and their implementation strategies.

Semester	Paper Code	Paper Title	Credits
I	EVS -501	Environmental Geo and Atmospheric Sciences	4
	EVS -502	Environmental Biology	4
	EVS -503 OR	Elective –I :Environmental Chemistry	4
	EVS -504	Or Elective –II Environmental Health, Toxicology and Safety	
	EVS -510	Research Methodology (Theory)	4
	EVS -520	Practical I: Practical based on Geo and Atmospheric Sciences and Environmental Biology	2
	EVS -521	Practical II: Practicals based on Environmental Biology, Environmental Chemistry and Environmental Health, Toxicology and Safety	2
	Total Semester Credits		
II	EVS -551	EIA and Environmental Audit	4
	EVS -552	Water and Wastewater Treatment Technologies	4
	EVS -553 OR	Elective –I : Biodiversity, Forestry and Conservation	4
	EVS -554	Or Elective –II: Ecosystem Restoration and Remediation	
	EVS -560	OJT/FP	4
	EVS -570	Practical III: Practicals based on EIA & Environmental Audit and Water and Wastewater Treatment Technologies	2
	EVS -571	Practical based on Water and Wastewater Treatment Technologies & Biodiversity, Forestry and Conservation	2
	Total Semester Credits		

Total PG-I Credits**40**

Semester	Paper Code	Paper Title	Credits
III	EVS -601	Remote Sensing and GIS	4
	EVS -602	Environmental Statistics and Computer Applications	4
	EVS -603 OR	Elective I: Climate Change and Sustainability	4
	EVS -604	Or Elective II: Environmental Issues And Solutions	
	EVS -610	Research Project	4
	EVS -620	Practical V : Practical based on Remote Sensing and GIS and Environmental Statistics and Computer Applications	2
	EVS -621	Practical VI: Practical based on Environmental Statistics and Computer Applications and Climate Change and Sustainability OR Environmental Issues and Solutions	2
	Total Semester Credits		
IV	EVS -651	Green Technologies	4
	EVS -652	Energy Resources and Technologies	4
	EVS-653 OR	Elective –I Environment Management Systems	4
	EVS -654	Or Elective –II Environmental Law, Ethics & Policy	
	EVS -660	Research Project	6
	EVS-670	Practical VII Practical based on Energy Resources and Technologies, Environmental Health, Toxicology and Safety, Environment Management Systems and Green Technologies	2
	Total Semester Credits		

M. Sc. II (Environmental Science)	Pattern 2023-24 NEP 2020
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Total PG-II Credits	40
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Deccan Education Society's
Fergusson College (Autonomous), Pune
S.Y. M.Sc. Environmental Science (Pattern 2023)
Under NEP-CBCS Pattern (2023) Effective from June 2023

M.Sc. Semester III

Title of the Course and Course Code	EVS -601: Remote Sensing and GIS	Credits-4
	Course Outcomes (COs) On completion of the course, the students will be able to	Bloom's Cognitive level
CO1	Recall basics of Electromagnetic radiation and Spectrum. Describe basic concepts, principles and processes of Remote sensing and GIS.	1
CO2	Discuss satellites in space and their applications.	2
CO3	Demonstrate map projection methods to understand its importance and limitations. Apply the techniques to address real life field issues using different software.	3
CO4	Compare Raster data, Vector data in GIS to recognize its role in generating information about different features on the earth and distinguish spatial data and Non-spatial data to understand characteristics and represent the earth features.	4
CO5	Select classification method, interpret satellite images visually and digitally judge the accuracy level of classified maps	5
CO6	Develop spatial thinking in GIS by using geo-processes and functions. Collect GIS data to study recent advances.	6

EVS -601: Remote Sensing and GIS (Credits 4)	
Units	Contents

Unit I**Basics of Remote Sensing**

- Introduction to Remote Sensing
- Remote Sensing Process
- Physics of Radiant Energy
- Electromagnetic Radiation and Electromagnetic Spectrum
- Energy Source and its Characteristics
- Atmospheric Interactions with Electromagnetic Radiation Atmospheric Properties
- Absorption of Ozone
- Atmospheric Effects on Spectral Response Patterns
- Energy Interactions with Earth's Surface Materials
- Energy Matter Interaction: Absorption, Emission, Transmission, Emission Spectral Reflectance Curves or Spectral Signature

Platforms & Sensors

- Introduction
- Sensor Types: Active and Passive
- Sensor Parameters Spatial Resolution Spectral Resolution Radiometric Resolution
- Imaging Sensor Systems
- Multispectral Imaging Sensor Systems Thermal Sensing Systems
- Microwave Image Systems
- Platforms
- Airborne remote sensing Spaceborne remote sensing
- Satellites in the Space
- Open Data Satellites
- Commercial Satellites
- Weather Satellites
- Geodesy Satellites
- Ocean Satellites

<p style="text-align: center;">Unit II</p>	<p>Visual Image Interpretation</p> <ul style="list-style-type: none"> ● Introduction ● Image Understanding and Interpretation ● Human Vision ● Interpretation elements ● Stereoscopic vision <p>Digital Image Processing</p> <ul style="list-style-type: none"> ● Introduction ● Principles of Image classification ● Image Classification Process Pre-processing ● Geometric Correction Radiometric Correction Atmospheric Correction ● Image Registration ● Image Enhancement Techniques Spatial Filtering Techniques ● Low Pass Filters High Pass Filters ● Filtering for Edge Enhancement Image Transformations ● Image Classification: Supervised and Unsupervised ● Accuracy assessment
<p style="text-align: center;">Unit III</p>	<p>Basics of GIS</p> <ul style="list-style-type: none"> ● Definition and Objectives of GIS, Concept of space and time, components of GIS, basic entities of GIS: line point and polygon ● Map Projection: Conical, Azimuthal and Cylindrical. LCC Projection, UTM and Polyconic projections. ● Types of datum <p>Data Structures in GIS</p> <ul style="list-style-type: none"> ● Spatial data: Raster data, Vector data, comparative overview. ● Non-spatial data - Hierarchical, Network and relational data. ● Concept and type of topology
<p style="text-align: center;">Unit IV</p>	<p>Spatial Analysis</p> <ul style="list-style-type: none"> ● Vector based: Overlays operations- point in polygon, line in polygon, polygon in polygon; ● Single layer operations and Multilayer operations. ● Raster based: Map algebra, Grid based operations. ● Buffering, Network Analysis, Terrain Analysis, Digital Terrain models and generation of Thematic maps. <p>Applications of RS and GIS</p> <ul style="list-style-type: none"> ● Land Use Land Cover (LULC) changes ● Natural hazards and hazard management: Floods, landslides and other hazards ● Monitoring water quality and soil quality ● Mineral exploration, ● Lithological and structural mapping ● Use of GIS to represent environmental status and highlight Environmental issues

Reference Books**Ebooks**

- Alan S. Belward and Carlos R. Valenzuela (1991) Remote Sensing and Geographical Information Systems for Resource Management in Developing Countries
- M. Anji Reddy (2008) Textbook of Remote Sensing and Geographical Information Systems Third Edition
- Norman Kerle Lucas L. F. Janssen Gerrit C. Huurneman Principles of Remote Sensing An introductory textbook. ITC Educational Textbook Series. version of 23rd September 2004.
- Fundamentals of Remote Sensing. A Canada Centre for Remote Sensing Remote Sensing Tutorial

Books

- Bhatta (2008) Remote Sensing and GIS, Oxford University press.
- Lillisand, T. M. and Keifer, R. W. (1990): Remote Sensing and Image interpretation, John Willey and Sons, New Delhi. •
- Joseph G. (2004): Fundamentals of Remote Sensing, Universities Press, Hyderabad.
- Burroughs, P. A (1986): Principles of Geographical Information Systems for land Resource Assessment, Oxford University Press.
- Gupta, R. P. 2003. Remote sensing geology, Springer, New York
- Barrett, E. C. and Curtis, L. F.1999. Introduction to environmental remote sensing. Chapman and Hall
- Jensen, J. R. (2005): Introductory Digital Image Processing, Prentice Hall, New Jersey
- Drury, S. A. (2001): Image Interpretation in Geology, Blackwell, Oxford
- Campbell, J. (2002): Introduction to Remote Sensing, Taylor & Francis, London
- Anji Reddy, M. (2008): Textbook of Remote Sensing and Geographic Information System, B.S. Publication, Hyderabad.

