School of Informatics

MSc Ecology (Specialization in Ecological Informatics)

Revised Course Syllabus -2023

Kerala University of Digital Sciences, Innovation and Technology
(Digital University Kerala)

Vision

We envision a ‘cooperatively competitive’ academic environment with focus on transmutation of information socially and temporarily relevant research backed by quality education to churn out graduates with professional acumen, exceptional leadership and a humane heart with an innovative and sustainable outlook for societal welfare.

Mission

To impart value-based education through three allied values: learn, transmute and transform and technology-oriented interdisciplinary education with a focus on sustainability to students to bring them up as citizens who are socially conscious, environmentally responsible, intellectually competent and morally upright.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

1. To prepare the program graduates to have successful careers as ecologists, academicians, researchers, professionals, and entrepreneurs developing innovative and sustainable solutions for the industry, government, and society by leveraging digital technologies.
2. To train in healthy negotiations, societal amelioration, progressive professional development, and become exceptional leaders.
3. To inculcate sensitivity towards ecological and social welfare as ethical and responsible citizens and contribute towards sustainable development.

PROGRAMME OUTCOMES (POs)

The graduates of MSc Ecology will be able to:

1. **Disciplinary knowledge**: Understand complex ideas and apply the knowledge of science and mathematics to arrive at feasible, sustainable solutions with a research mindset through an interdisciplinary approach.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex problems, reaching substantiated conclusions using the first principles of mathematics, natural and social sciences.

3. **Design/development of solutions**: Design solutions for complex problems and design system components or processes that meet the specified needs with appropriate public health and safety, cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods, including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling complex activities with an understanding of the limitations.
6. **Social responsibility**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal, and cultural issues and the consequent responsibilities relevant to the professional practice.
7. **Environment and sustainability**: Understand the impact of professional solutions in societal and environmental contexts and demonstrate the knowledge for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional, social, and environmental ethics and responsibilities
9. **Individual and team work**: Function effectively as an individual, member, or leader in diverse groups and multidisciplinary settings.
10. **Communication**: Communicate effectively on interdisciplinary activities with the peer community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of various scientific and management principles and apply these to one's work as a member and leader in a team to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

The post-graduates will be able to:

1. Develop a comprehensive understanding of core disciplines
2. Encourage interdisciplinary approaches by integrating ecological studies with other disciplines
3. Encourage critical thinking and problem-solving skills and provide feasible, innovative, and sustainable solutions to address real-world environmental and societal problems utilizing computational and technical skills.
4. Cultivate research competencies that empower students to conduct independent and innovative research and effectively communicate scientific findings to various audiences.
5. Prioritize conservation principles to upkeep environmental balance by catalyzing technological advances that promote societal welfare through STEM (science, technology, engineering, and mathematics).

PROFESSIONAL GOALS

1. Research and Academics
2. Environmental consultation and entrepreneurship
3. Professionals in Government/Non-Government organizations
4. Conservation professional

Program Outline

Course Code	S No.	Course Name	Type	Level	Credits			
					L	T	P	Total
Semester I								
	1	University Core	U. Core	200	-	-	-	3
M3321001	2	General Ecology	P. Core	300	2	1	0	3
M3321002	3	Biodiversity and Evolution	P. Core	300	2	0	0	2
M2321003	4	Quantitative Ecology	P. Core	200	1	0	1	2
M2321047	5	Ecological Informatics-1	P. Core	200	1	0	1	2
M2321006	6	Mathematical Thinking in Ecology	O. Elective	200	2	1	0	3
M3321007	7	General Ecology Lab	P. Core	300	0	0	2	2
							Total Credits	**17**
Semester II								
	1	University Core						2
M3321010	2	Population, Community and Ecosystem Ecology	P. Core	300	2	0	0	2
M3321048	3	Spatial Informatics	P. Elective	300	2	0	2	4
M3321049	4	Multivariate Statistics for Ecological Analysis	P. Elective	300	1	0	1	2
M3321050	5	Ecological Informatics-2	P. Core	300	1	0	1	2
M3321051	6	Bioinspired Design	O. Elective	300	1	1	1	3
M3321016	7	Research Methodology and Scientific Writing	O. Elective	300	2	0	0	2
M3321052	8	Conservation and Sustainable Development	O. Elective	300	2	0	0	2
M4321053	9	Summer Project	Additional	400	-	-	-	3
							Total Credits	**21**
Semester III								
M3321039	1	Ecological Modelling	P. Elective	300	2	0	1	3
M3321024	2	Global Change Ecology	P. Elective	300	1	0	1	2
M3321041	3	Ecological Engineering	P. Elective	300	1	1	1	3
M3321044	4	Ecology and Society	O. Elective	300	2	0	1	3
M3321027	5	Environment Impact Assessment	O. Elective	300	1	0	1	2
M3321028	6	Environmental Social Governance	O. Elective	300	1	1	0	2
M3321029	7	Environmental Legislation and Policy	O. Elective	300	2	0	0	2
M4321054	8	Advanced Topics in Ecology	P. Elective	400	1	0	1	2
M3321055	9	Forest Ecology	P. Elective	300	1	0	1	2
M3321056	10	Urban Ecology	P. Elective	300	1	0	1	2
M4321025	11	Seminar /Meta-Analysis	Additional	400	-	-	-	2
							Total Credits	**25**
Semester IV								
M4321032	1	Master Project	Core	400	-	-	-	**15**
							Total Credits	**15**

Semester I | Course Structure

SNo.	Course Code	Course Name	Type	Level	Credits			
					L	T	P	Total
1		University Core	U. Core	200	-	-	-	3
2	M3321001	General Ecology	P. Core	300	2	1	0	3
3	M3321002	Biodiversity and Evolution	P. Core	300	2	0	0	2
4	M2321003	Quantitative Ecology	P. Core	200	1	0	1	2
5	M2321047	Ecological Informatics-1	P. Core	200	1	0	1	2
6	M2321006	Mathematical Thinking in Ecology	O. Elective	200	2	1	0	3
7	M3321007	General Ecology Lab	P. Core	300	0	0	2	2
	Total Credits						**17**	

M3321001 General Ecology (3 Credits)

Course Description:

This course provides a comprehensive introduction to ecology. It touches upon the fundamental concepts and underlying principles linking biotic and abiotic components of the ecosystem and their interactions.

Course Objectives

1. Develop a foundational understanding of key ecological principles, concepts, and terminology.
2. Understand populations and communities and examine the dynamics of ecosystems, including energy flow, nutrient cycling, and the interactions between biotic and abiotic components.
3. Investigate biophysical and chemical processes occurring in the environment and examine how organisms adapt to these conditions.
4. Analyze the ecological consequences of human activities

Course Content

Introduction to Ecology: Overview, evolution of the discipline, Underlying concepts of physical and biological systems, physical system vs biological system, ecological hierarchy: organism to biome, Biotic factors: producers, consumers, decomposers, Abiotic factors: light, temperature, soil, water, air. Concept of limiting factors; Liebig's law of the minimum; Shelford law of tolerance. Ecosystem interaction and interrelationship between biotic and abiotic factors, Population and community, ecosystem structure and function, productivity, energy flow, trophic structure, ecological pyramids, food chain, food web, ecological efficiency, concept of ecological niche

Physical process in environment – Atmosphere and radiation: Transport of radiant energy, Radiation laws, atmospheric thermodynamics, boundary layer, Spatial relations - cosine law for emission and absorption, reflection, radiance and irradiance, radiation environment: solar radiation, attenuation of solar radiation in the atmosphere, solar radiation at the ground, terrestrial radiation, net radiation, precipitation.

Nutrient cycling: biogeochemical cycles - gaseous cycle: oxygen cycle, carbon cycle and nitrogen cycle. Sedimentary cycles: phosphorus cycle, Sulphur cycle, terrestrial ecosystem consolidation of concepts, aquatic ecosystem consolidation of concepts, human influence on nutrient cycling, estimation methods.

Understanding various environments: terrestrial and aquatics, organism-environment relations, adaptations, time-dependent energy budgets, steady-state energy budget, observed leaf temperatures, optimal leaf size, photosynthesis; light and temperature, adaptation to high radiation, steady-state energy budgets of animals, metabolic rate, thermal conductance, metabolism and body size, body temperatures, evaporative water loss, behavior, and special anatomical features. Ecological succession, ecosystem energetics, trophic dynamics

Macro ecology: Biogeography, global ecology, natural resources, ecosystems in the Anthropocene, ecological theories and applications, emerging trends in ecology.

Course Learning Outcomes

1. Understand key ecological concepts, principles and terminology
2. Explain the mechanism of population dynamics and interactions within the community
3. Examine various physical and chemical processes in the environment and how organisms adapt to it
4. Understand the geographic distribution of organisms and resources to evaluate the ecological consequences of human activities with a global perspective

M3321002 Biodiversity and Evolution (2 Credits)

Course Description:

This course is an introduction to the disciplines of evolutionary biology and biodiversity. The course deals primarily with the evolutionary processes that generate and maintain various life forms on the planet. The course enables learning the magnitude, distribution, and inter-relationships of biological diversity at all levels.

Course Objectives

1. Provide a comprehensive understanding of the evolution of life forms.
2. Appreciate the biological diversity and explore the complexity of major lineages of life on Earth
3. Explore various methods to measure biodiversity
4. Understand the principles and practices of conservation biology and citizen science

Course Content

Concept of Evolution: History of evolutionary biology, Pre Darwinian concepts, origin of species: Darwin's evolutionary theories, The Galapagos Islands and Darwin's Finches, Evidences of Evolution: Homology and Comparative Anatomy, Embryology. Vestigial Organs, The Fossil Record, Observational and Experimental Evidence Phylogenetics: reconstructing evolutionary history, the tree of life, Natural selection and Variations

Inheritance of variation, Mendelian genetics, Evolutionary genetics: -Mutation and genetic variation, genotypic and phenotypic variation, Migration, Genetic Drift and Nonrandom mating, population genetics, , Natural Selection and adaptation, Artificial Selection, Polymorphism, directional Selection, quantitative traits, Local Adaptation, Nature of adaptations, Sexual Selection, sex ratios, Life history traits and characters, specialist and generalists, Speciation, reproductive isolation, geography of speciation: allopatric sympatric and parapatric speciation, Species interaction: coevolution, social interaction and cooperation, competition and mutualism

Macroevolution: origin of earth: Geological fundamentals, History of life: Emergence of life, pre-Cambrian life, Geological time scale: life across Paleozoic, Mesozoic, Cenozoic era, extinction and adaptive radiation, Evolution of Biological Diversity, Evolutionary biogeography, geographic range limits, endemic, cosmopolitan and disjunct distribution

Biogeography, global pattern of biodiversity, biodiversity of Indian sub-continent, major biomes of the world, biodiversity and taxonomy, types of biodiversity- species, genetic and ecosystem, values of biodiversity, measurement of biodiversity: survey and field techniques, numerical methods. Threats to biodiversity, habitat loss, defaunation, biological invasion, biodiversity and climate change, biodiversity conservation -methods and practices, biodiversity conservation -national and international programs,

Biodiversity Data Standards and Portals: Data Standards, Darwin Core, biodiversity portals, Global Biodiversity Information Facility (GBIF), Retrieving data form portals

Citizen's contribution to Biodiversity data: Citizen Science / Community Science, Importance of citizen's science,, data standards for citizen's science, citizen's science data portals, iNaturalist, India Biodiversity Portal, Biodiversity Atlas of India.

