Climate Change Induced Disaster Management in Africa

Course Syllabus

Course title

Spatial Modelling for Disaster Analysis

Course ECTS credits: 10+5

Course hour distribution by methods of studies

Lectures	Exercises	Self-study	Seminar	Final project	Total
20h+10h	50h+30h	120h+75h	10h+10h	50+0h	250h+125h

Annotation of the course

This course is intended for students of mathematics, geography, environmental studies, engineering, and sustainability at both undergraduate and graduate levels.

This course will introduce spatial analysis and spatial modelling for disaster risk analysis and disaster management. This course is organized into two modules: one of 10 ECTS and one of 5 ECTS. The 5 ECTS module requires that the 10 ECTS one is acquired first. The first module introduces key concepts and methods for spatial analysis and modelling, then the 5 ECTS module presents an introduction to advanced spatial modelling, disaster modelling and damage assessment.

Aim of the course

This course aims at providing an in-depth knowledge and skills on the use of Geographic Information System (GIS), Remote Sensing (RS) and Spatial Modelling for effective disaster risk analysis, vulnerability assessment, mitigation, and management. Students will learn geospatial information science and technology related concepts, techniques, algorithms, and tools that can be used for Disaster Risk analysis and disaster Management.

Learning outcomes

On completion of the course, the student should be able to:

Knowledge and understanding

- Understand basic GIS and RS concepts
- gain in-depth knowledge and understanding of spatial analysis and spatial modelling
- Understand disaster management issues, especially urban disaster management issue, and how spatial analysis and spatial modelling can be used for disaster analysis and management
- Know what kind of data in general, free and open data in particular and which GIS, RS, and spatial modelling methods and functions are suitable for disaster analysis and management.

Skills and abilities

- be able to collect, analyze, and process geospatial data
- be able to use GIS, RS and spatial modelling tools
- be able to apply GIS, RS and spatial modelling tools for disaster risk analysis, vulnerability assessment, mitigation, and management in Mozambique
- Plan and conduct project-based activities

Critical judgement and evaluation

- Evaluate geospatial data quality and adequacy.
- Evaluate tools' and models' effectiveness
- Assess disasters risks and severity, and apply effective methods and applications towards providing mitigation recommendations
- Validate proposed solutions and understand the uncertainty

Methods of course studies (*Educational approach*)

Integrated approach (theory and practice): theory in parallel with applications and examples
Project-based learning

Methods for the assessment of student achievements (*the formula and the definition of the cumulative score)*

Tests and Exercises: 60%
Final Project (includes a report and a presentation): 40%

Study subject modules to be completed before this Course studies (*Prerequisites*)

Basic knowledge of mathematics, geography, physical processing, environmental studies, other natural sciences, engineering.
Basic skills of Information Technologies.

Schedule (lectures)

10 ECTS

Date	Topic	Objectives
Week 1	Core module, common to all courses: introduction to GIS and Remote Sensing 1.1. Basic data structures for both vector and raster (POLIMI) 1.2. Basic projections and coordinate systems (POLIMI) 1.3. Attribute handling and spatial operations (SQLs, buffers, spatial searches, overlays) (LU) 1.4. Basic Cartographic principles (POLIMI) 1.5. Basic electromagnetic radiation theories (LU) 1.6. RS resolutions (Spatial, Temporal, Radiometric, Spectral) (IST) 1.7. Different RS Sensors (IST) 1.8. Passive RS data formats, geo-referencing, metadata and resampling (LU) 1.9. Introduction to LiDAR and SAR (Active Sensors), plus Thermal RS (KTH) 1.10. Image pre-processing, enhancement and transformations (KTH) 1.11. Image classification (KTH)	Introduction to GIS and Remote Sensing
Week 2	Introduction to Spatial Analysis	Define and explain the unique features of spatial phenomena such as spatial autocorrelation, spatial heterogeneity, multiple area unit problem; Explain the importance of spatial modelling; Describe the process of cartographic modelling and multi-criteria evaluation
Week 3	Advanced Spatial Analysis	Spatial statistics: define spatial autocorrelation, describe and apply methods / measures for its detection using Moran's I, Geary's C, its characterization (variogram), spatial interpolation methods such as Inverse Distance Weighting (IDW) and Kriging, spatial regression (Geographically Weighted Regression (GWR))
Week 4	Introduction to Spatial Modelling	Provide an introduction to spatial modelling methods: • Spatial regression models
Week 5	RS for near real-time disaster monitoring and damage assessment	Provide an introduction to remote sensing for disaster management including: • Near real-time disaster monitoring with examples on droughts, flooding and wildfire monitoring
Week 6	GIS for disaster risk analysis and vulnerability assessment	Provide an introduction to for disaster risk analysis and vulnerability assessment, including

		• Apply GIS/remote sensing in hazard, vulnerability, and risk assessment • Visualize hazard and risk information
Week 7	Remote Sensing/GIS for disaster damage assessment	Provide an introduction to disaster damage assessment using remote sensing and GIS.

+5 ECTS

Week 1	Introduction to Advanced Spatial Modelling	Provide an introduction to advanced spatial methods: • Cellular automata • Agent-based modeling
Week 2	Spatial modelling for disaster risk analysis, e.g., Fire Weather Index (FWI), a meteorologically based model used worldwide to estimate fire danger.	Provide an introduction to Spatial modelling for disaster risk analysis, with examples on wildfires, • Fire Weather Index
Week 3	Remote Sensing/GIS for disaster damage assessment Examples	Provide addition examples of disaster damage assessment using remote sensing and GIS.