M.Sc. Semester III

Title of the Course and Course Code	EVS -602 : Environmental Statistics and Computer Applications	Credits-4
	Course Outcomes (COs) On completion of the course, the students will be able to	Bloom's cognitive level
CO1	Recognize and differentiate between various methods used for data sampling	1
CO2	Classify data into a frequency distribution table. Illustrate variables through diagrams and graphical representations.	2

CO3	Compute measures of dispersion using appropriate tools. Apply suitable software for the assessment of environmental variables.	3
CO4	Identify discrete and continuous distributions for probability assessment. Analyze probabilities using different distribution methods.	4
CO5	Evaluate Environmental datasets and calculate their central components.	5
CO6	Construct various indices using statistical tools.	6

EVS -602 : Environmental Statistics and Computer Applications

Units	Contents
Unit I	<p>Foundation of Environmental statistics</p> <ul style="list-style-type: none"> ● Concept of Population, Sample, variable, parameters, random variable and parameters of interest ● Sampling, Types of random and non-random sampling ● Experiment design ● Concepts of statistical inference, sample selection ● Concept of data, its types; Discrete and continuous data, frequency and non-frequency data ● Frequency distributions ● Data presentation methods; Diagrammatic methods Graphical methods
Unit II	<p>Measure of Central tendency</p> <ul style="list-style-type: none"> ● Mean ● Median ● Mode ● Geometric mean ● Harmonic mean ● Partition values <p>Measure of Dispersion</p> <ul style="list-style-type: none"> ● Range ● Variance and standard deviation ● Coefficient of variation ● Skewness and Kurtosis <p>Probability</p> <ul style="list-style-type: none"> ● Concept of Probability and distribution models; terms and definitions ● Normal distribution and its properties ● Binomial Distribution ● Poisson Distribution ● Calculations of probabilities for different events

<p>Unit III</p>	<p>Correlation & Regression</p> <ul style="list-style-type: none"> ● Concept of Correlation and Regression ● Linear and non- linear regression models ● Estimating coefficients of correlation and regression ● Calculation of fitted values and residuals <p>Test of Inference</p> <ul style="list-style-type: none"> ● Concepts of Hypothesis testing, p-value ● Concept of Parametric and non-parametric test ● Introduction to small sample and large sample test ● Applications of Chi- square test, t test, Z test ● One way & two-way ANOVA ● Concept & applications of PCA
<p>Unit IV</p>	<p>Concept of Mathematical model</p> <ul style="list-style-type: none"> ● Exponential, logistic models for population growth ● Lotka-Voltera Prey and predator model ● Box model ● Gaussian plume dispersion model ● Point source stream model Leslie's matrix model. <p>Applications</p> <ul style="list-style-type: none"> ● Statistical power and sample size ● Analysing and dealing with outliers ● Indices used for various Environmental variables ● Introduction to software used for Environmental data analysis
<p>Reference Books</p> <ul style="list-style-type: none"> ● Barnett Vic (2004) Environmental Statistics: methods and applications. ● Ott, Wayne R. (1995) Environmental Statistics and data analysis. ● Zar, Jerrold H. (1997) Biostatistical Analysis. Prentice Hall (India) ● Nychka, Douglas and Piegorsch Walter W (1998) Case studies in Environmental Statistics. ● Manly Bryan F.J. (2001) Statistics for Environmental Science and Management. ● Walpole R. and Myem R. (1993) Statistics for engineers and scientists. 	

M.Sc. Semester III

Title of the Course and Course Code	EVS603: Elective –I: Climate Change and Sustainability	Credits-4
	Course Outcomes (COs) On completion of the course, the students will be able to	Bloom's cognitive level
CO1	Identify list environmental, social, and economic impacts of anthropogenic activities and required sustainability framework for mitigation.	1
CO2	Discuss the anthropogenic and natural drivers of climate change and future developments aspects for sustainability. Outline scope, importance, and opportunities for climate change and sustainability studies	2
CO3	Calculate environmental impacts for different development projects by using common methodologies.	3
CO4	Analyze the impacts of climate change and compare with future goals of sustainability. Compare different policies and agreements regarding climate change and developmental goals.	4
CO5	Evaluate the impacts of climate change and sustainability by appropriate tools and techniques.	5
CO6	Compile the data and prepare reports by using different methods about climate change and sustainable practices.	6

EVS603: Elective –I: Climate Change and Sustainability	
Units	Contents
Unit I	Part I: Climatic Systems and Variations <ul style="list-style-type: none"> ● Global Climate System ● Causes for Modern Climate Change ● Internal Variability: Ocean-Atmosphere Variability, Ocean Currents ● External Climate Forces: Greenhouse Gases, Orbital Variations, Solar Fluctuations, Volcanism, Plate Tectonics ● Evidence and Measurement of Climate changes

	<p>Part II: Consequences and Challenges</p> <ul style="list-style-type: none"> ● Impacts on Life, Vegetation, Fauna ● Glaciers and Ice Sheets Melting ● Sea Level Changes ● Economics of Climate Change ● Climate Change and Water Scarcity ● Coastal Ecosystem and Vulnerability ● Threats to Forest and Biodiversity ● Agriculture and Food Security ● Energy Generation and Climate Change Mitigation
<p>Unit II</p>	<p>Part I: Confronting Climate Change: Policies and Efforts</p> <ul style="list-style-type: none"> ● India: National Action Plan on Climate Change (NAPCC) ● State Action Plan on Climate Change (SAPCC) ● National Adaptation Fund on Climate Change (NAFCC) ● India's Post-2020 Climate Goals ● Climate Change Action Programme (CCAP) ● National Carbonaceous Aerosols Programme (NCAP) ● Long Term Ecological Observatories (LTEO) Programme ● Clean Development Mechanism (CDM) ● UNFCCC and Conference of the Parties ● Kyoto Protocol and Agreements ● Copenhagen Conference ● Paris Agreement ● Findings and Efforts by NASA and ISRO <p>Part II: Mitigation Approaches in Climate Change</p> <ul style="list-style-type: none"> ● Climate and Weather Statistics ● Climate Change Modelling ● Carbon Emissions Reduction Technologies ● Climate Change Research, Blue Carbon Approach ● Climatology Journals and Top Institutions ● Governance for Climate Change ● Clean Development Mechanism ● Technology Options Fuel Switching and Carbon Sequestration ● The Economics of Carbon Mitigation: Integrated Assessment Models (IAM) ● Regional, National and International Experiences
<p>Unit III</p>	<p>Part I: Concepts in Sustainable Development</p> <ul style="list-style-type: none"> ● Origins of Sustainable Development: Definition, Evolution and Principles,

