2.1.3 Module Code and Title: GST501 Introduction to Geographic Information Systems and Remote Sensing

Programme: Master of Education in Geography
Credit Value: 15 Credits
Module Tutor: Kuenzang Gyeltshen

General Objectives

This module aims to provide theoretical background and practical experience necessary to understand the application of Geographic Information Systems (GIS) and Remote Sensing technologies in contemporary geographic studies. The module surveys a wide array of technological applications including observations of natural phenomenon and dimensions of human geography, with particular emphasis on authentic Bhutanese examples. The module aims to provide opportunity for students to develop skills in data acquisition, classification, manipulation, and storage. Further, it will develop the students' skills to communicate and represent geographic data with cartographic products that are essential in the study and practice of geography and geography education.

Learning Outcomes

On completion of the module, students will be able to:

i. discuss the fundamental concepts of GIS and remote sensing;
ii. interpret remotely sensed imagery using different techniques;
iii. compare applications of GIS and remote sensing in Bhutan with applications worldwide;
iv. create cartographic products using basic GIS skills;
v. analyse spatial data within a GIS using a variety of techniques;
vi. describe the role and importance of geospatial technologies (GST) within the contemporary field of geographic research and geography education;
vii. design and produce GST products capable of investigating and supporting authentic geographic research questions; and
viii. design and produce GST products and techniques capable of supporting interdisciplinary student learning experiences.

Learning and Teaching Approaches

Type	Approach	Hours per week	Total credit hours
Contact	Lecture	3	**90**
	Practical	3	
Independent Study	Written assignment	3	**60**
	VLE discussion	1	
Total			**150**

Assessment Approach

The module will be assessed through continuous assessment (80%) and class test (20%). The continuous assessment will be carried out through the following assignments:

A. Geospatial Inquiry Projet -30%

The aim of this assignment is to give students an opportunity to apply their skills of geospatial technology use and analysis with authentic data. Students will complete a practical (lab-based) inquiry project grounded in geospatial data after the mid semester. Guided by the Inquiry cycle,

students will identify a project of personal interest derived from the topics explored in the module. Students will acquire geospatial data (or generate it as necessary), apply skills of data manipulation and visualisation, and perform basic remote sensing and/or spatial analysis to answer their inquiry project question. (Examples may include: analysis of site suitability for a local waste disposal facility; investigating slope stability; performing cost analysis and local economic productivity mapping; using least cost path routines to identify efficient routing, reclassifying land cover data; creating suitability maps based on a variety of input attributes). Opportunities to partner with local organisations in need of geospatial products/analysis will be organised by the tutor to provide students options for authentic investigation projects. Students will then generate a report including a cartographic product that effectively communicates their project findings. The individual assignments will be assessed using the following criteria.

Criteria	Marks
Cartography: Final cartographic representation meets standards of best practices including appropriate attribution, inclusion of components (scale, legend, north arrow), and descriptions and data used.	6
Data and Analysis: Data collection and management procedures are appropriately described. Report includes a workflow documenting the appropriate use and procedure for spatial analysis to answer the intended project goal.	8
Inquiry Process: The final report presents a complete background and rational of the project. The findings and/or recommendations offered are based on accurate interpretation of the spatial analysis.	8
Organisation: The report is clearly organised and includes all relevant sections. Conclusions and recommendations are presented in a clear and compelling manner.	4
Referencing: The product is professionally presented with correct references to spatial data, analysis techniques, and relevant supporting literature.	4

B. Practical Exercises -40%

This series of practical exercises is designed to provide students with the opportunity to connect the theory of this course to authentic practice. Through completion of these practicals, students will build an E-Portfolio of geospatial products that can be used as resources for their future geography teaching. Students will complete this series of practical experiences to learn how geospatial technologies can be used to map, describe, and analyse patterns of natural and human geography. These practicals will be structured to provide application of the content covered within the teaching units. The practicals will be based on the list given at the end of the module descriptor, just before the reading list. While each practical will be linked to specific content and process information, all practicals will be assessed using the following general criteria:

Criteria	Marks
Content: E-Portfolio entry includes all relevant content required for the submitted practical report. All cartographic products are appropriately labelled and annotated, data descriptions and interpretations are rich in information,	2
Process E-Portfolio entry demonstrates mastery in regards to the skills of interpretation, analysis, and cartography with respect to the practical exercise. Accurate and complete documentation of workflows and analytical techniques are included as necessary.	2

Product: The E-Portfolio entry is professionally presented and appropriately references supporting literature. Work demonstrates personal pride and displays evidence of creativity, design, and attention to detail.	1

