PONDICHERRY UNIVERSITY
School of Life Sciences

DEPARTMENT OF ECOLOGY & ENVIRONMENTAL SCIENCES

CURRICULUM FOR M.Sc. PROGRAM IN ENVIRONMENTAL SCIENCES 2019-20 onwards

PONDICHERRY UNIVERSITY
School of Life Sciences
Department of Ecology & Environmental Sciences

Master of Science in Environmental Sciences

PROGRAM OBJECTIVES

The objectives of the MSc Environmental Sciences are:

1. to provide students the fundamental concepts and principles of environment

2. to make students aware of the importance of environment and its conservation

3. to introduce the modern tools and techniques available to study and understand the environment

4. to teach field techniques, sample collection, mapping and analysis

5. to make students to take up research and teaching in environmental sciences

PROGRAM OUTCOME

The students will

1. understand the concepts and principles of environment

2. understand the structural and functional aspects of environment and the need for its conservation

3. be familiar with modern tools and techniques and their appropriate use to conduct research.

4. be aware of the suitable use of field techniques, sample collection, mapping, analysis and interpretation.

5. be able to take up research and teaching in environmental sciences.

PONDICHERRY UNIVERSITY

School of Life Sciences
Department of Ecology & Environmental Sciences

Curriculum for
M.Sc. Environmental Sciences
2019-2020 onwards

Code	Name of the Hard core Courses	Credit	Page No.
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SEMESTER – II			
EVNS 411	ENVIRONMENTAL MANAGEMENT	3	10
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SEMESTER – III			
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Total Credit for Hard Core courses = 48
Total Credit for Soft Core courses = 24
Total Credit requirements = 72

FUNDAMENTALS OF ECOLOGY AND ENVIRONMENTAL SCIENCES

EVNS: 401 **CREDITS: 3**

COURSE OBJECTIVE: To introduce the basics of Ecology and Environmental Sciences to students coming from different background.

UNIT-I Introduction to Ecology & environmental sciences; Principles and Scope of Ecology Structure and Functions of Ecosystems- Abiotic and Biotic components, Flow of energy and cycling of materials; water, carbon, nitrogen and phosphorus, Trophic pyramids and food webs; Ecosystems Types and Diversity, Alterations of ecosystem function: acid rain, nuclear winter, global warming and ozone hole, an overview of IPCC. **(8 Hours)**

UNIT-II Diversity of life; origin of life on earth and Speciation; Human Ecology and Human Settlements, Evolution of early life and changes in earth's atmosphere. Mendelian genetics – and Darwin Wallace theory of inheritance. Five kingdoms overview; Monera, Protists, Fungi, plant and animal kingdoms. **(8 Hours)**

UNIT-III Populations and communities; Birth, death and population size, age structure; Trends in human population growth; Malthusian growth. Intraspecific interactions and density dependence, Parasitism, Prey-predator relationships, Interspecific interactions; Commensalism, mutualism, competition and predation. Species diversity, community stability and disturbance **(8 Hours)**

UNIT-IV Aquatic and terrestrial communities; rare communities; deep earth, deep sea floor, volcanoes. Primary productivity; basic concepts, Ecological succession inland, water; concepts, Invasive species and control **(8 Hours)**

UNIT-V Practical and Field Experiments using standard methods; Estimation of density and relative abundance of species using quadrats and plotless methods. Estimation of species diversity: introduction to indices. Estimation of primary productivity. Ecological adaptations of the Plant and animal species in the hydrophytes, mesophytes and xerophytes. **(8 Hours)**

Text books:

1. Smith, TM and Smith RL 2015. Elements of Ecology, Pearson Education, India.
2. Cain, ML, Bowman, WD and Hacker SD 2011. Ecology, 2nd Edition, Sinauer Associates Inc.
3. Odum, E. P. (2004). Fundamentals of Ecology, Oxford and IBH Publishing Co. Pvt. Ltd.