Course Learning Outcome

1. Understand the principles underlying evolution, biodiversity, and inheritance among diverse life forms on Earth.
2. Analyze the mechanism of evolution, interpret various biogeographical features, and assess the significance and values of biodiversity.
3. Apply multidimensional approaches in the assessment of ecological and evolutionary processes.
4. Apply comprehension of biodiversity, biodiversity patterns, and species distribution to draw interpretations.
5. Analyze biodiversity data standards and portals for effective information management and evaluate the role of citizen contributions in enhancing biodiversity data.

Text Books

1. Mark Ridley. (2003). Evolution (3rd ed.). Wiley-Blackwell
2. Douglas J Futumya & Mark Kirkpatrick. (2017). Evolution (4th ed.). OUP USA.
3. John C Horron & Scott Freeman. (2015). Evolutionary Analysis (5th ed.). Pearson.
4. Martha Taylor. (2018). Campbell Biology: Concepts & Connections (9th ed.). Pearson.
5. Kevin J Gaston, John I Spicer. (2004). Biodiversity - an introduction (2nd ed.). Blackwell.
6. Anne Magurran. (2003). Measuring Biological Diversity (1st Ed.). Wiley-Blackwell.
7. Julie L. Lockwood, Martha F. Hoopes, and Michael P. Marchetti. (2013). Invasion Ecology (2nd Ed.). Wiley–Blackwell.
8. Krishnamurthy. (2003). Textbook of Biodiversity (1st ed.). CRC Press

M2321003 Quantitative Ecology (2 Credits)

Course Description

The course covers foundational concepts in statistical analysis and the major inference paradigms in use today. Through the use of R programming, this course intends to convey concepts such as various distributions, correlations, regressions and apply them in the context of ecological datasets.

Course Objective

1. Introduce students to fundamental statistical concepts and techniques
2. Apply statistical methods, interpret results, and draw meaningful conclusions
3. Develop proficiency in data analysis skills using R programming

Course Content

Descriptive Statistics: Surveys: Census and sampling; Data collection methods for ecological data. Probability and Non-probability sampling methods; Frequency tables, Diagrams and Graphs; Averages; Measures of dispersion; Skewness and Kurtosis. Introduction to R and R studio.

Probability, Random Experiment, sample space, events; Definitions (Classical, Statistical, axiomatic),Conditional probability, Bayes' Theorem.

Random Variables, Probability distributions and Mathematical Expectation, Binomial, Poisson, Normal distributions; Distribution of sample mean, Chi –square distribution, t-distribution; F-distribution.

Bivariate distributions; Correlations and Regression, Covariance; Scatter diagram; Correlations; Simple linear Regression. Fitting of distributions; Computation of Correlation; Fitting Regression equation.

Statistical Inference: Point estimation, Properties of estimators – unbiasedness, consistency, efficiency and sufficiency; properties of estimators. Testing of Hypothesis- statistical hypotheses, simple and composite hypotheses, two types of errors, significance level, p-value, power of a test

Large sample tests- testing mean and proportion (one and two sample cases), Chi-square (χ 2) test of goodness of fit, independence and homogeneity.

Small sample tests- Z-test for means; One sample test for mean of a normal population, Equality of means of two independent normal populations, Paired samples t-test, Chi-square test for variance, F-test for equality of variances, ANOVA.

Non-parametric Tests: Kolmogorov – Smirnov test, Shapiro-Wilks test, Mann-Whitney test for equality of means, Kruskal- wallis H test, Wilcoxon test for paired samples; Friedman test**.** Analysis of ecological data using R studio

Course Learning outcome

1. Understand the basic concepts of statistics and describe data sets appropriate
2. Interpret the concept of probability and distributions
3. Distinguish between various correlation regression techniques.
4. Illustrate proper usage of statistical tools and interpretation of results

Text Books

1. Zar J. (2013). *Biostatistical Analysis* (5th Ed.). Pearson.
2. S. C. Gupta and V. K. Kapoor. (2014). *Fundamentals of Mathematical Statistics* (12th Ed.). S. Chand & Co
3. Aaron M. Ellison and Nicholas Gotelli. (2012). *A Primer of Ecological Statistics* (2nd Ed.). Oxford University Press.
4. Rosner, B. (2015). *Fundamentals of biostatistics* (8th Ed.). Brooks/Cole

M2321047 Ecological Informatics-1 (2 Credits)

Course Description

This course introduces students from various backgrounds to the field of computer programming. This course includes object-oriented program design, debugging, exception handling, and database management. The course focuses on making students acquainted with the syntax and semantics of logic, able to write programs in a programming language like Python, and capable of constructing simple programs.

Course Objective

1. Develop foundational skills in programming.
2. Familiarize with problem-solving, structured, and object-oriented programming logic and techniques.
3. Develop algorithms and design programs to deal with ecological problems.

Course Content

Introduction to programming, Generations of Programming Language, Programming paradigms, Algorithms and Flowchart, Language translators, Data representation - Concept of number systems

Introduction to Python- Operators, Data types, variables, expression, Statement, Control structures, String and String operations

Data structures: Built in data structures - List, Tuple, Dictionary, Sets, User defined Data Structures- Arrays, Stack, Queue, Linked Lists, Trees, and Graphs. Errors and Exception handling.

Functions and arguments, Packages, Introduction to Object oriented programming - Classes and object, Constructors, Destructors, Inheritance, Encapsulation Polymorphism. Introduction to python GUI programming.

File handling - operations on files, Advantages and disadvantages, Regular Expressions, Introduction to Database Management Systems (DBMS), Advantages of DBMS over file, Database creation and manipulation, Integrating database with python.

Information Systems, Internet and the web, Data Standards and Portals, Web data repositories, Data mining, Version control and collaboration platforms

Course Learning Outcomes

1. Recall the fundamentals of computer programming
2. Familiarize with the Python programming and explore data types, variables and control structures
3. Infer user defined functions, Object oriented programming and GUI programming

4. Make use of file operations, creation and manipulation of Database
5. Describe Information systems, Data standards and portals, Data repository and data mining

Text books

1. Dr. Nageswara Rao. (2021). *Core python programming* (3rd Ed.). Dreamtech press.
2. Balagurusamy. (2017). *Introduction to Computing & Problem Solving Using Python* (1st Ed.). McGraw Hill Education India Private Limited.
3. K Sinha & Priti Sinha. (2004). *Computer Fundamentals* (6th Ed.). BPB Publications;
4. David Beazley, Brian K. Jones. (2013). *Python Cookbook: Recipes for Mastering Python 3* (3rd Ed.). O'Reilly Media.
5. TJ O'Connor. (2012). *Violent Python: A Cookbook for Hackers, Forensic Analysts, Penetration Testers and Security Engineers*. Syngress.
6. Elements of Information Theory, T. M. Cover, J. A. Thomas, Wiley, 2006
7. Mathematical foundations of information theory, A. Khinchin, Dover, 2001

M2321006 Mathematical Thinking in Ecology (3 Credits)

Course Description

The course will help to develop deep insights into Mathematical concepts, their application to Ecological studies, numerical skills, and visualization capability. Mathematical thinking is different from doing typical mathematics. The course focuses on learning and understanding Mmathematics from elementary to advanced level that can be applied to ecological studies. After completing the course, students will be able to develop mathematical curiosity and out-of-the-box thinking. The course will also be able to use numerical reasoning and learn to apply mathematical tools to elucidate complex problems in ecological systems.

Course Objective:

1. Inculcate mathematical thinking and develop out of the box thinking
2. Develop numerical skills for ecological problem solving
3. Apply mathematical solutions to real-world problems

Course Content

Number system: natural numbers, integers, whole numbers, rational and irrational numbers, real numbers, infinitude of the number system, prime numbers, congruences, Pythagorean numbers, link to geometry, and Fermat's last theorem. Set theory: definition, algebra of sets, intervals, Russel's paradox, and applications. Functions: definition, injective, surjective and bijective functions, real-valued functions, polynomial, logarithmic, exponential, absolute value, and trigonometric functions, graph of functions. Analytics Geometry: coordinate systems, lines, planes, distance and angles, circles, ellipse, parabola, hyperbola, and equations.

Matrices: definition, properties, matrix algebra, determinants and system of linear equations, eigenvalues and eigenvectors.

Limits: Zeno's Dichotomy paradox, limit of a sequence, series, Euler's number e, the number, limit of real-valued functions. Continuity: precise definition of continuity of a function, limit approach, approach, and Stone-Weierstrass theorem.

Integrals: integration as a limit of sums, rules of integration, integration of simple functions
Integrals: indefinite and definite integrals, and areas of bounded regions
Derivatives: derivative as a limit of slopes, higher order derivatives, and rules of differentiation

Derivatives: Increasing and decreasing functions, maxima and minima of functions, applications of derivatives, and fundamental theorem of calculus

ODEs: Introduction to ordinary differential equations, first and second-order ODEs, and methods of solutions, PDEs: Introduction to partial differential equations and their applications

Numerical methods: errors, interpolation and extrapolation,

Numerical methods: numerical integration and differentiation

Numerical modelling: general introduction, mathematical models in ecology

Course Learning Outcome

1. Recall the fundamentals of mathematics and develop deep insights into the mathematical concepts.
2. Develop out-of-the-box thinking and utilize mathematical/numerical skills for ecological problem-solving.
3. Relate mathematical concepts and models to solve real-world ecological problems.

Text Books

1. Ledder G. (2013). *Mathematics for the Life Sciences*. Springer
2. Stevens M. H. (2009). *A Primer of Ecology with R* (1st Ed.). Springer.
3. Hastings A. (1997). *Population Biology: Concepts and Models*. Springer
4. Niven I., Zuckerman H.S., and Montgomery H.L. (1991). An introduction to theory of numbers (5th ed.). Wiley.
5. Courant, Robbins & Stewart. (2007). W*hat is mathematics* (2nd Ed.). Oxford HED.
6. George F. Simmons. (2017). *Differential equations with applications and historical notes* (2nd Ed.). McGraw Hill Education.
7. Martin Braun. (1993). *Differential equations and their applications* (4th Ed.). Springer.
8. Hirsch & Smale. (2012). *Differential equations and dynamical systems and an Introduction to Chaos* (3rd Ed.). Academic Press.
9. Burden, Faires & Burden. (2012). *Numerical analysis* (9th Ed.). Cengage Learning India.
10. Jain, Iyengar & Jain. (2020). *Numerical methods: problems and solutions* (3rd Ed.). New Age International Private Limited.
11. John Harte. (1991). *Consider a spherical cow – a course in environmental problem solving* (1st Ed.). University Science Books.
12. John Harte. (2001). Consider a cylindrical cow – more adventures in environmental problem solving (1st Ed.). University Science Books.