	<p>Brundtland Report</p> <ul style="list-style-type: none"> ● Strategies for Sustainable Development ● Sustainability and Human Development ● Green Politics and Sustainable Development ● Cultural Elements in Sustainable Development Frameworks ● Human Centered Designs in Sustainability ● The 2030 Agenda for Sustainable Development <p>Part II: Sustainable Development Goals and Issues</p> <ul style="list-style-type: none"> ● UN Sustainable Development Knowledge Platform ● Tools for Sustainable Development ● Sustainable Development Goals ● Communicating the Sustainable Development Goals ● Criticisms in Sustainability ● Insubstantial Stretching of the Term ● Cross-Cutting Issues ● Women and Gender Equality ● Education and Sustainable Development ● Implementation, Support and Tracking Progress ● Public Engagement in Sustainable Development
<p>Unit IV</p>	<p>Part I: Environmental Conservation and Sustainability</p> <ul style="list-style-type: none"> ● Technical Skills in Environment and Sustainability ● Vulnerability, Adaptation and Livelihoods ● Preservation of Biological Diversity ● Sustainable Forest Management ● Environmental Governance and Sustainability ● Environmental Economics and Sustainability ● Water Conservation and Sustainable Development ● Urbanization and Sustainable Cities ● Challenges in Energy, Food and Agriculture <p>Part II: New Developments in Sustainability</p> <ul style="list-style-type: none"> ● Appropriate Technology and Sustainability Science ● Consumption and Production Patterns ● Sustainable Transport ● Corporate Sustainability ● Sustainability Metrics and Indices ● Ecological and Carbon Footprint for Sustainability Measurement ● Sustainability Measurement and Reporting Tools ● Success Stories of Strategies in Sustainability ● Sustainability in Policy Design
<p>Reference Books</p> <ul style="list-style-type: none"> ● The Climate Fix: What Scientists and Politicians Won't Tell You About Global Warming by Roger Pielke, Basic Books (2010) 	

- The Climate Solution: India's Climate Change Crisis and What We Can Do About It by Mridula Ramesh, Hachette India (2018).
- This Changes Everything: Capitalism vs. the Climate by Naomi Klein, Penguin (2015).
- What Is Climate Change? (What Was?) by Gail Herman (Author), Illustrated by John Hinderliter, Penguin Workshop (2018).
- Climate Change Biodiversity and Green Economy by H.S. Sharma S. Padmaja and Ganesh Sharma, Concept Publishing Company Pvt. Ltd. (2013).
- Climate Change by Joseph Romm, OUP US (2018).
- Environment and Sustainable Development by M.H. Fulekar, Bhawana Pathak, R K Kale, Springer Nature (2013).
- Sustainable Development in Digital Era by Dr. Aparna Mishra, Dr. Vikas Dahiya, Dr. Kamini Tandon , JSR Publishing House LLP; (2019).
- The Age of Sustainable Development by Jeffrey D. Sachs and Ban Ki-moon, Columbia University Press (2015).
- Target 3 Billion: Innovative Solutions Towards Sustainable Development by APJ Abdul Kalam, Srijan Pal Singh, Penguin India (2011).
- Climate Change and Threatened Communities: Vulnerability, Capacity, and Action by Dan Taylor, Professor A. Peter Castro, et al. | 15 April 2012, Publisher : Practical Action Publishing
- South Asia and Climate Change: Unravelling the Conundrum Paperback – 16 July 2021 by Manisha Kar, Mausumi | Mukhopadhyay, Jayita | Deb Sarkar (Author), Publisher : Routledge India; First Edition
- Climate Change Science and Politics Paperback – 31 March 2021 by Sunita Narain (Author), Publisher : Centre for Science and Environment
- Global Warming and Climate Change: Story of India's Climate Disaster and How to Avoid it. Paperback – 26 October 2023, by A K Singh (Author), Publisher : Notion Press
- Climate Change in India: Threats, Challenges and Opportunities Paperback – Import, 15 March 2022, by Col C P Muthanna (Author), Publisher : Vij Books India
- Community-based Adaptation to Climate Change: Emerging lessons Paperback – Import, 15 January 2014, by Jonathan Ensor (Editor), Rachel Berger (Editor), Saleemul Huq (Editor), Publisher : Practical Action Publishing
- How to Talk to Your Kids About Climate Change: Turning Angst into Action Paperback – 12 May 2020, by Harriet Shugarman (Author), Publisher : New Society Publishers
- Climate Change: What Everyone Needs to Know (What Everyone Needs To Know) Paperback – Import, 8 December 2022, by Joseph Romm (Author), Publisher : Oxford University Press Inc
- How to Avoid a Climate Disaster Hardcover – 16 February 2021, by Bill Gates (Author), Publisher : Allen Lane

Title of the Course and Course Code	EVS604: Elective –II : Environmental Issues and Solutions	Credits-4
	Course Outcomes (COs) On completion of the course, the students will be able to	Bloom's cognitive level
CO1	Outline the important local and regional environmental issues	1
CO2	Discuss reasons, practices behind important environmental issues at the global, national and local level.	2
CO3	Calculate the impacts of the issues by using different methods and classify unique approaches towards the solution of the issues in different societies.	3
CO4	Compare the practices followed for solution of environmental issues in different societies and relate them with national practices	4
CO5	Compare and evaluate the strengths of advanced techniques and traditional practices to minimize impacts on the environment.	5
CO6	Prepare a plan for identification of local environmental issues and collect data to write a report about the solution of these issues.	6

EVS604: Elective –II : Environmental Issues and Solutions (4 Credits)	
Units	Contents
Unit I	Part I: Global Environmental Issues <ul style="list-style-type: none"> ● Ozone Layer Depletion ● Acid Rain and Its Spread ● Desertification and Expansion ● Greenhouse Effect and Global Warming ● Climate Change and Current Issues ● Energy Crisis and Issues ● Genetically Modified Organisms

	<ul style="list-style-type: none"> ● WTO and Environmental Issues ● Species Loss and Human Impacts <p>Part II: Global Environmental Issues</p> <ul style="list-style-type: none"> ● E-Wastes and Global Generation ● Food Crisis and Population ● Biological Warfare and Future Threats ● Eco-Terrorism and Issues ● Issues Related to Shipping ● Water Crisis and Future Conflicts ● Population Explosion and Resource Crunch ● Wastelands and Degradation
Unit II	<p>Part I: International Efforts</p> <ul style="list-style-type: none"> ● Sustainable Development Goals and Solutions ● Clean Development Mechanism ● Carbon Emissions and Future Targets ● Carbon Credits and Its Implementation ● Carbon Sequestration and Programmes ● Green Politics and Issues ● Role of IUCN and UNEP ● Important International Agreements ● Geopolitics and Environmental issues <p>Part II: Environmental Issues in India</p> <ul style="list-style-type: none"> ● Soil Erosion and Impacts on Production ● Alkaline and Saline Soils ● Industrial and Vehicular Air Pollution of Indian Cities ● Water Quality Degradation of Indian Rivers ● Groundwater Pollution and Its Consequences ● Municipal Solid Wastes and Conflicts ● Issues with Slums and Environmental Health ● Droughts and Floods in India ● Eutrophication Issues of Major Aquatic Ecosystems ● Dams and Displacement Issues
Unit III	<p>Part I: National Efforts to Curb Issues</p> <ul style="list-style-type: none"> ● Citizen Participation in Environmental Decisions ● Environmental Information System Network ● Right to Information and Environment Protection ● Policies and Laws on Environmental Protection ● Ganga Action Plan and Recent Programmes ● Interlinking of Rivers: Plan and Implementation ● Strategies under Disaster Management Plan ● Wasteland Development Programme ● Fly Ash Utilization Policy ● Rainwater Harvesting and Its Implementation

