GEM MSc

GEM Study Guide

Erasmus Mundus Joint Master Degree in Geo-Information Science and Earth Observation for Environmental Modelling and Management (**GEM**)

Version published on 1st of December 2020

ITC UNIVERSITY OF TWENTE.

UNIVERSITY OF TARTU

UCLouvain

LUND UNIVERSITY

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www.gem-msc.eu

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What is in this study guide

This study guide provides an overview of the structure and courses of the Erasmus Mundus Joint Master Degree in Geo-Information Science and Earth Observation for Environmental Modelling and Management (**GEM**) Master's programme for the academic year starting in September 2021.

The guide introduces the four partner universities, the structure and tracks of the **GEM** programme, and the overall learning outcomes of the **GEM** programme.

It also provides practical information on key dates in the academic calendars of each partner university (where already known for 2021-2023), and the scheduled teaching hours.

Finally, each course is presented with a description, course learning outcomes, teaching, and learning approach, time allocations, and assessment methods.

Practical information for students on travel, visas, housing, facilities, associations, and key contacts will be published in 2021 in the **GEM Student Handbook**.

Since this is an early edition of our study guide, details about specific dates and courses may change slightly, but the overall programme remains the same.

Introduction to the GEM programme

About the GEM programme

GEM is a two-year Master Degree programme of 120 ECTS. It is supported by the Erasmus+ Programme of the European Union. **The first intake is September 2021**. **GEM** integrates academic excellence from four leading universities and their respective MSc programmes in geospatial science in a strategic partnership to support innovative academic practices. Each partner addresses different aspects of human-environment interaction challenges with applied geospatial science:

- Natural resources management at ITC-University of Twente, the Netherlands (**ITC**)
- Ecosystems and the environment at Lund University, Sweden (**LU**)
- Agriculture and forestry at Université catholique de Louvain, Belgium (**UCLouvain**)
- Socio-ecological systems and urban planning at University of Tartu, Estonia (**UT**)

The **GEM** programme also includes several **associate partners** around the world from research, industry, public sector, and non-governmental organisations. They participate in joint events, internships and MSc theses, and bring real-world challenges and stakeholders into the classroom. Collaborating with these partners is designed to train students to become high-skilled professionals in geo-information (GI) and Earth observation (EO) science with a solid foundation in applied socio-environmental/socio-ecological modelling. The **GEM** programme:

- Bases its innovative teaching approaches on collaborative studies with stakeholders to address real socio-ecological challenges. This ensures academic excellence in applying GI and EO science and geospatial technologies to solve social and environmental challenges. Students will understand the scientific process and can apply it in their future careers, both inside and outside academia, to meet sector skill needs.
- Makes extensive use of open-source ICT to bring diverse groups of students, staff, and stakeholders together in virtual environments for interdisciplinary learning. This knowledge alliance ensures the co-creation of science-based solutions and the joint development of open educational materials in the geospatial domain. Students will interact with stakeholders in different sectors, and they will be comfortable doing so.
- Builds upon strategic partnerships between universities and industries to develop professional experience in the use of GI and EO science to address global challenges. This ensures that higher education meets market needs for applying geospatial technologies to environmental and land use issues. Students will develop leadership, negotiation, networking, management, and communication skills.
- Develops capacity by providing fair and equal access to top-tier education, especially to people in emerging and developing economies. This ensures that no one is left behind in terms of access to the geospatial knowledge and tools that support global development. This diversity increases access to education and develops the language and culture skills of students, broadening minds to new ways of thinking.

GEM programme learning outcomes

The aim of the **GEM** programme is to deliver top class graduates from the EU and around the world, with the skills and networks to better manage socio-ecological systems for sustainable and equitable growth. The learning outcomes for students who follow the **GEM** programme have been designed to relate to the programme aim, to refer where possible to relevant external reference points, and to provide clear expectations to staff, students, examiners and stakeholders.

The ten learning outcomes are organised in three groups.

Knowledge and understanding in technical and application domains. By the end of the programme, graduates will be able to:

1. Explain and apply geographical information management principles.
2. Use and design modern and innovative GIS, remote sensing, and related tools for environmental modelling and management.
3. Formulate and defend recommendations on how geo-spatial science and data can be used to address grand challenges/sustainable development goals.
4. Describe European and global environmental problems, and then co-design, implement and assess geo-spatial approaches to tackle them at local and regional levels.

Scientific skills. By the end of the programme, graduates will be able to:

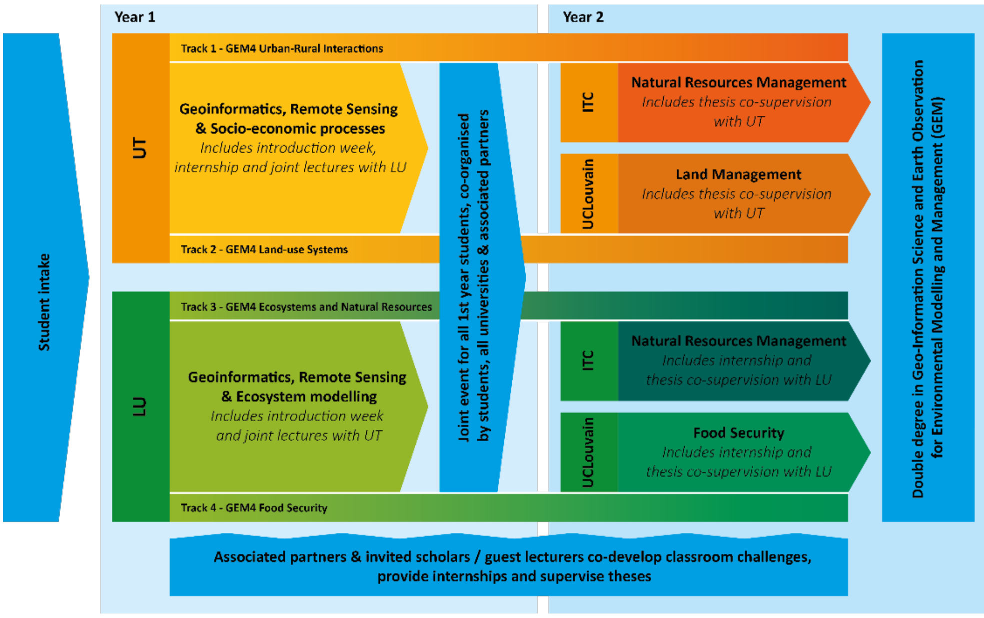
5. Describe the scientific process, plan, and implement scientific research, and synthesise scientific knowledge.
6. Implement FAIR (Findable, Accessible, Interoperable and Reusable) principles and recognise the importance of data documentation (metadata).

Professional and international experience. By the end of the programme, graduates will:

7. Be able to understand and use the principles of project and programme management – including financial and human resource aspects – to plan and implement multi-stakeholder projects.
8. Have developed and practiced teamwork, leadership, critical thinking, adaptability, negotiation, and communication skills.
9. Have developed and practiced their language and cultural skills and reflected on the differences and common values across cultures and societies.
10. Demonstrate that they can interact professionally with the economic and/or public sector in European and global settings.

Programme structure

GEM is organised into a foundation year (60 ECTS) and a specialisation year (60 ECTS) with four unique education tracks to choose from. Each of the tracks fits within the common, thematic approach of the **GEM** programme. Each track addresses societal and environmental challenges in regions where there is demand for GI and EO skills to address them. Successful completion of the compulsory and elective courses, internship, and MSc thesis in a track leads to a double degree.



Double degree in Geo-Information Science and Earth Observation for Environmental Modelling and Management (GEM)								
Track name		**Track 1: GEM4 Urban-Rural Interactions**		**Track 2: GEM4 Land Use Systems**		**Track 3: GEM4 Ecosystems and Natural Resources**		**Track 4: GEM4 Food Security**
Year 1 (60 ECTS)	UT	Compulsory - Data and analysis courses (26 ECTS)	UT	Compulsory - Data and analysis courses (26 ECTS)	LU	Compulsory - Geographical Information Systems, Basic Course (15 ECTS)	LU	Compulsory - Geographical Information Systems, Basic Course (15 ECTS)
		Compulsory - Social-economic processes courses (23 ECTS)		Compulsory - Social-economic processes courses (23 ECTS)		Compulsory - Geographical Information Systems, Advanced Course (15 ECTS)		Compulsory - Geographical Information Systems, Advanced Course (15 ECTS)
		Compulsory - Internship (5 ECTS)		Compulsory - Internship (5 ECTS)		Compulsory - Ecosystem Modelling (15 ECTS)		Compulsory - Ecosystem Modelling (15 ECTS)
		Electives (6 ECTS)		Electives (6 ECTS)		Compulsory - Satellite remote sensing (15 ECTS)		Compulsory - Satellite remote sensing (15 ECTS)
Summer	**Joint event for all 1st year students from all four tracks (location rotates each year to another partner)**							
Year 2 (60 ECTS)	ITC	Electives (15 ECTS)	UCLouvain	Compulsory - Land Management (16 ECTS)	ITC	Compulsory - Internship (10 ECTS)	UCLouvain	Compulsory - Internship (10 ECTS)
				Electives (14 ECTS)		Electives (5 ECTS)		Compulsory - Food Security (17 ECTS)
								Electives (3 ECTS)
		Compulsory - MSc research proposal and thesis (45 ECTS)		Compulsory - MSc thesis (30 ECTS)		Compulsory - MSc research proposal and thesis (45 ECTS)		Compulsory - MSc thesis (30 ECTS)

Track 1 - GEM4 Urban-Rural Interactions: In year 1, **University of Tartu** provides geospatial analysis, remote sensing, GI method foundation and socio-ecological / urban and planning. In year 2, **ITC-University of Twente** provides advanced remote sensing and entrepreneurship for natural resource management. This track addresses the challenge of sustainably meeting the natural resource demands of an urbanising world.

Track 2 - GEM4 Land Use Systems: In year 1, **University of Tartu** provides the same foundation year as track 1, but with year 2 at **Université catholique de Louvain** on environmental challenges related to agriculture, forestry, and nature conservation in the context of climate change. This track addresses the challenge of assessing the impact of land use change in a changing climate.

Track 3 - GEM4 Ecosystems & Natural Resources: In year 1, **Lund University** provides the foundation year in geospatial analysis, remote sensing, ecosystem modelling and dynamic process-based spatial models. **ITC-University of Twente** provides courses on environmental monitoring, ecosystem services and geo-journalism for natural resources management to address the challenge of managing and valuing natural resources to enhance the resilience of society.

Track 4 - GEM4 Food Security: In year 2, **Lund University** provides the foundation year with **Université catholique de Louvain** hosting the specialisation year on food security challenges on crop production, including its inter-annual variability and its environmental impacts. This track addresses the challenge of food security in the context of climate change and associated socio-environmental vulnerabilities.

Key dates, teaching periods and teaching hours in the programme

Since this is an early edition of our study guide, specific dates will change slightly when updated to reflect the 2021/22 academic year. Also, more details will be added in subsequent versions.

ITC-University of Twente, the Netherlands (ITC)

Academic calendar	
Event	**Date(s)**
Quartile 1	**31 August 2020 - 6 November 2020**
Quartile 2	**9 November 2020 - 29 January 2021**
Winter break	21 December 2020 - 1 January 2021
Quartile 3	**1 February 2021 - 16 April 2021**
Spring break	22 February 2021 - 26 February 2021
Good Friday	2 April 2021
Easter Monday	5 April 2021
Quartile 4	**19 April 2021 - 2 July 2021**
King's Day	27 April 2021
Liberation Day	5 May 2021
Ascension Day + Bridging day	13 May 2021 and 14 May 2021
Whit Monday	24 May 2021
Summer Break	26 July 2021 - 27 August 2021

Teaching periods	
1st period	08:45 - 10:30
2nd period	10:45 - 12:30
3rd period	13:45 - 15:30
4th period	15:45 - 17:30

There are coffee/tea breaks in the morning after the 1st period, and again in the afternoon after the 3rd period.

Lund University, Sweden (LU)

Academic calendar	
Event	**Date(s)**
Autumn semester	**30 August 2021 – 16 January 2022**
All Saints Day (Alla helgons dag)	6 November 2021
Christmas Day (Juldagen)*	25 December 2021
Boxing Day (Annandag Jul)*	26 December 2021
New Year's Day (Nyårsdagen)*	1 January 2022
Epiphany (Trettondedag)	6 January 2022
Spring semester	**18 January 2022 – 6 June 2022**
Easter Sunday (Påskdagen)*	4 April 2022
Easter Monday (Annandag påsk)*	5 April 2022
Walpurgis Night (Valborgsmässoafton)**	30 April 2022
Labour Day (Första maj)	1 May 2022
Ascension Day (Kristi himmelsfärds dag)	13 May 2022
Whit Sunday (Pingstdagen)	23 May 2022
Sweden's National Day (Nationaldagen)	6 June 2022
Midsummer Eve (Midsommarafton)	25 June 2022
Midsummer Day (Misommardagen)	26 June 2022

* Note on Christmas and Easter holidays: There is no official break in the academic calendar for Christmas or Easter, however in practice there is usually a break from classes over the Christmas/New Year's period and over the Easter period, including the public holiday days.

** Walpurgis Night (Valborgsmässoafton): This is an evening celebration, many workplaces have only half day off.

Teaching periods			
1st period	08:00 - 10:00	or	09:00 – 12:00
2nd period	10:00 - 12:00		
3rd period	13:00 - 15:00	or	13:00 – 16:00
4th period	15:00 - 17:00		

Université catholique de Louvain, Belgium (UCLouvain)

Academic calendar	
Event	**Date(s)**
1st semester and courses	**14 September 2020 – 19 December 2020**
1st semester exam period	**2 January 2021 – 23 January 2021**
French Community Day	27 September 2020
All Saints' Day	1 November 2020
Armistice	11 November 2020
New Year's Day	1 January 2021
2nd semester and courses	**1 February 2021 – 15 May 2021**
2nd semester exam period	**31 May 2021 – 26 June 2021**
Easter	April 4 2021
Easter Monday	5 April 2021
Suspension of classes - Spring break	5 April 2021 – 17 April 2021
Labor Day	1 May 2021
Ascension	13 May 2021
Pentecost	23 May 2021
Whit Monday	24 May 2021
National Holiday	21 July 2021
Assumption	15 August 2021

Teaching periods	
1st period	08:30 – 10:30
2nd period	10:45 – 12.45
3rd period	14:00 – 16:00
4th period	16:15 – 18:15

There are coffee/tea breaks in the morning after the 1st period, and again in the afternoon after the 3rd period.

University of Tartu, Estonia (UT)

Academic calendar	
Event	**Date(s)**
Autumn semester	**31 August 2020 - 31 January 2021**
Christmas holiday	21 December 2020 - 3 January 2021
Christmas Eve	24 December 2020
Christmas Day	25 December 2020
Boxing Day	26 December 2020
New Year's Day	1 January 2021
Spring semester*	**8 January 2021- 27 June 2021**
Winter holiday	1 February 2021- 7 February 2021
Independence Day	24 February 2021
Good Friday	2 April 2021
Easter Sunday	4 April 2021
Spring Day (May Day)	1 May 2021
Whit Sunday	23 May 2021
Victory Day	23 June 2021
St. John's Day (Midsummer Day)	24 June 2021
Day of Restoration of Independence	20 August 2021
Summer holiday	28 June 2021– 29 August 2021

* Officially the spring semester lasts until the end of last full week in August, thus no "typical classes" during July and August but there may be fieldwork, internships etc.

Teaching periods	
1st period	08:15 - 9:45
2nd period	10:15 - 11:45
3rd period	12:15 - 13:45
4th period	14:15 - 15:45
5th period	16:15 – 17:45

There are no fixed lunch or coffee/tea breaks. Lecturers can decide either 90 minutes in a row or with a break and then it may last a full hour.

Track 1 - GEM4 Urban-Rural Interactions

This section first lists all courses by track, with two university partners per track, and then provides the details of each course, partner by partner.