13. Gene H Golub & Charles F Van Loan. (2015). *Matrix Computations* (4th Ed.). Hindustan Book Agency.
14. Iyengar & Jain. (2020). *Numerical Methods* (1st Ed.). New Age International Private Limited.
15. Ian N. Sneddon. (2006). *Elements of partial differential equations*. Dover Pubns.
16. Chris Chatfield. (2003). The Analysis of Time Series: An introduction (6th Ed.). Chapman and Hall/CRC.

M3321007 General Ecology Lab (2 Credits)

Course Description

This course is a hands-on laboratory course designed to complement the theoretical concepts of core disciplines of ecology. It provides students with practical experience conducting ecological research, data collection, and analysis. Students will engage in fieldwork to collect ecological data such as soil, water, and biodiversity sampling and analyze using appropriate chemical and analytical methods.

Course objectives

1. Demonstrate proficiency in field data collection.
2. Familiarize students with instruments used in ecological research
3. Demonstrate environmental sample analysis
4. Analyze and interpret ecological data sets using quantitative techniques

Course Content

1. Ecological Observations and Hypotheses
2. Determination of water quality parameters (Alkalinity, Dissolved Oxygen, COD, Chloride, Nitrate)
3. Determination of soil parameters (TOC, Iron, Mg)
4. Quantitative analysis of vegetation
5. Taxonomical characterization using plant morphological traits
6. Measurement of soil invertebrate diversity
7. Investigation of the interaction between plant and animal
8. Evaluation of the influence of habitat loss on the population of endangered species
9. Phylogenetic analysis
10. Field data collection using digital handheld devices

Course Learning Outcome

1. Demonstrate the field sampling techniques in ecological studies.
2. Use digital techniques for field data collection
3. Analyze the Physico-chemical and biological characteristics of environmental samples.
4. Analyze and interpret ecological data sets using quantitative techniques

SEMESTER 2 | Course Structure

SNo	Course Code	Course Name	Type	Level	Credit			
					L	T	P	Total
1		University Core	U Core	300	-	-	-	2
	M3321010	Population, Community and Ecosystem Ecology	P. Core	300	2	0	0	2
2	M3321048	Spatial Informatics	P. Elective	300	2	0	2	4
3	M3321049	Multivariate Statistics for Ecological Analysis	P. Elective	300	1	0	1	2
4	M3321050	Ecological Informatics-2	P. Core	300	1	0	1	2
5	M3321017	Bioinspired Design	O. Elective	300	1	1	1	3
6	M3321016	Research Methodology and Scientific Writing	O. Elective	300	2	0	0	2
7	M3321051	Conservation and Sustainable Development	P. Elective	300	2	0	0	2
8	M3321022	Summer Project	Additional	300	-	-	-	3
	Total Credits							**22**

M3321010 Population and Community and Ecosystem Ecology (2 credits)

Prerequisite: M3321001: General Ecology and M3321002: Biodiversity and Evolution

Course Description

This course provides an advanced view of the concepts that underlie the spatial and temporal dynamics of populations and communities. The course will cover population and community ecology, as revealed through mathematical and graphical analyses emphasizing concepts and models.

Course Objectives

1. Discuss the principles behind population ecology and their interactions.
2. Describe the evolution of Community ecology and its applications.

Course Content

Principles of Population Ecology: Basic concepts of population (discrete and continuous population), community and ecosystem from cellular structure to ecosystem level; population group properties; density and indices of relative abundance; basic concepts of rates - natality and mortality; methods of analyzing population distribution; factors (dispersal, habitat selection, interrelations, temperature, moisture and other chemical and physical factors) that limit population distribution: life tables and schedule of reproduction; net reproductive value; age distribution; evolution of demographic traits; intrinsic rate of increase; survivorship curve; population regulation - density dependent and independent regulations; population growth and dynamics, mathematical theory, exponential and logistic growth and concept of “r” and “k”; ‘r’ and ‘k’ selection - life history strategies;

Interactions between populations: direct vs. indirect and complex population interactions - competition, predation, parasitism, mutualism, commensalism, amensalism; Lotka-Volterra equation and competition theory; competitive exclusion principle or Gause’s principle; graphical representation of competitive exclusion principle and co-existence; diffuse/apparent competition; niche breadth and overlap; resource partition and niche preemption; predation theory; basic mathematical model of continuous population of prey; basic mathematical model of prey and predator interactions of continuous population; basic mathematical model of discrete prey population; basic mathematical model of prey and predator interactions of discrete population; concept of metapopulation, patch colonization and extinction, Levin’s concept of metapopulation dynamics.

Community assemblage: shape and structure and states of the ecosystem and its functioning: Basics of community ecology; formation of the community; community structure; compartments in the community (guilds, trophic levels, food chain and food webs) and connectance; biomass and productivity; ecological pyramids (pyramids of number, wet weight, dry weight and energy); reverse pyramids; laws of thermodynamics and energy flow through ecosystem; primary and secondary productivity, ecological energetics and efficiencies; ecological succession - primary and secondary succession; climax theory; species diversity; different community indices such as dominant index, similarity index, richness index, evenness index and diversity index; food web dynamics; different types of the food web; bottom-up and top-down effects in the community.

Concept of refuge; numerical and proportional refuge in prey population; escape strategies of prey from predator and refuge of prey; dynamic of prey-predator interaction with prey refuge strategies; concepts of Allee effects; weak and strong Allee effects in population dynamics; disease model and dynamics of susceptible-infected-recovered population

Human Ecology; human demography and demographic transitions; carrying capacity of earth; new perspectives of carrying capacity of earth and recent syntheses on the aspects of ecological footprint

Course Learning Outcomes

1. Enumerate the principles of population ecology
2. Describe different types of interactions between various populations
3. Distinguish various types of ecological interactions and community assemblage mechanisms
4. Interpret the population and community dynamics and their applications

Text Books

1. Community Ecology, G. Mittelbach, Oxford University Press, 2012.
2. Herman A. Verhoef and Peter J. Morin, Community Ecology: Processes, Models, and Applications, Oxford University Press, 2009
3. Diamond, Jared and Case, Ted J., Community ecology, Harper & Row, 1986.
4. A Primer of Ecology, Gotelli, Nicholas JSinauer Press, 3rd ed, 2001.
5. An Illustrated Guide to Theoretical Ecology, Case T. J., OUP USA; Illustrated edition, 1999. (read pp. 79-100)
6. Lectures in Theoretical Population Biology, Ginzburg and Golenberg, Longman Higher Education, 1985 (read pp. 1-5 and 193-219)

7. Ecology: Individuals, Populations and Communities, Begon, M.; Harper, J.L. and Townsend, C.R., Blackwell Scientific Publications, 2006
8. Ecology, Ricklef and Miller, W. H. Freeman Publications, 1999
9. A New Ecology: Systems Perspective, S. E. Jorgensen and B. D. Fath, Elsevier, 2007
10. Ecology, C. J. Krebs, Pearson, 6th Edition., 2009
11. Fundamentals of Ecology, E. P. Odum and G. Barret, Brooks/Cole, 2004

M3321048 Spatial Informatics (4 credits)

Course Description

This course provides the knowledge and practical skills necessary to harness the power of geospatial technologies. As our world becomes increasingly data-driven, understanding how to collect, analyze, and visualize spatial information is invaluable in fields such as environmental science, urban planning, agriculture, and disaster management. This course in Spatial Informatics explores the intricacies of acquiring, managing, analyzing, and interpreting spatial data to unlock geospatial intelligence in various domains.

Course Objectives

1. Understand the fundamentals of Remote Sensing and Geographic Information Systems (GIS)
2. Acquire skills in working with remote sensing data (image interpretation, digital image processing and classification)
3. Develop and manage spatial data and perform geospatial analysis
4. Explore applications of spatial informatics in various fields

Course Content

Principles of Remote Sensing: Concepts of Remote Sensing, Physics of remote sensing, Electro Magnetic Radiation, atmospheric interactions, Spectral reflectance of earth's surface features: spectral characteristics of surface features (rocks, soils, vegetation, water), senors and platforms, IRS, Landsat, SPOT, NOAA, ERS, RADARSAT, INSAT satellites and their sensors, Multi-Spectral Optical Line-Scanner Systems, geometry and radiometry, Orbital characteristics, data products. Visual Image Interpretation, Resolutions in Remote Sensing: Spatial, Spectral, Temporal, & Radiometric, thermal scanning, hyperspectral sensing, Active Remote sensing techniques: Aerial / Drone / Lidar/active microwave Remote Sensing: Aerial Photography. Fundamentals of photogrammetry, principle of stereo photography, parallax and measurement of height & slope, Applications of Remote Sensing in ecological studies.

Digital Image Analysis: Image preprocessing: radiometric, geometric and atmospheric corrections, estimation of top of atmosphere reflectance, image enhancement, contrast manipulation, calculating radiances from DNs, subsets, Image Classification: Unsupervised Classification, Supervised Classification, hybrid classification, post classification smoothing, ground truth, accuracy assessment

Introductory concepts: definition and scope, history of GIS, precepts from Human Geography to understand GIS; Data for GIS, Sources of geospatial data- Spatial and non-spatial data collection, representation and standardization; data collection; Data organization (location, attributes, consistency, scale); meta data; data interoperability; accuracy and precision; The importance of error, accuracy, and precision, types of error, sources of error, data quality.

Spatial data; attribute data; GIS concepts; GIS operations; geographic grid; coordinate systems in GIS; map projections: properties of the spherical Earth (area, shape, distance, direction) and different types of map projections – equivalent, conformal, azimuthal, and equidistant. Data models: Vector data model; Raster data model; Vector data – objects and topology, vector data input, editing, attribute data input and management; Raster data – Types of raster data, Raster data structure, data conversion; integration of raster and vector data. Spatial Data Management using RDBMS, PostgreSQL, PostGIS,

Spatial Data Analysis: Vector data analysis – Buffering, Map overlay, Distance measurement, Map manipulation; Raster data analysis – Analysis environment, Local operations, Neighborhood operations, Zonal operations, Distance measure operations, overlay analysis, multi-criteria evaluation, spatial autocorrelation, modelling of spatial Phenomena, spatial interpolation: deterministic and stochastic models, global and local models, trend surface analysis, regression model, Inverse Distance Weighted (IDW), Triangulated Irregular Network (TIN), splines, geostatistical approach: kriging, semivariograms.

Global positioning system and GNSS, Geo web services, ISRO-Bhuvan, USGS Earth Explorer, Google Earth, Google Earth Engine, Interoperability, Volunteered geographic information, Mobile GIS, Introduction to Web-based GIS applications &Web mapping.

Course Learning Outcomes

1. Describe the fundamentals of Remote Sensing and understand the significance of remote sensing in earth observation
2. Interpret remote sensing data and perform digital image analysis
3. Summarize the concepts in GIS and its different data models
4. Create spatial data and perform various spatial data analysis
5. Explore the application of spatial informatics in different sectors and utilize various geo-web services

Text Books

1. Introduction to Remote Sensing, J B Campbell and R H Wynne,The Guildford Press, 2011.
2. Remote sensing and Image Interpretation, T.M. Lillesand and R.W. Kiefer, Wiley Publications, 2003.