	<p>Part II: Environmental Issues and Genesis of Movements</p> <ul style="list-style-type: none"> ● Genesis of Environmental Movements in India ● Chipko Movement and Its Message to World ● Narmada Bachao Andolan and Outcome ● Developments in Save Silent Valley Movement ● Tehri Dam Conflict and Current Situation ● Indian Case Studies to Solve Issues ● Environmental Movements in Developed Countries
<p>Unit IV</p>	<p>Part I: Practices Followed in Environmental Conservation</p> <ul style="list-style-type: none"> ● Environment as Core Part of Sustainability ● Conservation for Economic and Social Upliftment ● Vulnerability, Adaptation and Livelihoods Security ● Conservation of Biodiversity and Forests for Survival ● Water Conservation as Important Constituents of Ecosystems ● Conservation in Smart Cities ● Future Energy, Food, Agriculture Security and Conservation ● Technical Skills Required for Environmental Conservation <p>Part II: Current International Developments</p> <ul style="list-style-type: none"> ● Need for Appropriate Technologies ● International Environmental Governance ● Polluter Pays Principle and Legal Liabilities ● MNCs/TNCs and Corporate Social Responsibility ● Real Time Monitoring of the Issues ● Ecological and Carbon Footprint Calculations ● Life Cycle Assessment Studies for Organisations ● Sustainability Measurement and Reporting Tools ● Newer Approaches in Human Development Success Stories of Mitigating Environmental Issues
<p>Reference Books</p> <ul style="list-style-type: none"> ● Environmental Science by Santra S. C., New Central Book Agency (P) Limited (2001). ● Environmental Chemistry by Sharma B. K., Goel Publishing House, Meerut (1997). ● Environmental Chemistry by De A. K, New Age International (P) Limited (2017). ● Environmental Issues in India: A Reader by Rangarajan, Pearson Education India (2006). ● Climate Change and Environmental Issues by Singh N. and Thakur A. K., The Energy Resources Institute (TERI) (2016). ● Global Environmental Issues by Frances Harris, Wiley-Blackwell, (2012). ● An Introduction to Global Environmental Issues by Pickering K., Routledge (1994). ● Environmental Science by Daniel D. Chiras, Jones and Bartlett Publishers (2001). ● Environmental Science by Y.K. Singh, New Age International Private Limited; First edition (2006). ● Development, Ecology and Climate Change: Issues and Challenges: Volume 1 by Mohinder Kumar Slariya Createspace Independent Publication; (2015). ● Environmental Studies and Ethics by Gouri Suresh , U. S. Hampannavar I K International Publishing House Pvt. Ltd; (2009). ● Environmental Conservation and Life (Hindi) by Nisha Maharana, Agrawal Publications; 	

(2017).

- Environmental Issues in India: A Reader, by Rangarajan, Pearson Education India; (2006).
- The Climate Fix: What Scientists and Politicians Won't Tell You about Global Warming by Roger Pielke Basic Books; (2010).
- Climate Change and Environmental Science by S. C. Bhatia Agrotech Press; (2012).
- Environmental Management by Ajith Sankar Oxford University Press; (2015).
- Principles of Environmental Science: Inquiry and Applications (SIE) by William Cunningham and Mary Cunningham McGraw Hill Education; (2017).
- Principles of Environmental Science and Engineering by Rao P. Venugopala, Prentice Hall India Learning Private Limited; (2006).

M.Sc. Semester III

Title of the Course and Course Code	EVS620: Practical V : Practical based on Remote Sensing and GIS and Environmental Statistics and Computer Applications	Credits- 2
	Course Outcomes (COs) On completion of the course, the students will be able to	Bloom's cognitive level
CO 1	Outline distribution of frequencies in sample	1
CO 2	Classify environmental data with the help of suitable statistical methods and illustrate it by using software	2
CO 3	Illustrate the spatial data using attribute query or spatial query. Use vector data layers to form maps	3
CO 4	Analyze geo-spatial datasets. Relate the spatial and non-spatial data to create links between them. Explain the satellite data visually and digitally using softwares	4
CO 5	Review and evaluate the impacts based on assessment of data.	5
CO 6	Collect long term data for solutions to the environmental issues and prepare a final report with scientific techniques. Develop practical skills in using RS and GIS softwares	6

Practicals based on Remote Sensing and GIS:

1. Introduction to Visual interpretation of satellite Image with FCC and True colour composite.
2. Overview of softwares as QGIS, ArcGIS, Global Mapper, Erdas Imagine etc.
3. Introduction to GPS and its handling, spatial data acquisition and import.
4. Georeferencing using Toposheet/Satellite image/GPS and subset creation.
5. Image classification using supervised, unsupervised and hybrid methods.

6. Ground truthing: A Field survey visit.
7. Accuracy assessment of classified satellite image using ground truth data.
8. Preparation Vector data as Point, Line, polygon and Vector layers creation.
9. Geoprocessing of Spatial data: Buffering, Clip, Crop.
10. Creation and linking of spatial and non-spatial data.
11. Preparation of Digital Elevation Model (DEM).
12. Map composition with Raster data and Vector data.

Practicals based on Environmental Statistics

13. Classification of data and preparation of frequency distribution tables
14. Problem based on diagrammatic representation of data
15. Graphical data representation by Histogram and frequency polygon
16. Calculating measures of central tendency for the given data
17. Applications of partition values and problems based on it
18. Calculating variance, standard deviation and coefficient of variation for given data.
19. Problems based on probability distribution models

M.Sc. Semester III

Title of the Course and Course Code	EVS 621: Practical VI: Practical based on Environmental Statistics and Computer Applications and Climate Change and Sustainability OR Environmental Issues and Solutions	Credits-2
	Course Outcomes (COs) On completion of the course, the students will be able to	Bloom's Cognitive Level
CO1	Recall techniques used for frequency distribution and classification.	1
CO2	Outline software used in Environmental data analysis.	2
CO3	Construct hypothesis for Environmental issues and challenges.	3
CO4	Analyze correlation and regression using suitable methods.	4
CO5	Assess the climate change impacts on environmental by using various online tools and software bases approach	5
CO6	Design computer generated models to study impacts on environment	6

Practicals based on Environmental Statistics

1. Use of statistical tables, analysing level of significance, p-value
2. Computing correlation coefficient and testing its significance.
3. Computing simple linear regression. Plotting scatter diagram and regression line
4. Comparison between means of two independent samples - Paired t-test
5. Method of analysis of variance: one way and two- way classification
6. Introduction to software used in Environmental data analysis

Practicals based on Climate Change and Sustainability

7. Measurements for the impact of environmental stress conditions on plants
8. Estimation of carbon sequestration by using different methods
9. Studies on plants facing pollutants from selected areas
10. Filed Studies to Collect Climate Data
11. Statistical analysis of the secondary data collected from metrological sites
12. Measuring the impact of climate change in a vulnerable population
13. Impacts of extreme events in selected areas: A case study
14. Use of RS and GIS technology in mapping climatic changes
15. Measurement of ozone concentration and analysis of the data
16. Development and Evaluation of Strategies for Climate Change
17. Learning to Use and Run Climate Models to Simulate Past, Present and Future Climate Scenarios
18. Preparation of documentary on climate change and sustainability practices
19. Preparation of documentary on sustainable practices of an organization or agency or