Courses in year 1 at University of Tartu

Course name	Type
Spatial Data Studio (15 EC)	Compulsory
Spatial Data Analysis (5 EC)	Compulsory
Data Science in Remote Sensing (6 EC)	Compulsory
Planning project (15 EC)	Compulsory
Demography, Global Migration and Contemporary Cities (6 EC)	Compulsory
Geography, Communication and Spatial Mobility (6 EC)	Compulsory
Internship (5 EC)	Compulsory
Statistical Data Science (6 EC)	Elective
Geospatial Analysis with Python and R (6 EC)	Elective
Web Mapping (2 EC)	Elective
Spatial Data Infrastructures (6 EC)	Elective
Spatial Databases (6 EC)	Elective
3D modelling and analysis (6 EC)	Elective
Visual Geodata Mining (2 EC)	Elective
Economic Geography of Urban Systems (2 EC)	Elective
Introduction to Urban Planning (2 EC)	Elective
Energy Flows and Material Cycles (3 EC)	Elective
Start-up Project (3 EC)	Elective

Courses in year 2 at ITC-University of Twente

Course name	Type
MSc research proposal and thesis writing (45 EC)	Compulsory
Quantitative remote sending of vegetation (5 EC)	Elective
Entrepreneurship: A bridge towards geospatial innovation (5 EC)	Elective
Environmental Monitoring with Satellite Image Time Series (5 EC)	Elective
Geo-journalism (5 EC)	Elective

Track 2 - GEM4 Land Use Systems

Courses in year 1 at University of Tartu

Course name	Type
Spatial Data Studio	Compulsory
Spatial Data Analysis	Compulsory
Data Science in Remote Sensing	Compulsory
Planning Project	Compulsory
Demography, Global Migration and Contemporary Cities	Compulsory
Geography, Communication and Spatial Mobility	Compulsory
Internship	Compulsory
Statistical Data Science	Elective
Geospatial Analysis with Python and R	Elective
Web Mapping	Elective
Spatial Data Infrastructures	Elective
Spatial Databases	Elective
3D Modelling and Analysis	Elective
Visual Geodata Mining	Elective
Economic Geography of Urban Systems	Elective
Introduction to Urban Planning	Elective
Energy Flows and Material Cycles	Elective
Start-up project	Elective

Courses in year 2 at Université catholique de Louvain

Course name	Type
Decision tools and project management - Part 1: Decision tools for environmental management (3 EC)	Compulsory
Smart technologies for environmental engineering (3 EC)	Compulsory
Human and environmental toxicology (4 EC)	Compulsory
Master thesis (27 EC)	Compulsory
Land monitoring by advanced Earth Observation (3 EC)	Compulsory
Spatial modelling of land dynamics (3 EC)	Compulsory
Master thesis' accompanying seminar (3 EC)	Compulsory
Process-based modelling in bioscience engineering (5 EC)	Elective
Data Science in bioscience engineering - Part 1: Spatial temporal data (3 EC) + Part 2: Seminars and case studies (2 EC)	Elective
Algorithms in data science (5 EC)	Elective
Advanced Hydrology for Engineers (3 EC)	Elective
Decision tools and project management - Part 2: Project management (1 EC)	Elective
Soil erosion and conservation (4 EC)	Elective
Databases (6 EC)	Elective
Field trip – Forest, natural areas and land use (2 EC)	Elective
Economic Geography (5 EC)	Elective

Track 3 - GEM4 Ecosystems & Natural Resources

Courses in year 1 at Lund University

Course name	Type
Geographical Information Systems, Basic Course (15 EC)	Compulsory
Geographical Information Systems, Advanced Course (15 EC)	Compulsory
Ecosystem Modelling (15 EC)	Compulsory
Satellite remote sensing (15 EC)	Compulsory

Courses in year 2 at ITC-University of Twente

Course name	Type
MSc research proposal and thesis writing (45 EC)	Compulsory
Internship (10 EC)	Compulsory
Environmental Assessment using SDSS and advanced EO tools (5 EC)	Elective
Environmental Monitoring with Satellite Image Time Series (5 EC)	Elective
Spatial analyses of ecosystem services: nature's benefits to people (5 EC)	Elective
Geo-journalism (5 EC)	Elective

Track 4 - GEM4 Food Security

Courses in year 1 at Lund University

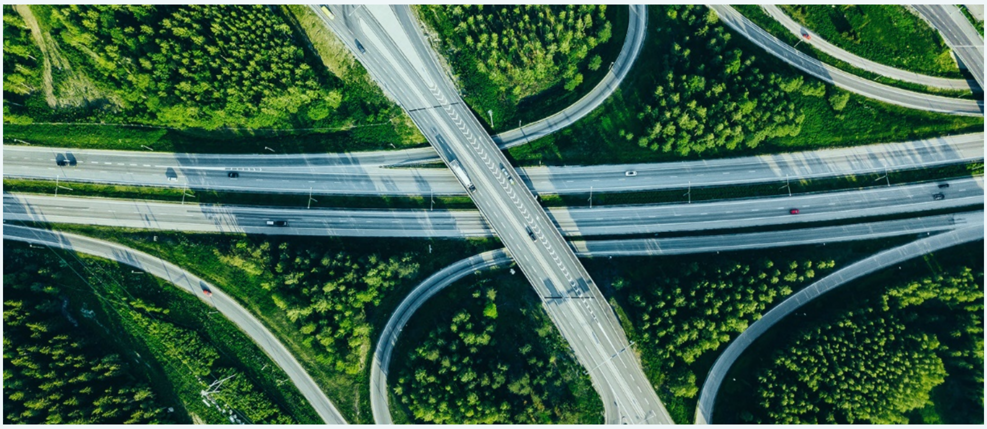
Course name	Type
Geographical Information Systems, Basic Course (15 EC)	Compulsory
Geographical Information Systems, Advanced Course (15 EC)	Compulsory
Ecosystem Modelling (15 EC)	Compulsory
Satellite remote sensing (15 EC)	Compulsory

Courses in year 2 at Université catholique de Louvain

Course name	Type
Elements of Agroecology (3 EC)	Compulsory
Economics of rural development (3 EC)	Compulsory
Smart technologies for environmental engineering (3 EC)	Compulsory
Master thesis (27 EC)	Compulsory
Land monitoring by advanced Earth Observation (3 EC) + part 1: Sustainable food production monitoring (1 EC) description missing at this moment	Compulsory
Soil erosion and conservation (4 EC)	Compulsory
Master thesis' accompanying seminar (3 EC)	Compulsory
Internship (10 EC)	Compulsory
Data Science in bioscience engineering - Part 1: Spatial temporal data (3 EC)	Elective
Data Science in bioscience engineering - Part 2: Seminars and case studies (2 EC)	Elective
Algorithms in data science (5 EC)	Elective
Climatology and hydrology applied to agronomy and the environment (6 EC)	Elective
Agricultural and rural policies (3 EC)	Elective
Decision tools and project management - Part 1: Decision tools for environmental management (3 EC)	Elective
Decision tools and farm management – Part 1: Farm management (3 EC)	Elective
Spatial modelling of land dynamics (3 EC)	Elective
Impact evaluation in agriculture (4 EC)	Elective

Courses in year 1 at University of Tartu

Track 1 - GEM4 Urban-Rural Interactions | Track 2 - GEM4 Land Use Systems



Spatial Data Studio	
Course code	TU-T1-C-001
Course type	Compulsory
Period	13 September 2021 - 15 January 2022
Credits	15
Coordinator	Evelyn Uuemaa
Keywords	spatial data | data quality | geospatial analysis | map design

Description

The students will learn about the variety of spatial data types, formats, and standards of relevant software and data used in GIS. Combined theoretical and practical study, the course has a strong emphasis on developing practical skills in order to get students fluent in working with data.

The lab sessions comprise ⅔ of the course. Main software used in the Spatial Data Studio will be QGIS, Python and PostgreSQL. Remainder ⅓ is covered by lectures of theoretical part and seminars where students present their work. The course will be led by PhD Evelyn Uuemaa and PhD Alexander Kmoch. The course aims to enable the students to effectively acquire, manage, and work with spatial and spatio-temporal data.

In the first part of the studio, students will apply methods of data acquisition in different fields and learn spatial data collection methods. Students will learn how to find, download, clean, and organise data from different data sources into useful data structures. The students will learn about scale, projection, accuracy, and precision of spatial data, and how these relate to the reliability and uncertainties of spatial data, thus, enabling them to use spatial data appropriately.

In the second part, students will design and manage spatial databases using PostgreSQL and access the data across different systems. This part helps to understand the technological basics of spatial databases and data management solutions for the Smart City and the Information Society.

In the third part, geospatial analysis and visualisation will be used on data collected in previous stages. Different spatial problems will be addressed by using spatial analysis and students will learn how to publish/share the results in the web.

Learning outcomes

- Understands and is able to apply methods of data acquisition in different fields
- Is able to design and manage spatial database
- knows the formats and software of important spatial data and databases
- Knows spatial coordinate systems and is able to choose correct coordinate system according to purpose
- Is able to use and create metadata
- Knows main spatial data standards and is able to estimate the spatial data quality
- Is able to independently pose and solve problem based on spatial data
- Is able to perform geoprocessing and basic spatial analysis
- Can perform basic geoprocessing and spatial analysis
- Knows the main concepts of spatial data quality

Content

Spatial Data Studio		
▪ Introduction, main data types in GIS ▪ Coordinate systems and map projections ▪ Open Geospatial Consortium and distributed geodata services ▪ Spatial data quality and data aggregation ▪ Map design ▪ Introduction to remote sensing ▪ Descriptive statistics and data classification in GIS ▪ Spatial urban data and geoprocessing ▪ Global environmental data and raster algebra		
Entry requirements		
Basic statistics; GIS experience (ArcGIS or QGIS); Ideally some geographical background		
Teaching and learning approach		
We combine theoretical lectures with hands-on lab session. Each topic will end with a seminar. Seminars are either based on student presentations and discussions followed afterwards, or debates on relevant topics. We encourage taking part in hackathons that are organised by the course managers or Tartu Science Park.		
Time allocation in hours per activity		
Lecture [contact]	20	
Supervised practical [contact]	40	
Tutorial [contact]	84	
Written/oral test	56	
Individual assignment	96	
Group assignment	38	
Self-study	56	
Sum	**390**	
Assessment		
Examiners	Evelyn Uuemaa, Alexander Kmoch, Bruno Montibeller	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical skills exam 1	8	individual
Practical skills exam 2	8	individual
Practical skills exam 3	8	individual
Practical skills exam 4	8	individual
Practical skills exam 5	8	individual
Practical skills exam 6	8	individual
Practical skills exam 7	8	individual
Practical skills exam 8	8	Individual
Practical skills exam 9	8	Individual
Practical skills exam 10	8	Individual
Final project	20	Individual

Spatial Data Analysis	
Course code	UT-T12-C-002
Course type	Compulsory
Period	1 March 2022 - 31 May 2022
Credits	5
Coordinator	Evelyn Uuemaa
Keywords	spatial analysis | spatial statistics | map algebra | network analysis

Description

The course gives an overview of the technics of spatial data analysis in contemporary geoinformatics and includes several hands-on exercises. The course provides students with skills necessary to investigate spatial patterns of social and environmental processes.

Learning outcomes

- Has a systematic overview of the main ideas of spatial data analysis and main methods.
- Is able to solve spatial analysis tasks by means of the common GIS software.
- Can independently solve complex spatial problems.
- Is able to discuss and reason the choice of spatial method

Content

- Conceptual Frameworks for Spatial Analysis
- Topology
- Spatial Statistics
- Queries, Computations and Density
- Distance Operations
- Grid Operations and Map Algebra
- Modelling Surfaces, Surface Geometry
- Network analysis

Entry requirements

Previous experience with GIS and base understanding of spatial concepts

Teaching and learning approach

Lectures combined with seminars, flipped classroom, practical sessions.

Time allocation in hours per activity

Lecture [contact]	4
Supervised practical [contact]	10
Tutorial [contact]	28
Individual assignment	30
Self-study	60
Sum	**130**

Assessment

Examiners: Evelyn Uuemaa, Kiira Mõisja, Raivo Aunap

Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical skills exam 1	10	individual
Practical skills exam 2	10	individual
Practical skills exam 3	10	individual

Spatial Data Analysis		
Practical skills exam 4	10	individual
Practical skills exam 5	10	individual
Practical skills exam 6	10	individual
Practical skills exam 7	10	individual
Practical skills exam 8	30	Individual

Data Science in Remote Sensing	
Course code	UT-T12-C-003
Course type	Compulsory
Period	1 September 2021 - 30 November 2021
Credits	6
Coordinator	Krista Alikas
Keywords	Remote Sensing | Copernicus | Ecosystem | Forestry | Waterbodies | Agriculture | Environment

Description

The course will focus on various methods and applications used in remote sensing of environment.

An overview will be given about passive and active remote sensing. Students will learn how to combine data from various origin and sources to analyse the changes in environment.

In the beginning of the course students can select a topic which they start to solve in a smaller group.

Every group has a supervisor. Course is based on a problem-based learning method.

Additionally, lectures about various remote sensing applications will be held.

Learning outcomes

- students have the overview about principles used in passive, radar and lidar remote sensing and their respective application fields
- knows the principles of spectral measurements (knows the terms spectrometer, radiance, irradiance, reflectance, atmospheric correction, calibration)
- knows the principles in water remote sensing (bio-optical modelling, adjacency effect)
- knows the principles in vegetation remote sensing (optical properties of the leaf, contribution of various features to the reflectance, leaf angles, various indices)
- student knows how to download, process, and analyse remote sensing and possibly ancillary data and apply this knowledge to solve various exercises
- they know how to plan and conduct groupwork

Content

- Introduction to Remote Sensing
- Introduction to spectral measurements
- Databases
- Machine learning models
- RS of plant canopies
- RS applications in forestry
- water RS
- Validation of EO data
- Multi-angle remote sensing

Entry requirements

None

Teaching and learning approach

We apply a problem-based project learning which is accompanied by weekly lectures.

Time allocation in hours per activity

Data Science in Remote Sensing		
Lecture [contact]	16	
Supervised practical [contact]	22	
Tutorial [contact]	2	
Written/oral test	6	
Individual assignment	10	
Group assignment	74	
Self-study	26	
Sum	**156**	
Assessment		
Examiners	Krista Alikas, Kaupo Voormansik, Jan Peter George, Kersti Kangro, Joel Kuusk, Mait Lang, Martin Ligi, Mihkel Kaha, Jan Pisek, Ave Ansper-Toomsalu	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam	65	individual
Weekly small assignments	10	Individual
Oral presentation & written report	25	Small groups

Planning Project	
Course code	UT-T12-C-004
Course type	Compulsory
Period	7 February 2022 - 20 May 2022
Credits	15
Coordinator	Siiri Silm, Veronika Mooses, Ingmar Pastak
Keywords	Spatial planning | GIS | Statistical analysis | Designing maps

Description

This course aims to provide knowledge on how to use spatial data and analysis in urban and regional planning. During the course, students will gain practical experience in the process of preparing a spatial plan.

Students will learn modern planning theoretical framework and methods and apply this knowledge in preparing a planning project as a group work. The general topic of each group project is given by lecturers. At the end of the course the group work will be presented and defended. The course is divided into three stages (theoretical context of spatial planning, empirical analysis, preparation of a planning solution) and is taught by different lecturers.

1. Contemporary spatial planning (Pille Metspalu, Ingmar Pastak)
In the first phase, students acquire knowledge of the basic concepts of planning and the most relevant topics in contemporary spatial planning (for example sustainability, mobility, etc.). In addition to this, students become acquainted with the main topics, regulations, and spatial plans of the area under study. Working teams are formed. By the end of the first phase, the main goal and task of the Planning Project for each group are formulated.

2. Statistical analysis (Siiri Silm, Veronika Mooses)
In the second phase, each group performs a quantitative analysis based on their specific group-work task. This is done using statistical analysis methods. The goal is to conduct an empirical data analysis and implement the results in the Planning Project. At the end of the second phase, students present their analysis results.

3. Compilation of a spatial plan (Pille Metspalu, Ingmar Pastak, Kiira Mõisja)
In the third phase, the results of the statistical analysis provide the basis for the sketch plans. The spatial plan and policy recommendations are developed, based on the goals and analysis of the results. Basic visualization principles are taught in the context of urban planning. A zoning map is designed, together with an explanatory text of a spatial plan, which sets out the goals for the spatial development.

Learning outcomes

- knows the principles of contemporary spatial planning
- is able to use relevant datasets for preparing spatial plans
- has an overview of the main quantitative and qualitative methods used in spatial planning
- is able to select, apply and evaluate appropriate GIS tools, visual and quantitative methods for data analysis and spatial planning
- is able to propose policy recommendations and planning solutions based on the analysis
- is able to compile spatial plan and design planning maps
- understands the concept of participatory planning and is able to present and defend his/her planning project in public

Planning Project		
▪ has been involved in group work ▪ has skills for academic writing		
Content		
▪ Modern concepts and issues in contemporary spatial planning. Spatial planning as a process and its different stages. ▪ Different data sources for spatial planning ▪ Quantitative data analysis and statistics ▪ Visual language of spatial planning. ▪ Compilation of planning document and a spatial plan map, defence.		
Entry requirements		
Basic statistics; GIS experience (maps)		
Teaching and learning approach		
We apply a mix of different teaching approaches which includes both individual and group work. The teaching includes (e-)lectures, (e-)seminars, computer-lab sessions, public presentation simulation, fieldtrip, roundtable discussion all combined in problem-based project learning.		
Time allocation in hours per activity		
Lecture [contact]	21	
Supervised practical [contact]	6	
Tutorial [contact]	39	
Study trip [contact]	4	
Written/oral test	3.5	
Individual assignment	70	
Group assignment	225	
Self-study	22.5	
Sum	**390**	
Assessment		
Examiners	Siiri Silm, Ingmar Pastak, Pille Metspalu, Veronika Mooses, Kiira Mõisja	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Literature overview	10	Individual
Empirical study	35	Group work
Test or group-work contribution	5	Individual
Review of empirical study	0	Group work
Planning project	40	Group work
Spatial plan map	10	Individual

Demography, Global Migration and Contemporary Cities	
Course code	UT-T12-C-005
Course type	Compulsory
Period	6 October 2021 - 20 January 2022
Credits	6
Coordinator	Tiit Tammaru
Keywords	Migration | segregation | contemporary cities | urban change

Description

The aim of this course is to get overview of the global population trends and their relationship to urban development and planning.