Reference books:

1. Singh, J.S., S.P & Gupta, S.R. 2006. Ecology, Environment and Resource conservation. Anamaya Publ., New Delhi, 688 pp.
2. Miller. G.T. 2004. Environmental Science. Thomson, California. 538 pgs.
3. Chapman, J.L.& M.J. Reiss. 1998. Ecology: Principles and Applications. Cambridge Univ. press. 2nd edition. 336 pgs.
4. Krebs, C.J. 2008. Ecology: The experimental Analysis of Distribution and Abundance (6th Edition), Benjamin Cummings Publ. 688pgs

COURSE OUTCOME: The students will understand the basics of Ecology & Environmental Sciences.

BIOSTATISTICS

EVNS: 402 **CREDITS: 3**

COURSE OBJECTIVES: To introduce the statistics for ecological and environmental data analysis.

UNIT-I Fundamentals of Biostatistics; sampling, Data collection and recording, central tendency-concept; arithmetic mean, mode, median for ungrouped and grouped data. Probability Rules and Theoretical Distributions: Basic probability rules, expectation, conditional probability; Probability distributions – Binomial, Poisson, Normal and Log-normal distributions; Fitting of probability distributions to environmental data. **(8 Hours)**

UNIT-II Sample survey**:** Need and Purpose of sampling, Sampling with and without replacement, Population and sample, Population parameters; Environmental sampling design - Methods for selecting sampling locations and times; Different techniques of sampling – simple random sampling, stratified random sampling, systematic sampling, two stage sampling, compositing and three-stage sampling; Relative advantages and disadvantages of different techniques. **(8 Hours)**

UNIT-III Sampling distribution and Test of Significance: Parameter and statistics; Sampling distribution, Standard error and its uses; Concept of t- distribution, F-distributions, Chi Square distribution without derivation and their applications; Null hypothesis and uses of t- test, F-test, X^2-tests; Test of significance of large samples. Correlation and Regression**:** Bi-variate data and scatter diagram; Simple (linear) correlation and regression; Coefficient of correlation and regression and their properties; Fitting of regression line; Multiple and partial correlations and regressions. **(8 Hours)**

UNIT IV Analysis of Variance: Different types of models used in AOV; Basic assumptions and its violation; One and two way classified data; Application of AOV to environmental data. Distribution- Normal, t and chi square test; Difference among means: f-test: 1 way ANOVA. Computer applications in environmental modeling, Computer based modeling for population and population studies. **(8 Hours)**

UNIT-V Multivariate analysis , hypothesis testing Model fitting; Biometry – principles and concepts; Matrices, simultaneous linear equations; tests of hypothesis and significance, time series analysis- moving averages (3 and 5 unit cycles); current development in the subject. **(8 Hours)**

Text books:

1 Zar, Jerrold H. (2010). Biostatistical Analysis. 5th Edition, Pearson Publication.
2 Sokal RR and Rohlf FJ (2009) Introduction to Biostatics, 2nd Edition, Dover Publications, Inc, New York.
3 Walpole, R. and R. Myres (1993). Statistics for Engineers and scientists, 5th edn. Mac Millan, N.Y.

Reference Books:

1. Wayne, R. Ott (1995). Environmental Statistics and Data analysis, CRC Press.
2. Manly (2001) statistics for environmental science and management, Chapman and Hall/CRC Press

COURSE OUTCOME: The students will be able to select appropriate statistical tool and to do statistical analysis on a proper dataset.

ENVIRONMENTAL LAW, POLICY AND EQUITY

EVNS: 403 **CREDITS: 3**

COURSE OBJECTIVE: To make students aware of Indian as well as International environmental laws and their importance.