- village area
20. Studies on measurements of sustainable farming practices
 21. Questionnaire survey based on online platforms and analysis
 22. Measurement and analysis of the data by using online software about sustainability
 23. Measurement of life cycle analysis by using online software
 24. Measurement of sustainability by using innovative approaches and designs
 25. Measurement of carbon footprint and ecological footprints by using online software
 26. Analysis of the data and presentation of the data by using different software
 27. Study of online En-Roads simulator for policy design and prediction of future temperature change
 28. Study of the HYSPLIT (Hybrid Single-Particle Lagrangian Integrated Trajectory) model for computing trajectories of dispersion and deposition simulations
 29. Study of CROPWAT for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data
 30. Calculation of carbon emissions based on given examples
 31. Study of Sustainability Assessment of Food and Agriculture Systems based on online software
 32. Study of WindRose plotting software to identify dispersion of pollutants
 33. Study of Municipal Government Self-Assessment Tool
 34. Study of Farm Sustainability Assessment Tool

Practicals Based on Environmental Issues and Solutions

35. Analysis of fly ash for various parameters
36. Effect of fly ash as on plants, laboratory-based experiments
37. Analysis of artificially prepared and natural solid waste leachate for selected wastewater parameters
38. Questionnaire survey based genetically modified organisms by using Google forms
39. Study of acid rain solutions and its impact on physical materials
40. Effect of acid rain solution on plants/seed germination study
41. Study on demand for ecofriendly products available in market
42. Online software analysis for relation between drought and groundwater quality
43. Online software for mapping of carbon footprint and ecological footprint
44. Preparation of documentary for environmental issues of a specific city
45. Estimation of organic carbon from given plant sample
46. Use of online software for trajectory analysis
47. Study of carbon sequestration in laboratory by addition of artificial agents
48. Participation in at least one activity run by international NGO to solve environmental issues
49. Study on issues associated with dams
50. Study on issues of vehicular pollution on city on physical and biological areas
51. Understanding and Mapping for degradation of river ecosystem
52. Estimation of rainwater harvesting potential of Fergusson College campus
53. Preparation of video documentary of the issues faced by nearby populated areas
54. Studies on social impact assessment based on selected developmental activity

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M.Sc. Semester IV

Title of the Course and Course Code	EVS 651: Green Technologies	Credits-4
	Course Outcomes (COs) On completion of the course, the students will be able to	Bloom's cognitive level
CO1	Recall different types of green technologies by giving examples. Examine and interpret different methods of green techniques.	1
CO2	Illustrate the importance of reduce, reuse, recycle and classify different techniques associated to environment protection and conservation issues through green practices.	2
CO3	Examine different examples of green practices with respect to Green cities. Distinguish between practices of Green city policy and recognize Environmental, economical, social well-being associated with it.	3
CO4	Analyse cost benefit analysis and propose an Energy audit at the institutional level. Revise and evaluate green practices for Rural development.	4
CO5	Compare key challenges posed by green technologies and develop key solutions to the different environmental problems at local and regional levels.	5
CO6	Design experiments to understand different types of processes and concepts used in Green technologies.	6

EVS 651: Green Technologies (4 Credits)	
Units	Contents
Unit I	<p>Part I: Introduction to Green Technologies</p> <ul style="list-style-type: none"> ● Definition, Need of green technologies towards a sustainable future ● Green technologies in historical and contemporary perspectives ● Agenda of green development for future of earth ● Sustainable consumption of resources ● Individual and community level participation and research ● Role of Industry, Government and Institutions ● 3 Rs of green technology: recycle, renew and reduce ● Emphasis on waste reduction instead of recycling,

	<ul style="list-style-type: none"> ● Emphasis on research and innovations for green future ● Advances in science and technology for Environment friendly technologies: Developed and developing world <p>Part II: Applications of Green Technologies</p> <ul style="list-style-type: none"> ● “Cradle to grave” approach in technology development ● Clean Production: Principles, importance, Historical evolution, Benefits, Promotion and Barriers ● Clean development mechanism, reuse, recovery, recycle, raw material substitution ● Waste audit. Wealth from waste, case studies. ● Pollution Prevention and Cleaner Production, Awareness Plan, Environmental Statement, carbon credit, carbon sequestration, carbon trading
Unit II	<p>Part I: Green Infrastructure</p> <ul style="list-style-type: none"> ● Advances in green buildings and materials of high efficiency Construction and cost and benefit analysis ● Outlined examples of green buildings of the world ● LEED certification of buildings and future ● Eco-mark certification, scope and implementation ● Green infrastructure and Transportation <p>Part II: Green city Planning and Economy</p> <p>1. Concept of Green Cities</p> <ul style="list-style-type: none"> ● Technologies in waste management in cities and case studies ● Green cities of world and plans ● Role of informal sector in waste management and need for training ● Common public transport: ideas and plans ● Green belt development under various climatic conditions <p>2. Green Economy</p> <ul style="list-style-type: none"> ● UNEPs green economy initiative ● Inclusive economic growth of the society ● UN REDD+ initiative and cap and trade concept ● Green banking and success stories ● Green practices to conserve natural resources ● Importance and advances in ecological footprint
Unit III	<p>Part I: Green Biotechnology: Green solutions to reduce pollution</p> <ul style="list-style-type: none"> ● Biopolymers and bioplastics: Concept, types and applications ● Biodegradable polymers: production and applications ● Biodegradation of synthetic polymers ● Comparative studies of polymer degradation and environmental significance ● Bioindicators: Concept, classification and applications ● Biotechnology for environmental remediation ● Microbial remediation process: Principles of bioremediation, ● Concept of bio augmentation and bio stimulation. ● Factors affecting bioremediation process ● Types of Bioremediation: i) In situ ii) Ex situ

	<ul style="list-style-type: none"> ● Phytoremediation: Concept, types and applications <p>Part II : Green Biotechnology : Green technologies in rural environment</p> <ul style="list-style-type: none"> ● Biopesticides: Classification of Biopesticides: Bacterial, Fungal, viral ● Microbial bio pesticides Production process, stabilization, formulation and mode of action. ● Plant Product as biopesticides: production, mode of action, effectiveness in pest management e.g. Neem pesticides ● Biofertilizers: Role of Nitrogen fixing and phosphate solubilizing microbes in soil fertility, ● Types and production of biofertilizers, ● Composting and Vermicomposting: Raw material, Process, Design aspect, influencing factors. ● Need of decentralised composting in rural and urban areas ● Green fuels: Biofuels and Biodiesel ● Food safety and security using sustainable farming practices ● Hydroponics: Classification, production and application ● Agroforestry applications ● APCAEM and Green Technology Initiative ● Impact of green technology in rural areas: Socioeconomical, ecological and Environmental aspects. Case studies
<p>Unit IV</p>	<p>Part I : Green Chemistry</p> <ul style="list-style-type: none"> ● Introduction to green chemistry ● Principles and recognition of green criteria in chemistry ● Biodegradable and bio-accumulative products in environment ● Nanotechnology and its environmental applications ● Development of biodegradable and eco-friendly products ● Current research areas in green chemistry ● Waste reduction technologies in industries ● Biomimic approach <p>Part II : Energy efficiency enhancement</p> <ul style="list-style-type: none"> ● Green House Gas (GHG) emissions reduction: ● Carbon capture and storage (CCS) technologies, purchase and use of carbon offsets, methane emissions reduction and/or reuse ● Pollution reduction and removal (Flue Gas Desulfurization (FGD) methods, catalytic or thermal destruction of NOX, ● Fluidized Bed Combustion, Dioxins reduction and removal methods ● Thermal Oxidizers or Wet Scrubbers to neutralize chemicals or heavy metals ● Solvent recovery systems ● Low Volatile Organic Compound (VOC) paints and sealers)