The course will combine international perspective to migration with the local demographic processes, and place European and Estonian urban trends within the context of the global urbanization. The main migration and demographic approaches and concepts will be discussed: types of migration and intra-urban residential mobility, socio-economic and ethnic segregation, lifecourse theories, transnationalism.

Practical exercises and discussions will be carried out during the course, with an aim to develop students' analytical skills and capabilities to independently carry out fieldwork in the field of urban geography. Different pedagogic methods will be applied to combine individual exercises with teamwork, discussion seminars with lectures. During the course meetings will be organized with the key persons among Estonian urban and immigration policy implementors. In this way students will be able to combine theoretical knowledge with the practical outputs.

The course will partly be carried out in combination with a related course "Demography and Urban Social Geography" (4EAP, LOOM.02.341) within the Master programmes in the field of human geography. The mix of students with different backgrounds in both courses provides added value to the study outputs.

Learning outcomes

- understand the development of global population trends in different regions of the globe
- understand the relationship between migration, social inequalities, and urban spatial segregation
- know the main concepts in demography, migration, and segregation
- obtain analytical skills in the field, including composing population forecast, measure segregation, and evaluate life quality in urban neighbourhoods
- be able to place Estonia and Europe among the global framework of urbanization and migration trends
- obtain practical knowledge on urban and migration policy development in Estonia

Content

- Migration flows and migration policies
- Population projection
- Inequalities, vicious circles
- Residential segregation, school segregation, workplace segregation, leisure time segregation
- Processes of neighbourhood transition (gentrification, suburbanisation)
- Interventions
- Integration
- Urban analysis of Asian cities

Demography, Global Migration and Contemporary Cities		
Entry requirements		
None		
Teaching and learning approach		
We use different teaching methods: (e-)lectures, seminars, practicums, individual and group work. Home assignments are done in various ways to give an insight of different methods: practical exercises, summary based on reading materials, poster session.		
Time allocation in hours per activity		
Lecture [contact]	10	
Supervised practical [contact]	4	
Tutorial [contact]	10	
Written/oral test	2	
Group assignment	72	
Self-study	58	
Sum	**156**	
Assessment		
Examiners	Tiit Tammaru, Kadri Leetmaa, Kadi Kalm	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Home assignment 1	10	small groups
Home assignment 2	10	small groups
Home assignment 3	10	small groups
Home assignment 4	10	small groups
Home assignment 5	20	small groups
Written exam	40	individual

Geography, Communication and Spatial Mobility

Course code	UT-T12-C-006
Course type	Compulsory
Period	March 2022 - May 2022
Credits	6
Coordinator	Anto Aasa
Keywords	geography | ICT, mobile positioning | mobility analysis | social media

Description

The aim of the course is to introduce the theoretical and methodological aspects of spatial mobility, information society and Smart City.

Special focus is on mobile telephone and ICT-based research methods and applications used in urban planning.

Learning outcomes

- understands terminology and concepts of spatial mobility
- is aware how spatial mobility, social mobility and activities of individuals are interrelated
- is aware of the impacts of information and communication technologies (ICT) on spatial mobility
- knows the data collection methods of spatial mobility
- has an overview of passive mobile positioning data
- has an overview of active positioning methods and smartphone-based data
- is able to measure individuals' spatial mobility with mobile positioning
- understands the concepts of information society and Smart City
- has an overview of social media data and research applications
- is able to use mobile phone and social media-based information sources for urban studies and planning

Content

- Information society
- Geography of information society
- Spatial mobility, social mobility, activities, and travel
- Methods for collecting movement data
- Collecting movement data with mobile phones - passive and active mobile positioning data in urban studies and transportation.
- BIG data and initiatives with mobile phones
- Analysing spatial mobility with mobile positioning data
- information and communication technologies (ICT) and society
- Spatial mobility and ICT
- Active mobile positioning and data collection with Smartphone
- Business plan exercise with mobile big data
- Information society and social media

Entry requirements

Basic statistics; Spatial analysis

Teaching and learning approach

Lectures, practical sessions, independent work, seminars

Time allocation in hours per activity

Geography, Communication and Spatial Mobility		
Lecture [contact]	24	
Supervised practical [contact]	4	
Individual assignment	36	
Group assignment	50	
Self-study	42	
Sum	**156**	
Assessment		
Examiners	Anto Aasa	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical skills exam 1	10	individual
Practical skills exam 2	15	group work
Practical skills exam 3	15	group work
Practical skills exam 4	15	group work
Practical skills exam 5	15	individual
Written test	30	individual

Internship		
Course code	UT-T12-C-007	
Course type	Compulsory	
Period	February 2022 - August 2022	
Credits	5	
Coordinator	Kristina Sohar, Merle Muru	
Keywords	Internship	
Description		
The aim of work placement is to broaden the understanding of student about the work with spatial data in practice and about the arrangement of work in organizations and teams as well as to give the student practical experiences of solving real life tasks in teamwork.		
Learning outcomes		
▪ get the understanding of the use of spatial data in practice: the architecture and functions of spatial data sets and their applied values ▪ understand the work arrangement and team management in organizations working with spatial data ▪ know the GIS tools used in practice and be able to solve some practical tasks concerning spatial processes ▪ obtain experience about working with colleagues and in teams ▪ be able to analyse and evaluate the obtained skills and experiences during work placement and defend the report in front of the committee		
Content		
▪ The student will work in an enterprise, public sector office or nongovernmental organization and solve tasks about spatial processes with GIS tools in teams. After the work placement, the student will defend the report of work placement in front of the committee.		
Entry requirements		
Basic GIS experience		
Teaching and learning approach		
Individual internship (minimum three weeks) in an enterprise/organisation with introductory seminars and concluding presentation at the university.		
Time allocation in hours per activity		
Seminar [contact]	8	
Individual internship	105	
Self-study	17	
Sum	**130**	
Assessment		
Examiners	Kristina Sohar, Merle Muru	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Work plan/contract	20	individual
Evaluation by employer received	32	individual
Report	32	individual
Defence	16	individual

Statistical Data Science	
Course code	UT-T12-E-001
Course type	Elective
Period	13 September 2021 - 15 January 2022
Credits	6
Coordinator	Krista Fischer
Keywords	R | statistical models | multivariate analysis

Description

Basic modulus: Data description, visualization, and basic analysis - 2 ECTS
The aim of the modulus is to give systematic overview on elementary principles of data management and analysis. The data package R is introduced (with submodule RStudio) and applied in primary data analysis and visualization. The modulus gives to PhD students knowledge for planning their future empirical research and the following analysis of collected data. It also gives necessary knowledge for critical reading research papers and data analysis reports to evaluate correctness and validity of the conclusions made in literature.

Modulus: Statistical models and multivariate analysis - 2 ECTS
The aim is to present main statistical methods for discovering patterns and regularities in data in the analysing and testing process. After passing the modulus a student is aware of basic statistical models, is able to use linear and loglinear regression models using R. He/she is able to use main methods of multivariate analysis.

Modulus: Analysis of complex data structures - 2 ECTS
The aim of the modulus is to present more specific and advanced methods of statistical data analysis. Aim of the methods is to discover hidden data structures and to suggest realistic forecasting methods. Also, an overview is given about the methodology of analysing specific data formats (repeated measurements, longitudinal and spatial data).

Learning outcomes

After passing the basic modulus a student is able to
- carry out elementary data analysis using R
- use knowledge for planning his/her own empirical research
- evaluate critically data analysis in research papers on his/her speciality

After passing the second modulus a student is able to
- use main methods of multivariate analysis when analysing data
- make correct conclusions from the results of analysis

After passing the third modulus a student
- has got an overview on specific advanced data analysis methods
- is able to carry out analysis of specific data (repeated measurements, longitudinal and spatial data)

Content

- Basic principles of data collection and organization. Types of data, datasets, and data files. Data description and visualization: frequency tables, basic summary statistics, simple graphs for data visualization. Interpretation of data summaries and their presentation in research reports and publications.

Statistical Data Science		

- Introduction to R language and environment for statistical computing and data science. RStudio and R-Markdown. Importing data into R. Obtaining basic descriptive statistics and graphs with R.
- Probability theory as the foundation of data science. Concepts of probability and conditional probability, basic calculations with probabilities. Probabilistic dependence and independence. Sensitivity and specificity of diagnostic/prognostic tests, ROC curves. Bayes formula and its application for finding predictive value of the test.
- Obtaining two-way frequency (contingency) tables and relative frequencies with R. Production of publication-quality tables for grouped data. Estimation of sensitivity and specificity of tests, based on a dataset or a frequency table.
- Concept of probability distribution as a basic statistical model for the data. Examples of distributions: Normal (Gaussian) distribution, Binomial distribution, Poisson, and exponential distributions, etc. Assessing the distribution of the data and comparing it to a theoretical probability distribution. Sampling distribution of means and percentages. Confidence intervals and their interpretation.
- Methods to visualize data distributions in R: histogram, bar chart, Q-Q plot (quantile-quantile plot). Obtaining confidence intervals for means and percentages, visualisation of confidence intervals (error bar plots) for grouped data.
- Basic principles of statistical hypothesis testing. The concept of p-value. Some commonly used statistical tests: t-test to compare two means, Z-test for comparing percentages. Chi-square test for association in a 2-way table.
- Conducting statistical tests with R. Presenting a two-sample comparison table in a scientific report or publication.
- Statistical associations and ways to visualize them, Coefficients of correlation. The concept of a statistical (association) model. Linear regression model, its assumptions and interpretation.
- Estimation and visualization of statistical associations with R.
- Planning of studies and experiments. Study types: cross-sectional studies and sample surveys, cohort studies, case-control studies, randomized experiments in different fields (medicine, biology, etc.). Concept of statistical power and principles of planned sample size calculation. Methods for estimating validity and reliability of tests (Cronbach's alpha and other measures).
- Tools for study planning, power, and sample size calculation (R packages, web-based tools). Validity and reliability measures in R. Summary of the module, feedback on homework and tests.

Entry requirements

None

Teaching and learning approach

Theoretical lectures are combined with practical lab sessions

Time allocation in hours per activity

Lecture [contact]	32	
Supervised practical [contact]	32	
Written/oral test	8	
Individual assignment	20	
Self-study	64	
Sum	**156**	

Assessment

Examiners	Krista Fischer, Märt Möls, Kaur Lumiste	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**

Statistical Data Science		
Written test	15	individual
Written test	15	individual
Written test	15	individual
Written test	15	individual
Individual work	20	individual
Individual work	20	individual

Geospatial Analysis with Python and R	
Course code	UT-T12-E-002
Course type	Elective
Period	01 October 2021 - 20 December 2021
Credits	6
Coordinator	Alexander Kmoch, Anto Aasa
Keywords	Python | R | geospatial | programming | data analysis

Description

Introductory course on concepts, skills, and tools for working with the Python and R scripting environments. Acquaintance with practical Python and R libraries for everyday scientific and professional GIS use, with a focus on automating different standard GIS-related tasks that support clear documentation of methods and productivity.

These lessons assume no prior knowledge of the skills or tools. It is a hands-on teaching course, so the majority of this course will be together in front of a computer and working on exercises.

Learning outcomes

- Knows basic concepts, skills, and tools for working with the Python and R scripting environments
- Compiles an overview of practical Python and R libraries for everyday scientific and professional GIS use
- Understands how to make use of integration of Python and R environments from other software packages
- Is able to apply to solve common data-related tasks using Python and R in concrete GIS projects
- Is competent of using spatial and non-spatial data in order to answer a research question
- Knows how to conduct and automate different standard GIS-related tasks that support clear documentation of methods in the Python and R scripting environments

Content

- Setup environments and notebooks; Recap Getting started Python and R.
- Spatial data model; Geometric Objects; Shapely.
- Working with GeoDataFrames; Managing projections.
- making spatial queries and joins.
- Reclassifying data.
- Working with raster data
- Visualization, making static and interactive maps.

Entry requirements

Basic statistics; GIS experience; basic programming skills

Teaching and learning approach

The majority of this course will be spent in front of a computer learning to program in the Python and R languages and working on exercises.

Time allocation in hours per activity

Tutorial [contact]	64
Individual assignment	48
Self-study	44
Sum	**156**

Assessment

Geospatial Analysis with Python and R		
Examiners	Alexander Kmoch, Anto Aasa	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical skills exam	12.5	individual
Practical skills exam	12.5	individual
Practical skills exam	12.5	individual
Practical skills exam	12.5	individual
Practical skills exam	50	individual

Web Mapping		
Course code	UT-T12-E-003	
Course type	Elective	
Period	01 February 2022 - 31 March 2022	
Credits	2	
Coordinator	Barbara Hofer, Alexander Kmoch, Evelyn Uuemaa	
Keywords	Leaflet | web mapping | cartography	
Description		
The objective of this short course is to introduce general principles of web maps in practical terms and to explore the functionality provided by the Leaflet API. Particular focus is on interactive features included in web maps (highlighting of features, display of additional information on click etc).		
Learning outcomes		
▪ to develop a web map for a specific topic that contains base maps, vector data layers and interactive functionality ▪ to decide on the use of specific functionality for a project at hand ▪ have an overview on typical features of web maps		
Content		
▪ The course covers an introduction to general principles of web map design; an introduction to the application programming interface (API) Leaflet and the practical use of Leaflet for the development of interactive web maps ▪ Starting from an exemplary web map, course participants will prepare their own web map for a topic of interest, which can be related to touristic features in a region of interest, biking/hiking routes, university facilities etc.		
Entry requirements		
GIS experience (ArcMap, QGIS); geoinformation background		
Teaching and learning approach		
The course is structured as introduction to cartography in the web, a series of hands-on tutorial work and a final individual project work.		
Time allocation in hours per activity		
Lecture [contact]	10	
Supervised practical [contact]	10	
Individual assignment	22	
Self-study	10	
Sum	52	
Assessment		
Examiners	Barbara Hofer, Alexander Kmoch, Evelyn Uuemaa	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Individual assignment	100	individual

Spatial Data Infrastructures	
Course code	UT-T12-E-004
Course type	Elective
Period	01 March 2022 - 16 May 2022
Credits	6
Coordinator	Alexander Kmoch, Valentina Sagris
Keywords	Spatial Data Infrastructures

Description

This introductory course aims to provide a comprehensive overview on the state-of- the art in Open Standards-based Spatial Data Infrastructures (Open SDI) and its key components, and introduce participants to the underlying principles of Open SDI, and let them experience hands-on what it means to establish and maintain an Open SDI.

A number of topics will be tackled: spatial data infrastructures as well open data principles, key standards, architectures, (network) services, relevant EU-regulations and policies, governance strategies, and key institutions.

We will learn how to access and use SDI web services, what is behind their specifications, and how these form the data backbone in online geoportals. We will work with different data and corresponding service types for web maps, vector and raster data and you will learn to create your own data model and service.

At the end of the course, participants are: informed about Open SDI strategies around the world, aware of the main strengths, weaknesses, opportunities and threats of Open SDI, familiar with the latest technological developments, capable to facilitate the opening of open data using latest developed tools, and able to evaluate Open SDIs.

Learning outcomes

- learn more about the components and standards that make up SDI
- find, access, and use different types of data and services within an SDI
- reading and creating data specifications according to INSPIRE rules
- publish data via SDI services such as Web Map Service (WMS), Web Feature Service (WFS) and Web Coverage Service (WCS) using the SDI software platforms Deegree and Geoserver

Content

- Learn more about Spatial Data Infrastructure (SDI), its components and standards
- Introduction to spatial data modelling with GML and data specifications
- geospatial modelling using Unified Modelling Language (UML)
- using Geography Markup Language (GML) as a standard for geospatial data encoding and transporting through the web
- Using GIS software as clients to SDI
- Publish and styling maps of raster and vector data in the web

Entry requirements

GIS experience

Teaching and learning approach

We apply a mix of theory, e-learning, practical lab sessions, individual and group work.

