GE/ES 340 - GEOGRAPHIC INFORMATION SYSTEMS (GIS)
IES Abroad Freiburg

DESCRIPTION:
This course introduces the fundamental concepts of Geographic Information Systems (GIS) and the major functionality of the open-source GIS application QGIS. After presenting various definitions of GIS, the basic principles of modelling the infinitely complex real world in a computer system with limited resources are portrayed. Different data models, such as vector and raster data, and their respective (dis-)advantages are discussed, and the relational data model is introduced. The essentials of geographic reference systems and transformations are shown and possible problems related to working with data from different data sources are discussed. Basic vector as well as raster data analyses are conducted and the most commonly used tools for data analyses are presented. Wherever possible, data from original research projects or the students' hometowns is used.
This course has an extensive practical component. Typically, afternoon sessions take place in the computer lab where students learn solving spatial problems using GIS software. Sample data is either provided by the instructor or students research datasets for their respective hometowns online. The students work on specific tasks individually or in small groups in order to deepen the understanding of basic concepts of GIS. The results are presented and are evaluated as part of the class participation grade.
Through the course, the students should acquire a knowledge base that enables them to conduct their own GIS projects (e.g. in the course of their Master thesis), including data collection, preparation, analyses and presentation in form of maps. Furthermore, the students learn how to work with the software QGIS that is widely used in public administration, private enterprises, and non-profit organizations.

CREDITS: 3 credits

CONTACT HOURS: 46 hours

LANGUAGE OF INSTRUCTION: English

PREREQUISITES: Basic knowledge of geographic reference systems as well as data formats, computer literacy.

ADDITIONAL COST: none

METHOD OF PRESENTATION:
- Lectures
- E-Learning
- Student presentations
- Tutoring/ practical exercises
- Group work
- Application of Moodle

REQUIRED WORK AND FORM OF ASSESSMENT:
- Course participation – 10 %
- Midterm Exam – 20 %
- Written Assignment – 20 %
- Final Exam – 50 %

Course Participation – 10 %
Students are expected to participate in debates with questions related to the readings and Students are required to complete all reading assignments and will be expected to demonstrate this through regularly assigned homework, pop quizzes, and/or insightful and relevant contributions to in-class discussion. All these components will count toward the class participation grade. Participation also applies to course-related trips, outings and/or special events in and around Freiburg. A rubric for participation is available in the appendix and on Moodle.

Midterm Exam – 20 %
The mid-term assessment is a written exam and tests the students' overall knowledge and ability to analyze and apply the concepts presented during the first week of the course.

Final Exam – 50 %
The final assessment is a written exam and tests the students' overall knowledge and ability to analyze and apply the concepts presented during the course.

Written Assignment – 20 %
The assignment takes the form of a project report (around ten pages); a number of topics for data analyses are named by the instructor. Based on the lectures (theoretical input) and E-Learning modules (practical knowledge), each student works on a small GIS project from data search to data presentation.

LEARNING OUTCOMES:
By the end of the course students will be able to:

- Implement the principles of GIS as a digital representation of complex spatial interactions in the real world.
- Search for possible spatial data sources and critically review their quality, comprehensiveness, and suitability for the respective task.
- Visualize spatial data and the respective attributes.
- Conduct basic analyses using vector data as well as raster datasets.
- Produce maps showing the results of spatial analyses in an easy-to-understand manner.
- Analyze and discuss the potential as well as the constraints of GIS for spatial analyses on different scales.
- Manage complex spatial problems and a complex and powerful software package.

Attendance Policy (see also the detailed version on Moodle ESS Academics page)
IES Abroad courses are designed to utilize the unique contribution of the instructor; the lecture/discussion format is regarded as the **primary mode of instruction**. Therefore, attendance is mandatory. Any unexcused absence will incur a penalty on your final course grade. Deductions from grades due to absences are based on contact hours (= 45 minutes). Any unexcused absence will result in a penalty on your final course grade (1 unexcused contact hour absence - 1%, 2nd unexcused contact hour absence -2%, 3rd unexcused contact hour absence – 3% and so on). Any student who misses more than 25% of a course (= more than 11 contact hours), whether the absences are excused or are unexcused, will receive an "F" as the final grade in the course.
ESS courses may have entire course blocks that take place on one day in addition to longer field trips that count for several contact hours. In this case, the actual missed contact hours are added together, and the absences are sanctioned according to the rule above. If you are late for a planned field trip, you will generally not be able to join the trip, since the group needs to leave on time and cannot wait for one person. Punctuality is therefore essential here. If you miss a class, it is **your responsibility** to make up on everything that was covered in class. Tests/presentations missed during unexcused absences **cannot be made up.**
Arriving late for class: Punctuality is important for the planned course schedule. If you are late for class, the late time will be recorded and added up at the end of the course. You will receive a grade reduction based on the accumulated amount of missing contact hours (as outlined above; i.e., if you were late by 15 minutes on 3 days, your grade would be reduced by 1% for 1 missing contact hour).
LATE OR FAILURE SUBMISSION OF ASSIGNMENTS: Late submission of assignments or failure of submission of assignment results in the grade F of that particular assignment. This does not apply to late or non-submission due to illness with an excused absence.
Excused absence: Please call the IES Center before the start of your first class if you are ill and would like to be excused from your course, as outlined in the "Cell Phone and Attendance Policy" handed out during orientation. Student Affairs staff will decide whether your absence can be excused directly or whether a doctor's note is necessary. Absences due to religious observances and family emergencies may be excused at the discretion of the Center Director, with written approval. A petition for an excused absence due to a religious holiday needs to be submitted 2 weeks in advance. If permission is granted, the student needs to inform the Academic

