Semester – VII

COURSES OFFERED BY DEPARTMENT OF ENVIRONMENTAL SCIENCE

Category-I

Environmental Science Courses for Undergraduate Programme of study with Environmental Science as a Single Core Discipline

BSC (H) ENVIRONMENTAL SCIENCE

DISCIPLINE SPECIFIC CORE COURSE – 19 (DSC-EVS-19): METHODS IN ECOLOGICAL RESEARCH

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-19: METHODS IN ECOLOGICAL RESEARCH	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Equip with principles and methods of ecological research and acquire a broad understanding of its different subfields
- Understand the ethical considerations involved with technological approach used in ecological research
- Familiar with how to design and conduct ecological research in laboratory or in field environment
- Introduce with emerging approaches and tools in different types of ecological research

Learning outcomes

After this course, students will be able to:

- Design and implement experiments for different types of ecological research and explain the steps involved in hypothesis testing
- Use appropriate sampling strategy to collect data and conduct observational studies in ecological research
- Analyze and interpret ecological data using appropriate statistical methods
- Evaluate the strengths and limitations of different tools, methods and techniques for different types of ecological research

SYLLABUS OF DSC-EVS-19

Theory (02 Credits: 30 hours)

Unit 1: Basics of Ecological Research and Scientific Method (7 hours)
Overview of ecological research methods; Scientific method and hypothesis testing; Experimental design and field sampling techniques; Data collection methods: quadrats, transects, plot sampling; Introduction to ecological data types; Ethical considerations in ecological research; Scientific communication and reporting.

Unit 2: Biodiversity, Conservation, and Behavioral Ecology Methods (8 hours)
Biodiversity measurement: species richness, diversity indices; Conservation planning and prioritization; Methods for assessing endangered and invasive species; Habitat mapping and classification; Basic restoration monitoring approaches; Behavioral observation and recording; Bioacoustics and movement tracking; Introduction to behavioral data analysis.

Unit 3: Population and Community Ecology Methods (7 hours)
Population dynamics: growth models, density estimation; Mark-recapture techniques; Species abundance and distribution estimation; Methods for studying competition and niche partitioning; Mutualism and basic co-evolutionary interactions; Introduction to genetic diversity (molecular markers, no phylogeny); Field-based adaptation studies.

Unit 4: Ecosystem and Landscape Ecology Methods (8 hours)
Remote sensing and GIS for ecological mapping (introductory); Carbon and nutrient cycling measurements; Ecosystem function and service assessment tools; Basic hydrology and water quality monitoring; Monitoring climate change impacts on ecosystems; Fundamentals of ecological restoration and management; Introduction to ecological data analysis and visualization (basic stats, charts).

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Use random quadrat sampling to measure species richness and abundance of herbaceous plants in a campus or nearby green area.

2–3. Practice belt and line transect methods to assess population density or diversity of plants or insects in two different habitats (e.g., lawn vs. woodland).

4. Create a basic habitat map of a local area (e.g., college campus or park) using freely available GIS tools (e.g., QGIS) and mark observed presence of a common species.

5–6. Use open-source land use data (e.g., Bhuvan, Google Earth) to assess changes in land cover and relate it to species observations or known distributions.

7. Conduct a behavioral observation session on birds or urban animals (e.g., squirrels, dogs), record focal behavior and analyze simple patterns (time budgets, frequencies).
8. Observe and record foraging behavior of birds (e.g., pigeons, crows) and test basic hypotheses of niche use or resource sharing.
9. Set up a simple pot experiment to test the effect of different fertilizers (e.g., compost, chemical) on seedling growth of a common plant.
10. Use Google Earth or open GIS data to identify and measure landscape fragmentation (e.g., green patches, built-up areas) in the college surroundings.
11. Construct a basic plant family tree using morphological characters or literature data for a group of local plant species (e.g., Fabaceae, Asteraceae).
12. Use secondary data (e.g., herbarium records, published sources) to map the biogeographic distribution of a group of native or invasive plants in the region.

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b) Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Essential/recommended readings

- Pardo, S. and Pardo, M., 2018. Statistical methods for field and laboratory studies in behavioral ecology. Chapman and Hall/CRC.
- Jørgensen, S.E., 2009. Ecological modelling: an introduction. WIT press.
- Gotelli, N. J., & Ellison, A. M. (2004). A primer of ecological statistics (2nd ed.). Sinauer Associates.
- Zuur, A. F., Ieno, E. N., & Smith, G. M. (2007). Analyzing ecological data. Springer Science & Business Media.