Time allocation in hours per activity

Spatial Data Infrastructures		
Lecture [contact]	32	
Supervised practical [contact]	16	
Tutorial [contact]	16	
Written/oral test	2	
Individual assignment	30	
Group assignment	16	
Self-study	44	
Sum	**156**	
Assessment		
Examiners	Alexander Kmoch, Valentina Sagris	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical skills exam	10	individual
Quiz	10	individual
Practical skills exam	20	individual
Practical skills exam	30	individual
Practical skills exam	30	small groups

Spatial Databases	
Course code	UT-T12-E-005
Course type	Elective
Period	01 February 2022 - 16 April 2022
Credits	6
Coordinator	Valentina Sagris
Keywords	Database | Spatial data and functions | postgreSQL and PostGIS

Description

The objectives of the course are:

- to review the basics of relational database theory.
- to learn how spatial data is represented in conventional databases and related standards; to learn how to manage and analyse spatial data in databases.
- to learn how to access and use spatial data from databases with different client applications.
- to apply theoretical knowledge in creating and working with geospatial databases and publishing spatial data with PostgreSQL/PostGIS

Students build on general database theory and how spatial data is incorporated. They are introduced to standards for encoding geometry and spatial reference systems in the database realm. This course is about designing a database and working with geospatial data. Students learn spatial functions that form the building blocks of more sophisticated analytical models. Accessing own database with desktop and web applications is an important part of practical exercises.

Learning outcomes

- design and create databases using PostgreSQL/PostGIS
- manage data and spatial data in PostgreSQL/PostGIS databases
- perform geospatial analysis in the spatial database

Content

- Learn more about Spatial Data Infrastructure (SDI), its components and standards
- Introduction to spatial data modeling with GML and data specifications
- Geospatial modelling using Unified Modelling Language (UML)
- Using Geography Markup Language (GML) as a standard for geospatial data encoding and transporting through the web
- Using GIS software as clients to SDI
- publish and styling maps of raster and vector data in the web

Entry requirements

GIS experience (ArcMap, QGIS); geoinformation background

Teaching and learning approach

We apply a mix of different teaching approaches which includes process-based instruction, inquiry teaching, reflective teaching (learning by doing), e-learning, individual project work.

Time allocation in hours per activity

Lecture [contact]	24
Supervised practical [contact]	44
Written/oral test	4
Individual assignment	84
Sum	**156**

Spatial Databases		
Assessment		
Examiners	Valentina Sagris	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Oral exam	50	individual
seminar presentation	50	individual

3D Modelling and Analysis	
Course code	UT-T12-E-006
Course type	Elective
Period	September 2021 - October 2021
Credits	6
Coordinator	Raivo Aunap, Merle Muru
Keywords	Surface models | point clouds | 3D | visualisation

Description

Aim of the course is to give basic knowledge and skills of the use of 3D geospatial data and models in terrain and surface analysis and planning.

The course consists of combined theoretical and practical study.

The topics are: creation and analysis of terrain and surface models; static and dynamic models and visualisations; visibility analysis; hydrological and flood analysis; 3D modelling, analysis and visualisation in city and landscape planning.

Learning outcomes

- Knows primary principles of handling and presenting 3D data in terrain and surface, incl. city modelling
- Knows primary data structures used in 3D modelling
- Understands and is able to apply basic methods and techniques of 3D modelling and analysis of terrain and various surfaces
- Is able to visualize modelling results in 3D scenes
- Knows implementations of 3D modelling and analysis

Content

- Terrain/relief representation and elements terrain models
- Lidar technique and point clouds
- Basics of landscape 3D visualization
- City and buildings 3D models
- Sea level change and flood modelling
- Hydrological modelling

Entry requirements

Basic GIS experience

Teaching and learning approach

Mainly computer labs combined with lectures, seminars, in form of classroom and e-learning, individual project.

Time allocation in hours per activity

Lecture [contact]	8
Supervised practical [contact]	32
Seminar [contact]	8
Individual assignment	26
Self-study	82
Sum	**156**

Assessment

3D Modelling and Analysis		
Examiners	Raivo Aunap, Merle Muru	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Moodle assignments	NA	individual
Seminar presentation	10	individual
Individual research/essay	20	individual
Portfolio	70	individual

Visual Geodata Mining		
Course code	UT-T12-E-007	
Course type	Elective	
Period	01 March 2022 - 01 April 2022	
Credits	2	
Coordinator	Jukka Matthias Krisp	
Keywords	Geodata | visualisation | visual data mining	
Description		
The course deals with spatial and visual data mining techniques in multivariate data sets.		
Learning outcomes		
▪ understand applications and methods to "visual data mining" ▪ assess visual data mining tools (anticipated "GeoVista/GeoViz") ▪ understand the overall "visual mining process" ▪ use methods and applications of "visual spatial data mining" ▪ evaluate methods of "visual spatial data mining		
Content		
▪ The course will be giving brief overview of visual geodata mining. During the course students will get reading materials which later on will follow with discussion. ▪ Course also contain exercises with visual data mining programme GeoVista/GeoViz which will be held in the computer room and supervised by prof. Krisp		
Entry requirements		
None		
Teaching and learning approach		
We apply a mix of different teaching approaches which includes e-lectures, seminars and problem-based learning supported by computer practicals.		
Time allocation in hours per activity		
Lecture [contact]	12	
Tutorial [contact]	3	
Group assignment	33	
Self-study	4	
Sum	**52**	
Assessment		
Examiners	Jukka Matthias Krisp, Janika Raun	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Exercise	50	individual
Exercise	50	individual

Economic Geography of Urban Systems	
Course code	UT-T12-E-008
Course type	Elective
Period	01 March 2022 - 31 March 2022
Credits	2
Coordinator	Frank Jacomina Albert Witlox, Janika Raun
Keywords	Economic geography | location theories | production networks

Description

The course provides students with an understanding of contemporary urban networks, including their role in economic processes, creativity and the logistical challenges of contemporary cities and urban systems.

Learning outcomes

- familiar with the basic concepts of economic geography and urban networks
- able to understand how businesses deal with decisions concerning locational choice.
- able to answer questions regarding urban geography
- able to analyze the complex relationship between city and economy
- able to understand how creative industries operate and what their contribution is to the urban economy.

Content

The course deals with a number of relevant economic geography topics:

- what is economic geography
- the location problem analysed
- location theories: classical, neo-classical, and alternative approaches
- location factors
- demography of the enterprise
- city and economics
- urban economic development: competition and networks
- internal urban differentiation: land use
- production networks in a global economy
- 'new economic geography'
- geography of the world economy
- evolutionary economic geography

Entry requirements

None

Teaching and learning approach

We apply a mix of different teaching approaches which includes e-learning, reflective teaching (learning by doing), individual and group work and problem-based learning.

Time allocation in hours per activity

Lecture [contact]	12
Tutorial [contact]	3
Group assignment	33
Self-study	4
Sum	**52**

Assessment

Economic Geography of Urban Systems		
Examiners	Frank Jacomina Albert Witlox, Janika Raun	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Report	100	small groups

Introduction to Urban Planning

Course code	UT-T12-E-009
Course type	Elective
Period	01 January 2022 - 31 January 2022
Credits	2
Coordinator	Daniel Baldwin Hess
Keywords	Urban planning | urban design | urban theory

Description

The aim of this course is to explore underlying theories and approaches in urban planning, as well as to introduce the profession and understand historical motivations for planning intervention in cities and metropolitan regions.

This course focuses on the spatial structure and function of cities and regions and the roles that town planners play in analysing and shaping cities and regions.

Our inquiry will be aimed at reaching a critical understanding of the cultural and historical processes and planning actions and policies that have influenced cities and regions.

We will develop both a theoretical and practical understanding of town planning processes as we explore problems and challenges currently facing communities locally and throughout the world.

Learning outcomes

- evolution of urban spatial structure
- planning challenges in complex metropolitan regions
- evolution of theories of urban planning
- modes of reasoning of urban planners
- professional planning practice

Content

- The course will examine town planning practice, paying particular attention to the times, circumstances, and events in which certain planning paradigms prevailed, with the goal of creating a context for explaining town planning in the past
- The course will use as its foundation a body of literature examining historical and contemporary town planning, urban design, urban theory, and the various historical, social, regulatory, and physical conditions that influence the form of cities
- We will also examine characteristics of patterns of settlement and attitudes towards urban life that are identified with urban places as we try to explain cultural meanings embedded in the process of city-making

Entry requirements

None

Teaching and learning approach

We apply a mix of different teaching approaches which includes reflective teaching (learning by doing), e-learning, individual and group work, and problem-based learning.

Time allocation in hours per activity

Lecture [contact]	12
Written/oral test	2
Group assignment	19

Introduction to Urban Planning		
Self-study	19	
Sum	**52**	
Assessment		
Examiners	Daniel Baldwin Hess	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Attendance and participation	10	individual
Written assignment	20	small groups
Written assignment	20	small groups
Final examination	50	individual

Energy Flows and Material Cycles	
Course code	UT-T12-E-010
Course type	Elective
Period	6 September 2021 - 24 October 2021
Credits	3
Coordinator	Ülo Mander
Keywords	Energy flows | climate, carbon, and nutrient cycles | urban climate, green infrastructure | ecological engineering | constructed wetlands

Description

The aim of the course is introduce the mutual relations of various environmental elements and processes of landscape ecology, to give an overview of the contemporary problems an methods in physical geography and landscape ecology as well as skills to solve them.

Learning outcomes

- understand the development patterns of natural features and their mutual relations
- know the terminology of physical geography and landscape ecology and is able explain the principles of the functions of main natural complexes
- know the main flows of matter in natural landscapes on local, regional, and global scale
- know the development of contemporary landscapes and is able to characterize regional units of landscape
- know the causes and effects of global environmental changes
- be acquainted with the main datasets of physical geography and be able to analyse these
- know the main methods of analysis in physical geography
- know the evaluation methods of landscape structures and the methods of data analysis in this field

Content

- The course introduces various approaches and methods used in landscape and climate change studies
- The students practice the use of complex study and data analysis methods in physical geography

Entry requirements

None

Teaching and learning approach

We apply a mix of different teaching approaches which includes process-based instruction, inquiry teaching, reflective teaching (learning by doing), e-learning, individual and group work, and problem-based project learning.

Time allocation in hours per activity

Lecture [contact]	20
Supervised practical [contact]	6
Study trip [contact]	8
Written/oral test	4
Group assignment	16
Self-study	24
Sum	**78**

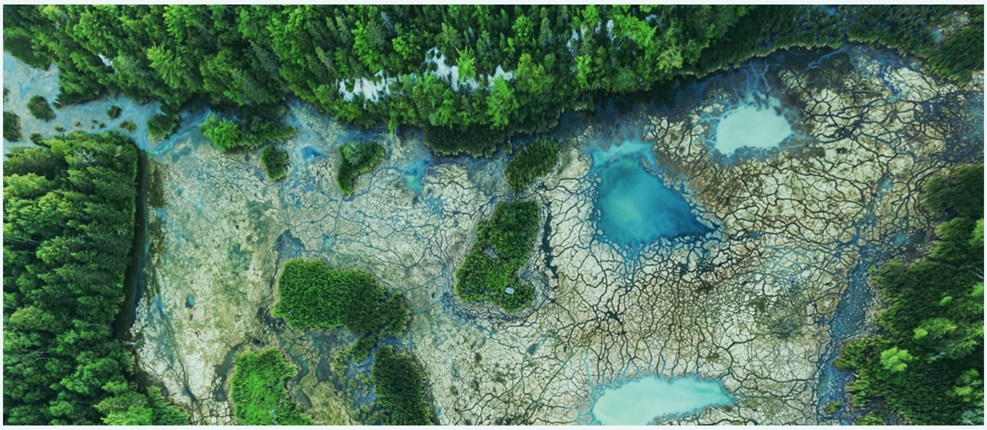
Assessment

Energy Flows and Material Cycles		
Examiners	Ülo Mander, Jaak Jaagus, Ivika Ostonen-Märtin, Jaan Pärn	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written test	40	individual
Written test	20	individual
Examination	40	small groups

Start-up project		
Course code	UT-T12-E-011	
Course type	Elective	
Period	6 September 2021 - 18 December 2021	
Credits	3	
Coordinator	Raivo Aunap	
Keywords	Innovation | business plan | idea formation	
Description		
To shape the pro-active attitude towards developing new ideas and products. Give students the experience in entrepreneurship, team building, developing a new product or start-up.		
Learning outcomes		
▪ Student will be able for problem identification, innovation, idea formation & brainstorming, idea validation, risk assessment, financial planning, marketing, pitching, and managing a startup ▪ Knows the main steps of product development ▪ Can do team building		
Content		
▪ Student develops individually or as a team member one specific project, product, or idea by participating in UT Idea Lab events, hackathon or another similar event.		
Entry requirements		
None		
Teaching and learning approach		
Theoretical lectures are combined with practical lab sessions.		
Time allocation in hours per activity		
Lecture [contact]	2	
Supervised practical [contact]	28	
Individual assignment	20	
Self-study	28	
Sum	**78**	
Assessment		
Examiners	Ülo Mander, Jaak Jaagus, Ivika Ostonen-Märtin, Jaan Pärn	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Report and presentation	100	individual

Courses in year 1 at Lund University

Track 3 - GEM4 Ecosystems & Natural Resources | Track 4 - GEM4 Food Security



Geographical Information Systems, Basic Course	
Course code	LU-T34-C-001
Course type	Compulsory
Period	30 August 2021 - 29 October 2021
Credits	15
Coordinator	Micael Runnström
Keywords	Spatial data management | vector - and raster analyses

Description

The course aims to provide basic knowledge of concepts and methodologies of the management and analysis of geographical data, as well as an introduction to cartography and geodesy.

The most significant learning outcomes of this course are to give the students knowledge and understanding in conceptual spatial modelling, different data models, interpolation and data bases, as well as proficiency and skills in organizing environmental spatial data and solving and presenting problems using GIS.

Learning outcomes

Knowledge and understanding

- Describe different conceptual models of spatial phenomena
- Describe different data models for digital spatial data (raster - vector), and describe how these are stored digitally and their advantages and disadvantages
- Account for basic spatial analysis methods
- Account for basic cartographic methods
- Explain the meaning of different map projections, geodesic reference systems and coordinate systems

Skills and ability

- Organise and handle digital geographic data
- Independently carry out basic analyses of geographic data in raster and vector format by means of standard GIS software
- Present procedure and results from collection and analysis of geographic data in writing and as maps for specialists and laypeople
- Carry out and present basic statistical evaluations of spatial data
- Use simple database management systems (basic SQL)
- Search for and collect public geographic data

Assessment skills and approach

- Be aware of the importance to use geographic information and analysis within natural sciences and other application fields
- Understand the importance of and have achieved a critical approach to geographic data and analysis results

Content

Geographical Information Systems, Basic Course		
▪ The course gives a broad theoretical basis to further work with digital geographic data. Understanding of representation and analysis of spatial elements are emphasised. ▪ The course also highlights general geographic problems within environment and society through practical GIS-applications. These treat both Swedish and international conditions and vary in scale from local to regional. ▪ The components of GIS-technique that is treated comprise basic cartography, including projections, reference systems, geographic data in digital form (maps, images and tables) and basic analysis of geographic data in raster and vector format and cartographic and graphical presentation of digital maps. In the course, communication training is also included. Specific emphasis is placed on cartographic presentation of digital geographic data.		
Entry requirements		
None		
Teaching and learning approach		
A mix of different teaching approaches including process-based instruction, inquiry teaching, reflective teaching (learning by doing), e-learning, individual and group work, and problem-based project learning.		
Time allocation in hours per activity		
Lecture [contact]	27	
Supervised practical [contact]	44	
Tutorial [contact]	23	
Written/oral test	5	
Individual assignment	115	
Group assignment	71	
Self-study	115	
Sum	**400**	
Assessment		
Examiners	Micael Runnström, Helena Elvén Eriksson, Abdulghani Hasan, Andreas Persson, Vaughan Philips, Per-Ola Olsson, Karin Larsson	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical assignment 1	0	Individual
Practical assignment 2	0	Individual
Practical assignment 3	0	Individual
Practical assignment 4	0	Individual
Practical assignment 5	0	Group
Practical assignment 6	0	Group
Practical assignment 7	0	Individual
Practical assignment 8	0	Individual
Practical assignment 9	0	Individual
Practical assignment 10	0	Individual
Data management project	30	Group
Exam	70	Individual

Geographical Information Systems, Advanced Course	
Course code	LU-T34-C-002
Course type	Compulsory
Period	01 November 2021 - 14 January 2022
Credits	15
Coordinator	David Tenenbaum
Keywords	

Description

In this course the student continues to develop skills in spatial environmental modelling.

Digital spatial data (from RS a well as other sources) are used in a GIS in order to integrate and analyse data and information for mapping and monitoring.

The learning outcomes include knowledge and understanding of basic programming and the effect of error propagation in environmental/geographical modelling, how society's geographical infrastructure is organised, laws and regulations that affect the use of geographical data, as well as examples of advanced use of GIS in environment and society.

