Programme	BS Computational Statistics and Data Analytics	Course Code	CSTA-407	Credit Hours	3
Course Title	Spatial Analysis				

Course Introduction

Spatial Analysis: Spatial data analysis involves examining geographical data patterns and relationships. Students learn spatial statistics, geostatistics, spatial interpolation techniques, and GIS (Geographic Information Systems) applications for spatial data visualization and analysis.

Learning Outcomes

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

1. Conceptualize models as representations of real life systems with inputs, outputs, and processes.
2. Apply, integrate, and develop models with geospatial data.
3. Utilize spatial models to make simulations and predictions of real life phenomena.
4. Evaluate models in terms of accuracy, sensitivity, and uncertainty.
5. Use a system-based approach for problem solving, with an emphasis on sustainability.

	Course Content	Assignments/Readings
Week 1	**Unit – I** Introduction to Spatial and Spatio-Temporal Statistics: Overview of spatial statistics and its applications in analyzing geographic data	
	Unit – II Introduction to spatio-temporal statistics and its importance in understanding temporal trends in spatial data	
Week 2	**Unit – III** Virogram: Explanation of variogram analysis as a fundamental tool in spatial statistics for measuring spatial dependence or variability	
	Unit – IV Understanding the concepts of variogram modeling	

	and interpretation	
Week 3	**Unit – V** Modeling Spatial and Spatio-Temporal Structures: Techniques for modeling spatial and spatio-temporal structures in data, including spatial autocorrelation and spatio-temporal correlation	
	Unit – VI Discussion on the importance of considering spatial and temporal dependencies in statistical models	
Week 4	**Unit – VII** Systems-Based Modeling: Introduction to systems-based modeling approaches for analyzing complex spatial systems and processes	
	Unit – VIII Understanding how systems-based modeling integrates spatial data with other types of data for holistic analysis	
Week 5	**Unit – IX** Vector-Based Modeling: Overview of vector-based modeling techniques for spatial data analysis, including regression analysis (linear and logistic)	
	Unit – X Hands-on exercises on performing linear and logistic regression analysis using spatial data	
Week 6	**Unit – XI** Raster-Based Modeling: Introduction to raster-based modeling techniques and map algebra for analyzing spatial data represented as grids	
	Unit – XII Raster-based Techniques Continued	
Week 7	**Unit – XIII** Hands-on exercises on performing raster-based modeling	
	Unit – XIV	

	Application on Real life Case Studies	
Week 8	**Unit – XV** Exploring surface modeling techniques for analyzing continuous spatial phenomena	
	Unit – XVI Areal Data: Understanding areal data and its characteristics in spatial statistics, including spatial aggregation and zoning	
Week 9	**Unit – XVII** Techniques for analyzing and modeling areal data using spatial statistical methods	
	Unit – XVIII Techniques for analyzing and modeling areal data Continued	
Week 10	**Unit – XIX** Gaussian Markov Random Field: Introduction to Gaussian Markov random field (GMRF) models as a flexible framework for spatial data analysis	
	Unit – XX Application of GMRF models in spatial smoothing, interpolation, and prediction	
Week 11	**Unit – XXI** Hands on Exercises on GMRF models in spatial smoothing, interpolation, and prediction	
	Unit – XXII Spatial Disease Mapping: Overview of spatial disease mapping techniques for analyzing the geographic distribution of diseases or health outcomes	
Week 12	**Unit – XXIII** Understanding the role of spatial statistics in	

	epidemiology and public health research	
	Unit – XXIV Practice Exercises	
Week 13	**Unit – XXV** Bayesian and Hierarchical Models: Introduction to Bayesian statistical methods for modeling spatial data and incorporating prior information	
	Unit – XXVI Discussion on hierarchical models for capturing spatial variability at multiple scales	
Week 14	**Unit – XXVII** Advanced topics in spatial and spatio-temporal statistics, such as geostatistics, point pattern analysis, and spatial regression models.	
	Unit – XXVIII Hands-on workshops or practical sessions using software tools like R, Python with libraries like GeoPandas, PySAL, and ArcGIS for spatial data analysis and modeling.	
Week 15	**Unit – XXIX** Case studies and research projects where students apply spatial statistical methods to real-world datasets and address specific research questions or problems.	
	Unit – XXX Case Studies Practice Continued	
Week 16	**Unit – XXXI** Group projects or presentations where students work collaboratively to design and implement spatial statistical analyses and present their findings to the class.	
	Unit – XXXII Review and Applications: Recap of key concepts and techniques	

Textbooks and Reading Material

Textbooks:

1. Blangiardo, M., & Cameletti, M. (2015). *Spatial and spatio-temporal Bayesian models with R-INLA*. John Wiley & Sons.
2. Cressie, N., & Wikle, C. K. (2015*). Statistics for spatio-temporal data*. Wiley.

Suggested Readings:

1. Carlin, B. P., Gelfand, A. E., & Banerjee, S. (2014). *Hierarchical modeling and analysis for spatial data*. CRC Press.
2. Chiles, J. P., & Delfinder, P. (2012). *Geostatistics: Modeling spatial uncertainty*. Wiley.
3. Gamerman, D., & Lopes, H. F. (2006). *Markov chain Monte Carlo: Stochastic simulation for Bayesian inference*. CRC Press.
4. Gilks, W. R., Richardson, S., & Spiegelhalter, D. (1995). *Markov chain Monte Carlo in practice*. CRC Press.

Teaching Learning Strategies

Class Lecture method, which includes seminars, discussions, assignments and projects. (Audio-visual tools are used where necessary)

Assignments: Types and Number with Calendar

According to the choice of respective teacher.

Assessment

Sr. No.	Elements	Weightage	Details
1.	Midterm Assessment	35%	It takes place at the mid-point of the semester.
2.	Formative Assessment	25%	It is continuous assessment. It includes: Classroom participation, attendance, assignments, and presentations, homework, attitude and behavior, hands-on-activities, short tests, quizzes etc.
3.	Final Assessment	40%	It takes place at the end of the semester. It is mostly in the form of a test, but owing to the nature of the course the teacher may assess their students based on term paper, research proposal development, field work and report writing etc.