3. Principles of Geographical Information Systems for Land Resources Assessment, P.A. Burrough, Oxford University, 1986.
4. Principles of Geographical Information Systems, O Huisman and Rolf A. de By, ITC The Netherlands, 2001.
5. Physical Principles of Remote Sensing, W. G. Rees, Cambridge University Press, 2nd Edition, 2001.
6. Remote Sensing and Geographical Information Systems, Reddy, M. Anji, BS Publications, 2008.
7. Fundamentals of Remote Sensing", Joseph G., Jeganathan C, University Press 3rd Edition, 2018

M3321049 Multivariate Statistics for Ecological Analysis (2 Credits)

Prerequisite: Quantitative Ecology (M2321003), Mathematical Thinking in Ecology (M2321006)

Course Description

This course explores applications of advanced statistics and mathematics to various ecological problems. By the end of this course, students will be able to derive, interpret, solve, simulate, understand, discuss, and critique discrete and differential equation models of ecological systems.

Course Objectives

1. Deepen students' understanding of advanced statistical techniques used in ecological research.
2. Develop critical thinking skills for designing and interpreting advanced statistical analyses in ecology.
3. To prepare students for independent ecological research and more specialized coursework.

Course Contents

Regression - Hypothesis tests with regression. Different regression analyses - Robust regression, Quantile regression, Logistic regression, Non-linear regression, Multiple regression, Path Analysis. Model selection criteria for multiple regression and path analysis.

Analysis of Variance - one way, two way. Analysis of categorical data - two-way contingency table, multiway contingency table and tests for goodness of fit.

Multivariate data, Comparing multivariate means, Multivariate normal distribution, multivariate distance, Ordination - Principal Component Analysis, factor analysis, correspondence analysis, Non-metric multidimensional scaling.

Classification - Cluster analysis, Discriminant analysis, Multivariate multiple regression - Redundancy analysis, Mantel's test.

Time series analysis. Components of time series, moving averages, stationary time series, autoregressive moving average (ARMA) processes, time series modeling and forecasting, Monitoring, modeling and forecasting change: statistical monitoring methods for environmental systems, change-point analysis, statistical methods for non-stationarity.

Introduction to spatial statistics - autocorrelation, kriging, geostatistics, point pattern analysis, spatial modeling and interpolation

Course Learning outcomes

1. Summarize different regression methods and its application
2. Discuss how to handle analysis of variance and categorical data
3. Analyze multivariate data and ordination techniques
4. Summarize classification and multivariate multiple regression techniques
5. Apply time series analysis and spatial techniques

Text Books

1. Aaron M. Ellison and Nicholas Gotelli. (2012). *A Primer of Ecological Statistics* (2nd Ed.). Oxford University Press.
2. Rosner, B. (2015). *Fundamentals of biostatistics* (8th Ed.). Brooks/Cole
3. *Data Analysis in Community and Landscape Ecology*, C. J. F. ter Braak, O. F. R. van Tongeren, and R. H. Jongman
4. Gotelli, N.J. and A.M. Ellison. 2004. A Primer of Ecological Statistics. Sinauer Assoc. Inc., Sunderland, MA, USA
5. The Theoretician's Toolbox: Quantitative Methods for Ecology and Evolutionary Biology by Marc Mangel, Cambridge University Press 2006
6. Noel A. Cressie , *Statistics for Spatial Data*, John Wiley & Sons, Inc., 1993.

M3321050 Ecological Informatics-2 (2 Credits)

Prerequisite: M2321047 Ecological Informatics 1

Course Description

This course is intended for learning how to analyze, visualize and model environmental and ecological data and implement machine learning techniques using Python.

Course Objectives

Prepare the students for more advanced programming courses as well as a self-contained course for those who want to use Python for their studies or professional work.

Course Content

Introduction to Data analytics : Definition, Importance, Data sources, Characteristics, Data analytics applications. Introduction to Ecological Data Analytics (EDA) : Methods and application, Life cycle, Python packages and Libraries for EDA.

Importing data, Introduction to data preprocessing, handling missing values, handling outliers, encoding, Scaling, Normalization & Feature reduction, Merging, Joining & Concatenating dataframes. Exploratory data analysis

Data Visualization and interpretation : Introduction to data visualization, Python packages for data visualization, Introduction to Matplotlib, Basic Plotting with Matplotlib, Line plots, Area plots, Histograms and Bar chart; Advance visualization tools- Introduction Seaborn and Regression Plots

Machine Learning fundamentals: Overview, Role of machine learning in ecological research, Types of machine learning: supervised, unsupervised, reinforcement learning, Choosing the right machine learning approach for ecological problems, validation techniques, Applications, Feature reduction

Modeling: Supervised learning: Logistic regression, KNN, Confusion matrix, SVM, Decision trees and Random Forest, Unsupervised learning: K Mean Clustering, Random initialization trap and Elbow Method, Hierarchical Clustering, Principal Component Analysis (PCA).

Course Learning Outcomes

1. Discuss the basic concepts of data analytics in the context of ecological data using Python
2. Identify the processes involved in data preprocessing

3. Demonstrate data visualization techniques using python and relate the fundamentals of machine learning
4. Illustrate data modelling using Python

Text Books

1. Python Programming: A Modern Approach, Vamsi Kurama, Pearson, 2018.
2. Learning Python, Mark Lutz, O'reilly, 2008.
3. Think Python, Allen Downey, Green Tea Press, 2009
4. Core Python Programming, W.Chun, Pearson, 2012.
5. Introduction to Python, Kenneth A. Lambert, Cengage
6. Core Python Programming, Rao N. R., Prentice Hall, 2012.
7. Introduction to Computing and Problem Solving using Python, E Balagurusamy, Khanna Book Publishing, 2019
8. Machine Learning using Python, Wei-Meng Lee, Wiley, 2019.
9. Data Analysis in Community and Landscape Ecology, Book by C. J. F. ter Braak, O. F. R. van Tongeren, and R. H. Jongman
10. Python Data Analytics: With Pandas, NumPy, and Matplotli, Fabio Nelli, Apress 2018

M3321051 Bioinspired Design (3 Credits)

Course Description

This course will create awareness regarding nature-inspired solutions to daily life problems from a technical perspective. It will enable appreciation of the beauty and sophistication of life by investigating the biological mechanisms and functions of organisms as well as the dynamics of whole ecosystems. By incorporating some basics of design procedures, biomechanics, and physics of living systems and utilizing computational designing tools to solve sustainability challenges, this course focuses on integrating inspirations from nature to human life and designing sustainable, eco-friendly, innovative products, processes or services.

Course Objectives

1. Discover the values of biomimicry as a connection between human and nature and interpret the basic steps involved in bioinspired designing
2. Develop an interest in bio-inspired solutions, and understand the basics of strength and stability towards bioinspired designing
3. Utilize computer-aided drafting tools such as AutoCAD for design visualization
4. Associate computer-aided design and computation methods like finite element analysis (FEA) using software such as ANSYS for design and analysis.

Course Content

Introduction to Bioinspired Design (BiD): Nature's unique strategies, Theory and methods behind bioinspired design, types, origin, significance, scope and growth, subsets of BiD, Philosophy of biomimicry, Basic principles of biomimicry, challenges and limitations, bioinspired materials and structures, Iconic and Emerging case studies in different fields.

Fundamentals of design engineering: Concept of Designing, design constraints and functions, brainstorming, stages, Visual thinking and Tools: Mind maps, concept maps, affinity maps, Morphological matrix, Design thinking and idea generation, Analogies, modelling, material selection, tolerance, Prototypes, design standards.

Bioinspired designing: Approaches towards bioinspired designing: Biology to Technology, Applications to Biology, Incorporating biomimetics: Characteristics, design stages and processes, methods, biomimetic design methods and tools: Retrieval, abstraction and transfer methods, Technical Lens approach and Patterns Approach; Function-Based Biologically Inspired Design, TRIZ tool, Intelligent Biologically

Inspired Designing, State of the Art, Integrations between Biology, Design and Innovation, Biomimicry towards sustainability and innovations: green engineering; Biophilic design: Benefits, Biophilic Plans and Codes, Biophilic Architecture and Design, Restoring and Reintroducing Nature into the City

Biomechanics for Bioinspired Designing: basic concepts of statics and dynamics, basic concepts of solid mechanics, Force system, Principle of moments, Resultant, Centre of gravity and centroid, Mechanical vibrations, Equilibrium of deformed bodies;

Materials of the Living: stress and deformation, nature of biological materials, rigidity and stability, tension and compression, bending and twisting, Principal stress, Moment, Shear and Torsion, elastic and plastic behaviour, stiffness failure, durability, fatigue; Pressure, force and displacement measurement;

Shapes of the Living: surface forces and volume forces, capillarity, growing trees and water-walkers, Curved Surfaces and Minimal Surfaces, Surfaces of Revolution, Seashells and Gastropods, Phyllotaxis, Scaling laws.

Computer-aided design and drafting: definition and significance of computer-aided drafting and designing, steps in CADD, drafting tools, concepts of parametric and generative designing, Drafting using AutoCAD. Basic concepts of Finite Element Analysis and its application, how it works, merits and limitations; Formulation of finite element equations, Different finite elements and shape functions, Concepts of Discretization and meshing, Assembly and solutions, concepts of Modal analysis, linear, nonlinear analysis; Structure of FEA software package. Introduction to ANSYS software package, Analysis using ANSYS.

Course Learning Outcome

1. Identify the values of biomimicry as a connection between human and nature
2. Use design engineering to illustrate bioinspired designing
3. Use the concepts of biomechanics, physics of living systems and strength of materials for bioinspired designing
4. Demonstrate design and analysis using Computer aided drafting and designing (CADD) tools

Text Books

1. Biomimetic Design Method for Innovation and Sustainability, Cohen Y. H., Reich Y., Springer, ISBN 978-3-319-33996-2
2. The Philosophy of Biomimicry, Dicks H., Philos. Technol. (2016) 29:223–243
3. Biologically Inspired Design: Computational Methods and Tools, Goel A. K., McAdams D. A., Stone R. B., Springer, ISBN: 978-1-4471-5247-7

4. Biomimicry: Innovation Inspired by nature; Benyus J. M., Collins H., William Morrow Paperbacks, ISBN-10: 9780060533229/ ISBN-13: 978-0060533229
5. Biomimetics: Nature-Based Innovation, Yoseph Bar-Cohen, CRC Press, 2016, ISBN 9781439834763
6. Maria G. Trotta, Bio-inspired Design Methodology, International Journal of Information Science 1(1), pp 1-11 (2011).
7. Biologically Inspired Design: Methods and Validation, C.A.M. Versos,Denis A. Coelho, Industrial Design - New Frontiers
8. Handbook of Biophilic City Planning and Design', Beatley T., Island Press, 2016.
9. Serene Urbanism A biophilic theory and practice of sustainable placemaking', Tabb P. J., Routledge, Taylor & Francis, 2017.
10. Ecology and Biomechanics: A mechanical approach to ecology of animals and plants; Herrel A., Speck T., Rowe N. P., Tayor and Francis, 2006
11. The Nature of Investing: Resilient Investment Strategies through Biomimicry; Collins K., Bibliomotion, 2014
12. Introduction to the finite element method; Nikishkov G. P., University of Aizu, 2004
13. Fundamental Principles for CAD-based Ecological Assessments; Leibrecht S., Centre for Design at RMIT University, Melbourne, Australia
14. Principles of Measurement Systems; Bentley J. P., Pearson Education, 2005
15. Plant Biomechanics: An Engineering Approach to Plant Form and Function.', K. J. Niklas, University of Chicago Press, 1984.
16. The Physics of Living Systems', Cleri F., Springer, 2016
17. Finite Element Procedures; Bathe K. -J., PHI Learning, 2012

M3321052 Conservation and Sustainable Development (2 Credits)

Course Description:

This course delves into the intricate realm of natural resource management, providing a multidimensional perspective on the utilization and conservation of Earth's invaluable resources for sustainable development. The course traverses a journey from the fundamental concepts of resources to contemporary challenges and strategies for their conservation.