UNIT-I International Environmental Laws: Evolution and Development on International Environmental Laws with references to Stockholm Conference, Nairobi Declaration, Rio conference, Rio+5, Rio +10 Environmental issues and international laws: to control Global warming, Ozone depletion, Acid rain, hazardous waste, CITES Role of UN authorities in protection of Global Environment, Multinational authorities and agreements, future of International law. **(8 Hours)**

UNIT–II Environmental Laws in India: Environmental Policy and Laws. Constitutional and Statutory laws in India: Doctrine Principles of State Policy, Fundamental duties and Fundamental Rights and Panchayat Raj System, Statutory protection of the Human environment: such as Indian penal court, Factories Act, Motor Vehicle Act, Hazardous waste legislation for pollution abatement. Anti-Pollution Acts: The Water Act, 1974, The Air Act, 1981.The Environment Protection Act 1986. Objectives of the Anti-Pollution Acts. Institutional mechanism created under these acts and role contribution in combining environmental pollution. The role of courts. Wildlife Protection Act, 1972 amended 1991, Forest Conservation Act, 1980; Indian Forests Act revised 1982; Air (Prevention and Control of Pollution) Act 1981 as Amended by Amendment Act 1987 and rule 1982. Scheme of labeling of environmentally friendly products (Ecomark), Public liability Insurance Act, 1991 and Rules 1991.Provision of Constitution of India regarding Environment (Article 48A and 58A).**(8 Hours)**

UNIT–III Equity Environment versus Development: Importance of critical review of plan with respect to local, regional& immediate & long term gains & Effect of development. Comparison between a Exploitation and safe guard for conservation, b. rate of utilisation and regeneration, c. natural and manmade growth, d. Survival need of mankind and protection of Environment Integration of development with carrying capacity of environment Case study of current issue Requirement of Rule 14 for Environmental audit under Environment protection Act 1986; Rule & regulation & guidelines given for disposal of hazardous protection waste, municipal solid wastes & bio-medical waste. **(8 Hours)**

UNIT–IV National Environmental Policy: National Policy on EIA and Regulatory Framework: Rule & regulation of central & State Government and Central & State pollution control boards for Safeguard for Environment Protection. **(8 Hours)**

UNIT–V Sustainable Development: Definition and concepts of Sustainable development, Integration of: a. Economic, Social and Environmental sustainability, b. Biodiversity and c. Availability of natural resources in development. Critical review of drawbacks in traditional (based on economics) evaluation development, Cost benefit analysis. **(8 Hours)**

Text Books

1. Leelakrishnan, P. (2016). Environmental law in India. LexisNexis.
2. Dwivedi, O. P. (2016). India's Environmental Policies, Programmes and Stewardship. Springer.
3. McGuire, C. J. (2014). Environmental Law from the Policy Perspective: understanding how legal frameworks influence environmental problem solving. Routledge.

Reference Books

1. Bell, S., McGillivray, D., Pedersen, O., Lees, E., & Stokes, E. (2017). Environmental law. Oxford University
2. Jacob I. Bregman, Robert D. Edell, Environmental Compliance Handbook, 2016, Lewis Publications
3. Ashford, Nicholas Askounes, and Charles C. Caldart. Environmental law, policy, and economics: Reclaiming the environmental agenda. Mit Press, 2008.
4. Fletcher, S. R. (Ed.). (2008). Environmental Laws: Summaries of Major Statutes Administered by the Environmental Protection Agency (EPA). Nova Publishers.

COURSE OUTCOME: Students will know the national and international environmental laws, national environmental policy and sustainable development.

ENVIRONMENTAL POLLUTION AND MITIGATION

EVNS: 404 **CREDIT: 3**

COURSE OBJECTIVES: To impart students the different types of pollution, causes and mitigation strategies.