The students learn to work independently and, in a group,, suggesting workflow and methods for solving complex geographical tasks, and applying them in a GIS.

Learning outcomes

Knowledge and understanding

- Explain basic methods and conceptual models of the contents of a geographic database
- Explain the principles of transformation between different geodesic reference system
- Explain concepts and calculation methods within advanced spatial analysis
- Explain basic logics of computer programming and describe how programming can be used with geographic data and problems
- Account for effects of data accuracy in geographic analysis and modelling
- Account for geographic data infrastructure in society
- Describe at a general level which laws that concern the use of geographic data
- Illustrate advanced using GIS within environment and society

Skills and ability

- Carry out interpolation with geographic data
- Carry out and present simple statistical evaluations of interpolated spatial data
- Independently suggest procedure and methods to solve complex geographic issues and to carry out these with GIS
- Present results of GIS analysis in writing and as maps for specialists and laypeople in the subject
- Collect knowledge in the area in an independent way

Judgement and approach

- Compile, evaluate and discuss choice of analytical method to solve a given geographic problem
- Review and discuss the reliability of analyses with GIS critically
- Describe and evaluate using GIS in the society

Content

Geographical Information Systems, Advanced Course		
The course is a balanced mix of theoretical foundation and practical applications. It contains eight modules including: ▪ data management in GIS ▪ database development (management, SQL, metadata) ▪ geostatistics (interpolation, semi-variance) ▪ fuzzy logic ▪ GIS programming ▪ spatial data infrastructure ▪ map accuracy assessment ▪ spatial analysis project The course includes exercises for each module (except SDI and map accuracy, which are presented theoretically). The course provides basic as well as advanced methodologies for ▪ data capture (digitalization, remote sensing) ▪ data correction ▪ map accuracy assessment ▪ data processing and enhancement (interpolation) Advanced analyses include fuzzy set theories and modelling as well as topographical modelling. Teaching consists of lectures and practical exercises that you will submit to the teachers. The course ends with a written exam.		
Entry requirements		
Completion of Geographical Information Systems, Basic Course or equivalent		
Teaching and learning approach		
We apply a mix of different teaching approaches which includes process-based instruction, inquiry teaching, reflective teaching (learning by doing), e-learning, individual and group work, and problem-based project learning.		
Time allocation in hours per activity		
Lecture [contact]	24	
Supervised practical [contact]	44	
Written/oral test	7	
Individual assignment	90	
Group assignment	139	
Self-study	96	
Sum	**400**	
Assessment		
Examiners	David Tenenbaum, Helena Elvén-Eriksson, Virginia Garcia, Abdulghani Hasan, Karin Larsson, Ulrik Mårtensson, Andreas Persson, Mitch Selander, David Wårlind	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Data Management Exercise	0	Individual
Database Development Exercise	0	Individual
Geostatistics Exercise	0	Individual
Fuzzy Logic Exercise	0	Individual

Geographical Information Systems, Advanced Course		
GIS Programming Exercise	0	Individual
Written Examination	70	Individual
Final Project	30	Small Group

Ecosystem modelling

Course code	LU-T34-C-003
Course type	Compulsory
Period	17 January 2022 – 18 March 2022
Credits	15
Coordinator	Anders Ahlström
Keywords	

Description

In this course the students learn the general principles and methods for defining, parameterising, and evaluating an ecosystem model.

They also learn about various types of process-oriented models, computer programming, and the ways in which models and model results are utilized in various contexts in the environmental area.

Participants undertake a small project in groups, focusing on a real-world problem using available data, in order to learn how to carry out an integrated environmental study.

Learning outcomes include participating in a group-based activity using models to approach a scientific question or applied problem.

Learning outcomes

Knowledge and understanding

- Account for the general principles and methods to define, parameterize and evaluate an ecosystem model
- Account for some of the various types of process-oriented models that are used within ecosystem - and environmental research and planning, their general properties and their advantages and limitations
- Design an ecosystem model in the form of a computer program
- Account for how models and model results could be used in different applications connected to the environment.

Application and assessment

- Analyse various types of problems related to the environment and develop methods to tackle these by means of existing models and appropriate input data and validation data.
- Critically review, evaluate, and interpret results of model design.
- Parameterize, evaluate, and apply a process-oriented mathematical model of an ecosystem or one of its components.

Communication skills

- Present various types of studies both orally and in written format,
- lead and summarise discussions during seminars and group work
- summarise and visualise models and their results
- lead a group assignment to solve scientific or applied problems by means of models.

Study skills and information competence

- developed the ability to within the subject area seek relevant information in articles, reports, and other scientific literature.

Content

Ecosystem modelling		
▪ Simulation models are important tools within the environment sector, where they are used to produce basic foundations for environment political decision making and planning. In research context, modelling is used to describe complex systems and to increase the understanding of these. ▪ The course treats some of the various types of process-oriented models that are used within the ecosystem - and environmental research and relevant sectors. Further, principles, methods, and tools to define, parameterize, evaluate, and apply models and the visualisation and interpretation of their results with regard to underlying assumptions and uncertainties are treated. ▪ Connections are made to relevant issues and to current application fields within e.g. research, environmental management, agriculture, and forestry industries. ▪ Exercise in the use of computer-based analysis and presentation tools, information retrieval and oral and written presentation technique are included as a part of certain learning activities		
Entry requirements		
None		
Teaching and learning approach		
We apply a mix of different teaching approaches which includes process-based instruction, inquiry teaching, reflective teaching (learning by doing), e-learning, individual and group work, and problem-based project learning.		
Time allocation in hours per activity		
Lecture [contact]	22	
Supervised practical [contact]	88	
Tutorial [contact]	6	
Written/oral test	3	
Individual assignment	39	
Group assignment	53	
Self-study	189	
Sum	**400**	
Assessment		
Examiners	Anders Ahlström	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Savanna modelling report	0	group
Biome modelling report	0	individual
problem analysis report	10	individual
Sensitivity analysis report	10	individual
Main project report and oral presentation	30	group
Written exam	50	individual

Satellite remote sensing	
Course code	LU-T34-C-004
Course type	Compulsory
Period	23 March 2022 – 5 June 2022
Credits	15
Coordinator	Lars Eklundh
Keywords	remote sensing | vegetation | optical | earth

Description

This course aims at providing students with basic knowledge and understanding of physical principles of land remote sensing, the basic technical principles of satellites, sensors and remotely sensed data, the principles of digital image processing in remote sensing, important applications for satellite remote sensing in research and operational applications, and the ability to suggest uses for remote sensing in different climate zones and for various types of ecosystems and land-usages.

The main emphasis of the course is on vegetation remote sensing. Technical skills include analyses of digital remote sensing data using existing image processing software, planning and carrying out a field study to support remote sensing, choice of data and methodology for remote sensing in different application fields, and integrating remote sensing data with other data in geographical information systems.

Presentation and discussion of results from remote sensing is achieved by group work, written reports, and oral presentations.

Learning outcomes

Knowledge and understanding

- Describe the basic physical principles of remote sensing
- Account for the basic technical principles of satellites, sensors and ground receiving and treatment systems for data collection and the properties of available data from these systems
- Account for the principles of digital image handling and image processing within remote sensing
- Describe important fields of application for satellite remote sensing in research, society, and private activities
- Illustrate and suggest use remote sensing in different climate areas and for various types of ecosystem and land use and understand and account for limitations with the current technology

Skills and abilities

- Independently analyse digital remote sensing data with existing image handling software packages
- Independent and in groups plan and carry out a field survey connected to an application of remote sensing
- Based on literature choose right data and method for applying remote sensing in applications that concern soil, vegetation, water, and human use of these resources
- Integrate remote sensing data with other data in geographic information systems
- Actively contribute to discussions and present the results from remote sensing analyses in writing, orally and as maps for specialists and laypeople
- Collect knowledge in the field of remote sensing in a more or less independent way

Assessment skills and approach

Satellite remote sensing

- Compile, evaluate and discuss choice of data and analytical method to solve a given problem by the use of remote sensing
- Review, evaluate and discuss the reliability of analyses that are based on remote sensing data critically.

Content

The aim of the course is to communicate advanced knowledge and skills within digital satellite remote sensing for studies of the environment and human influence on it. The course consists of two sub-parts:

- Remote sensing theory and image processing. The sub-part treats basic physical principles, terminology for remote sensing and an overview of existing satellites and sensors. Further, data processing, basic image processing methods within remote sensing including radiometric and geometric correction, image enhancement, image classification methods and image transformations and integration of field data and thematic map production are dealt with.
- Applications within environment, society, and research. The sub-part treats the use of satellite remote sensing in important application fields e.g. environmental problems, agriculture, forestry, urban applications, water management or using satellite data in different time - and room resolution, using models in remote sensing, analysis of data from different climate areas and applications within society and research.

Entry requirements

None

Teaching and learning approach

Theoretical lectures are combined with practical lab sessions.

Time allocation in hours per activity

Lecture [contact]	28
Supervised practical [contact]	70
Study trip [contact]	2
Written/oral test	5
Individual assignment	29
Group assignment	138
Self-study	128
Sum	400

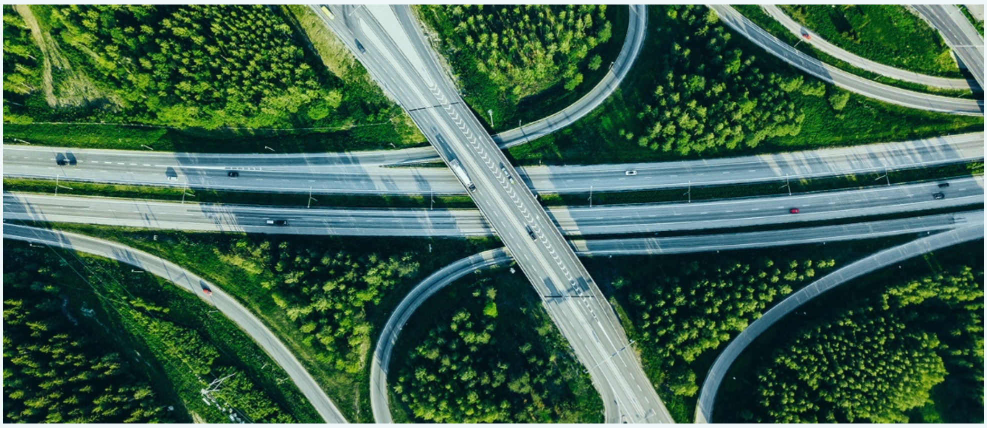
Assessment

Examiners Lars Eklundh

Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Image classification	15	Group
Time series	15	Group
Written exam	70	Individual

Courses in year 2 at ITC-University of Twente, the Netherlands

Track 1 - GEM4 Urban-Rural Interactions



MSc research proposal and thesis writing	
Course code	t.b.d.
Course type	Compulsory
Period	September 2022 – July 2023
Credits	45 EC
Coordinator	Raymond Nijmeijer
Keywords	MSc proposal | MSc thesis

Description

The first stage of this course is spent on developing an MSc Research Proposal with support and feedback from staff and peers. Through the MSc Research Proposal, the students should demonstrate the ability to undertake independent research. At the end of the first quartile the MSc Research Proposal will be assessed by a Proposal Assessment Board based on a written proposal, a presentation and an oral defence. The Proposal Assessment Board decides if the proposal is acceptable, as one of the conditions to continue with the MSc Research phase.
The second stage of the course is dedicated to the execution of an individual research project. Each student works independently on the basis of an approved research proposal.
In this final part of the course, the students further develop their research skills, interact with their fellow students, PhD researchers and staff members and, finally, demonstrate that they have achieved the learning outcomes of the Master's programme by research, on a satisfactory academic level.

Learning outcomes

1. Address a well-formulated relevant research problem of sufficient scope and depth related to the application of geo-information and earth observation and linked to relevant literature (scientific scope and depth)
2. Undertake research with a clear and transparent methodology with proper use of concepts, methods and techniques (scientific method)
3. Write a well-structured and readable thesis report with a clear layout (reporting)
4. Orally present and defend the research and use proper argumentation in the discussion about the research (presentation and defence)
5. Work in a structured and independent way, while making adequate use of the guidance of the supervisor (process)
6. Reflect and discuss in the thesis, the relevance of the research in different cultural and international contexts, or present the research in an international setup, through reflecting on its utility in overarching cultural and societal differences and fostering of stakeholder partnerships.

Content

Guided Proposal Writing
Introductory lectures on:
- MSc Research phase process Research ethics

Tutorials and peer discussion on :
- Formulating sub-objectives and research questions Methodology
- Ethical considerations in MSc research Optional, theme-specific tutorials
- Data collection methods Data analysis methods

Proposal defence
- Oral presentation and defence of the MSc research proposal before the Proposal Assessment Board

Thesis Writing

MSc research proposal and thesis writing		
▪ Based on the accepted research proposal the student will carry out the planned activities. Regular individual progress meetings with the supervisors will be held to facilitate the progress on the research and thesis writing, and records of the progress will be kept. The activities include: ▪ Deepen literature review, including assessment of the usability of literature and previous research; Collection of relevant data. If appropriate, preparation and execution of fieldwork to collect primary data required for the research; ▪ Data processing and analysis ▪ Active participation in seminars and activities of the research theme under which the MSc research resorts; ▪ Mid-term presentation: A formative assessment is made on the research progress approximately half- way the thesis development time-frame ▪ Preparation of the final manuscript of the MSc thesis ▪ A critical review of the quality, use, and usefulness of the data and results, as well as the learning process ▪ Oral presentation and defence of the MSc thesis before the Thesis Assessment Board.		
Entry requirements		
Students should have at least 60 credits of the first year. Supervised MSc thesis writing can only start after a successful MSc proposal defence.		
Teaching and learning approach		
Students are assigned a supervisor or team of supervisors to guide them during their individual research. Students will make individual arrangements with their supervisor(s) regarding the frequency of supervision meetings and the extent of the guidance they can expect.		
Time allocation in hours per activity		
Lecture [contact]	4	
Supervised practical [contact]	12	
Tutorial [contact]	12	
Written/oral test	4	
Self-study	1228	
Sum	**1260**	
Assessment		
Examiners	ITC and Tartu staff	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Proposal assessment	n/a	individual
Thesis defence	100	individual

Geo-journalism	
Course code	t.b.d.
Course type	Elective
Period	November 2022 – April 2023
Credits	5
Coordinator	Valentijn Venus
Keywords	Geo-journalism | valorization | motivation | personal branding | fact-checking

Description

The objective of this course is to equip students with an interest in valorization (e.g. geo-journalism) to deliver their scientific results as re-usable research objects for delivery through digital NEWSrooms, such that analysis can be repeated fully independently and best practices in journalism can be adhered to.

Stories about our Planet are broad by nature and it is the job of a journalist to help pin down the often interconnected reasons that drive environmental change. The growth of large, publicly accessible datasets presents the media community with new opportunities, but this also comes with the need for new skills to turn this trove of information into easy-to-understand, evidence-based stories. Simultaneously, ITC/UT has been teaching applied geo-information sciences for +60 years, but with increasing emphasis on academic skills in recent years. According to a recent survey, however, more than 80% of our alumni do not pursue an academic career. Therefore, an all-new MSc course module on geo-journalism is presented which teaches students to combine geodata, data analytics, and various Bodies of Knowledge (BoK) in creating compelling (cartographic) infographics to support their storytelling. Using this knowledge and skill, students are enabled to create compelling (cartographic) infographics in minutes rather than days. These infographics are fully semantically enriched, allowing others to see and question the data sources and underlying analyses. With each course assignment, students gradually populate their online NEWSroom with blog articles annotated by these (cartographic) infographics. As a portfolio of the student's environmental storytelling efforts, this NEWSroom also helps improve their personal branding since their reporting is automatically indexed by Microsoft Bing and Google search because of the adherence to the Semantic Web-standards of our NEWSroom tooling.

The semantic tools and data models used in geo-journalism provide important 'spill-overs'; the open-source technology stack not only facilitates fact-checking of claims made in news and blog articles, but also those in scientific journal articles. Studies show that only 10~30% of published science articles are reproducible. Many argue this is a logical result of the publishing format as in most papers textual reference is made such as "this experiment was conducted as previously reported [insert reference here]" instead of a live reference to the online executable algorithm and workflow to recreate the results. Our hope is that it will enable those with an enthusiasm for storytelling to use these rapid geo-information pipelines to support their valorization efforts in publishing (reviews) of scientific findings and how to stimulate viral spread across the Internet.

