Course Title: Spatial Data Modelling and Analysis			
Course code: UES 210	**No. of credits:** 3	**L-T-P: 34-0-22**	**Learning hours: 45**
			L: Lecture**; T:** Tutorial**; P:** Practical
Pre-requisite course code and title (if any):			
Department: Department of Natural and Applied Sciences			
Course coordinator:		**Course instructor:**	
Contact details:			
Course type: Minor		**Course offered in:** Semester 4	

Course Description

This course is designed to equip students with the theoretical knowledge and practical skills needed to effectively manage, analyze, and visualize spatial data in various contexts. This course delves into the principles and methodologies of spatial data analysis, emphasizing the importance of geographic information systems (GIS), remote sensing, and statistical techniques in understanding spatial phenomena. Upon successful completion of the course, the students will be able to apply a range of statistical and geospatial analysis methods, such as spatial autocorrelation, interpolation, and surface analysis, to uncover patterns and relationships within spatial datasets.

Course objectives

- Develop an understanding of fundamental spatial concepts, terminology, and theories that underpin spatial data modeling and analysis.
- Develop skills in applying spatial analysis methods such as interpolation, and spatial statistics to identify patterns and relationships within spatial datasets.
- Develop proficiency in visualizing spatial data using maps and graphs, emphasizing the importance of effective communication of spatial information to diverse audiences.

Course content

Module	Topic	L	T	P
1	**Basics of Geospatial Data Modelling**			
	This module will provide an in-depth knowledge of geospatial modeling techniques. In addition, students will explore normalization methods and levels of measurement critical in geospatial analysis. Geospatial models: types and modelling: descriptive, prescriptive, and predictive	4		
2	**Concepts of Spatial Analysis**			
	The module will help students to explore how spatial relationships influence various phenomena and how these concepts can be applied in diverse fields such as geography, urban planning, environmental science, and social sciences. Introduction to algorithms and flowcharts; map algebra: operators and functions: mathematical, logical comparison and boolean; operations and functions: local, focal, zonal, and global; spatial interaction models; Key concepts of Spatial analysis: distance, adjacency, interaction, and neighbourhood	6		
3	**Point Pattern Analysis**			
	The module covers the advanced techniques for analyzing spatial distributions of points. Students will learn to identify patterns and assess spatial relationships, enabling them to draw meaningful conclusions from spatial data. Centrography; Distance based analysis: Nearest Neighbour Distance, K and L functions; Density based analysis: Quadrant, local, global and kernel, Cluster analysis: K-means Clustering, Hotspot analysis; Thiessen polygons; Spatial Autocorrelation - Moran's I	4		2
4	**Terrain Analysis**			
	The module covers the concepts of terrain analysis, their importance, and how they	2		2

	are applied in natural resource management. Local neighbourhood operation–slope, aspect, curvature, viewshed			
5	**Network Analysis and Dynamic Segmentation**			
	The module equips students with the fundamental concepts of network analysis and dynamic segmentation, which are crucial for understanding and interpreting complex data flows within a network. Network Analysis**:** Geocoding, optimum routing, closest facilities, resource allocation; Watershed analysis: flow direction, flow accumulation, Stream Network Link; Dynamic Segmentation: route, section, events, and its application	6		10
6	**Spatial Interpolation**			
	The module delves into the theoretical foundations, methodologies, and practical applications of spatial interpolation, equipping students with the skills to analyze spatial data and make informed predictions. Regression model, Trend surface Analysis, Interpolation techniques: Local and global methods; Inverse Distance Weighting (IDW), Natural Neighbor Inverse Distance Weighted (NNIDW); Triangulated Irregular Network (TIN), Lattice Model	6		4
7	**Multi-Criteria Decision Support System**			
	The module provides insights into the methodologies and tools designed to aid decision-making in complex scenarios involving multiple conflicting criteria. Introduction to decision support systems, problem structuring and criteria definition, pairwise comparison, consistency, and sensitivity analysis; application of Multi-Criteria Decision Analysis (MCDM) - Analytical Hierarchy Process (AHP); Weighted Sum Method, Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)	6		4
	Total	34	0	22
	Practical Modules			
1.	Point Pattern analysis			2
2.	Terrain analysis			2
3.	Watershed analysis			2
4.	Network analysis			4
5.	Dynamic segmentation			4
6.	Geostatistical analysis			4
7.	Multi-criteria decision analysis			4
	Total	34	0	22