Unit I Air: Natural and anthropogenic sources of pollution. Primary and secondary pollutants. Transport and diffusion of pollutants. Gas laws governing the behaviour of pollutants in the atmosphere. Methods of monitoring and control of air pollution, SO_2, NO_x, CO, SPM. Effects of pollutants on human beings, plants, animals, materials and climate. Acid Rain, Air quality standards **(8 hours)**

Unit II Water-Types, sources and consequences of water pollution. Water quality standards, Sewage and wastewater treatment and recycling, Human use of surface and ground waters, Ground water pollution. Soil Pollution control. Industrial waste effluents and heavy metals, their interaction with soil components. Soil micro-organisms and their functions, degradation of different insecticides fungicides and weedicides in soil Different kinds of synthetic fertilizers (NP &K) and their interactions with different components of soil **(8 hours)**

Unit III Solid Wastes-Sources and generation of solid waste, Different methods of disposal and management of solid wastes (Hospital wastes and Hazardous wastes) Recycling of waste materials. Waste minimization technologies **(8 hours)**

UNIT IV Noise-Sources of noise pollution measurement of noise and indices, Effect of meteorological parameters on noise proposition. Noise exposure levels and standards. Noise control and abatement measures. Impact of noise on human health **(8 hours)**

UNIT V Marine- Ocean pollution by toxic wastes Sources of marine pollution and control. Criteria employed for disposal of pollutants in marine system-coastal management. Radioactive pollution radioactive waste and radioactivity from nuclear reactors and Thermal Pollution **(8 hours)**

Text Books:

1. Rieuwerts, J, 2015, The Elements of Environmental Pollution, Routledge Taylor & Francis Group, UK
2. Hill, MK. 2010 Understanding Environmental Pollution, Cambridge University Press, UK
3. Vesilind, PA J. Jeffrey Peirce, JJ, Weiner RF, 1990, Environmental Pollution and Control, 3rd Edition, Elsevier Publication.

Reference Books:

1.Rana, S. V. S. 2011. Environmental Pollution: Health and Toxicology. Alpha Science International Limited.
2. Brusseau, M, Pepper, I, Gerba, Charles 2019. Environmental and Pollution Science, 3rd Edition, Elsevier Publication.

COURSE OUTCOME: The students will be aware of the types of pollutants, sources, impacts and mitigation practices.

LAB / FIELD WORK - 1

EVNS: 405 **CREDITS: 2**

INTRODUCTION TO ECOLOGY AND ENVIRONMENTAL SCIENCES – FIELD VISIT

a. Field visit to forest patch – data collection and report preparation
b. Field visit to wetland – data collection and report preparation
c. Field visit coast - data collection and report preparation

ENVIRONMENTAL POLLUTION AND MITIGATION – LAB

a. Jar test Experiments –Optimization of coagulant, pH and dose
b. Determination of residual chlorine
c. Determination of total dissolved solids / suspended solids
d. Determination of volatile suspended solids
e. Biotreatment of textile / dairy / paper industrial effluent
f. Production of biogas from different organic waste materials
g. Exercises on estimation, composition and segregation of solid waste
h. An air quality survey report of an area
i. Design of point of use (POU) water treatment systems
j. Industry visit/ Minor project

ENVIRONMENTAL MANAGEMENT

EVNS: 411 **CREDITS: 3**

Objective: To be conversant with the basic principles and techniques of Environment Management Tools, Industrial Ecology and Environmental Economics.

UNIT-I Environmental priorities and sustainable development, Concept and strategies of sustainable environment, Master equation for the estimation of total environmental impact, Technological evolution, Analogy of biological ecology and industrial ecology, Food webs and Industrial Eco parks, Industrial symbiosis-Kalundborg – a case study. **(8 Hours)**

UNIT II Introduction to Life Cycle Assessment-History & definition of LCA; Components in a product's life cycle- Structure of LCA – Advantages of LCA, Case studies. Biomimicry. Strategy of Industrial ecology- Material Substitution-De-materialization, Trans materialization-examples - Reuse and recycling, Typical constraints on reuse and recycling. Delinking and decoupling. Design for the environment. Material flow analysis (MFA). **(8 Hours)**

UNIT-III Environment Management System, Tool box for environmental management – Environmental auditing & Standards. Ecological foot print, Cleaner Production- Principles of green chemistry and green engineering. **(8 Hours)**