A. Article Review: Geospatial Technology in Education -10%

The purpose of this assessment is to provide students with exposure to the current understandings on the relationship between geospatial technologies and student learning. The students will individually identify and review an article relating to the use of geospatial technology in education. This article should be published within the past five years and represent recent developments in the use of these technologies in education. The article critique will be evaluated on the following criteria:

Criteria	Marks
Content: The review will include a section summarising the primary points of the article, a section of critical evaluation of the merits of article's findings and arguments, and a section where the students reflect how the findings from the article are relevant for their future teaching practice.	4
Process: Summary section demonstrates a thorough review of the chosen article. The evaluation section demonstrates a critical assessment and analysis of the article's claims and findings. The reflection section demonstrates authentic consideration for the implications of this article's findings in their future teaching practice.	4
Product: The review is professionally presented with correct referencing. The product demonstrates attention to detail.	2

B. Class Test -20%

This assessment provides a comprehensive opportunity for students to apply their theoretical knowledge of geospatial technologies. The students will be evaluated based on the class test conducted at the end of the semester The test will be conducted for two hours for total of 50 marks and it will be converted to 20%.

a. 20% - Multiple choice and short answers questions related to GST content and basic theoretical application.
b. 30% - Open response questions requiring students to describe theoretical models (drawings & workflows) for remote sensing and spatial analysis scenarios, and descriptions of using geospatial technologies in future teaching practice.

Overview of the assessment approaches and weighting

Areas of assignments	Quantity	Weighting (%)
A. Geospatial inquiry project	1	30
B. Practical exercises	8	40
C. Article critique	1	10
D. Class test	1	20

Pre-requisites: None

Subject Matter

Unit I: Introduction to Remote Sensing

This unit will provide students with the foundational knowledge of remote sensing systems, applications and data resources available for geographic studies. Students will explore the fundamental background of remote sensing, the multiple processes used for interpreting imagery,

and a selection of authentic applications of remote sensing products. An emphasis on place-based local phenomenon will be used to explore the potential of this technology as a tool for geography education.

1.1. Fundamentals of Remote Sensing

1.1.1. Definitions & History: early applications, aerial images, development of satellite technology, evolution of analysis, commercialization, future of remote sensing
1.1.2. Components: sensors, imagery, hardware, software, analysts, and consumers
1.1.3. Rationale for Remote Sensing: researching Earth and human systems, government objectives, planning for disaster response and human development, supporting education and public information

1.2. Introduction to Electromagnetic Radiation

1.2.1. Electromagnetic spectrum: frequencies and wavelengths the electromagnetic spectrum, EMR interaction with atmosphere (absorption, scattering & reflectance), EMR interaction with Earth's Surface
1.2.2. Spectral properties of materials: principles of spectroscopy, absorption bands, spectra of common observable targets (vegetation, soil, and water) [*Practical 1 – Spectral Properties*]

1.3. Review of Sensors & Data Acquisition

1.3.1. Sensor Types: active sensors, passive sensors, public vs. private imagery
1.3.2. Resolution: spatial, spectral, radiometric, temporal
1.3.3. Panchromatic/Visual: Corona, IKONOS, QUICKBIRD
1.3.4. Multispectral: LANDSAT, Sentinel, ALOS, WorldView (WV)
1.3.5. Hyperspectral: Hyperion, Hymap, AVIRIS
1.3.6. Radar: RADARSAT, TanDEM-X
1.3.7. Data Access: Public imagery collections (USGS Earth Explorer, ESA Sentinel Online), Google Earth and Google Earth Engine

1.4. Imagery Interpretation & Enhancement

1.4.1. Preprocessing: imagery acquisition, data types, metadata, georeferencing
1.4.2. Visual Interpretation; altering display functions, identifying common features, comparing historical imagery
1.4.3. Basics of Spectral Analysis: band combinations, spectral indices, identifying change over time, web-based platforms such as ESRI Landsat Explorer, Google Earth Engine [*Practical 2 - Vegetation Analysis*]
1.4.4. Image Classifications: unsupervised classification, selecting training regions, supervised classification [*Practical 3 – Land use classification*]

1.5. Applications of Remote Sensing

1.5.1. Common Terrestrial Applications: geologic, ecological, geomorphology, natural resource management, hydrologic
1.5.2. Common Marine and Meteorological Applications: algal blooms, sea ice, cloud coverage, meteorological and climate monitoring
1.5.3. Common Human Applications: human geography and population migration, urban mapping, rural development, land use and land capability planning
1.5.4. Remote Sensing in Bhutan – glacial assessment and monitoring, mass wasting and erosion, urban expansion, disaster response [*Practical 4 – Remote Sensing for Natural Hazards*]

Unit II: Introduction to Geographic Information System (GIS)

This unit provides students with the foundational knowledge of Geographic Information Systems in order to confidently use the technology at an introductory level. Students will be engaged in learning the primary types of GIS data, basic processes in data display and analysis, and applications of the technology as a support for science, governance, and research.