Reference Books

- Anastas, P.T. & Warner, J.C. 1998. Green Chemistry: Theory & Practice. Oxford University Press. 2. Arceivala, S.L. 2014.
- Green Technologies: For a Better Future. Mc-Graw Hill Publications.
- Baker, S. 2006. Sustainable Development. Routledge Press.
- Hrubovcak, J., Vasavada, U. & Aldy, J. E. 1999. Green technologies for a more sustainable agriculture (No. 33721). United States Department of Agriculture, Economic Research Service.
- Thangavel, P. & Sridevi, G. 2015. Environmental Sustainability: Role of Green Technologies. Springer Publications.
- Woolley, T. & Kimmins, S. 2002. Green Building Handbook (Volume 1 and 2). Spon Press.
- Pollution Prevention: Fundamentals and Practice' by Paul L Bishop (2000), McGraw Hill International.
- 'Pollution Prevention and Abatement Handbook – Towards Cleaner Production' by World Bank Group (1998), World Bank and UNEP, Washington D.C.
- 'Cleaner Production Audit' by Prasad Modak, C.Visvanathan and Mandar Parasnis (1995), Environmental System Reviews, No.38, Asian Institute of Technology, Bangkok
- Handbook of Organic Waste Conversion by Bewik M.W.M.
- Green Technology Choices: The Environmental and Resource Implications of Low-Carbon Technologies International Resource Panel Report.
- A Feasibility Study on the Application of Green Technology For Sustainable Agriculture Development: Assessing the policy impact in selected member countries of ESCAP-APCAEM.
- Environmental Biotechnology. M. H. Fulekar.
- Environmental Biotechnology. Alan Scragg, Oxford University Press.
- Environmental Biotechnology: Basic Concepts and Applications. Indu Shekhar Thakur, I. K. International Pvt. Ltd.
- 'Energy, The Solar Hydrogen Alternative' by Bokris J.O.

M.Sc. Semester IV

Title of the Course and Course Code	EVS 652: Energy Resource and Technologies	Credits-4
	Course Outcomes (COs) On completion of the course, the students will be able to	Bloom's cognitive level
CO1	Recall concepts of renewable and non-renewable energy resources, its importance and limitations	1
CO2	Describe the basic principles and technologies to harness various energy resources. Discuss the merits and demerits of energy generation technologies	2
CO3	Develop energy generation process using lab scale models of biogas plant, wind mills, solar devices.	3
CO4	Analyze advanced technologies available for energy harnessing by using different methods.	4
CO5	Evaluate appropriate energy harvesting techniques based on its availability, importance and technological and ecological and economical aspects; Judge the potential of renewable energy resources.	5
CO6	Design a method to study biogas production. Develop protocol to work on biomass conversion process.	6

EVS 652: Energy Resource and Technologies (4 Credits)

Units	Contents
Units I	Energy and Environment <ul style="list-style-type: none"> ● Sustainable energy resources, ● Energy Policy of India ● Energy use: A measure of prosperity Vs Impacts on Environment ● Energy usage: Heat, power, transportation, light ● Sources of energy and their classification ● Solar radiations: Absorption, reflection, scattering and diffusion in the atmosphere ● Renewable energy integration and decentralized generation systems. ● Electricity production and distribution: Electrical grid, smart grid, energy storage

	<p>Solar Energy</p> <ul style="list-style-type: none"> ● Harnessing of solar energy, ● Photovoltaics, Solar Home Systems ● Solar energy collectors and concentrators, ● Solar thermal heating: Water heater and Concentrated Solar Power ● Solar electricity generation <ul style="list-style-type: none"> Direct: with PV modules Indirect: with Concentrated Solar Power (CSP) ● Solar energy storage methods ● Solar Kiosk ● Emerging technologies ● Applications of solar energy: Solar heaters, dryers, and cookers, solar thermal cooling
<p>Units II</p>	<p>Hydro Electricity</p> <ul style="list-style-type: none"> ● Principle, Generating methods, Calculating available power ● Sizes, types and capacities of hydroelectric facilities. ● Classification of hydropower plants <ol style="list-style-type: none"> 1) Based on size: Large, medium, mini, micro, pico 2) Based on facility: Run-of river, Storage / Reservoir, Pumped storage ● Peaking with hydropower. ● Hydropower Potential: World and India ● Hazard related to hydropower generation and distribution, ● Hydropower, Society and the Environment <p>Geothermal and Hydrothermal Energy</p> <ul style="list-style-type: none"> ● Types of geothermal resources: hydrothermal geopressured, hot dry rock, magma ● Natural geothermal fields, Exploration and drilling ● High temperature and low temperature aquifers, ● Power generation from Geothermal energy: Dry Steam Plants, Flashed Steam Plants, Binary-Cycle Plants, supercritical cycle ● Prospects of geothermal energy: World and India ● Hydrothermal Energy: Vapour and liquid system; ● Operation and environmental problems. ● Applications of Geothermal energy
<p>Units III</p>	<p>Fossil Fuels</p> <ul style="list-style-type: none"> ● Concept of fossil fuels. ● Classification and composition ● Formation, reserves, and consumption ● Exploration, hydraulic fracturing, drilling mining, processing, and transportation ● Environmental problems associated with fossil fuel ● Case studies of thermal power plants

	<p>Bio-energy</p> <ul style="list-style-type: none"> ● Biomass composition and types ● Biomass Conversion processes: direct combustion, thermo chemical, biochemical processes ● Production of Solid, liquid and gaseous fuels from biomass: pyrolysis, charcoal production, ethanol, methanol, esters and hydrogen ● Electricity generation from biomass ● Biodiesel Production ● Energy plantation ● Biogas: anaerobic digestion production and uses, ● Energy from Solid Wastes: Sources, types, energy production. ● Bio-energy and Waste to Energy Conversion Systems ● Energy Conservation and Management
<p>Unit IV</p>	<p>Nuclear energy</p> <ul style="list-style-type: none"> ● Nuclear energy generation: Nuclear fission and fusion ● Nuclear fuel cycle: Nuclear fuel production and processing Mining and processing of Uranium, concentration, refining, Enrichment and fuel fabrication ● Nuclear waste generation sources and classification ● Treatment and disposal of radioactive waste. ● Environmental implications of Nuclear energy. <p>Wind energy</p> <ul style="list-style-type: none"> ● Principle of Harnessing of wind energy ● Factors affecting wind energy generation ● Power generation by wind mills, concentrators, ● Wind characteristics and siting, ● Environmental considerations ● Wind energy potential in India. ● Numerical Methods and Computational Techniques, ● Wind Energy. ● Conversion Systems
<p>Reference Books</p> <ul style="list-style-type: none"> ● Non-conventional Energy Sources by G.D. Rai (2004-12-01) Mass Market Paperback ● Industrial Energy Conservation Techniques: Concepts, Applications and Case Studies Hardcover – 1 January 2007, by K. Nagabhushan Raju (Author), Publisher : Atlantic ● Principles of Sustainable Energy System, 2ND EDN Hardcover – 18 September 2013 by Frank Kreith (Author), Publisher : CRC Press ● Water and Energy Resources Paperback – 1 January 2000 by Satish Tiwari (Author) ● Environmental Energy Resources Hardcover – 1 January 1995 by R S Sharma (Author), Publisher : Commonwealth Publishers ● Energy Resources, Utilization and Technologies Paperback – 1 January 2012 by Anjaneyulu Yerramilli (Author), Publisher : BS Publications/BSP Books ● Renewable Energy and Resources Paperback – 5 February 2023 by Dr. Samyak Samgyan Sarangi (Author), Dr. Aruna.M (Author), Ar. Rubina Mehraj (Author), Prof. Pramod Ram Wadate (Author), Publisher : Academic Guru Publishing House ● Renewable Energy Sources and Emerging Technologies Paperback – 30 March 2022 by D.P. Kothari (Author), K.C. Singal (Author), Rakesh Ranjan (Author), Publisher : PHI Learning 	