UNIT-IV Environmental Economics - Market failure, Externalities, Common goods and public goods, Ecosystem valuation, Solution to correct externalities – Environmental regulation, Quotas on pollution, Taxes and tariff on pollution, Pigovian tax, Ecological Economics **(8 Hours)**

UNIT-V Sustainable Tourism, Net metering, Green politics, Marginal Abatement Cost (MAC), Pollution haven hypothesis, Renewable energy commercialization. Carbon emission trading, Carbon footprint, Low-carbon economy. **(8 Hours)**

Text Books

1. Scott J. Callan, Janet M. Thomas, 2015 Environmental Economics and Management Theory, Policy and Applications, South Western publishers, , ISBN-10: 8131527646
2. Ayres R.U. & L.W. Ayres 2012. A Handbook of Industrial Ecology. INSEAD, France.
3. Ahmed M. Hussen, 2012. Principles of Environmental Economics and Sustainability: An Integrated Economic and Ecological Approach, , Routledge publisher ISBN 0415676908

Reference Books:

1. Tyler Miller, G. Jr. 2011. Living in the Environment: Principles, Connections, and Solutions (with Environmental Science (13th edition) CD-ROM and Info Trac) 17th Edition, Thomson/Brooks Cole.
2. Tyler Miller, G. Jr, 2010. Advantage Series: Sustaining the Earth - An Integrated Approach 10th Edition. Thomson/Brooks Cole.
3. Understanding ISO 9001 : 2015 Quality Management System, Virendra Kumar Gupta, Kojo Press (2017), ISBN-10: 8174890548
4. Mary Ann Curran 2010, Environmental life cycle assessment. McGraw – Hill, New York.

COURSE OUTCOME: The students will learn how to apply innovative and modern solutions for a sustainable economy, society and environment.

ENVIRONMENTAL IMPACT ASSESSMENT

EVNS: 412 **CREDITS: 3**

COURSE OBJECTIVE: To provide theoretical and as well as practical knowledge , to plan and carry out an environmental impact assessment and environmental management plans in compliance with the environmental clearance procedures in India

UNIT – I Development Projects and Impacts; EIA and types of EIA methods; definition of EIA & EIS. Negative & positive aspects & uncertainties in EIA, Historical synopsis; Approach to EIA studies – mandatory requirements, project screening, scoping. Environmental baselines, best practices, terms of reference; Phases of EIA – Identification, Prediction, Evaluation, Decision Making and Post impact Monitoring the question of Significance; Complexities in environmental measurement; Special issues & concerns for different type of projects. **(8 Hours)**

UNIT – II Review of methodologies of EIA: Impact Identification Techniques – Checklists, Matrices, Map Overlays, Networks, Leopold Matrix; Environmental Evaluation System; Economic Approaches to EIA (Cost Benefit with market and shadow prices); Ecological Mapping; Global Change Assessment & Estimation Developing an Ecological Perspective to EIA. **(8 Hours)**

UNIT – III National Policy on EIA and Regulatory Framework: Environmental Impact Assessment Notification 2006 and Coastal Zone Notification 1991; Environmental Clearance Process in India; Legislative requirements (discharge requirements and area restrictions); Environmental Appraisal procedure for mining, industrial, thermal power, nuclear power and multipurpose river valley projects; Central & State pollution control boards for Safeguard for Environmental Protection. **(8 Hours)**

UNIT – IV Environmental, Methods, Risk Analysis-: Definition of Environment Audit & its importance for industries, Requirements of Rule 14 for Environmental Audit under Environmental protection Act 1986, Definitions of a. Signatory, b. Consumption Audit, c. Pollution Audit, d. Hazardous Audit, e. Solid waste Audit, f. Disposal Audit, g. Cost Audit, h. Investment Audit, i. Voluntary Audit. Need & Definition of Risk Analysis, Identification of risk due to project activities, Cost of alleviation of risk & impact on project cost. Disaster Management **(8 Hours)**