Learning outcomes

Upon completing this course the students are able to:

- Discover and tell a story that is appealing
- Gain insights in journalistic best practices for publishing scientific results in the media
- Master tools for geo-journalism and online, rapid executable EO workflows
- Master robust, online peer-review workflow to stimulate viral spread across the Internet

Geo-journalism

- Facts and values in journalistic practice; appreciate how facts are socially produced, why values are contested, and how facts and values constitute each other.
- Valorize on research results by appraising and recommending suitable methods to summarize scientific findings for a broad audience using infographics and social media blog articles
- Understand practical ways to build-out your personal brand name by developing sound social media strategies

Content

- This course will prepare the students to become vocal individuals who have ability, attitudes, skills and know-how necessary for sound geo-journalism for the valorization of research results and uptake addressing the appropriate level of understanding for an audience.
- The course is structured as follows: (**a**) basic theory (frontal teaching) (**b**) flipped classroom teaching where the transfer of theoretical information from teacher to student ('lecturing') is taken out of the classroom/lectures and presented as material to study before the lecture. The lecture itself is then used to discuss important questions about the material, and assess the student's level of understanding (**c**) getting practical, including storytelling exercises (**d**) editorial meetings (**e**) develop a NEWSroom consisting of co-authored blogs and infographics, and, finally, a self-reflection report (**f**) where participants reflect on their learning curve and possible follow-ups are identified.

A. Basic theory

- The course starts with lectures (incl. guest lectures), followed by practical assignments.
- *A.1 Lectures*
- A. Develop storytelling skills to repot about our Natural world:
- Discover the story by identifying elements in scientific findings that contradict, agree, or deviate from popular opinion
- How to write a news article in a 'foldable' manner
- Business models for (semi) professional geo-journalism;
- *A.2. Guest lectures*
- A series of guest lectures will be organized from UTwente staff who have experience with:
- How to write an enticing introductory section of a news story, *aka* "lede", that helps keep the reader's attention
- Understand design criteria for easy-to-understand visuals that support or tell your story

B. Advanced concepts: flipped classroom

Online materials are provided to the course participants to enhance their competencies in authoring and reviewing blog articles, accompanied by an appropriate (cartographic) infographic, related to a contemporary issue. The aim of this phase is to discover a students' learning path and to prepare them for the role of author, editor, and publisher in a role-play (phase in C).

- Master rapid, online executable EO workflows for geo-journalism and online publishing:
- Appraise methods, tools, and data that help summarize these findings using an infographic
- Elaborate data needs for the infographic
- Subset geo-data by time, space, and parameter for the infographic
- Propose rapid geo-data processing functions & reduce the data dimensionality meaningful for the infographic
- Present and augment computer-generated infographics to be visually appealing and easy-to-understand
- Master robust, online peer-review workflow to stimulate viral spread across the Internet:
- Understand the basic principles of the Semantic Web 3.0 and the structured data types for "fact-checking"
- Demonstrate an understanding of the full definition of ClaimReview (schema.org/ClaimReview)

Geo-journalism

- Demonstrate authoring of a (review) claim (schema.org/CreativeWork)
- Understand how truthfulness ratings are assigned using the reviewRating of the ClaimReview-process (schema.org/Rating)
- Understand how the claim being checked by multiple reviewers can be summarized programmatically (based on this crowd of fact-checkers)
- Appraise strategies and reasons to build a personal brand :
- Understand practical ways to build-out your online presence
- Be able to tell a story orally, pitch your perspective on a contemporary environmental issue in less than 3 minutes
- Discriminate social media strategies
- Understand (non)monatery business models for (semi) professional geo-journalism (e.g. freelance journalism, personal branding, or valorization of research results)

C. Getting practical; storytelling (oral and written) and roleplaying

- In this phase you get to improve your geo-journalism skills by working on a story covering a real-life, contemporary environmental issue backed by geoinformation science. This requires that you use multiple theories and tools from geoinformation and journalism in an integrated fashion. Given the technical readiness of geo-journalism, several social-cultural aspects also deserve attention such as what are the (perceived) occupational or cultural barriers to be publicly outspoken.
- Four contemporary issues (study cases) are presented to students, whereby groups of students will jointly work on the design cycle of a story, frequently alternating the student's role from author-editor-publisher-reader. Below an example design cycle:
- Read up on promising fact-checking articles and discuss why some spread virally across the Internet
- Compare the findings of 3 scientific articles (focus on the abstract & conclusions), are there elements that deviate from popular opinion (contradict, agree)?
- Write an appropriate "lede" for the story you have in mind: hard-news ledes are generally used for breaking news and for more important, time-sensitive stories. Feature ledes are generally used on stories that are less deadline-oriented and for those that examine issues in a more in-depth way.
- Write the main body of the blog post in a 'foldable' manner such that the reader can 'skip over' sub-paragraphs while still understanding the main point of the story
- By hand, sketch a dummy infographic that would support the main elements of the story.
- Review the handwritten dummy infographic from one of your peers: does it support the main elements of the story?
- Create the online-referenceable, reproducible EO workflow needed to create the infographic (based on the sketch).
- Etc.
- The design cycle of a blog or a news article is an iterative process. This means that throughout the project you will improve each design step by going back and forth between steps until a satisfactory result is achieved, and checked by a potential reader or paying publisher. This means design iterations and rework are a natural part of this design cycle, all with the sole goal of improving the young geo-journalist.

D. Editorial meetings

- Editorial meetings are foreseen to monitor and stimulate the progress of the students. The student groups will be presenting their progress in identifying and telling stories, addressing the challenges, and proposing possible solutions. The students will have the opportunity to comment on each other's works and ask questions to the scientific and professional consultants.

E. NEWSroom

Geo-journalism		
▪ As part of the students' growing journalistic aspirations, with each course assignment students gradually populate their online NEWSroom with blog articles annotated by (cartographic) infographics as personal portfolio of their environmental storytelling efforts. This NEWSroom also helps to improve their personal branding since their reporting is automatically indexed by Microsoft Bing and Google search because of the ReviewClaim-tag, incl. their work in the various role-playing modes, e.g. as editor and reviewer, where fact-checking and feedback on the scientific rigor of underlying facts, incl. data, method, results and discussion, are presented in a scientific and clear manner. ***F. Self-reflection report*** ▪ A written self-reflection report (max 400 words) on the learning process within the context of the learning outcomes of the course and the contribution to the case studies supported with evidence ▪ (individual & mark)		
Entry requirements		
Affinity with the use of geo-information science and building an online presence.		
Teaching and learning approach		
Time allocation in hours per activity		
Lecture [contact]	24	
Supervised practical [contact]	14	
Tutorial [contact]	10	
Individual assignment	26	
Group assignment	26	
Self-study	42	
Sum	**140**	
Assessment		
Examiners	Valentijn Venus	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical storytelling assignment(s)	0	individual
Theory 1 written test	30	individual
Write a Blog/news article and fact-check one	60	individual
self-reflection report	10	individual

Geo-entrepreneurship: a bridge towards geospatial innovation	
Course code	t.b.d.
Course type	Elective
Period	November 2022 – April 2023
Credits	5
Coordinator	Valentijn Venus
Keywords	Entrepreneurship | internationalization | innovation | geoinformation

Description

The objective of this course is to equip the students with entrepreneurial skills.

Entrepreneurship is defined as the capacity and willingness to develop, organize and manage a business venture, along with any of its risks, in order to make a profit. Entrepreneurship can be as an owned company or internal in a company. This module focuses on Entrepreneurial 'spirit' and is characterized by innovation and risk-taking; this is an essential part to succeed in an ever-changing and increasingly competitive global marketplace (from 'Business dictionary'; 2013). However, entrepreneurship is much broader than the creation of a new business venture. It is also a mind-set – a way of thinking and acting. It is about imagining new ways to solve problems and create value. In the context of changing paradigms in development corporations, giving a major role to the private sector in the aid to trade agenda, this entrepreneurial mind-set will help our students to understand and effectively communicate with stakeholders in public-private partnerships and to be active in the private sector as well. Entrepreneurship is not without a reason one of 21th century skills.

Hence, the focus of this course lies on creating an entrepreneurial mind-set to identify and develop business cases from geoinformation

Learning outcomes

Upon completing this course the students are able to:

1. Understand the importance of the basic principles of the lean startup method
2. Design startup business models and experiment with relevant tools (e.g. business model canvas)
3. Perform idea validation using tools (e.g. questionnaires, interviews, etc.)
4. Analyse the competition and pivot their original idea accordingly
5. Understand the importance of team, raising capital and pitching
6. Appraise inclusive innovation business (model) ideas that are likely work in "Bottom-of-Pyramid" (BoP) markets

Content

This course has been designed to facilitate a strong social and learner-centered environment, meaning that learning is active and requires participation from all learners. You will be actively engaged in sharing, reading, reviewing, and commenting on your classmates' work they post to their learnings and through our discussion forums. Teaching is not something that can only be done by an instructor, you will also need to be involved and participate in the process.

A. Theory: Lean Start-ups

The content for this course is divided into 9 modules that are grouped into the following units:

- Introduction
- Orientation and Expectations
- Session 1 – Assess proposition
- Session 2 – Users

Geo-entrepreneurship: a bridge towards geospatial innovation

- Session 3 – Tech/Eco opportunities
- Session 4 – Functionalities & tech. architecture
- Session 5 – Use & Bizz case
- Session 6 – Concept Validation
- Session 7 – Tech & Market PoC, Project Plan
- Session 8 – Startup Branding and Pitching
- Session 9 – Investment Readiness and Raising Capital

B. Project: design and evaluate a business idea

In this project you get to improve your professional and academic entrepreneurial and valorisation skills by scoping a real-life entrepreneurial opportunity based on geoinformation science.

C. Progress meetings & peer-feedback

Progress meetings and peer-feedback are foreseen to monitor and stimulate the interaction between staff and students. Students will groups will be presenting their progress, identifying the challenges and possible solutions. The students will have the opportunity to comment on each other's works and ask questions to the scientific consultants.

D. Pitch

A pitch (with supporting 60 second movie) will be designed such that the business idea can be presented in a compelling and clear manner to appeal to a broader audience.

E. Self-reflection report

A written self-reflection report (max. 400 words) on the learning process within the context of the learning outcomes of the course and the contribution to the case studies supported with evidence (individual & mark).

Entry requirements

Affinity with the use of geoinformation science and or entrepreneurship.

Teaching and learning approach

Acknowledging the strength and effectiveness of peer learning, this course has been designed to facilitate a strong social and learner-centred environment, meaning that learning is active and requires participation from all learners. You will be actively engaged in sharing, reading, reviewing, and commenting on your classmates' work they post to their learnings and through our discussion forums. Teaching is not something that can only be done by an instructor, you will also need to be involved and participate in the process.

Time allocation in hours per activity

Lecture [contact]	38
Supervised practical [contact]	14
Tutorial [contact]	10
Individual assignment	26
Group assignment	26
Self-study	36
Sum	**140**

Assessment

Examiners	Valentijn Venus

Geo-entrepreneurship: a bridge towards geospatial innovation		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
MOOC assignment and tracking	30	Individual
Project report	60	Individual
Self-reflection report	10	individual

Environmental Monitoring with Satellite Image Time Series	
Course code	t.b.d.
Course type	Elective
Period	September 2022 – November 2022
Credits	5
Coordinator	Michael Marshall, Margarita Huesca-Martinez
Keywords	

Description

The 21st century has witnessed an increase in the availability and use of satellite images to capture changes in landscape patterns through time. You may have already been exposed to classical change detection analysis, which is a type of monitoring in which changes in landscape patterns are quantified from satellite imagery between two snapshots in time. Change detection analysis in this way is insufficient however when the processes under investigation are highly dynamic, e.g. agricultural droughts, ecosystem "tipping points" and forest fires. Such cases require continuous monitoring of satellite images at daily, bimonthly or monthly intervals with time series analysis (TSA). Continuous satellite image data, referred to as Satellite Image Time Series (SITS) in this course, are used to monitor highly dynamic processes. Ecological indicators derived from SITS capture landscape patterns consistently at frequent intervals, which enable researchers and natural resource managers to detect both abrupt changes and slow trends over time. In addition, SITS spanning long periods of time, provide insights into the "drivers of change" and underlying mechanisms governing change. Several satellite image archives are now publicly available with the eemergence of relatively inexpensive high-performance cloud computing platforms. Each archive presents unique challenges in terms of acquisition and processing. At the same time, TSA encompasses an array of quantitative approaches to monitor and forecast ecological indicators derived from SITS. These include among others, autoregressive (AR), moving average (MA) and autoregressive moving average (ARMA) models.
The number of SITS and methods for TSA can make environmental monitoring with remote sensing a daunting task. The overall goal of this course therefore is to provide you with sufficient knowledge and tools to acquire and process SITS, perform TSA on ecological indicators derived from SITS and design a successful environmental monitoring project. In the NRM Specialization Earth Observation for Natural Resources Management, students are asked to follow the Phinn et al. (2003) procedure when selecting and using a single satellite image and analytical technique to address specific problems in natural resources management (Figure 1). In this course, we shift attention away from early steps of the procedure (scale of observation and general analytical approaches) to latter steps of the procedure (data acquisition, processing, analysis and evaluation). These steps are detailed in Kennedy et al. (2009) for scientists and natural resource managers interested in integrating SITS into their environmental monitoring project.

Learning outcomes

Upon completion of this course, the student will be able to:

1. Deconstruct SITS based on trend, seasonality, cyclical irregularity and structural changes using the BFAST algorithm
2. Model and predict ecological indicators with SITS using the Box–Jenkins method for TSA
3. Detect agricultural droughts, ecosystem tipping points and forest fire activity with SITS
4. Design and implement an environmental monitoring project that acquires, processes, analyzes and evaluates SITS

Content

Environmental Monitoring with Satellite Image Time Series

- Key terms and concepts in remote sensing and environmental monitoring
- Ecological indicators derived from SITS
- SITS: data acquisition and processing
- Time series decomposition
- Box–Jenkins method for TSA
- Detecting agricultural droughts with remote sensing-based evapotranspiration indices
- Detecting ecosystem tipping points with spectral vegetation indices
- Modeling and forecasting forest fire risk behavior with AR models
- Environmental monitoring group project

Entry requirements

Basic statistics
GIS and RS experience (ILWIS and/or ArcMap, Erdas)
Ecological background

Teaching and learning approach

The course takes a student-centred (inquiry-based) approach to teaching and learning. Students assume an active/participatory role in their education, while teachers are facilitators who encourage interaction with new material presented and reflective thinking. The teacher uses class discussions, hands-on practicals and other experiential learning tools to track student comprehension, learning needs and academic progress over a teaching unit. Four summative assessments (writing assignment×2 + written exam + final group project) measure how well the students achieve higher order thinking and learning outcomes.

Time allocation in hours per activity

Lecture [contact]	22
Supervised practical [contact]	22
Tutorial [contact]	10
Written/oral test	6
Individual assignment	17
Group assignment	25
Self-study	38
Sum	**140**

Assessment

Examiners Michael Marshall, Margarita Huesca-Martinez

Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written assignment	10	Individual
Written assignment	10	Individual
Written test	40	Individual
Oral presentation	40	Small groups

Quantitative Remote Sensing of Vegetation Parameters	
Course code	t.b.d.
Course type	Elective
Period	September 2022 – November 2022
Credits	5
Coordinator	Roshanak Darvishzadeh
Keywords	Vegetation traits | phenology | empirical models | time-series images | radiative transfer model

Description

This course is about the retrieval of quantitative information on vegetation. In particular, the focus will be on vegetation traits, namely leaf area index and phenology and how they can be estimated using remote sensing.
Definitions and details about these parameters, how they are measured in the field, and how they are estimated using remote sensing data will be provided during the course.

Learning outcomes

11. Upon completion of this course, the student will be able to:
12. To explain the spectral properties of vegetation and explain the use and role of vegetation parameters in various applications for terrestrial ecosystems
13. To conduct field and laboratory measurements for several pant traits
14. To describe modelling approaches of plant traits, including general statistical approaches (such as calculation of various vegetation indices), and simple radiative transfer models.
15. To explain existing phenological analysis techniques and its relevance to a range of applications.
16. To estimate phenological parameters, such as start- and end-of-season, from satellite image time series
17. To apply the learned techniques in an individual assignment related to the student's MSc thesis

Content

- Introduction to biophysical and biochemical parameters
- Measurements of leaf area index (LAI)
- Field and laboratory measurements
- Spectral properties of leaves, canopies and soil
- Lab spectroscopy
- Statiscal methods (Vegetation indices, Red edge inflection Point, Multivariate methods)
- leaf and canopy radiative transfer models and their inversion.
- introduction to phenology and its applications for studing ecosystems, agriculture, and climate
- retrieval phenology from coarse-resolution remote sensing time series
- retrieval of phenology at fine spatial detail from Sentinel-2
- validation: linking phenological retrievals to field data, including from digital repeat cameras

Entry requirements

GIS and remote sensing skills

Teaching and learning approach

A series of lectures, tutorials in the forms of discussions and Q&A sessions, supervised practical, use of online materials, field and lab tutoring will be implemented.