Dean, the Student Affairs Team and their instructors. Absences due to private travel or travel delays cannot be excused, even with advanced notice.

ACADEMIC INTEGRITY CODE:
Students are expected to abide by the IES Abroad Code of Academic Integrity. The detailed IES Abroad academic integrity code can be accessed on Moodle.
All work submitted by a student for academic credit should constitute the student's own original work. Regardless of the quality of work, plagiarism will result in a failing grade for the course and/or an academic review and possible expulsion from the program. Plagiarism may be broadly defined as "copying of materials from sources, without acknowledging having done so, claiming other's ideas as one's own without proper reference to them, buying materials such as essays/exams, and using AI-generated content without disclosure."
As AI tools continue to evolve, learning how to use them responsibly is an important emerging skill. Some of our courses allow students to explore the use of generative artificial intelligence (GAI) tools such as ChatGPT for some assignments and assessments. The instructor of each course will communicate whether GAI may be used in a course and provide specific guidelines and procedures for its appropriate use.

Updated information on your course and readings, including additional readings from journalistic articles, can be found on the Moodle platform at https://moodle.iesabroad.org/login/index.php

CONTENT:

Week	Content	Assignments and Readings
Week 1	**Session 1: General Introduction and Introduction of QGIS** This session gives a presentation of the course content followed by an overview of the different proprietary as well as open-source software packages that can be used for spatial analysis. The GIS application QGIS is introduced**.**	
	Session 2: Definition of GIS, basic data models Several definitions of GIS used by different actors are presented and discussed. Fundamental data models (vector data vs. raster data) are introduced and ways of systematically representing the complex real world in computer software are shown. Furthermore, the georelational data model as the foundation for spatial analysis is portrayed.	Making a map. Basic vector styling.
	Session 3: Geographic coordinate systems The students gain understanding of the principles of referencing geodata, based on varying reference systems. Furthermore, they learn how to	Working with projections.

	transform datasets having different coordinate reference systems. As spatial data – even for small GIS projects – often is provided in different reference systems, understanding the differences is essential.	
	Session 4: Databases, data formats, value ranges During this session, an overview is given of the different ways of storing spatial data. Particular attention is given to databases in general, and geodatabases in particular. The importance of database normalization is emphasized, and the three basic Normal Forms are introduced. Different data types are mentioned, and their respective (dis-)advantages are discussed. Eventually, data ranges are explained, and their application is shown.	Importing Spreadsheets or CSV files Working with WMS Data
Week 2	**Session 5: Relational Database Management Systems (RDBMS)** Relational database management systems (RDBMS) as the most common way of storing spatial data is explained extensively. In the second part of this session, the Structured Query Language (SQL) is introduced, and students learn how to apply basic SQL terms. Furthermore, they learn to link different datasets using 'join' and 'relate'.	Searching and Downloading OpenStreetMap Data
	Session 6: Topology and Data Consistency In this session, an overview is given of data topology in general and topology of spatial data in particular. Students learn why data consistency is important and how to make sure that data is captured, edited, and stored in a consistent way. Particular attention is thereby given to the ArcGIS Geodatabase Topology and its implementation in the data editing workflow.	Calculating Line Lengths and Statistics Working with attributes Handling invalid geometries
	Session 7: Geometric and Topologic Queries, Toolboxes The students learn what the differences are between geometric and topologic queries, how to design these queries and how to execute them in ArcGIS. As a basic principle they get to know the Egenhofer-Matrix as well as the Clementinis-Matrix. An overview is given about the most commonly used Toolboxes and Tools within the software environment and examples are provided when the respective tools can be used.	Performing Table Joins Performing Spatial Joins
	Session 8: Modifiable Area Unit Problem (MAUP), Ecological Fallacy, and GIS The Modifiable Area Unit Problem (MAUP) as one of the challenges in spatial analyses is introduced and ways of solving this issue are presented. Furthermore, the ecological fallacy as an additional potential trap in geodata analyses is discussed. Students will get to know a standardized way of translating real world problems into a smooth GIS workflow. Therefore, complex problems are disaggregated into smaller problems that can be solved using individual GIS tools.	Performing Spatial Queries Nearest Neighbor Analysis