UNIT – V Environmental impact Analysis of Development Project: Case studies of any two development projects. Public Participation: Methodology and approach for public participation in Environmental decision making. Preparation of Environmental Management plans (EMPs): Environmental management overview, Environmental management Issues and considerations. Environmental management systems (EMS) – Principles, Elements and Standards of ISO 14001 & ISO18001 **(8 Hours)**

Text Books

1. Reddy, A and Mereddy (2017) Environmental Impact Assessment, 1st Edition, Elsevier Publication,
2. Lawrence, DP (2003).Environmental Impact Assessment: Practical Solutions to Recurrent Problems, John Wiley & Sons, Inc.

3. Canter L.W. (1996) Environmental Impact Assessment, Mc Graw Hill Publication, New York.

Reference Books

1. Ch. Wood, (1996).Environmental Impact Assessment – A comparative review,
2. Welsh Office, 1989.Environmental Assessment – A guide to the procedure, DoE,
3. Riki Therivel, (1996).Methods of Environmental Impact Assessment, Peter Morris,
4. Asit K. Biswas et.al, (1987) EIA for Developing Countries, United Nations University

COURSE OUTCOME: Students will be equipped to identify environmentally sound technologies or policies to resolve environmental problems

SUSTAINABLE DEVELOPMENT

EVNS: 413 **CREDITS: 3**

COURSE OBJECTIVE: To introduce the student to the Concept and History of Sustainable development and appreciate the intricacies involved in the march towards this goal.

UNIT –I Introduction and History: Brundtland, Rio, SDGs

UNIT –II Basic Concepts, Strategies and Measurement Efficiency and Innovation, Green Growth and Rebound

UNIT –III Sufficiency, Income and Labor, Consumption Patterns and Lifestyles; Poverty and Inequality

UNIT –IV Instruments for SD Governance, Education and Science System Climate Change & Biodiversity

UNIT –V Industrial and Corporate Perspectives.

Text Books

1. Margaret Robertson (2017) Sustainability Principles and Practice, 2nd Ed, Routledge Publication
2. Peter Rogers, Kazi F. Jalal, John A. Boyd (2007) An Introduction to Sustainable Development Paperback, Routledge Publication

Reference Books

1. John Blewitt, (2008) Understanding Sustainable Development, EarthScan Publishing, London, UK

COURSE OUTCOME: The student would be able to understand the basic concept of Sustainable Development (SD), the environmental, social and economic dimensions; be able to comprehend the conflicts which are involved in the SD concept on the national as well as on the global scale

LAB / FIELD WORK – 2

EVNS: 414 **CREDITS: 2**

ENVIRONMENTAL MONITORING AND ASSESSMENT – LAB

a. Spectrophotometric Methods of Estimation: Fluoride, Nitrate, Phosphate
b. Flame photometric analysis of Na, K, and Ca.
c. Estimation of sulphate by turbidimetry.
d. Sampling and analysis of SO2, CO2, NOX, HC
e. Determination of
f. SPM in ambient air by high volume sampler, (ii) PM2.5, PM 10
g. Water quality analysis: Determinations of DO, BOD, COD, TKN, TDS, TSS, turbidity, conductivity, alkalinity, acidity, nitrate, chloride, total hardness - Instrumental and wet chemical methods of analysis.
h. Detection and estimation of noise pollution
i. Physical, Chemical and Biological properties of soil: Collection, particle size analysis (silt and clay), Soil profile, water holding capacity, density, porosity, pH, conductivity, NPK, TOC.
j. Analysis of heavy metals (Hg, Pb, Cd)
k. Basic Environmental Microbiology - Preparation of culture media, Membrane Filter Technique, Bacteriological analysis of wastewater (Coliforms, E. coli, Streptococcus) – MPN.