Course Objectives

1. Instill awareness of natural resource conservation and management significance
2. Enhance Understanding of Environmental Sustainability and Resilience
3. Familiarize with Diverse Approaches, Technologies, and Policies for Sustainable Development

Course Content

Concept of resource, different types of natural resources: classification and interrelationship, resource availability, distribution, Water, land, Biodiversity, Forest, etc. Energy Resources: Non-conventional and conventional forms of energy.

Drivers, pressures, and natural resource use trends, Resource economics, Direct and indirect benefits from various resources, Natural Resource Market, NRM sectors product marketing and their roles, promoting NRM products- NTFPs, livestock, watershed, fisheries, agriculture, and medicinal plants and ecotourism resource exploitation, population growth, carrying capacity, socio-economic factors, Resource conflicts: Resource extraction, access, and control system.

Conservation challenges, depletion of natural resources, threats to biodiversity, species extinction, habitat loss, habitat loss and fragmentation, the impact of climate change, conservation values and ethics: ecological, social, and economic considerations, Conservation approaches to species, ecosystem, and landscape-level approaches, in-situ and ex-situ methods, biodiversity hotspots, and megadiversity countries, protected areas, ecological engineering for conservation, models for conservation: landscape model, habitat reconstruction, integration of conservation science and policy, future of conservation, case studies, conservation psychology: conservation and human society, legal foundations of conservation.

Ecological, social, and economic dimensions of resource management, approaches in Resource Management: Ecological approach; economic approach; ethnological approach, integrated resource management strategies. Resource Management Paradigms: Management of Common International

Resources, Integrated approach for resource protection and management, sustainable consumption and production, circular economy

Sustainable Development and Natural Resource Management: History and emergence of the concept of Sustainable Development, Social environmental and economic perspective of sustainability, climate change resilience, carbon sequestration, carbon credit, carbon footprint, carbon neutral, Trade, and environment, Life cycle assessment, Environment-friendly technologies, Sustainable engineering, Energy conservation, energy efficiency, Multilateral environmental agreements and protocols, Sustainable development goals, Measurement of sustainable development: Sustainable development indicators, sustainable methods and traditional concepts towards sustainable engineering; Clean development mechanism, Zero waste concept, Green habitat and green materials, Regenerative designing, Nexus between Technology and Sustainable development, 3P concept, Green Economy, Sustainability reporting.

Course Learning outcome

1. Explain the interrelationships between different types of resources and their availability and distribution.
2. Summarize the drivers and pressures affecting natural resource use trends, including population growth and socio-economic factors.
3. Analyze the ecological, social, and economic considerations of conservation values and ethics.
4. Apply circular economy concepts to suggest sustainable consumption and production strategies.
5. Analyze the nexus between technology and sustainable development and evaluate the concept of ESG (Environmental, Social, Governance).

Text Books

1. Fundamentals of Materials for Energy and Environmental Sustainability, D S Ginley, David Kahen, Cambridge University Press, 2012
2. Design for Environmental Sustainability, Carlo Vezzoli, Ezio Manzini, Springer, 2008
3. Renewabe Energy Resources and Emerging Technologies, D P Kothari, K C Singhal, Ranjan R., Prentice Hall of India, New Delhi
4. Climate Change and Sustainable Development: Prospects for Developing Countries, Anil Markandya, 2002, Routledge.
5. Basic concepts in Environmental Management, Mackenthun KM, 1998, Lewis Publications, London
6. Ecological Engineering design Restoring and conserving ecosystem services; Marty D. Matlock, Robert A. Morgan, Wiley, 2011, ISBN: 978-0-470-94999-3

7. Applications in Ecological Engineering, Jørgensen S. E., Academic Press, Elsevier, 2009, ISBN: 0123813689, 9780123813688
8. The Routledge Handbook of Sustainable Cities and Landscapes in the Pacific Rim, Yizhao Yang, Anne Taufen, ISBN 9780367471149, Taylor and Francis, 2022
9. Sustainable Natural Resource Management: For Scientists and Engineers, D. R. Lynch, Cambridge University Press, 2009.
10. An Introduction to Sustainable Development. Publisher: Routledge; P. Rogers, K. F. Jalal, J. A. Boyd, 1 edition, ISBN-10:1844075206, 2007.

M3321016 Research Methodology and Scientific Writing (2 Credits)

Course Description

This course is designed to equip students with the essential skills and knowledge to conduct rigorous research and effectively communicate their findings through scholarly writing. It offers a methodical and practical approach to achieving academic and professional excellence.

Course Objectives

1. Introduce the fundamentals of research methodology
2. Understand the research process and discuss the tools and techniques for conducting research
3. Emphasize the ethical considerations in research
4. Hone scientific writing abilities, including crafting research proposals, reports, and academic papers

Course Content

Introduction to research and research methodology, meaning of research, objectives of research, motivations in research, scientific thinking, essence of scientific inference, scientific methods, pseudo-science and non-science, research problem, situation gap analysis, types of research, criteria of good research, defining and delimiting research problem, validity and reliability, legal and ethical issues, time management.

Types of ecological research, ecological problems and approaches, research questions and hypothesis, aims and objectives, variables and their linkages, characteristics of a good hypothesis. formulation of hypotheses-directional and non-directional hypotheses

Concept of measurement, levels of measurement, primary and secondary data, data collection and methods: observation method, experimental method, Sampling strategies: Invasive and non-invasive methods

Research design: field observation and experiments, experimental design, statistical considerations in research design, biases, trade-offs in ecological experimentation, Completely Randomized Design (CRD), Randomized Complete Block (RCB) Design, Latin Square (LS) Factorial Experiments, Randomization, Replication and pseudoreplication, research proposal.

Data Analysis: Fundamental logic of parametric and non-parametric data, Statistical tests and its applicability, hypothesis testing, data Preparation – univariate analysis (frequency tables, bar charts, pie charts, percentages), bivariate analysis – cross tabulations and Chi-square test including testing hypothesis of association, multivariate statistics, statistical inference.

Scientific Writing: Research communication, types of communications Scientific writing as a means of communication, different forms of scientific writing, writing process: formulation of outlines, reviewing literature, paragraphs and organizational strategies, drafting, reflecting, re reading, grammar and punctuations, tricks for clarity, brevity, and finesse, illustrations, style and formatting, citations and bibliography, Ethical issues related to publishing, plagiarism. tools / techniques for Research: methods, Reference Management Software like Zotero/Mendeley, Software for paper formatting like LaTeX/MS Office, Software for detection of Plagiarism, online repositories, publication of scientific article

Course Learning outcomes

1. Understand the research process and ethical considerations
2. Demonstrate the ability to choose appropriate research methodologies, data collection techniques, and sampling strategies
3. Develop skills in data analysis and interpretation
4. Demonstrate scientific writing skills

Text Books

1. C R Kothari, Research Methodology: Methods and Techniques, New Age International (P) Limited Publishers
2. Sameer Phanse, Research Methodology- Logic, Methods and Cases, Oxford University Press, 2016.
3. Gotelli, N.J. and A.M. Ellison, A Primer of Ecological Statistics, Sinauer Assoc. Inc., 2004
4. C. Philip Wheater, James R. Bell, Penny A, Cook Practical Field Ecology: A Project Guide, 2nd Edition, Wiley, 2020.
5. E. David Ford, Scientific Method for Ecological Research, Cambridge University Press, 2010
6. C. J. F. ter Braak, O. F. R. van Tongeren, and R. H. Jongman, Data Analysis in Community and Landscape Ecology, Cambridge University Press, 2009.
7. Heard S. B., Princeton, The Scientist's Guide to Writing: How to Write More Easily and Effectively throughout your Scientific Career, University Press, 2016

SEMESTER 3 | Course Structure

SNo	Course Code	Course Name	Type	Level	Credit			
					L	T	P	Total
1	M3321039	Ecological Modelling	P. Elective	300	2	0	1	3
2	M3321024	Global Change Ecology	P. Elective	300	1	0	1	2
3	M3321041	Ecological Engineering	P. Elective	300	1	1	1	3
4	M3321044	Ecology and Society	O. Elective	300	2	0	1	3
5	M3321027	Environment Impact Assessment	O. Elective	300	1	0	1	2
6	M3321028	Environmental Social Governance	O. Elective	300	1	1	0	2
7	M3321029	Environmental Legislation and Policy	O. Elective	300	2	0	0	2
8	M4321054	Advanced Topics in Ecology	P. Elective	400	1	0	1	2
9	M3321055	Forest Ecology	P. Elective	300	1	0	1	2
10	M3321056	Urban Ecology	P. Elective	300	1	0	1	2
11	M4321025	Seminar /Meta-Analysis	Additional	400	-	-	-	2
	Total Credits							**25**

M3321039 Ecological Modelling (3 Credits)

Course Description

This course intends to expose the students to an application level of data analytics and modelling in the context of ecology

Course Objectives

1. To identify the key terms of ecological data and utilize various modelling techniques for data analysis
2. To understand and interpret various ecological modelling techniques

Course Content

Basic concept of ecological modeling; types of ecological modeling - deterministic, stochastic, theoretical model, simulation model, dynamic model, structural dynamic model and static model; theoretical modeling - analytical solutions of the theoretical model, concepts of equilibrium point, limit cycle, period doubling, chaos, persistence, Hopf bifurcation and different aspects of stability of the system such as local stability, global stability and asymptotic stability; example case study of theoretical model.

Dynamic simulation modeling - elements of dynamic modeling (state variables, control variables, forcing functions, rate parameters, model constant); procedure of dynamic modeling (conceptualization of the system, transform of a conceptual model to the mathematical model, sensitivity analysis and calibration, validation and verification), case study of dynamic simulation modeling.