Schedule (Exercises, Lab work/Self-studies)

10 ECTS

Date	topic	Type*/objective
Week 1	Introduction to GIS and Remote Sensing	Gain basic analytical skills in GIS and Remote Sensing
Week 2	Spatial Analysis I: Map Algebra, Multi Criteria Evaluation (MCE)	Apply map algebra and MCE in the context of disaster management using QGIS, e.g., find suitable locations for emergency field hospitals.
Week 3	Spatial Analysis II: Spatial Autocorrelation, Interpolation, and Regression	Apply interpolation and spatial regression to model the relationship between topography, rainfall, land-use / land-cover and flood damage in QGIS.
Week 5	Project 1 Part 1: Remote Sensing for Near Real-Time Flood Mapping and Damage Assessment	Apply SAR remote sensing for near real-time flood mapping using GEE.
Week 6	Project 1 Part 2: Remote Sensing for Near Real-Time Flood Mapping and Damage Assessment	Apply optical remote sensing for flood damage assessment using GEE.
Week 7	Project 2 Part 1: Wildfire Modelling	Understand fire behaviour in tropical savannas with “Incendiary” simulation models.

+5 ECTS

Week 1	Introduction to Advanced Spatial Modelling	Learn Game of Life, one of the most common examples of two-dimensional Cellular Automata (CA) models within the programmable modelling environment NetLogo.
Week 2	Project 2 Part 2: Remote Sensing for Burn Severity Mapping	Apply remote sensing for wildfire burn severity mapping using GEE.
Week 3	Project 2 Part 2: Remote Sensing for Burn Severity Mapping (continued)	Apply remote sensing for wildfire burn severity mapping using GEE.

* e.g. answering questions, collecting data, performing analysis, writing codes, etc.

Schedule (Seminar, Project)

10 ECTS

Date	topic	Type*/objective
Week 1	Introduction to GIS and Remote Sensing	Introduction to GIS and Remote Sensing
Week 2	Introduction to Spatial Analysis	Understand basic spatial analysis concepts and analytical methods
Week 3	Advanced Spatial Analysis	Understand advanced spatial analysis concepts and analytical methods
Week 4	Introduction to Spatial Modelling	Understand basic concepts of spatial modelling
Week 5	RS for near real-time disaster monitoring and damage assessment	Understand the literature on remote sensing for near real-time disaster monitoring and damage assessment
Week 6	GIS/RS for disaster risk analysis and vulnerability assessment	Understand the literature on GIS/RS for disaster risk analysis and vulnerability assessment
Week 7	GIS/RS for disaster risk analysis and vulnerability assessment (continued)	Understand the literature on GIS/RS for disaster risk analysis and vulnerability assessment

+5 ECTS

Week 1	Introduction to Advanced Spatial Modelling	Understand advanced spatial modelling: • Cellular automata • Agent-based modeling
Week 2	GIS/RS for disaster damage assessment	Understand the literature on GIS/RS for disaster damage assessment

Week 3	Project	Project

Main bibliography (no more than 3 sources)

No.	Publication authors, year of issue, name, place of issue, publisher, (address of electronic publications and website)
1	Geospatial Analysis - A comprehensive guide
2	Geographic Information Systems (GIS) for Disaster Management
3	Geospatial Techniques in Urban Hazard and Disaster Analysis

Additional bibliography (no more than 10 sources)

No.	Publication authors, name, place of issue, publisher, year of issue (address of electronic publications and website)
1	Weekly reading list, see examples below:
2	Jarkko Kari. Cellular Automata: Tutorial https://grammars.grlmc.com/LATA2008/slides/lata2008_cellular_automata.pdf
3	Teng, J., A.J. Jakeman, J. Vaze, B.F.W. Croke, D. Dutta, S. Kim, 2017. Flood inundation modelling: A review of methods, recent advances and uncertainty analysis. Environmental Modelling & Software, Volume 90, pp. 201-216, https://doi.org/10.1016/j.envsoft.2017.01.006.
4	Hartnett, M and S. Nash, 2017. High-resolution flood modeling of urban areas using MSN_Flood, Water Science and Engineering, Volume 10, Issue 3, pp. 175-183, https://doi.org/10.1016/j.wse.2017.10.003.
5	Oulad Sayad, Y., H. Mousannif, H. Al Moatassime, 2019. Predictive modeling of wildfires: A new dataset and machine learning approach, Fire Safety Journal, Volume 104, pp. 130-146, https://doi.org/10.1016/j.firesaf.2019.01.006.
6	F Di Giuseppe et al., 2020. Fire Weather Index: the skill provided by the European Centre for Medium-Range Weather Forecasts ensemble prediction system. EGU2020. https://nhess.copernicus.org/articles/20/2365/2020/nhess-20-2365-2020.pdf
7	Hadi Allafta & Christian Opp (2021) GIS-based multi-criteria analysis for flood prone areas mapping in the trans-boundary Shatt Al-Arab basin, Iraq-Iran, Geomatics, Natural Hazards and Risk, 12:1, 2087-2116, DOI: 10.1080/19475705.2021.1955755.
8	Kurbanov, E.; Vorobev, O.; Lezhnin, S.; Sha, J.; Wang, J.; Li, X.; Cole, J.; Dergunov, D.; Wang, Y. Remote Sensing of Forest Burnt Area, Burn Severity, and Post-Fire Recovery: A Review. *Remote Sens.* **2022**, *14*, 4714. https://doi.org/10.3390/rs14194714.

Required IT Resources

No.	*Name of the software, manufacturer*	*License type*
1	QGIS	Open access
2	Google Earth Engine (GEE)	Open access
3	Cellular Automata	Open access
4	Fire Weather Index (FWI)	Open access

Course completed by

(Signatures)

(Signatures)

Project Coordinator

(Signature)

Confirmation

The module certified by	Faculty of ….., University of ….		
Chairman of the studies committee (full name, signature)		**Date**	