ENVIRONMENTAL IMPACT ASSESSMENT – MINI PROJECT

a. Field work,
b. Data collection
c. Analysis
d. Mapping
e. Report submission

GEOGRAPHICAL INFORMATION SYSTEM

EVNS: 501 **CREDITS: 3**

COURSE OBJECTIVE: To instruct the students about the basics of Geographical Information systems and enable them to make effective use of Open source software QGIS/GRASS

UNIT –I Cartography - Scale, Coordinate Systems, Projections Essential Map Elements -Map Design and Layout - Attribute data for Thematic Mapping -Data Classification

UNIT –II GIS Vector Data Model - Topology, Shape files -Generalization Problems – Selection Methods - Overlay Operations

UNIT –III GIS Raster Data Model, Raster Analysis

UNIT –IV QGIS – elements – using QGIS

UNIT –V GRASS – elements – using GRASS

Practical:
1. Introduction to QGIS software
2. Introduction to GRASS software
3. Map reading – SOI topographical map
4. Geometric correction of SOI topographical map
5. Map Editing – Working with editing tools
6. Digitization of feature from SOI topographical map
7. Digitization of feature from Satellite data
8. Editing Attribute data
9. Editing map symbols and labels
10. Map composition

Text Books

1. Chang, KT, 2017, Introduction to Geographic Information Systems, McGraw Hill Education 4th Editon.
2. Robinson, AH, Morrison, JL, Muehrcke, PC, Kimerling, AJ, Guptill, SC, 2009, Elements of Cartogrphy, 6th Edition, Wiley Publication.
3. Husain, M, 2014, Evolution of Geographical Thought, Rawat Publishing house.

Reference Books

1. Hands-On Geospatial Analysis with R and QGIS https://www.packtpub.com/application-development/hands-geospatial-analysis-r-and-qgis Author: Shammunul Islam Date: November 2018
2. QGIS Tutorials and Tips, downloadable from https://www.qgistutorials.com/en/

COURSE OUTCOME: Student would be fluent in the use of GIS

CLIMATE CHANGE, ADAPTATION AND MITIGATION

EVNS: 502 **CREDITS: 3**

COURSE OBJECTIVE: To make students aware of scenario of climate change and to provide exposure on discussions happening at national and international levels

UNIT – I A simple example of global change: stratospheric ozone depletion – impacts and policy responses; A complex example of enhanced greenhouse effect- fundamentals of the climate system – changing composition of the atmosphere from human population growth & activities – climate variability in the last millennium and the recent climate record – future emissions and future climate. **(8 Hours)**

UNIT – II Impacts on earth system and society; Impact- regional, national, global; ecosystems; agriculture and food security; sea level rise; acid rain; ocean acidification, coral bleaching; human health; Forestry and Fishery. **(8 Hours)**

UNIT – III Understanding Vulnerability: Key concepts of Sensitivity and Vulnerability – Adaptive capacity, Resilience and Coping ranges and Critical Thresholds; Determinants of vulnerability and adaptive capacity; Variations among regions and sectors; Conceptual framework for assessing vulnerability to climate change; Necessity for adaptation to climate variability; Adaptation types and forms- planned versus autonomous adaptation; No-regrets adaptation options. **(8 Hours)**

UNIT – IV Assessing Impacts and Vulnerabilities: Climate change scenarios and Vulnerability; Methods of Vulnerability Assessment; Indicators of vulnerability and livelihood; Climate sensitivity analysis; Uncertainties in prediction and detection; Vulnerabilities and adaptation practices in forestry, agriculture, soil & land, water resources; Measures for heat waves, coastal inundation – cities – critical infrastructure; Global Policy on Climate and Adaptation. **(8 Hours)**

UNIT – V Policy responses and mitigation strategies to a changing planet – Energy options and making decisions; IPCC assessments and scenarios; Kyoto protocol; REDD, REDD+, CDM, International Geosphere and Biosphere Programme (IGBP) and other planned interventions. **(8 Hours)**

Text Books

1. Rathinasamy, M, Chandramouli S. Phanindra K.B.V.N. Uma Mahesh 2018, Resources and Environmental Engineering II: Climate and Environment
2. Parry, ML et al. Climate change 2007: Impacts, Adaptation and Vulnerability, Cambridge University Press.
3. Patt, A et al. 2009 Assessing Vulnerability to global environmental change: making research useful for adaptation decision making policy, Earth scan London.