Structural dynamic modeling - Basic concept of structural dynamic modeling and its difference from dynamic modeling, methodology of structural dynamic modeling, optimization of structural dynamic modeling; ecological goal functions - eXergy, eMergy and Ascendency; case study of structural dynamic modeling; complexity and self-organization of the ecological system; cybernetics in ecology

Static modeling - history of static modeling from Leontief input-output analysis to Ecological Network Analysis (ENA); basic structure of ecological network; transformation of ecological food web to matrix (flow matrix, input, output and respiratory vectors); total system throughflow (TST), development capacity, ascendency, redundancy, dependency and contribution coefficients, robustness of the ecological system on the basis of performance and resilience and determination of ecosystem health; keystoneness; some case studies

Course Learning outcome

1. Identify the different types of ecological modelling and their applications.

2. Demonstrate static and dynamic ecological modelling and their simulations.

Text Books

1. Networks, Mark Newman, Oxford, 2nd Edn, New York, 2018
2. Jørgensen & Fath, Fundamentals of Ecological Modelling (2011)
3. Haefner, Modeling Biological Systems: Principles and Applications (2005)
4. http://wgbis.ces.iisc.ac.in/energy/HC270799/em.html
5. https://ocw.mit.edu/courses/earth-atmospheric-and-planetary-sciences/12-086-modeling-environmental-complexity-fall-2014/syllabus/
6. C.Berge: Graphs and Hypergraphs, North Holland/Elsevier, (1973)
7. F.Harary: Graph Theory, Narosa, (1988)
8. J.A.Bondy and U.S.R.Murty: Graph Theory,Springer, 2008.
9. R.Diestel: Graph Theory,Springer(low price edition) 2000.

M3321024 Global Change Ecology (2 Credits)

Course Description

Even while concerns about global warming are growing, the quickly developing discipline of global change ecology is only now starting to address how species and ecosystems may react. This course will cover the key causes, mechanisms, and effects of major types of global changes on ecosystem structure and functions, focusing on the physical science perspectives on global environmental change. The course will emphasize how combining ecology, physiology, behaviour, and evolution helps us understand previous reactions and predict future ones at various scales (from cell to the globe).

Course Objectives

1. To develop a thorough grasp of the processes by which communities, ecosystems, and living things are adapting to climate change
2. To connect closely with the main literature and choose subjects at the cutting edge of global change study
3. To develop communication skills for science and familiarise oneself with techniques and instruments for forecasting future reactions to climatic change.

Course Content

Introduction and overview of global change ecology, earth climate system, greenhouse gases, and greenhouse gas effect, resources and the global commons, Human population, energy, patterns of consumption & emissions, global carbon cycle, Global ecology of CH_4 and N_2O, Our future climate: global and regional predictions

Plants- Plant physiology and global change, Ecosystem biogeochemistry, GC manipulation experiments, Carbon auction.

Animals - Thermal tolerance and stress, Temperate versus tropical impacts, Range shifts and models, Evolutionary responses.

Species interaction and communities - Phenological change, Community change, Case study

Climate, environmental drivers and aquatic ecosystems, Responses of an aquatic ecosystem to climate change - Streams and rivers, lakes, freshwater wetlands, coastal ecosystems, Impact of global warming on aquatic life Marine Impacts and Acidification, Coral bleaching and disease, Freshwater impacts, Terrestrial water cycle and global change, Climate change and wetland/water resources,

Climate change impacts on plants and animals, Climate change impact on biodiversity and communities, Impacts of climate change on ecosystem and resources - Diversity, extinction, species ranges, fragmentation, impacts on forest ecosystems and the forestry sector, Impacts on grasslands and tundra, Ellen Wohl: Climate change and water resources, Resilience of ecosystems to change, Case study: subsistence societies.

Global change phenomenon, Biological invasions, coral reef biology, nitrogen, and ozone pollution, nitrogen deposition and invasive species, climate change mitigation and adaptation - Rich Conant: Carbon sequestration in soils, Mitigation: biofuels, Mitigation: forestry & agriculture, Ecosystem/biodiversity management under globe change, climate change politics and negotiations, Bioclimate modeling: Maxent.

Course Learning outcome

1. Infer the mechanisms by which plants, animals, communities, and ecosystems are responding to global change.
2. Interpret and critically analyze information about the causes and biological consequences of major global change due to human activities.
3. Use mitigation measures and modelling to deal with global changes.

Text Books

1. Poff, N.L., Brinson, M.M. and Day, J.W., 2002. Aquatic ecosystems and global climate change. Pew Center on Global Climate Change, Arlington, VA, 44, pp.1-36.
2. Houghton, R.A., 2005. Tropical deforestation is a source of greenhouse gas emissions. Tropical deforestation and climate change, 13.
3. Schimel, J., 2001. Biogeochemical models: implicit versus explicit microbiology. In Global biogeochemical cycles in the climate system (pp. 177-183). Academic Press.
4. Sexton, J.P., McIntyre, P.J., Angert, A.L. and Rice, K.J., 2009. Evolution and ecology of species range limits. Annual Review of Ecology, Evolution and Systematics, 40(1), pp.415-436.
5. Cleland, E.E., Chuine, I., Menzel, A., Mooney, H.A. and Schwartz, M.D., 2007. Shifting plant phenology in response to global change. Trends in ecology & evolution, 22(7), pp.357-365.
6. Visser, M.E. and Both, C., 2005. Shifts in phenology due to global climate change: the need for a yardstick. Proceedings of the Royal Society B: Biological Sciences, 272(1581), pp.2561-2569.
7. Bruno, J.F. and Selig, E.R., 2007. Regional decline of coral cover in the Indo-Pacific: timing, extent, and subregional comparisons. PLoS one, 2(8), p.e711.

M4321025 Seminar /Meta-Analysis (2 Credits)

Course Description

This course aims to teach how to do quantitative meta-analyses using statistical methods. This course aims to teach students how to calculate different effect sizes and use them to conduct meta-analyses. It includes pooling effect size estimates, estimating and interpreting results from meta-regression models, describing and discussing quantitative meta-analytic methods and associated results, handling various methodological dilemmas encountered when conducting a quantitative meta-analysis, and understanding the statistics used broadly in meta-analytic scenarios.

Course Objectives

1. Familiarize the concept of meta-analysis and research synthesis
2. Gain knowledge of the research gaps, loops, coding, categorizing, and organizing study data for meta-analysis;
3. Learn basic techniques for meta-analysis and examine how meta-analysis aids research and strategic decision-making.

Course Content

Introduction to meta-analysis, Research design, Finding relevant databases, Developing search protocols and methods, Data analysis, Meta-analysis software, and Presentation of findings.

Literature review, problem Identification, dataset development, coding scheme, overall analysis and results, moderator analysis and results, Research synthesis, report and presentation

Course Learning outcome

1. Discuss meta-analysis for research and utilize the knowledge gained with relevant databases for research and interpretations.
2. Interpret various analysis methods and tools for assessing, critically appraising, sorting, and presenting the primary studies from database searches.
3. Develop an original problem statement and use the problem statement to complete and submit a meta-analysis.

Text Books

1. Borenstein, M., Hedges. L. V., Higgins, J. P. T. and Rothstein, H. R. (2009). Introduction to meta-analysis. John Wiley & Sons, Chichester

2. Lipsey M. W. & Wilson D. B. (2001). Practical meta-analysis. Thousand Oaks, CA: Sage Publications, Inc
3. Hedges, L. V., & Olkin, I. (1985). Statistical methods for meta-analysis. Academic Press, San Diego, CA

M3321041 Ecological Engineering (3 Credits)

Course Description

This course focuses on conveying the basic principles behind ecological engineering and ecosystem restoration methods.

Course Objectives

1. Utilize ecological understanding in the context of ecological engineering
2. Understand ecological engineering principles and develop technical skills for practicing ecological engineering and restoration methods.
3. Identify and combine information from different disciplines to develop effective conservation plans.

Course Content

Ecological engineering: definition, classification, scope, significance, design principles; self-designing and self-organization of ecosystems, complexity, and diversity, ecological resilience, energy signature approach, fundamentals of ecological modeling, human population growth, and impacts, sustainable ecosystems, system ecology approach, ecosystem functions and services, ecosystem thermodynamics.

Environmental fluid mechanics: fundamentals, viscous flow, laminar and turbulent flow, boundary layer, stratification, open channel flow; Dispersion of pollutants: dispersion in rivers and groundwater, gaussian plumes in the air, basics of fluid dynamics, hydraulics of surface water flow, environmental transport process, environmental hydrology, ecohydraulics, interaction between aquatic and terrestrial systems, processes at atmospheric and water interfaces; water cycle management and watershed management, environmental modelling and simulation, Basics of Computational Fluid Dynamics (CFD). CFD analysis using softwares.

Pollution abatement: air, water, soil, noise; Problem-solving in nonpoint source pollution, methods for evaluating the extent, rate, timing, and fate of non-point source (NPS) pollutants. Wastewater treatment and management, waste water quality analysis, design of wastewater treatment system, Solid waste management, Air pollution management, Noise pollution management.

Disturbance and degradation of ecosystems, recovery and restoration: goals of restoration ecology, Ecosystem services, ecosystem restoration, and reclamation, types of restoration design, regional processes, environmental and habitat impacts; restoration of streams and rivers, lakes, wetlands, and coastal ecosystems, terrestrial ecosystems, Ecosystem/nature-based adaptations and solutions, constructed ecosystem; Bioremediation, Soil, Remediation of Surface Waters; Resilience and stability of ecological systems, Climate change scenarios and Vulnerability; Hazard vulnerability analysis, Disaster management, disaster risk reduction, case studies; Ecosystem-based adaptation, ecosystem-based disaster reduction, climate resilience, ecological engineering for natural resource management: biodiversity conservation, landscape, and vegetation, forest management, habitat reconstruction, case studies.

Course Learning outcome

1. Infer ecological principles to derive engineering solutions
2. Discuss the concepts of environmental fluid dynamics and hydraulics for pollution abatement and management.
3. Understand ecosystem disturbance and apply ecological restoration techniques for different ecosystems.
4. Utilize ecosystem-based adaptation methods for climate change resilience and disaster risk reduction.

Text Books

1. Environmental Hydrology, V. P. Singh, Springer Science+Business Media Dordrecht, ISBN 978-90-481-4573-7, 1995
2. Environmental Fluid Mechanics, Hillel Rubin and Joseph Atkinson, MARCEL DEKKER, INC, New York, ISBN: 0-8247-8781-1, 2001
3. Fluid Mechanics of Environmental Interfaces, Second Edition, Carlo Gualtieri Dragutin T. Mihailovic, Taylor & Francis Group, 2012
4. Mitsch, W.J. and S.E. Jorgenson. 2004. Ecological Engineering and Ecosystem Restoration. John Wiley and Sons, Hoboken, New Jersey, 411pp. ISBN: 978-0471332640
5. Hobbs, Richard J. Foundations of restoration ecology. Island Press, 2013.
6. Palmer, Margaret A., Joy B. Zedler, and Donald A. Falk. Ecological theory and restoration ecology"; Foundations of restoration ecology. Island Press, Washington, DC, 2016. 3-26.
7. Groom, M. J., Meffe, G. R. and C. R. Carroll. 2006. Principles of conservation biology. Sinauer associates, Inc., USA
8. Primack, R. 2006. Essentials of Conservation Biology.Sinauer associates, Inc., USA
9. Hambler, C. 2004. Conservation. Cambridge University Press.
10. Van Dyke, F.2008.Conservation Biology Foundations, Concepts, Applications 2nd Edition, Springer.