Suggestive readings

- Buckland, S.T., Anderson, D.R., Burnham, K.P., Laake, J.L., Borchers, D.L. and Thomas, L., 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford university press.
- Krebs, C. J. (2016). Ecology: the experimental analysis of distribution and abundance (6th ed.). Pearson.
- Van Dyke, F., 2008. Conservation biology: foundations, concepts, applications. Springer Science & Business Media.
- Zuur, A. F., Ieno, E. N., & Saveliev, A. A. (2017). Beginner's guide to spatial, temporal and spatial-temporal ecological data analysis with R-INLA. Highland Statistics Ltd.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Semester – VIII

DISCIPLINE SPECIFIC CORE COURSE – 20 (DSC-EVS-20): ENVIRONMENTAL STATISTICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
DSC-EVS-20: ENVIRONMENTAL STATISTICS	4	2	0	2	Class XII pass	NA

Learning objectives

The Learning Objectives of this course are as follows:

- Gain insights into application of probability theory in solving environmental problems
- Explore environmental data using descriptive and inferential statistics
- Understand regression analysis for determining environmental relationships
- Equip with methods of analyzing time series data and identify trends in environment
- Practice spatial statistics to identify spatial patterns in environmental variables

Learning outcomes

After this course, students will be able to

- Apply probability theory to assess risks in environment
- Analyze and visualize environmental data using descriptive statistics and graphicalmethods
- Formulate and test hypotheses to understand problems in environmental science
- Apply regression analysis to decipher the relationships between different sets ofenvironmental variables
- Analyze time series data and spatial statistics to identify trends and spatialrelationships among different variables

Unit 1: Basics of Environmental Statistics and Probability (7 hours)
Definition, scope, and applications of environmental statistics; Types of environmental data, sampling and data collection; Data exploration and basic visualization (boxplots, histograms); Introduction to probability theory, conditional probability, and independence; Overview of random variables and probability distributions in environmental applications.

Unit 2: Descriptive Statistics and Data Relationships (7 lectures)
Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation, variance); Skewness, kurtosis, and graphical summaries; Correlation and covariance; Introduction to Spearman's rank correlation; Conceptual introduction to principal components (without calculation).

Unit 3: Hypothesis Testing and Regression Analysis (8 hours)
Formulating null and alternative hypotheses; Type I and II errors; Parametric tests: t-test (one-sample and two-sample), Chi-square test (goodness of fit, independence), and one-way ANOVA; Introduction to simple linear regression and its applications in environmental management.

Unit 4: Time Series, Non-Parametric Methods, and Spatial Basics (8 hours)
Basics of time series data: trend, seasonality, decomposition (qualitative understanding); Introduction to forecasting applications in environment; Non-parametric tests: Mann-Whitney U, Wilcoxon signed-rank, Kruskal-Wallis (concepts and application); Introduction to spatial data types and environmental relevance (without deep geostatistics or spatial modeling).

Teaching and learning interface for theoretical concepts

To achieve the course objectives and match with the contents, a wide range of teaching and learning tools will be employed, including (a) Formal lectures; (b)Interactive sessions using visual aid; (c) Case study analyses; (d) Hypothetical scenario building; (e) Group discussion on key topics; and (f) documentary screening and critical analyses.

Practicals/Hands-on Exercises – based on theory (02 Credits: 60 hours)

1. Visualize an environmental data set using descriptive statistics and graphicalmethods
2. Estimate risk for a given environmental hazard using probability distributions
3. Use one-sample t-test and test a hypothesis about a population parameter andinterpret the results.
4. Test a hypothesis about the difference between multiple population means usingANOVA
5. Analyze environmental data using a linear regression model and interpret thecoefficients and goodness of fit
6. Analyze the given time series data set using trend analysis or analyze a spatialdata set using spatial regression models
7. Use cluster analysis to group environmental samples based on their similarities.

Teaching and learning interface for practical skills

To impart training on technical and analytical skills related to the course objectives, a wide range of learning methods will be used, including (a) laboratorypracticals; (b) field-work exercises; (c) customized exercises based on available data; (d) survey analyses; and (e) developing case studies; (f) demonstration and critical analyses; and (h) experiential learning individually and collectively.

Essential/recommended readings

- Cressie, N. A. C., & Wikle, C. K. (2011). Statistics for spatio-temporal data. JohnWiley & Sons.
- Gotelli, N. J., & Ellison, A. M. (2004). A primer of ecological statistics. SinauerAssociates.
- Hoshmand, R., 2017. Statistical methods for environmental and agriculturalsciences. CRC press.
- Millard, S.P., 2013. EnvStats: an R package for environmental statistics. SpringerScience & Business Media.
- Qian, S.S., 2016. Environmental and ecological statistics with R. Chapman and Hall/CRC.

Suggestive readings

- Brown, J. A., & Lovett, G. M. (2018). Spatial models for environmental andecological data. CRC Press.
- Clark, J.S. and Gelfand, A.E. eds., 2006. Hierarchical modelling for the environmentalsciences: statistical methods and applications. OUP Oxford.
- Helsel, D. R. (2012). Statistics for censored environmental data using Minitab and R.John Wiley & Sons.
- Hoshmand, R., 2017. Statistical methods for environmental and agriculturalsciences. CRC press.
- Fletcher, R. and Fortin, M., 2018. Spatial ecology and conservation modeling (p.523). Cham: Springer International Publishing.

Note: Examination scheme and mode shall be as prescribed by the ExaminationBranch, University of Delhi, from time to time.