Evaluation criteria

- Minor Test 1: Written test [at the end of teaching of modules 1 and 2] -- 20%
- Minor Test 2: Written test [at the end of teaching of module 3 and 4] -- 20%
- Major Test: Written test [at the end of the semester, full syllabus] -- 40%
- Practical Test: [at the end of the semester, full syllabus] -- 20%

Learning outcomes

By the end of the course, students will be able to:

- differentiate between different geospatial models and apply mathematical, logical, and Boolean operators to analyze spatial data. [Module 1 and 2; Minor Test 1]
- demonstrate a comprehensive understanding of the theoretical concepts underlying point pattern analysis and terrain analysis. [Module 3 and 4, Minor Test 2]
- apply optimal routing algorithms to determine the most efficient paths based on distance, time, and traffic conditions. [Module 5]
- demonstrate a comprehensive understanding of both local and global interpolation methods and their applications in spatial analysis. [Module 6]

- apply Multi-Criteria Decision Making (MCDM) techniques to real-world problems, demonstrating competence in decision-making frameworks. [Module 1-7; Major Test]

Pedagogical approach

- The course incorporates spatial data modeling and analysis while promoting student discussions through lectures and practicals.
- Students will have the opportunity to actively interact with spatial statistics tools and techniques through practical exercises and real-world applications.

Reading Resources (* = compulsory readings)

- O'Sullivan, D., & Unwin, D. J. (2010)*. *Geographic Information Analysis*. John Wiley & Sons.
- Verbyla, D. L. (2002)*. *Practical GIS analysis*. CRC press.
- Chang, K. T. (2019). *Introduction to geographic information systems, 9th Edition*. Mc Graw Hill Higher Education.
- Maguire, D. J., Batty, M., & Goodchild, M. F. (2005). *GIS, spatial analysis, and modeling*. ESRI Press ISBN 1589481305, 9781589481305
- Longley, P. (2005). *Geographic information systems and science*. John Wiley & Sons.

Suggested Readings

- Longley, Paul A., Michael F. Goodchild, David J. Maguire, and David W. Rhind. (2015). *Geographic Information Systems and Science, 4th ed.,* John Wiley and Sons, Toronto.
- Bhatta, B. (2008). *Remote sensing and GIS (Vol. 2).* New Delhi: Oxford University Press.
- Lo, C.P., and Albert K.W. Yeung, (2007). *Concepts and Techniques of Geographic Information Systems, 2nd ed*., Pearson Education Canada, Inc., Toronto.
- Burrough, P. A., McDonnell, R. A., & Lloyd, C. D. (2015). *Principles of geographical information systems*. Oxford University Press, USA.
- DeMers, Michael N. (2008). *Fundamentals of Geographic Information Systems, 4th. ed*., John Wiley and Sons, Toronto.

Journals:

- Advances in Water Resources
- Agricultural and Forest Meteorology
- Asian Journal of Geoinformatics
- Ecological Modelling
- International Journal of Geoinformatics
- International Journal of Remote Sensing

Student Responsibilities

The students must come prepared with the readings given in the class. The students are required to participate in the discussion.

Course Designed by:

- Dr Ayushi Vijhani, Assistant Professor, Department of Natural and Applied Sciences, TERI School of Advanced Studies, New Delhi

Course Reviewers:

The course is reviewed by following reviewers:

- Dr. P. K. Joshi, Professor, School of Environmental Sciences, Jawaharlal Nehru University, New Delhi
- Dr. Vinay SP Sinha, Professor, Centre of the Study Regional Development, School of Social Sciences, Jawaharlal Nehru University, New Delhi
- Dr. Sameer Saran, Dy General Manager (DGM) & Scientist/Engineer 'SG", Regional Remote Sensing Centre - North, NRSC/ISRO