11. https://www.sciencedirect.com/book/9780123736314/models-for-planning-wildlife-conservation-in-large-landscapes
12. Wastewater Engineering: Treatment and Resource Recovery, Metcalf and Eddy, fifth edition, McGraw-Hill
13. Basic concepts in Environmental Management, Mackenthun KM, 1998, Lewis Publications, London
14. Ecological Engineering design Restoring and conserving ecosystem services; Marty D. Matlock, Robert A. Morgan, Wiley, 2011, ISBN: 978-0-470-94999-3
15. Applications in Ecological Engineering, Jørgensen S. E., Academic Press, Elsevier, 2009, ISBN: 0123813689, 9780123813688
16. The Routledge Handbook of Sustainable Cities and Landscapes in the Pacific Rim, Yizhao Yang, Anne Taufen, ISBN 9780367471149, Taylor and Francis, 2022

M4321054 Advanced Topics in Ecology (2 credits)

Course Description:

The course covers advanced topics in (but not limited to) Ecology and evolution. It utilizes critical readings (focusing on literature) and discussion of recent trends in ecological research across scales from genes to ecosystems. Probable topics are covered in (but not limited to) the course content and will be discussed explicitly.

Course Objectives

1. Critically read and discuss classical/contemporary hot topics in ecology and evolutionary studies of interest.
2. Develop an appreciation of how classical ecological and evolutionary studies have influenced current thinking in ecology and evolutionary research.
3. Develop the skills for digging literature from databases and writing a quality review on ecological or evolutionary topics of interest needing synthesis.
4. Improve presentation/communication skills by discussing ideas in peer/scientific communities.

Course Content

Ecological Heterogeneity, Trait-based approaches for ecological predictions, Ecological impacts of climate change, Interdisciplinary Approaches-Acoustics ecology, Colour Science, Beyond ecology: Science & Society

Course Learning Outcome

1. Discuss in-depth aspects of current ecology and evolutionary studies.
2. Identify potential topics needing synthesis/meta-analysis in recent ecology and evolution research.
3. Conduct a thorough literature search, synthesize the information, and write a publication-quality report/manuscript on a hot topic of interest.
4. Communicate concepts/ideas in ecological and evolutionary studies of interest to peers/experts with clarity and defend their views, concepts, methods, interpretations, and inferences made in the syntheses.

M3321044 Ecology and Society (3 Credits)

Course Description

The course deals with understanding the interrelation between social and ecological systems. By introducing the concepts of sociology, demography, anthropology, human ecology and ecological economics, the course focuses on creating awareness on the impacts of society onto the environment. The aim is to create an understanding and appreciation of the interrelation between social and ecological systems.

Course Objectives

1. Understand the Population dynamics and need of changes in social systems as an adaptive response
2. Ability to understand various sociological approaches in studying the society and environment interaction
3. Learn the dynamic relationships between human cultures and their ecological environments
4. Develop an interdisciplinary approach to environmental issues and to integrate this approach with their own perspective on the environment

Course Content

Indian population, structure and growth. Components of population growth: Births, Deaths and Migration. Fertility-Mortality Relationship, Overview of demographic theories and demographic methods. India's National Population Policy.

Social dimensions of development. Notion of Social Problem. Social Identity. Poverty and Slums. Poverty and Deprivation, Social Stratification, social differentiation and social classes. Social Change Social structure and social movements. Environmental sociology.

Social-cultural anthropology. Concepts of Kinship, Marriage, Culture, Patterns of Subsistence. Grouping by Gender, Age, Class and Common Interests. Concepts of developmental anthropological perspective and participatory development, Culture Ecology and Sustainable development.

Differential interests and their impact on ecology and environment. Issues of Displacement and rehabilitation its impact on biodiversity, natural resources, environment, economy and society. Idea of social relations and 'who benefits and who loses' by environmental degradation

An overview of Ecological Economics. Notion of Natural Resource and Natural Capital, Environmental Ethics, Critical Perspectives on 'environment and development'. Environmental governance: approaches of society to problems of decision making

Course Learning Outcome

1. Discuss the basics of demography in the context of ecology
2. Explain various sociological approaches in studying the society and environment interaction and relate how they contributes towards sustainable development
3. Interpret the impacts of social, cultural and economic factors on environment through the notions of human ecology and ecological economics

Text Books

1. Bougue, Donald J. (1969). Principles of demography. John Wiley and Sons.
2. Bhende, Asha A and Tara Kanitkar. (2019). Principles of population studies (19th ed.). Himalaya Publishing House.
3. Misra.B.D.(1981). An Introduction to the study of population. New Delhi: South Asian publishers. (p) Ltd.
4. United Nations: Determinants and consequences of Population trends, New York, United Nations
5. Shryock H S et al. (1976). The Methods and Materials of Demography. (Condensed ed ed.). Academic Press Inc.
6. Ramakumar R. (2018). Technical Demography (2nd Ed.). New Age International.
7. Schomleo F. (1966). The Urban Scene – Human Ecology and Demography. The Free Press, New York.
8. Nadel, S. F. (2013). The foundations of social anthropology (1st ed.). Routledge.
9. Metcalf, Peter. (2005). Anthropology: the basics (1st Ed.). Routledge.
10. Patnaik SM. (1966). Displacement, Rehabilitation & Social Change (1st Ed.). Inter India Publications.
11. Singh, Yogender. (2009). Social Change and Stratification (2Rev Ed ed.). Manohar Publishers and Distributors.
12. Ember, Ember and Peregrine. (2020). Anthropology (15th Ed.). Pearson Education.
13. Sengupta, B., Ramprasad, T.V. and Sinha, A.K. (2003). Challenges of Sustainable Development: The Indian Dynamics.
14. Narasaiah Lakshmi, M. (2006). Population and Biodiversity. New Delhi: Discovery Publishers.
15. Daly, H, and J. Farley. (2010). Ecological Economics: Principles and Applications (2nd Ed.). Island Press (available online through the Cline Library website).
16. Common, M. and S. Stagl. (2005). Ecological Economics: An Introduction. (Illustrated ed.). Cambridge University Press.

17. Costanza, R. (ed). (1992). Ecological Economics: The Science and Management of Sustainability. Columbia University Press.
18. Sengupta, Ramaprasad. (2002). Ecology and Economics. New Delhi: Oxford University Press.
19. Chopra, K., K.G. Kadekodi, and M.N. Murthy. (1989). Participatory Development: People and Common Property Resource (1st Ed.). Sage Publications.

M3321027 Environment Impact Assessment (2 Credits)

Course Description:

The course intends to make the students understand the basic steps involved in Environmental Impact Assessment for environmental management and sustainability

Course Objectives

1. To carry out scoping and screening of developmental projects for environmental impact assessment
2. To carry out baseline environmental surveys
3. To assessing and predicting environmental impacts using different methodologies
4. To develop environmental management plans
5. To review and evaluate environmental impact assessment reports

Course Content

Concepts of Environmental Impact Assessment, emergence, and history of EIA, definition, and types of EIA, Environmental Impact Assessment and Environmental Impact Statement; EIA in the project cycle, EIA Notification, and legal framework.

Screening and Scoping in EIA – Drafting of Terms of Reference, Baseline monitoring: air; water; noise; land and soil, Baseline monitoring of Socio-economic environment – Identification of Project Affected Personal – Rehabilitation and Resettlement Plan- Economic valuation of Environmental impacts – Cost-benefit Analysis

Prediction and Assessment of Impact on land, water, air, noise, flora, and fauna - Matrices – Networks – Checklist Methods - Mathematical models for Impact prediction. Evaluation techniques, Environmental risk analysis, risk assessment, and risk management

Plan for mitigation of adverse impact on water, air, and land, water, energy, flora, and fauna – Environmental Management Plan, Analysis of Alternatives, Public Hearing, Project Benefits; Environmental Cost-Benefit Analysis, Environmental auditing

EIA report preparation, EIA notification September 2006, 2020 and amendments: Categorization of projects, Procedure for getting environmental clearance. Public participation in the environmental decision-making process. Case studies on EIA for Industries and Infrastructure projects

Course Learning outcome

1. Discuss the concepts of Environmental Impact Assessment and carry out baseline environmental surveys to demonstrate scoping and screening of developmental projects for EIA
2. Interpret, assess and predict environmental impacts using different methodologies
3. Employ environmental management planning for mitigation of adverse impact on environment
4. Prepare and review environmental impact assessment reports

Text Books

1. Environmental Impact Assessment – by Larry Canter; McGraw Hill publications
2. Marriott B., "Environmental Impact Assessment: A Practical Guide",McGraw-Hill Publication,1997
3. Anjaneyulu Y., Manickam Valli, "Environmental Impact Assessment Methodologies", CRC Press 2011
4. Handbook of Environmental Impact Assessment Vol I and II, J. Petts, Blackwell Science,London, 2010
5. Peter Morris, Riki Therivel "Methods of Environmental Impact Assessment", Routledge Publishers,2009
6. EIA Notification, 2006, 2020, Govt of India

M3321028 Environmental Social Governance (2 Credits)

Course Description

This is an introductory course to Environmental, Social and Governance factors which forms part of a framework that helps stakeholders understand how a company manages risks and opportunities around sustainability issues.

Course Objectives

To introduce the students to Environmental, Social and Governance factors and the ESG market to develop clarity on the fundamentals of each of these factors.

Course Content

Introduction to ESG Factors: Definition and Scope - CSR - Responsible Investment - Integrating ESG - ESG in Practice - Reporting Frameworks

The ESG Market: A brief history - Size and Scope of ESG investing - Stakeholders: Asset owners, Asset Managers, Fund Promoters, Financial Services, Policymakers and regulators etc.

Environmental Factors: Environmental issues (Climate change, Natural resource depletion etc.) - Businesses and the Environment - Drivers influencing environmental change - Materiality Assessment of Environmental Issues - Approaches in Environmental Analysis & Risk Management - Applying material environmental factors - Opportunities

Social Factors: Effects of social megatrends - Social issues and business activities - Material social factors - Applying material social factors

Governance Factors: Why does governance matter - Development of a formalised governance approach - Key characteristics - Structural differences - Regarding auditing - Impact of governance on investment - Applying material corporate governance factors

Course Learning outcome

1. Explain the significance of E, S and G factors in responsible investment and the ESG market
2. Relate the role of environmental factors, systemic relationships, material impacts, megatrends and approaches to environmental analysis at country, sector and company levels.
3. Relate the role of social factors, systemic relationships, material impacts and approaches to social analysis at country, sector and company levels.

4. Relate the role of governance factors, key characteristics, main models and material impacts.

Text Books

1. Environmental, Social, and Governance (ESG) Investing: A Balanced Analysis of the Theory and Practice of a Sustainable Portfolio, John Hill, Academic Press, Elsevier, 2020.
2. ESG and Responsible Institutional Investing Around the World: A Critical Review, Pedro Matos, CFA Institute Research Foundation, 2020, ISBN:9781944960988, 1944960988
3. ESG Investment: Opportunities and Risks for Asia, Naoko Nemoto, Naoyuki Yoshino, Brookings Institution Press, 2020, ISBN:9784899742067, 4899742061
4. Responsible Investing: An Introduction to Environmental, Social, and Governance Investments, Matthew W. Sherwood, Julia Pollard, Taylor & Francis, 2018
5. Handbook on Sustainable Investments: Background Information and Practical Examples for Institutional Asset Owners, Swiss Sustainable Finance, CFA Institute Research Foundation, 2017.