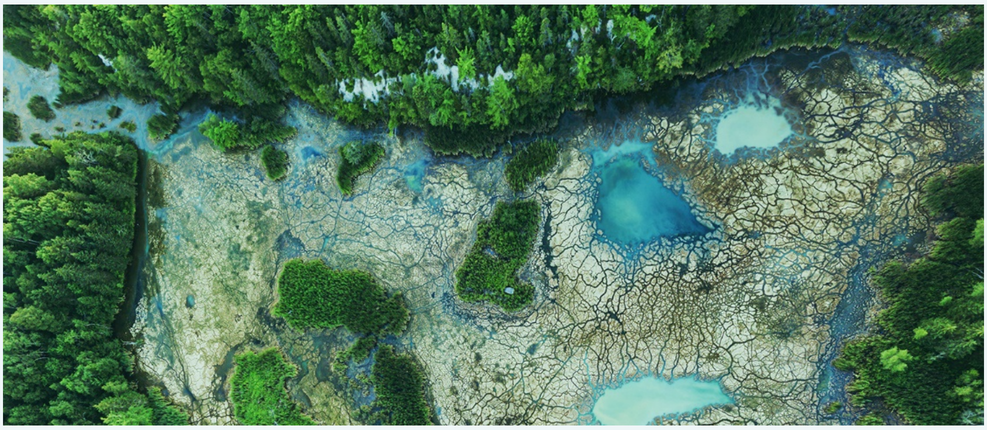
Time allocation in hours per activity

Lecture [contact]	26
Supervised practical [contact]	14

Quantitative Remote Sensing of Vegetation Parameters		
Tutorial [contact]	22	
Study trip [contact]	8	
Written/oral test	4	
Individual assignment	42	
Group assignment	8	
Self-study	16	
Sum	**140**	
Assessment		
Examiners	Anton Vrieling	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical skills in LAI retrieval	20	individual & group
Practical skills in Phenology	20	individual & group
Individual report and presentation	60	individual

Courses in year 2 at ITC-University of Twente, the Netherlands

Track 3- GEM4 Ecosystems & Natural Resources



MSc research proposal and thesis writing	
Course code	t.b.d.
Course type	Compulsory
Period	September 2022 – July 2023
Credits	45 EC
Coordinator	Raymond Nijmeijer
Keywords	MSc proposal | MSc thesis

Description

The first stage of this course is spent on developing an MSc Research Proposal with support and feedback from staff and peers. Through the MSc Research Proposal, the students should demonstrate the ability to undertake independent research. At the end of the first quartile the MSc Research Proposal will be assessed by a Proposal Assessment Board based on a written proposal, a presentation and an oral defence. The Proposal Assessment Board decides if the proposal is acceptable, as one of the conditions to continue with the MSc Research phase.
The second stage of the course is dedicated to the execution of an individual research project. Each student works independently on the basis of an approved research proposal.
In this final part of the course, the students further develop their research skills, interact with their fellow students, PhD researchers and staff members and, finally, demonstrate that they have achieved the learning outcomes of the Master's programme by research, on a satisfactory academic level.

Learning outcomes

7. Address a well-formulated relevant research problem of sufficient scope and depth related to the application of geo-information and earth observation and linked to relevant literature (scientific scope and depth)
8. Undertake research with a clear and transparent methodology with proper use of concepts, methods and techniques (scientific method)
9. Write a well-structured and readable thesis report with a clear layout (reporting)
10. Orally present and defend the research and use proper argumentation in the discussion about the research (presentation and defence)
11. Work in a structured and independent way, while making adequate use of the guidance of the supervisor (process)
12. Reflect and discuss in the thesis, the relevance of the research in different cultural and international contexts, or present the research in an international setup, through reflecting on its utility in overarching cultural and societal differences and fostering of stakeholder partnerships.

Content

Guided Proposal Writing

Introductory lectures on:
- MSc Research phase process Research ethics

Tutorials and peer discussion on :
- Formulating sub-objectives and research questions Methodology
- Ethical considerations in MSc research Optional, theme-specific tutorials
- Data collection methods Data analysis methods

Proposal defence
- Oral presentation and defence of the MSc research proposal before the Proposal Assessment Board

Thesis Writing

MSc research proposal and thesis writing		
▪ Based on the accepted research proposal the student will carry out the planned activities. Regular individual progress meetings with the supervisors will be held to facilitate the progress on the research and thesis writing, and records of the progress will be kept. The activities include: ▪ Deepen literature review, including assessment of the usability of literature and previous research; Collection of relevant data. If appropriate, preparation and execution of fieldwork to collect primary data required for the research; ▪ Data processing and analysis ▪ Active participation in seminars and activities of the research theme under which the MSc research resorts; ▪ Mid-term presentation: A formative assessment is made on the research progress approximately half- way the thesis development time-frame ▪ Preparation of the final manuscript of the MSc thesis ▪ A critical review of the quality, use, and usefulness of the data and results, as well as the learning process ▪ Oral presentation and defence of the MSc thesis before the Thesis Assessment Board.		
Entry requirements		
Students should have at least 60 credits of the first year. Supervised MSc thesis writing can only start after a successful MSc proposal defence.		
Teaching and learning approach		
Students are assigned a supervisor or team of supervisors to guide them during their individual research. Students will make individual arrangements with their supervisor(s) regarding the frequency of supervision meetings and the extent of the guidance they can expect.		
Time allocation in hours per activity		
Lecture [contact]	4	
Supervised practical [contact]	12	
Tutorial [contact]	12	
Study trip [contact]	0	
Written/oral test	4	
Individual assignment	0	
Group assignment	0	
Self-study	1228	
Sum	1260	
Assessment		
Examiners	ITC and Tartu staff	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Proposal assessment	n/a	individual
Thesis defence	100	individual

Internship	
Course code	t.b.d.
Course type	Compulsory
Period	September 2022 – July 2023
Credits	10 EC
Coordinator	Belinda Jaarsma-Knol
Keywords	internship

Description

The internship is defined as a credit-bearing experiential activity in a professional work environment. Its main purpose is to integrate knowledge and theory with practical applications and skill development in a host organization that is an associate partner in the GEM programme.

The internship may be carried out within consultant companies, government agencies, research institutes, NGOs or intergovernmental organisations in the Netherlands or abroad. ITC has a working relation and has made agreements on the possible placement of interns with these organisations. The student will be able to apply for an internship topic based to interests and preferences and will develop this topic into an internship project plan (IPP) prior to the start of the internship. During the internship, the student will receive guidance from a daily supervisor in the organisation concerned. A member of the ITC scientific staff who is an expert on the area of the internship topic will be assigned as ITC internship supervisor. At the end of the internship, the student will have to hand in several deliverables such as an internship report (IR) and an internship reflection report (IRR) report in which the results experiences will be discussed and highlight the learning that has been achieved during the internship. The supervisor of the host organization will give feedback on the professional skills using the Host Evaluation Form (HEF).

Students choosing to carry out internships will have the opportunity to:

- Develop a working knowledge in the operationalization of geo-information science;
- Learn new practical skills and gain confidence in entrepreneurial and professional settings;
- Practice communication and teamwork skills;
- Establish a network of professionals;
- Boost their career prospects;
- Become a more motivated life-long learner.

Learning outcomes

Upon completion of this course, the student is able to:

1. Develop a deliverable that integrate GEM knowledge with the practical applications of a host/client organization.
2. Operate practically and confidentially in entrepreneurial and professional settings.
3. Reflect/evaluate the content and process of the learning experience of the internship.
4. Communicate the internship results effectively to the client/industry and academics.

Content

The internship focuses on executing specific tasks of a project or research related to the integration of GEM knowledge within the context of a host/client organization. It involves spending part of the second year working at a company/organization as part of a team and can be carried out before or after MSc thesis defence.

Entry requirements

Teaching and learning approach

The process of the search for the internship is predominantly the student's own responsibility but it is

Internship		
facilitated by the ITC internship coordinator. Orientation for an internship can be started the moment the student is enrolled in the academic year but should start at least 6 months prior to the desired start date for an internship in The Netherlands and preferably a whole year in advance for an international internship. This extra time is required for arrangements that need to be made. ITC is providing a database with host organizations and internship assignments from which the student can choose. It is also possible that the student suggests an internship assignment or organization in the field of the GEM programme. The internship coordinator facilitates and supports the student throughout the whole internship process. The UT online tool “mobility online” is used to monitor the internship procedure. An internship can only start after approval and signing of the internship assignment and the Internship Project Plan (IPP) – to be signed by three parties; host organization, student and ITC internship supervisor (i.e., examiner). The ITC supervisor is responsible for the quality check of the content of the internship assignment and Internship Project Plan. It is also mandatory to have a signed internship agreement before the internship commences. During the internship, the student will receive supervision and guidance from an ITC internship supervisor as well as a daily supervisor at the host organization. A minimum of 7 full-time weeks will have to be spent on the internship, with an indicative maximum of 20 weeks (i.e., 2 quartiles). Irrespective of the length of the internship within these limits. The number of credits awarded after successful completion of the internship remain 10 EC > (280 hours). The internship has to be concluded with an internship report (IR) and preferably with a presentation in the organization and/or at ITC. This internship report provides a content description of the process and results of the internship and includes a discussion of the problem and context, objectives of the assignment, the question addressed, the method used, analyses performed, results and discussion. An internship reflection report (IRR) is mandatory to hand in. This Internship Reflection Report highlights on the learning process of the professional skills during the internship.		
Time allocation in hours per activity		
Lecture [contact]	0	
Supervised practical [contact]	0	
Tutorial [contact]	0	
Study trip [contact]	0	
Written/oral test	24	
Individual assignment	0	
Group assignment	0	
Self-study	256	
Sum	280	
Assessment		
Examiners	ITC staff & associate partners	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Internship project plan	0	individual
Internship report and internship reflection report	100	individual

Environmental assessment using SDS and advanced EO tools	
Course code	t.b.d.
Course type	Elective
Period	November 2022 – January 2023
Credits	5 EC
Coordinator	Joan Looijen
Keywords	Environmental assessment | spatial decision support | EO | planning

Description

How can spatial decision support (SDS) and advanced earth observation tools enhance the environmental assessment process to ensure sustainable planning and decision-making?

Ad hoc and often uncontrolled development initiatives can have undesired social, economic and ecological consequences. Rapid population growth, pollution, climate change, exposure to hazards and disasters, and the loss of biodiversity and ecosystem services require effective assessment tools to assist sustainable planning and decision-making.

Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) are the basic procedures to support this process. The key principles of EIA and SEA are the involvement of relevant stakeholders, a transparent and adaptive planning process, consideration of alternatives, and using the best possible information for decision and policymaking. They, therefore improve both the (spatial) planning process and the information used in this process. In addition, earth observation (EO) tools can provide the biophysical baseline occurring in a given geographical area and be used in monitoring of the proposed activity, making the environmental assessment process more efficient.

In this course, you will not only explore how SEA can be integrated in the planning process to enhance sustainable decision-making, but also will address how GIS, spatial decision support and advanced EO tools such as unmanned aerial vehicle (UAV) and high-resolution space-borne imagery, can be used to help identify and structure the problem(s), as well as generate and compare possible solutions, and monitor and evaluate the proposed activities.

Hands-on experience with real EIA and SEA projects will be a major part of the course.

Learning outcomes

- Explain the basic principles, procedures and steps in EIA & SEA and their integration in the planning process.
- Analyze the potential application of GIS and advanced EO tools in the environmental assessment process
- Incorporate hazard, vulnerability and risk in EA for (spatial) planning
- Apply SDS tools to define, analyse and assess alternatives
- Carry out an EA project dealing with a typical application within the field of SEA & EIA for spatial planning
- Evaluate the use of GIS, EO and SDS tools in EA

Content

The course exists of eight modules and includes the following topics:

- Introduction and EIA
- SEA: concepts, principles, stages and interaction with the planning process
- Advanced EO tools: review of UAV and high-resolution space-borne imagery principals, applications in environmental assessments and their advantages
- Screening & Scoping: key elements & plan objectives, key issues, SEA objectives and identification of alternatives & options

Environmental assessment using SDS and advanced EO tools		
▪ Assessment: baseline information, impact prediction & significance, mitigation, comparison of alternatives and justification for selected one(s); SEA report ▪ Spatial Decision Support tools in EA: spatial multi-criteria evaluation for site selection and vulnerability analysis ▪ Review and decision-making ▪ Monitoring ▪ Final project dealing with a typical application within the field of environmental assessment for spatial planning		
Entry requirements		
▪ GIS and Remote Sensing skills ▪ Basic understanding of environmental issues		
Teaching and learning approach		
The course will be 'problem-driven', based on learning by doing. Several real-life based case studies from different disciplines will be offered to gain hands-on experience in environmental assessment for sustainable planning and decision-making. Teaching will be based on presentations, supervised and un-supervised practical, self-study, plenary discussions, self-tests; project work.		
Time allocation in hours per activity		
Lecture [contact]	26	
Supervised practical [contact]	26	
Tutorial [contact]	6	
Study trip [contact]	0	
Written/oral test	0	
Individual assignment	32	
Group assignment	20	
Self-study	30	
Sum	140	
Assessment		
Examiners	Joan Looijen	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Individual assignment	50	individual
Summary report	50	group

Spatial analyses of ecosystem services: nature’s benefits to people	
Course code	t.b.d.
Course type	Elective
Period	September 2022 – November 2022
Credits	5 EC
Coordinator	Louise Willemen
Keywords	Social-ecological systems | Geo-information | Sustainability | Planning | Resource management

Description

Ecosystem services i.e., the contributions of nature to human well-being, are increasingly used to describe human-nature interactions in an inclusive way. The ecosystem services concept addresses management objectives that go beyond natural resources or human practices alone, as it focuses on the interactions between nature and society. Geo-information is inherent to ecosystem service assessments, since the supply (from ecosystems) and demand (from society) for ecosystem services are spatially explicit. Understanding the ecosystem service concept, selecting and using mapping methods for specific management objectives is therefore essential for incorporating human-nature interactions into environmental management and hence the key objective of this course. Managing natural resources in a sustainable way by taking into account human well-being is also at the core of the Sustainable Development Goals as set by the United Nations. After completing this course, the student will have obtained knowledge in the theoretical aspects of ecosystem services and the definitions, classification systems. The student will also be able to select and apply mapping methods for ecosystem service assessments on real-life applications in the context of diverse management objectives.

Learning outcomes

Upon completion of this course, the student is able to:

- Summarise the history, explain the definitions and types of classification of ecosystem services.
- Distinguish ecosystem service supply, use, demand and value.
- Interpret ecosystem service information for diverse decision-making objectives in three different systems (urban, rural and marine).
- Use data and tools for ecosystem service mapping for one case study application
- Evaluate and select tools for ecosystem service mapping for selected decision-making objectives.
- Formulate opportunities and challenges of geo-information on ecosystem services for resource management and planning.

Content

Knowledge, methods, skills, approaches that the students will learn:

- Human-nature relations: Scientific concepts over time, terminology of ecosystem services, Natural Capital, Nature-based Solutions, Green/Blue Infrastructure
- Ecosystem service classifications
- Concepts of ecosystem service supply, use, demand, and value
- Decision making frameworks: phases and (geo-) information needs
- Decision making & mapping challenges: in urban, rural and marine systems
- ES quantification and valuation approaches: social, economic and ecological measures, interactions, relevance.
- Ecosystem service mapping methods/tools/software: based on GIS, Remote Sensing, Participatory GIS, and analysis of the results
- Ecosystem service data: requirements, sources, challenges
- Comparing and contrasting ecosystem service mapping methods for decision making challenges

Spatial analyses of ecosystem services: nature's benefits to people		
Entry requirements		
Able to independently use GIS software; strong interest in interdisciplinary work		
Teaching and learning approach		
(guest) lectures, computer practicals, practice professional implementation of course topic, self-study includes reading and exercises , plenary discussions.		
Time allocation in hours per activity		
Lecture [contact]	20	
Supervised practical [contact]	18	
Tutorial [contact]	11	
Study trip [contact]	4	
Written/oral test	2	
Individual assignment	0	
Group assignment	43	
Self-study	42	
Sum	140	
Assessment		
Examiners	Evangelia Drakou, Nina Schwarz, Louise Willemen	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam	50	individual
Assignment	50	group

Environmental Monitoring with Satellite Image Time Series	
Course code	t.b.d.
Course type	Elective
Period	September 2022 – November 2022
Credits	5
Coordinator	Michael Marshall, Margarita Huesca-Martinez
Keywords	

Description

The 21st century has witnessed an increase in the availability and use of satellite images to capture changes in landscape patterns through time. You may have already been exposed to classical change detection analysis, which is a type of monitoring in which changes in landscape patterns are quantified from satellite imagery between two snapshots in time. Change detection analysis in this way is insufficient however when the processes under investigation are highly dynamic, e.g. agricultural droughts, ecosystem “tipping points” and forest fires. Such cases require continuous monitoring of satellite images at daily, bimonthly or monthly intervals with time series analysis (TSA). Continuous satellite image data, referred to as Satellite Image Time Series (SITS) in this course, are used to monitor highly dynamic processes. Ecological indicators derived from SITS capture landscape patterns consistently at frequent intervals, which enable researchers and natural resource managers to detect both abrupt changes and slow trends over time. In addition, SITS spanning long periods of time, provide insights into the “drivers of change” and underlying mechanisms governing change. Several satellite image archives are now publicly available with the eemergence of relatively inexpensive high-performance cloud computing platforms. Each archive presents unique challenges in terms of acquisition and processing. At the same time, TSA encompasses an array of quantitative approaches to monitor and forecast ecological indicators derived from SITS. These include among others, autoregressive (AR), moving average (MA) and autoregressive moving average (ARMA) models.
The number of SITS and methods for TSA can make environmental monitoring with remote sensing a daunting task. The overall goal of this course therefore is to provide you with sufficient knowledge and tools to acquire and process SITS, perform TSA on ecological indicators derived from SITS and design a successful environmental monitoring project. In the NRM Specialization Earth Observation for Natural Resources Management, students are asked to follow the Phinn et al. (2003) procedure when selecting and using a single satellite image and analytical technique to address specific problems in natural resources management (Figure 1). In this course, we shift attention away from early steps of the procedure (scale of observation and general analytical approaches) to latter steps of the procedure (data acquisition, processing, analysis and evaluation). These steps are detailed in Kennedy et al. (2009) for scientists and natural resource managers interested in integrating SITS into their environmental monitoring project.