2.1. Fundamentals of Geographic Information System

2.1.1. Definitions & history: geographic information science, early computerization, software foundations and commercialization, future of GIS

2.1.2. Components: data, hardware, software, apps/methods, and people

2.1.3. Rationale for GIS: organising and managing spatial data, analysing and investigating spatial questions, communicating spatial information

2.2. GIS Data Acquisition

2.2.1. Types of data: vector (points, lines, polygons, and polyline), raster data,

2.2.2. Field derived data: introduction to global positioning systems (GPS), collecting GPS data

2.2.3. Remotely sensed data: integrating satellite imagery, digital elevation models (DEM)

2.2.4. Publicly Available Data: ArcGIS Online (AGOL), Living Atlas, citizen-science and crowdsourced data

2.3. Data Preparation and Management

2.3.1. Spatial Reference: coordinate systems, map projections

2.3.2. Data preparation: file types (shapefile, feature service), metadata, clipping layers, exporting data

2.3.3. Creating data: using layers, georeferencing, digitization

2.3.4. Data attributes: field definitions, methods of data entry, attribute data verification), manipulation of fields and filtering data [*Practical 5 – Working with GIS Data*]

2.4. Spatial Data Analysis

2.4.1. Performing basic analysis: proximity, summarization, routing, spatial statistics [*Practical 6 – Basic Spatial Analysis*]

2.5. Principles of Cartography

2.5.1. Displaying data: changing scales and selecting layers, modifying symbology, classification; Integrating multiple data types onto one platform

2.5.2. Cartographic Representation: spatial features, map symbols: categorical, counts and amounts, percentage or ratio,)

2.5.3. Map design: layout and visual hierarchy, thematic mapping (choropleth, isopleth, bar, pie, dot, and proportional)

2.5.4. Interactive products: 3D maps, Story Maps, web applications [*Practical 7 – Creating Cartographic Products*]

2.6. Applications and Uses of Geographic Information System

2.6.1. GIS in Bhutan: route analysis and urban planning, agricultural analysis, educational assessment

2.6.2. Common Applications; Land use land capability analysis, water resource management, site and service planning, health and crime mapping, Governance - Urban information, Revenue and Civil administration

Unit III: Using GST in research and teaching

This unit serves to link the content of both Unit 1 and Unit 2 under the authentic applications of research and education. Students will explore how GST can be effectively used as a support for interdisciplinary educational studies, and consider how to craft GST products to help support their educational pursuits.

3.1. Role of GST in 21st Century Geography:

3.1.1. Areas of GST research: GIScience, GST as a support for disciplinary research, GST educational research

3.1.2. Contemporary uses of geospatial technology: geography research, land management, policy-based decision making, and education

3.2. Creating GST products for Educational Practice

3.2.1. Benefits of GST in Education: interdisciplinary learning opportunities, support of student inquiry and problem-based learning, opportunities to engage with GNH aligned projects, 21st Century skills
3.2.2. Geospatial Literacy: knowledge, geospatial thinking and reasoning skills, and dispositions
3.2.3. Creating lessons with geospatial technologies: backwards planning, developing educational resources, implementing practices without access to technology [*Practical 8 – Teaching with geospatial technologies*]

List of Practicals

Unit	Practical Number	Title	Scope & Parameters
I. Remote Sensing	1	Basics of Spectral Characteristics	Students will use online and printed resources to investigate the spectral properties of common materials. Students will produce a report for their E-Portfolio that synthesises the properties of common spectral targets and describes the characteristics of a hypothetical sensor suitable to observe a target of interest.
	2	Vegetation Analysis	Students will apply different band combinations and spectral indices to online and downloaded Landsat imagery to analyse change in vegetation properties over time. Students will produce a vegetation analysis report for their E-Portfolio that evaluates change in forest cover/health for an area of interest in Bhutan.
	3	Land-use classification	Students will compare supervised and unsupervised classification techniques to map land-use patterns. Students will produce a final report for their E-Portfolio documenting a landcover classification analysis for an area of interest in Bhutan.
	4	Observing Natural Hazards	Students will apply visual analysis techniques to true color imagery for the monitoring and assessment of natural hazards. Students will produce a final report for the E-Portfolio that that documents Himalayan glacial retreat and earthquake damage assessment.
II. GIS	5	Working with GIS Data	Students will practice the basic skills of GIS data acquisition and management including: data creation, digitization, coordinate systems, georeferencing, and editing. Students will assemble an annotated spatial data collection of common data in Bhutan (environmental, infrastructure, demographics, etc.) for their E-Portfolio. Students can use this organised data for future projects.
	6	Basics of Spatial Analysis	Students will apply the skills of basic spatial analysis (including: proximity, summarization, routing, and spatial statistics) to data generated in the previous practical. Students will create a workflow report outlining processes of the common analysis techniques for their E-Portfolio. Each technique will