M3321029 Environmental Legislation and Policy (2 Credits)

Course Description:

Law has a vital role in civilized societies in the conservation and management of natural resources. It is also required to reign in pollution. This course intends to introduce the students to the vast field of Environmental Law in India. The course is divided into three broad areas. The first part covers the basic concepts and principles of Environmental Law. It includes judicial precedents, which is an integral part of environmental jurisprudence. The second part introduces modules on forests and wildlife, including biodiversity related laws; Air and Water-related laws, including mega projects and marine laws; and laws relating to hazardous substances. The third part discusses the developments at the international level in the field of environmental law. After completing the course, it is expected that the students will gain a broad understanding of the environmental laws of India and international obligations.

Course Objectives

1. To learn about the evolution of environment-related laws in India, their scope and applicability.
2. To explain the role of law and legal institutions in the conservation and management of natural resources as well as pollution control
3. To introduce the laws and policies both at the national and international level relating to the environment
4. To equip the students with the skills needed for interpreting laws and judicial decisions

Course Content

Basic concepts in environmental law: An introduction to the legal system; Constitution, Acts, Rules, Regulations; Indian Judiciary, Doctrine of precedents, judicial review, Writ petitions, PIL–liberalization of the rule of locus standi, Judicial activism. Introduction to environmental laws in India; Constitutional provisions, Stockholm conference; Bhopal gas tragedy; Rio conference. General principles in Environmental law: Precautionary Principle; Polluter pays principle; Sustainable development; Public trust doctrine. Overview of legislations and basic concepts.

Forest, Wildlife, and Biodiversity related laws: Evolution and Jurisprudence of Forest and Wildlife laws; Colonial forest policies; Forest policies after independence. Statutory framework on Forests, Wildlife and Biodiversity: IFA, 1927; WLPA, 1972; FCA, 1980; Biological Diversity Act, 2002; Forest Rights Act, 2006. Strategies for conservation–Project Tiger, Elephant, Rhino.

Air, Water and Marine Laws: National Water Policy and Kerala state policu. Laws relating to the prevention of pollution, access and management of water and institutional mechanism: Water Act, 1974; Water Cess Act, 1977, EPA, 1986. Pollution Control Boards. Groundwater and law. Judicial remedies and procedures Marine laws of India; Coastal zone regulations. Legal framework on Air pollution: Air Act,1981; EPA, 1986.

Environment protection laws, Mega Projects and Hazardous Materials: Legal framework on environment protection-Environment Protection Act as the framework legislation–strength and weaknesses; EIA; National Green Tribunal. The courts' infrastructure projects. Legal framework: EPA and rules made thereunder; Public Liability Insurance Act, 1999. Principles of strict and absolute liability.

International Environmental Law: An introduction to International law; sources of international law; law of treaties; signature, ratification. Evolution of international environmental law: Customary principles; Common but differentiated responsibility, Polluter pays.

Course Learning outcome

1. Discuss basic concepts, principles and scope of Environmental Law in India
2. Explain the role of law and legal institutions in the conservation and management of natural resources as well as pollution control
3. Identify the developments at the international level in the field of environmental law

Text Books

1. Development of Environment Laws in India – Manju Menon- Cambridge University Press.
2. Indian Environment Law; Key Concepts and Principles – Shibani Ghosh – Orient Black Swan.
3. Divan S. and Rosencranz A. (2005) Environmental Law and Policy in India, 2nd ed., Oxford, New Delhi.
4. Leelakrishnan P. (2008) Environmental Law in India, 3rd ed., Lexis Nexis, India

Text Books

1. Birnie P. (2009) et al., International Law and the Environment, 3rd ed., Oxford.
2. Desai A. (2002) Environmental Jurisprudence, 2nd ed., Modern Law House, Allahabad.
3. Gadgil M. and Guha R. (1995) Ecology and Equity, Oxford, New Delhi.
4. Gadgil M. and Guha R. (1997) This Fissured Land, Oxford, New Delhi.
5. Guha R. (2000) Environmentalism: A Global History, Oxford, New Delhi.

6. Kamala S. and Singh U.K. (eds.) (2008) Towards Legal Literacy: An Introduction to Law in India, Oxford, New Delhi.
7. Leelakrishnan P. (2006) Environmental Law Case Book, 2nd ed, Lexis Nexis, India.
8. Sands P. (2002) Principles of International Environmental Law, 2nd ed, Cambridge.
9. Singh C. (1986) Common Property and Common Poverty, Oxford, New Delhi.
10. Upadhyay S. and Upadhyay V. (2002) Hand Book on Environmental Law- Forest Laws, Wildlife Laws and the Environment; Vols. I, II and III, Lexis Nexis- Butterworths-India, New Delhi.

M3321055 Forest Ecology (2 Credits)

Course Description:

This course explores the intricate ecosystem dynamics within forests, delving into the interactions between biotic and abiotic components. Students will gain a deep understanding of forest structure, function, and management practices, enabling them to analyze and address ecological challenges.

Course Objectives

1. To familiarize with the fundamental concepts of forest ecosystems, including biodiversity, succession, and ecosystem services.
2. Describe the role of disturbances, such as fire and pests, in shaping forest dynamics
3. Develop knowledge on forest ecology to evaluate the impact of human activities on forest health and biodiversity.
4. Equip the students to assess the effectiveness of conservation strategies in maintaining forest biodiversity

Course content

Introduction to Forest Ecology

Forest ecology and its significance, Forest types and classifications (climate, vegetation, and geography), Biotic and abiotic components of forest ecosystems, Ecological succession (Primary and secondary) and disturbance regimes, Forest structure and function: canopy layers and vertical structure, Photosynthesis and nutrient cycling in forests, Ecosystem services provided by forests

Biodiversity and Interactions

Species diversity and richness in forests: measurement and interpretation, relationship between biodiversity and ecosystem stability in forests, trophic interactions and food webs, Mutualism, competition, and predation within forest communities

Human Impact and Management

Deforestation, forest fragmentation, logging, urbanization, and pollution, key drivers contributing to human induced changes in forest landscapes, Sustainable forest management practices , Effects of climate change on forest ecosystems, case studies demonstrating the impacts of deforestation and habitat fragmentation on forest ecosystems.

Disturbances and Resilience

Fire ecology and adaptation, Invasive species and their impacts, Forest recovery and resilience after disturbances

Conservation and Restoration

Conservation strategies for forest biodiversity, Habitat Restoration and conservation strategies, including reforestation, protected areas, and community-based management, Ethical considerations in forest management

Course Learning Outcome

1. Understand the basic concepts in forest ecology and explain the relationship between biodiversity and ecosystem stability in forests
2. Apply the knowledge of human impact to analyze specific case studies demonstrating the effects of deforestation and habitat fragmentation.
3. Explain how forest ecosystems adapt to and recover from the disturbances.
4. Apply ethical considerations to analyze a scenario involving competing priorities in forest management.

Text Books

1. Kimmins, J. P. (2004). Forest Ecology. Pearson Education.
2. Newton, A. C. (2007). Forest Ecology and Conservation: A Handbook of Techniques. Oxford University Press.
3. Begon, M., Townsend, C. R., & Harper, J. L. (2006). Ecology: From Individuals to Ecosystems. Blackwell Publishing.
4. Cain, M. L., Bowman, W. D., & Hacker, S. D. (2020). Ecology (4th ed.). Sinauer Associates.
5. Creed, I. F., & Pace, M. L. (2019). Forest Management and the Water Cycle: An Ecosystem-Based Approach. CRC Press.
6. Walker, L. R. (2011). Ecology of Disturbed Habitats. Oxford University Press.
7. Van Dyke, F. (2008). Conservation Biology: Foundations, Concepts, Applications. Springer.

M3321056 Urban Ecology (2 credits)

Course Description

In the Anthropocene, urbanization has emerged as a key characteristic, signifying the substantial and profound impact that humans have had on the planet's ecosystems. Understanding the intricate interactions between human-urban environments and the natural landscape is crucial for promoting sustainable and habitable cities in a time of growing urbanization. The Urban Ecology course explores the complex interplay between urbanization and ecological systems, giving students the knowledge and abilities to successfully negotiate the opportunities and problems posed by urban settings.

Objectives

1. Understand the principles of Urban Ecology and identify various features and functions of urban ecosystems.
2. Analyze the ecological impact of urbanization
3. Familiarize with various quantitative techniques to analyze urban dynamics
4. Explore sustainable approaches to urban planning and design

Course content

Introduction to Urban Ecology, human-nature interactions, ecological features in the urban ecosystem: urban climate, soil, air, and water; biological systems: flora and fauna: patterns and processes, urban features: human structures, residential, commercial, and industrial areas, green spaces and parks

Urban form, structure, & function, drivers of urban ecosystem, socio-ecological systems, social processes in urban ecosystems, land use and land cover changes, spatial patterns and mosaics, urbanization: flow and movements, urban metabolism: biophysical and system perspectives

Ecological impacts of urbanization: biodiversity loss, impacts on ecological interactions, invasive alien species, environmental pollutions- air, water, and soil, public health and sanitation issues, wastewater and solid waste problems, urban greenhouse gas budgets, urban heat island, changes in terrestrial biogeochemistry, food security, impacts of artificial light at night.

Modeling urban growth, urban scaling laws, management of urban ecosystems, restoration, grey to green concept, sustainable urban planning & design, ecosystem services in urban planning, green infrastructure, sustainable and smart cities, nature-based solutions, governance and planning

Course learning outcomes

1. Explain the concept of urban ecology and its relevance in understanding urban ecosystems and human-nature interactions.
2. Apply ecological principles and methods to interpret urban environmental patterns and processes.
3. Evaluate the ecological consequences of urbanization
4. Evaluate sustainable urban planning practices and policies enhancing ecological resilience and livability
5. Apply critical thinking skills and synthesize knowledge to propose innovative solutions to urban ecology challenges.

Text Books

1. Adler and Tanner (2013) Urban Ecosystems – Ecological principles for the built environment
2. Gaston, Kevin J. Urban Ecology. Cambridge University Press, Cambridge; New York, 2010.
3. Forman, Richard TT. Urban ecology: science of cities. Cambridge University Press, 2014.
4. Verma, P., Singh, P., Singh, R., & Raghubanshi, A. S. (Eds.). (2020). Urban ecology: emerging patterns and social-ecological systems. Elsevier.
5. Weinberger, Vanessa P. "Understanding Urban Ecology: An Interdisciplinary Systems Approach, Myrna HP Hall, Stephen B. Balogh (Eds.), Springer International Publishing (2019)." (2019): 108781.
6. Niemelä, J., Breuste, J. H., Guntenspergen, G., McIntyre, N. E., Elmqvist, T., & James, P. (Eds.). (2011). Urban ecology: patterns, processes, and applications. OUP Oxford.