Week 3:	**Session 9: How to Search and Find Geodata, Geodata Infrastructures, Selected Examples** This session concentrates on finding suitable geodata for different kinds of research questions. Several online databases as potential data sources are introduced and students practice data import into GIS. Standardized geodata infrastructures, such as the GDI-DE, INSPIRE, and an online database of the Food and Agriculture Organization of the United Nations are portrayed. The students learn to critically evaluate the suitability of datasets for their respective research project.	Search and find Geodata
	Session 10: Raster Data Analysis, Terrain Analysis While the main focus of this course is on vector data analysis, this session focusses on the analysis of raster data. A wide range of possible analyses are shown, and students gain practical experience in basic analysis steps. A Digital Elevation Model (DEM) is provided and some terrain analyses, such as slope, visibility analysis, and contour line generation are reproduced by the students. Furthermore, an overview of hydrological analyses is given.	Basic Raster Styling and Analysis Raster Mosaicking and Clipping Working with Terrain Data
	Session 11: Georeferencing Raster Data In the course of spatial analysis projects, unreferenced raster data, such as scanned maps and survey plans, often form the foundation of the analysis. Therefore, the students learn how to georeference raster data based on ground control points. The importance of referenced data is emphasized using the example of multi-temporal satellite images of the Amazonian pioneer front. Polynomial transformations are introduced and the implementation of the process in GIS is shown.	Sampling Raster Data using Points or Polygons Interpolating Point Data
	Session 12: Capturing Data Different ways of capturing data are presented and evaluated. Students get to know the basic principles of GPS usage in the field as well as more sophisticated devices, such as Qfield or KoboToolbox. Limitations and potentials of using these devices in the field are discussed and students gain an understanding of which tools should be used in which environments.	Georeferencing Topo Sheets and Scanned Maps Georeferencing Aerial Imagery
	Session 13: Repitition and Q&A The contents of the course are briefly summarized and the main lessons learnt are emphasized. The students are given the chance to address open questions. An outlook is given on the final exam.	

REQUIRED READINGS:

- Bernhardsen, T. Geographic Information Systems: An Introduction. 3rd Edition. New York: Wiley, 2002.

- Bradley, B. Introduction to GIS – Spatial Analyst. Lecture Materials, 2014.URL: http://bit.ly/1kGKIh2
- Diamond, L. Geographic Data Assumptions: MAUP and Ecological Fallacies, 2013. URL: http://bit.ly/1uAZzgw
- Huisman, O. and de By, R.A. Principles of Geographic Information Systems. An introductory textbook, 4th Edition. Enschede: Spears Media Press, 2009.
- McEntee, J. and Agyeman. J. "Towards the development of a GIS method for identifying rural food deserts: Geographic access in Vermont, USA," in Applied Geography, 30 (2010), pp. 165-176.
- Tripathi, R. et al. "Climate change, urban development, and community perception of an extreme flood: A case study of Vernonia, Oregon, USA," in Applied Geography, 46 (2014), pp. 137-146.
- Van Haaren, R. and Fthenakis, V. "GIS-based wind farm site selection using spatial multi-criteria analysis (SMCA): Evaluating the case of New York State," in Renewable and Sustainable Energy Reviews, 15/7 (2011), pp. 3332-3340.

RECOMMENDED READINGS:

- Jokar Arsanjani, J. et al. OpenStreetMap in GIScience. Experiences, Research, and Applications. Lecture Notes in Geoinformation and Cartography, Heidelberg/New York: Springer, 2015.
- Krygier, J. Making Maps, Second Edition: A Visual Guide to Map Design for GIS. New York City: Guilford Publications, 2011.
- Longley, P. Geographic information systems & science. Hoboken: Wiley, 2011.
- Nyerges, T. The SAGE handbook of GIS and society. Los Angeles: SAGE Publications, 2011.

Appendix:

Rubric for course participation:

A	**Excellent participation** The student's contributions reflect an active reading of the assigned bibliography. Skillfully synthesizes the main ideas of the readings and raises questions about the applications and implications of the material. Demonstrates, through questions and comments, that they have been capable of relating the main ideas in the readings to the other information discussed in the course and with their own life experience. The student makes informed judgments about the readings and other ideas discussed in class, providing evidence and reasons. They respectfully state their reactions about other classmates' opinions and can contribute to the inquiry spiral with other questions. The student gets fully involved in the completion of the class activities.
B	**Very good participation** The student's contributions show that the assigned materials are usually read. Most of the time, the main ideas are identified, even though sometimes it seems that applications and implications of the information read were not properly reflected upon. The student can construct over others' contributions, but sometimes seems to interrupt the shared construction to go over tangents. They are respectful of others' ideas. Regularly involved in the activities but occasionally loses concentration or energy.
C	**Regular participation** The participant evidences a regular reading of the bibliography but in a superficial way. They try to construct over others' ideas, but commonly provide comments that indicate a lack of preparation about the material. Frequently, contributions are shallow or unarticulated with the discussion in hand.
F	**Insufficient participation** Consistently, the participant reads in a shallow way or does not read at all. Does not participate in an informed way and shows lack of interest in constructing over others' ideas.