- Wind Power Technology, 3rd Edition Paperback – 25 July 2019 by Joshua Earnest (Author), Sthuthi' Rachel (Author), Publisher : PHI Learning Pvt. Ltd
- Energy Resources, Utilization and Technologies Paperback – 1 January 2012 by Anjaneyulu Yerramilli (Author), Publisher : BS Publications/BSP
- Renewable Energy Sources and Emerging Technologies Paperback – 30 March 2022 by D.P. Kothari (Author), K.C. Singal (Author), Rakesh Ranjan (Author), Publisher : PHI Learning
- Renewable Energy Resources Paperback – 1 January 2019 by John & Tony Weir Twidell (Author), Publisher : ROUTLEDGE BSP
- Renewable Energy Sources and Emerging Technologies Paperback – 1 January 2011 by Kothari (Author), Publisher : Prentice Hall India Learning Private Limited
- Renewable Energy Resources: Basic Principles and Applications Tiwari, G.N., Narosa Publishing House.
- Renewable Energy Programs in India: some recent developments, Sinha P.C., Natural Resource Forum, 18(3), 1994.
- Renewable Energy Environment and Development, Maheswar Dayal Konark Publishers pvt. Ltd.
- Alternative Energy: S. Vandana; APH Publishing Corporation
- Nuclear Energy – Principles, practice and prospects: S. K. Agarwal; APH Publishing Corporation
- Bio-Energy Resources: Chaturvedi; Concept Pub.
- Geography and Energy – Commercial energy systems and national policies: J. D. Chapma
- Reclamation, managing water in the west: Hydroelectric power. us department of interior Bureau of Reclamation Power Resources office, 2005
- https://energypedia.info/wiki/Main_Page
- <https://www.studentenergy.org/topics/>

Title of the Course and Course Code	EVS 653: Elective I Environmental Management Systems	Credits-4
	Course Outcomes (COs) On completion of the course, the students will be able to	Bloom's cognitive level
CO1	Recall basic concepts, principles in relation with environmental management.	1
CO2	Explain important guidelines of Environmental management system standards.	2

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CO3	Identify Environmental problems and apply appropriate knowledge, skills to selected case studies or real-life situations.	3
CO4	Interpret and present EMS related data using different qualitative and quantitative techniques.	4
CO5	Evaluate concept of circular economy and its role in sustainable development.	5
CO6	Prepare reports based on different judgements and implementation in different parts of society	6

EVS 653: Elective I Environmental Management Systems (4 Credits)	
Units	Contents
Unit I	<p>Introduction to EMS</p> <ul style="list-style-type: none"> ● Organization's approach to the Environment ● Basics of Environmental Management ● The system of Environmental management ● Projecting EMS: planning, implementation, general requirements, control tasks ● Evaluation of Environmental performance ● Selection of Environmental indicators ● CSR and Environmental management <p>Sustainability and cleaner production</p> <ul style="list-style-type: none"> ● Principles of sustainable development ● Concept of clean production ● Characteristics of cleaner production ● Clean process and clean products ● Industrial ecology ● Use of alternative resources, clean energy and technology ● Evaluation of cleaner production
Unit II	<p>ISO 14001:2015</p> <ul style="list-style-type: none"> ● Introduction to ISO governance, structure and functions ● PDCA cycle ● ISO 14000 family of standards ● ISO 14001:2015: Guidelines for implementation of standard <p>Life cycle assessment</p> <ul style="list-style-type: none"> ● Concept of LCA ● Phases: Goal and Scope definition, Inventory analysis, Impact assessment, Interpretation ● Types: Cradle to grave, Cradle to gate, gate to gate, gate to grave ● Applications of LCA ● Benefits and value of LCA evaluation

<p style="text-align: center;">Unit III</p>	<p>Circular Economy</p> <ul style="list-style-type: none"> ● Concept of circular economy ● Principles ● Implementation of circular economy ● Waste to wealth solutions ● Circular economy and sustainable development ● Benefits: Environmental, economic and social ● Challenges <p>Eco-innovation</p> <ul style="list-style-type: none"> ● Concept of eco-innovation ● Preparation, Strategy, Business model, Implementation and review ● Eco-designs ● Environmental cost and benefits ● Environmental aspects and impact assessment in process ● Sustainable value chain
<p style="text-align: center;">Unit IV</p>	<p>Environmental regulations in India</p> <ul style="list-style-type: none"> ● The Water (Prevention and Control of Pollution) Act,1974 ● The Air (Prevention and Control of Pollution) Act,1981 ● The Environment (Protection) Act,1986 ● The Public Liability Insurance Act, 1991 ● National Green Tribunal Act,2010 ● Battery Act <p>Environmental Ethics</p> <ul style="list-style-type: none"> ● Concept of Environmental Ethics ● Ethical theories applied to the Environment ● Ethics in Environment management ● Environmental ethics and pollution ● Challenges of World Environmental Ethics ● Environmental ethics and sustainability
<p>Reference Books</p> <ul style="list-style-type: none"> ● Sheldon, C., & Yoxon, M. (2012). Environmental management systems: a step-by-step guide to implementation and maintenance. Routledge. ● Tinsley, S., & Pillai, I. (2012). Environmental management systems: understanding organizational drivers and barriers. Taylor & Francis. ● Jackson, S. L. (1997). The ISO 14001 implementation guide: creating an integrated management system (Vol. 3). John Wiley & Sons. ● Welford, R. (2016). Corporate environmental management 1: Systems and strategies. Routledge. ● Ciambrone, D. F. (1997). Environmental life cycle analysis. CRC Press. ● Klöpffer, W., & Grahl, B. (2014). Life cycle assessment (LCA): a guide to best practice. John Wiley & Sons. ● Guinée, J. B., & Lindeijer, E. (Eds.). (2002). Handbook on life cycle assessment: operational guide to the ISO standards (Vol. 7). Springer Science & Business Media. ● Stahel, W. R. (2019). The circular economy: A user's guide. Routledge. ● Lacy, P., & Rutqvist, J. (2016). Waste to wealth: The circular economy advantage. Springer. 	

- Stahel, W. R. (2016). The circular economy. *Nature*, 531(7595), 435-438.
- Carrillo, J., Pablo del. Río González, & Totti. Könnölä. (2009). *Eco-innovation: when sustainability and competitiveness shake hands*. Palgrave Macmillan.