Reference Books

1. Climate Change and Biodiversity; By Thomas E. Lovejoy, Lee Jay Hannah Published by Yale University Press, 2006 ISBN 0300119801, 80300119800 418 pages.

2. William H. Schlesinger. 1997. Biogeochemistry: An Analysis of Global Change. Academic Press, San Diego, CA. 2nd edition. Available at the Bay Tree Bookstore.
3. Global Environmental Change: Research Pathways for the Next Decade, National Research Council, 1999.
4. Our Common Journey: A Transition toward Sustainability, National Research Council, 1999.

COURSE OUTCOME: Students would be able to address climate change mitigation and adaptation issues

RENEWABLE ENERGY TECHNOLOGY

EVNS: 503 **CREDITS: 3**

COURSE OBJECTIVE: To enable an understanding of renewable energy in the broadest terms.

UNIT-I Wind energy - Wind energy resources, power in wind, wind turbine design considerations, grid connected wind farms, hybrid power systems, economics of wind power systems, economic analysis methods, wind energy conversion system. **(8 Hours)**

UNIT-II Solar energy – Introduction, Earth's orbit, solar constant and solar spectra, solar angles, collector angles, solar irradiance, photovoltaic energy conversion, types of photovoltaic systems; solar thermal electric power plant - solar thermal systems, environmental impact .**(8 Hours)**

UNIT-III Bio Fuels – Biomass as a source energy, types of biomass, energy content of biomass, harvesting methods of biomass, conversion of biomass, thermos-chemical conversion of biomass, biodiesel production, bioethanol production**,** forest biomass production, forest species, environmental impact resulting from the generation and exploitation of forest biomass.**(8 Hours)**

UNIT-IV Ocean and Small hydro energy systems – Marine energy, understanding the power of marine energy, global development of marine energy, ocean wave energy, ocean tide energy, mathematical modelling of tidal schemes, global environmental impact; low power hydro plants, micro hydro plants **(8 Hours)**

UNIT-V Energy planning for renewable energy systems -Modern power electronic technology for renewable energy sources, future trends in wind-power technology, power electronics in photovoltaic systems, recent trends in energy storage technologies, power quality instrumentation, regulatory framework, energy resource allocation, region dependent development in energy planning.**(8 Hours)**

Text Books

1. Buchla, DM, Kissell TE and Floyd TL, 2017, Renewable Energy Systems, Pearson Education.
2. Zobaa, AF and Bansal, RC, 2011 Handbook of Renewable Energy Technology, World Scientific Publishing Co. Pte. Ltd. Singapore.
3. Boyle, 2012, Renewable Energy: Power for a Sustainable Future, Oxford University Press, 3rd Edition.

Reference Books

1. Renewables 2005: Global Status Report: Notes and References Companion Document, REN21 Network Report, 2005
2. Khan, 2017, Non-Conventional Energy Resources, McGraw Hill Education, India Pvt Ltd.

COURSE OUTCOME: Students will be able to define the different key renewable energy technologies, will have a broad appreciation of the potential applications for renewable energy technologies and will understand the strengths and weaknesses of the different renewable energy technologies.

LAB / FIELD WORK – 3

EVNS: 504 **CREDITS: 2**

1. CLIMATE CHANGE, ADAPTATIONS AND MITIGATION – MINI PROJECT

a. Field work,
b. Data collection
c. Analysis
d. Mapping
e. Report submission

2. RENEWABLE ENERGY TECHNOLOGY – INDUSTRIAL VISIT

a. Data collection
b. Analysis
c. Report submission