			include a final product display that can be used in future geographic teaching exercises.
	7	Creating Cartographic Products	Students will use the data and analysis products generated in previous practicals to design and create a professional cartographic product. Students must choose appropriate design characteristics and thematic representations to best communicate the findings from their data. Students will be guided through the creation of static maps and online mapping products (i.e. story maps and applications). Final products will be added to the student's E-Portfolio.
III. GST in Education	8	Teaching with GST	Students will develop a lesson plan that uses products from their E-Portfolio to achieved targeted outcomes in geography curriculum standards, geospatial thinking and reasoning, and GNH values. Students will write a final synthesis for their portfolio reflecting on the opportunities, challenges, and proposed solutions for integrating geospatial technologies in their future geography teaching.

Reading Lists

Essential Reading

Anji, R., M. (2016). *Textbook of remote sensing and GIS*. Hyderabad: BS Publications.

Balram, S., & Boxall, J. (Eds.). (2019). *GIScience teaching and learning perspectives*. New York: Springer.

Burrough, P.A., & McDonnell, R. A. (2013). *Principles of Geographic Information Systems.* New York: Oxford University Press.

Committee on the Support for the Thinking Spatially, Committee on Geography, & National Research Council. (2006). *Learning to think spatially: GIS as a support system in the K-12 curriculum*. National Academies Press.

Lillesand, T., Keifer, R. W., & Chipman, J. (2015). *Remote sensing and image interpretation*. New York: John Wiley and Sons.

Muñiz Solari, O., Demirci, A., & Schee, J. (Eds.). (2015). *Geospatial technologies and geography education in a changing world*. Spring. https://doi.org/10.1007/978-4-431-55519-3

Additional Reading

Baker, T. R., Battersby, S., Bednarz, S. W., Bodzin, A. M., Kolvoord, B., Moore, S., … Uttal, D. H. (2015). A research agenda for geospatial technologies and learning. *Journal of Geography*, *114*(3), 118–130. doi.org/10.1080/00221341.2014.950684

Bednarz, S. W. (2004). Geographic Information Systems*:* A tool to support geography and environmental education? *GeoJournal*, *60*(2), 191-199.

Bodzin, A. M., & Anastasio, D. (2006). Using web-based GIS for earth and environmental systems education. *Journal of Geoscience Education*, *54*(3),295-300.

Church, R. L., & Murray, A. T. (2009). *Business site selection, location analysis, and GIS*. Hoboken, NJ: John Wiley & Sons.

Crampton, J. W. (2011). *Mapping: A critical introduction to cartography and GIS* (Vol.11). Neqw York: John Wiley & Sons.

Goodchild, M. F. (2009). Geographic information systems and science: today and tomorrow. *Procedia Earth and Planetary Science*, *1*(1), 1037-1043.

Jensen, J. R. (2007). *Remote sensing of the environment*: *An earth resource perspective*. Singapore: Pearson Education (Singapore) Ptc. Ltd. SK products.

LeGates, R. T. (2005). *Think globally, act regionally: GIS and data visualization for social science and public policy research*. Redlands, CA: Esri Press.

Machiwal, D., Mishra, A., Jha, M. K., Sharma, A., & Sisodia, S. S. (2012). Modeling short term spatial and temporal variability of groundwater level using Geostatistics and GIS. *Natural resources research*, *21*(1), 117-136.

Mohan, A., & Mohan, L. (2013). *Spatial thinking about maps: Development of concepts and skills across the early school years* (p. 46). National Geographic Education Programs.

Moorman, L. (2019). The evolution and definition of geospatial literacy. In *GIScience teaching and learning perspectives* (pp. 9–36). New York, NY: Springer Science+Business Media, LLC.

National Research Council, & Geographical Sciences Committee. (2005). *Learning to think spatially*. National Academies Press.

Nayak S., & Zaltanova, S. (Eds) (2008). *Remote sensing and GIS technologies for monitoring and prediction of disasters.* Springer Science & Business Media.

Mitchell, A. (2001). *ESRI guide to GIS analysis.* ESRI Press. USA: Red Lands.

Solimini, D. (2016). *Understanding earth observation: The electromagnetic foundation of remote sensing* (Remote Sensing and Digital Image Processing) (1st ed). New York: Springer.