M.Sc. Semester IV

Title of the Course and Course Code	EVS 654: Elective –II : Environmental Law, Ethics and Policy	Credits-4
	Course Outcomes (COs) On completion of the course, the students will be able to	Bloom's cognitive level
CO1	Identify important provisions of Environmental laws in India and international agreements	1
CO2	Discuss about important provisions of environmental laws in India and international agreements.	2
CO3	Carry out critical examination of the different legal case studies from India and abroad. Solve the examples based on provisions of the environmental laws	3
CO4	Explain the role of the constitution and different administrative mechanisms.	4
CO5	Review the Environmental ethics and justify challenges associated with it	5
CO6	Compile legal requirements of policies related to different natural resources.	6

EVS 654: Elective –II : Environmental Law, Ethics and Policy (4 Credits)

Units	Contents
Unit I	<p>Environmental Law and Policy</p> <ul style="list-style-type: none"> ● Introduction to Law, Policy: Meaning, Basic difference and Importance. ● Indian Constitution and Environment ● Role of Constitution in Environment Protection, ● Fundamental Rights and Duties, Article 48A, 51A (g) and 58A ● Precautionary and Polluter pays principles; Absolute and Strict liability <p>Principles and Frameworks</p> <ul style="list-style-type: none"> ● Stockholm declaration ● Nairobi Declaration

	<ul style="list-style-type: none"> ● Rio Conference ● Kyoto Protocol ● World Summit on Sustainable Development (Rio + 10) ● Paris Agreement, CoP ● International Conventions: Convention on Biological Diversity, Convention on Climate Change, Ramsar Convention, Vienna Convention, Basal convention ● Role of UN authorities in protection of Global Environment
Unit II	<p>Environmental Laws in India: Anti-Pollution Acts</p> <ul style="list-style-type: none"> ● The Water (Prevention and Control of Pollution) Act,1974 ● The Air (Prevention and Control of Pollution) Act,1981 ● The Environment (Protection) Act,1986 ● The Public liability Insurance Act, 1991 ● The National Environmental Tribunal Act, 1995 <p>Environmental Laws in India: Conservation Acts</p> <ul style="list-style-type: none"> ● Indian Forests Act (Revised),1982 ● The Indian Wildlife (Protection) Act,1972 amended 1991 ● The Biological Diversity Act, 2002 ● National Green Tribunal Act,2010 ● Public Interest Litigation (PIL)
Unit III	<p>Rules and Regulations</p> <ul style="list-style-type: none"> ● Hazardous waste management and handling rules ● Solid waste management and handling rules ● Biomedical waste regulations ● Plastic waste management regulations ● Noise Pollution Rules ● E-Waste management rules <p>Consent applications and forms</p> <ul style="list-style-type: none"> ● Introduction to consent applications and categories; Process for new application and amendments ● Environment statement form ● Water cess form ● MSW applications ● Hazardous waste applications ● Bio-medical waste applications ● Plastic regulation application ● E-waste application
Unit IV	<p>Policies</p> <ul style="list-style-type: none"> ● National Environmental Policy ● National Forest Policy ● National Water Policy ● Policies on Renewable and Non-renewable energy resources ● Environmental Status report <p>Environmental Ethics</p> <ul style="list-style-type: none"> ● Introduction and concept of Environmental Ethics ● Ethical theories applied to the Environment ● The ethical dilemma: Environmental ethics and population, ethics and pollution

- Human life and its Environment: art of ethics and an ethical dilemma
- Challenges of World Environmental ethics

Reference Books

- P. Leelakrishnan: Environmental Law in India, Lexisnexis, 2010.
- Alexander Gillespie: International Environmental Law, Policy and Ethics. Oxford University Press, 2014.
- Divan Shyam and Armin Rosencranz: Environmental Law and Policy in India, Oxford University Press, 2002.
- P. B. Sahasranaman: Handbook of Environmental Laws, Oxford University Press, 2012.
- Nancy K. Kubasek and Gary S. Silverman: Environmental Law, Pearson, 1999.
- Paul Pojman and Louis Pojman: Environmental Ethics, Wadsworth Publishing, 2011.
- Joseph R. Des Jardins, Environmental Ethics: An Introduction to Environmental Philosophy, Wadsworth Publishing, 2005.

Title of the Course and Course Code	EVS 670: Practical VII Practical based on Green Technologies; Energy Resources and Technologies, Environment Management Systems or Environmental Law, Ethics and Policy	Credits-2
	Course Outcomes (COs) On completion of the course, the students will be able to	Bloom's cognitive level
CO1	Recall parameters used for green infrastructure.	1
CO2	Identify aspects and impacts of various industrial processes.	2
CO3	Construct PDCA cycle for sustainable management in an organization.	3
CO4	Analyze practices used monitoring green technologies.	4
CO5	Evaluate the energy efficiency of various products and assess energy audit of selected industrial units	5
CO6	Design and development of energy producing devices and experimental studies based on it	6

EVS 570: Practical IV

Practicals based on Green Technologies

1. Monitoring a plan for Green city
2. Study of various indices used for Green City.
3. Conducting green audit of a building/ institution.
4. Market survey for organic products/green product/eco-friendly products.
5. Development and study of hydroponic system.
6. Study the plant growth characteristics using hydroponic system.
7. Survey and analysis of data for sustainable agriculture practices/organic farming in rural area.
8. Isolation of phosphate solubilizing bacteria/fungi.
9. Estimation of phosphate solubilisation efficiency of bacteria/ fungi.
10. Wastewater treatment by phytoremediation technique

Practical Based on Energy Resource and Technologies

11. Monitoring `of Sustainability of Solar Home Systems based on Questionnaire and field survey.
12. Development/ designing and application of simple sustainable and innovative energy

- devices for rural and undeveloped sectors. e. g solar bottle bulb, solar lamps, biofuel-based devices etc.
13. Estimate monthly average daily solar radiation incident on horizontal surface of Fergusson College campus based on given data
 14. Estimate calorific value of given wood sample
 15. Prepare simple flow sheet for requisites for energy audit? Calculate energy conservation saving measures and cost benefits based on given data
 16. Mention significance of Fuel and Energy Substitution. Calculate simple payback period if Agro Fuel (coconut chips) is used in place of Furnace oil in a Boiler based on given data
 17. Prepare a diagrammatic format for Pre-requisites for Mini Hydropower project? Also, calculate power generated with the help of given data.
 18. Design and studies on biogas plant
 19. Study solar photovoltaic system
 20. Studies on various solar powered energy generation systems
 21. Design of renewable energy systems
 22. Assessment on measurement of energy efficiency of the building
 23. Data analysis and modelling on evaluation for forecast of energy demand and impact of changed policies
 24. Techno-economic assessment of different energy technologies
 25. Studies and development of the bio-battery biomass

Practicals based on Environmental Management Systems

1. Study of industrial process for Environmental management
2. Identification of Environmental aspects of a process
3. Identification of Environmental impacts and its assessment
4. Writing Environmental policy for an organization
5. Understanding environmental objectives from policy statement
6. Study of PDCA cycle
7. Case studies based on circular economy
8. Study of success stories of Eco-innovation
9. Study of challenges associated with Environmental governance
10. Study of issues and challenges associated with Environmental ethics

Practicals based on Environmental Law, Ethics and Policy

1. Baseline survey on provisions under selected environmental laws
2. Learning and understanding law specific case study
3. Study of regulations under specific laws
4. Study of major judgement given by courts on selected law
5. Study of case studies related to fundamental duty and rights
6. Preparation of drafts report on various Environment related policies in India
7. Learning: How to file case under Environmental laws
8. Study and understanding of consent forms
9. Study of challenges associated with Environmental governance
10. Study of issues and challenges associated with Environmental ethics