Learning outcomes

Upon completion of this course, the student will be able to:

5. Deconstruct SITS based on trend, seasonality, cyclical irregularity and structural changes using the BFAST algorithm
6. Model and predict ecological indicators with SITS using the Box–Jenkins method for TSA
7. Detect agricultural droughts, ecosystem tipping points and forest fire activity with SITS
8. Design and implement an environmental monitoring project that acquires, processes, analyzes and evaluates SITS

Content

Environmental Monitoring with Satellite Image Time Series		
▪ Key terms and concepts in remote sensing and environmental monitoring ▪ Ecological indicators derived from SITS ▪ SITS: data acquisition and processing ▪ Time series decomposition ▪ Box–Jenkins method for TSA ▪ Detecting agricultural droughts with remote sensing-based evapotranspiration indices ▪ Detecting ecosystem tipping points with spectral vegetation indices ▪ Modeling and forecasting forest fire risk behavior with AR models ▪ Environmental monitoring group project		
Entry requirements		
Basic statistics GIS and RS experience (ILWIS and/or ArcMap, Erdas) Ecological background		
Teaching and learning approach		
The course takes a student-centred (inquiry-based) approach to teaching and learning. Students assume an active/participatory role in their education, while teachers are facilitators who encourage interaction with new material presented and reflective thinking. The teacher uses class discussions, hands-on practicals and other experiential learning tools to track student comprehension, learning needs and academic progress over a teaching unit. Four summative assessments (writing assignment×2 + written exam + final group project) measure how well the students achieve higher order thinking and learning outcomes.		
Time allocation in hours per activity		
Lecture [contact]	22	
Supervised practical [contact]	22	
Tutorial [contact]	10	
Written/oral test	6	
Individual assignment	17	
Group assignment	25	
Self-study	38	
Sum	**140**	
Assessment		
Examiners	Michael Marshall, Margarita Huesca-Martinez	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written assignment	10	Individual
Written assignment	10	Individual
Written test	40	Individual
Oral presentation	40	Small groups

Geo-journalism

Course code	t.b.d.
Course type	Elective
Period	November 2022 – April 2023
Credits	5
Coordinator	Valentijn Venus
Keywords	Geo-journalism | valorization | motivation | personal branding | fact-checking

Description

The objective of this course is to equip students with an interest in valorization (e.g. geo-journalism) to deliver their scientific results as re-usable research objects for delivery through digital NEWSrooms, such that analysis can be repeated fully independently and best practices in journalism can be adhered to.

Stories about our Planet are broad by nature and it is the job of a journalist to help pin down the often interconnected reasons that drive environmental change. The growth of large, publicly accessible datasets presents the media community with new opportunities, but this also comes with the need for new skills to turn this trove of information into easy-to-understand, evidence-based stories. Simultaneously, ITC/UT has been teaching applied geo-information sciences for +60 years, but with increasing emphasis on academic skills in recent years. According to a recent survey, however, more than 80% of our alumni do not pursue an academic career. Therefore, an all-new MSc course module on geo-journalism is presented which teaches students to combine geodata, data analytics, and various Bodies of Knowledge (BoK) in creating compelling (cartographic) infographics to support their storytelling. Using this knowledge and skill, students are enabled to create compelling (cartographic) infographics in minutes rather than days. These infographics are fully semantically enriched, allowing others to see and question the data sources and underlying analyses. With each course assignment, students gradually populate their online NEWSroom with blog articles annotated by these (cartographic) infographics. As a portfolio of the student's environmental storytelling efforts, this NEWSroom also helps improve their personal branding since their reporting is automatically indexed by Microsoft Bing and Google search because of the adherence to the Semantic Web-standards of our NEWSroom tooling.

The semantic tools and data models used in geo-journalism provide important 'spill-overs'; the open-source technology stack not only facilitates fact-checking of claims made in news and blog articles, but also those in scientific journal articles. Studies show that only 10~30% of published science articles are reproducible. Many argue this is a logical result of the publishing format as in most papers textual reference is made such as "this experiment was conducted as previously reported [insert reference here]" instead of a live reference to the online executable algorithm and workflow to recreate the results. Our hope is that it will enable those with an enthusiasm for storytelling to use these rapid geo-information pipelines to support their valorization efforts in publishing (reviews) of scientific findings and how to stimulate viral spread across the Internet.

Learning outcomes

Upon completing this course the students are able to:

- Discover and tell a story that is appealing
- Gain insights in journalistic best practices for publishing scientific results in the media
- Master tools for geo-journalism and online, rapid executable EO workflows
- Master robust, online peer-review workflow to stimulate viral spread across the Internet

Geo-journalism
▪ Facts and values in journalistic practice; appreciate how facts are socially produced, why values are contested, and how facts and values constitute each other. ▪ Valorize on research results by appraising and recommending suitable methods to summarize scientific findings for a broad audience using infographics and social media blog articles ▪ Understand practical ways to build-out your personal brand name by developing sound social media strategies
Content
▪ This course will prepare the students to become vocal individuals who have ability, attitudes, skills and know-how necessary for sound geo-journalism for the valorization of research results and uptake addressing the appropriate level of understanding for an audience. ▪ The course is structured as follows: (**a**) basic theory (frontal teaching) (**b**) flipped classroom teaching where the transfer of theoretical information from teacher to student ('lecturing') is taken out of the classroom/lectures and presented as material to study before the lecture. The lecture itself is then used to discuss important questions about the material, and assess the student's level of understanding (**c**) getting practical, including storytelling exercises (**d**) editorial meetings (**e**) develop a NEWSroom consisting of co-authored blogs and infographics, and, finally, a self-reflection report (**f**) where participants reflect on their learning curve and possible follow-ups are identified. ***A. Basic theory*** ▪ The course starts with lectures (incl. guest lectures), followed by practical assignments. ▪ <u>*A.1 Lectures*</u> ▪ A. Develop storytelling skills to repot about our Natural world: ▪ Discover the story by identifying elements in scientific findings that contradict, agree, or deviate from popular opinion ▪ How to write a news article in a 'foldable' manner ▪ Business models for (semi) professional geo-journalism; ▪ <u>*A.2. Guest lectures*</u> ▪ A series of guest lectures will be organized from UTwente staff who have experience with: ▪ How to write an enticing introductory section of a news story, *aka* "lede", that helps keep the reader's attention ▪ Understand design criteria for easy-to-understand visuals that support or tell your story ***B. Advanced concepts: flipped classroom*** Online materials are provided to the course participants to enhance their competencies in authoring and reviewing blog articles, accompanied by an appropriate (cartographic) infographic, related to a contemporary issue. The aim of this phase is to discover a students' learning path and to prepare them for the role of author, editor, and publisher in a role-play (phase in C). ▪ Master rapid, online executable EO workflows for geo-journalism and online publishing: ▪ Appraise methods, tools, and data that help summarize these findings using an infographic ▪ Elaborate data needs for the infographic ▪ Subset geo-data by time, space, and parameter for the infographic ▪ Propose rapid geo-data processing functions & reduce the data dimensionality meaningful for the infographic ▪ Present and augment computer-generated infographics to be visually appealing and easy-to-understand ▪ Master robust, online peer-review workflow to stimulate viral spread across the Internet: ▪ Understand the basic principles of the Semantic Web 3.0 and the structured data types for "fact-checking" ▪ Demonstrate an understanding of the full definition of ClaimReview (schema.org/ClaimReview)

Geo-journalism
▪ Demonstrate authoring of a (review) claim (schema.org/CreativeWork) ▪ Understand how truthfulness ratings are assigned using the reviewRating of the ClaimReview-process (schema.org/Rating) ▪ Understand how the claim being checked by multiple reviewers can be summarized programmatically (based on this crowd of fact-checkers) ▪ Appraise strategies and reasons to build a personal brand : ▪ Understand practical ways to build-out your online presence ▪ Be able to tell a story orally, pitch your perspective on a contemporary environmental issue in less than 3 minutes ▪ Discriminate social media strategies ▪ Understand (non)monatery business models for (semi) professional geo-journalism (e.g. freelance journalism, personal branding, or valorization of research results) ***C. Getting practical; storytelling (oral and written) and roleplaying*** ▪ In this phase you get to improve your geo-journalism skills by working on a story covering a real-life, contemporary environmental issue backed by geoinformation science. This requires that you use multiple theories and tools from geoinformation and journalism in an integrated fashion. Given the technical readiness of geo-journalism, several social-cultural aspects also deserve attention such as what are the (perceived) occupational or cultural barriers to be publicly outspoken. ▪ Four contemporary issues (study cases) are presented to students, whereby groups of students will jointly work on the design cycle of a story, frequently alternating the student's role from author-editor-publisher-reader. Below an example design cycle: ▪ Read up on promising fact-checking articles and discuss why some spread virally across the Internet ▪ Compare the findings of 3 scientific articles (focus on the abstract & conclusions), are there elements that deviate from popular opinion (contradict, agree)? ▪ Write an appropriate "lede" for the story you have in mind: hard-news ledes are generally used for breaking news and for more important, time-sensitive stories. Feature ledes are generally used on stories that are less deadline-oriented and for those that examine issues in a more in-depth way. ▪ Write the main body of the blog post in a 'foldable' manner such that the reader can 'skip over' sub-paragraphs while still understanding the main point of the story ▪ By hand, sketch a dummy infographic that would support the main elements of the story. ▪ Review the handwritten dummy infographic from one of your peers: does it support the main elements of the story? ▪ Create the online-referenceable, reproducible EO workflow needed to create the infographic (based on the sketch). ▪ Etc. ▪ The design cycle of a blog or a news article is an iterative process. This means that throughout the project you will improve each design step by going back and forth between steps until a satisfactory result is achieved, and checked by a potential reader or paying publisher. This means design iterations and rework are a natural part of this design cycle, all with the sole goal of improving the young geo-journalist. ***D. Editorial meetings*** ▪ Editorial meetings are foreseen to monitor and stimulate the progress of the students. The student groups will be presenting their progress in identifying and telling stories, addressing the challenges, and proposing possible solutions. The students will have the opportunity to comment on each other's works and ask questions to the scientific and professional consultants. ***E. NEWSroom***

Geo-journalism		
▪ As part of the students' growing journalistic aspirations, with each course assignment students gradually populate their online NEWSroom with blog articles annotated by (cartographic) infographics as personal portfolio of their environmental storytelling efforts. This NEWSroom also helps to improve their personal branding since their reporting is automatically indexed by Microsoft Bing and Google search because of the ReviewClaim-tag, incl. their work in the various role-playing modes, e.g. as editor and reviewer, where fact-checking and feedback on the scientific rigor of underlying facts, incl. data, method, results and discussion, are presented in a scientific and clear manner.		
F. Self-reflection report		
▪ A written self-reflection report (max 400 words) on the learning process within the context of the learning outcomes of the course and the contribution to the case studies supported with evidence ▪ (individual & mark)		
Entry requirements		
Affinity with the use of geo-information science and building an online presence.		
Teaching and learning approach		
Time allocation in hours per activity		
Lecture [contact]	24	
Supervised practical [contact]	14	
Tutorial [contact]	10	
Individual assignment	26	
Group assignment	26	
Self-study	42	
Sum	**140**	
Assessment		
Examiners	Valentijn Venus	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Practical storytelling assignment(s)	0	individual
Theory 1 written test	30	individual
Write a Blog/news article and fact-check one	60	individual
self-reflection report	10	individual

Courses in year 2 at Université catholique de Louvain, Belgium

Track 2 - GEM4 Land Use Systems

Decision tools and project management - Part 1: Decision tools for environmental management		
Course code	S1, Q1	
Course type	Compulsory	
Period	September 2022 - December 2022	
Credits	3	
Coordinator	Frédéric Gaspart	
Keywords		
Description		
▪ Understanding decision processes and the various methods of decision making most commonly relied upon in agronomics, environmental sciences, economics and management. ▪ Taking into account risk and multi-criteria objectives. ▪ Formulating decision problems as they occur in agronomics and in natural resources management. ▪ Selecting adequate methods.		
Learning outcomes		
▪ Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology. ▪ Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology. ▪ Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.		
Content		
▪ The course outlines, explains and compares various methods and decision making tools available in natural and social sciences. It distinguishes and shows the complementarities of statistics and economic analysis. Multi-criteria decisions and decisions under uncertainty in situations with several interacting decision-makers are illustrated with examples taken in fields relevant for the students.		
Entry requirements		
Knowledge and know-how in basic courses of the bio-enginering programme Organization and planning (i.e. Course Design)		
Teaching and learning approach		
Time allocation in hours per activity		
Lecture [contact]	22.5	
Supervised practical [contact]	7.5	
Sum	**30**	
Assessment		
Examiners	Frédéric Gaspart	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**

Decision tools and project management - Part 1: Decision tools for environmental management		
Written exam	100	Individual

Smart Technologies for environmental engineering	
Course code	S1, Q1
Course type	Compulsory
Period	September 2022 - December 2022
Credits	3
Coordinator	
Keywords	Technology

Description

This course aims to teach technologies for characterization and monitoring of agroecosystems. In particular, geophysical imaging and characterization techniques of soil properties are presented, such as ground penetrating radar, electromagnetic induction or electrical tomography. Also, the course discusses the use of drones for environmental monitoring, including multispectral, thermal infrared, LiDAR sensors as well as photogrammetry. Fundamental concepts, instruments and methods of signal analysis will be particularly seen in-depth. The student will be made familiar with these tools through practical works and an integrated project.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
 - Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook
- Demonstrate independence and be proactive in acquiring new knowledge and developing new skills in order to adapt to changing or uncertain situations and to grow, to build a professional project within a continuing development approach.

At the end of this course, students will be able to:
- understand the concepts of the different environmental sensors (geophysics, remote sensing);
- understand and implement different signal processing methods;
- develop a critical analysis on the application of these technologies;
- to master the use of some of the instruments studied.

Content

Smart Technologies for environmental engineering		
Theorical class : ▪ Geophysical techniques: ground penetrating radar, electromagnetic induction, radiometry, electrical tomography, seismic, reflectometry. ▪ Drone remote sensing techniques: thermal infrared sensor, multispectral sensor, LiDAR. ▪ Sensor networks ▪ Signal processing methods: inversion, tomography, photogrammetry, data fusion, artificial neural networks. **Practical work :** The main concepts presented during the courses will be applied during practical work sessions (operational mastery) and an integrated project carried out by group. **Seminars:** Students analyze, synthesize and present a scientific article dealing with a scientific question relating to environmental monitoring.		
Entry requirements		
Applied Geomatics; Soil Physics		
Teaching and learning approach		
Time allocation in hours per activity		
Lecture [contact]	22.5	
Supervised practical [contact]	15	
Sum	**37.5**	
Assessment		
Examiners		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written Exam		Individual
Project Report		Group
Seminar		Group

Human and Environmental Toxicology	
Course code	S1, Q1
Course type	Compulsory
Period	September 2022 – December 2022
Credits	4
Coordinator	Cathy Debier
Keywords	Toxicology | pollutant | environment

Description

Human Toxicology (30h): Historical Overview, concepts and basic concepts in toxicology, assessment methods - Metabolism of xenobiotics : absorption by inhalation, ingestion or dermal; distribution; biotransformation (phase I and II reactions) and excretion - Toxicity of major pollutants or contaminants dangerous to humans: lead, cadmium, mercury, pesticides, dioxins, PCBs, air pollutants, carcinogens - Risk assessment.

Environmental Toxicology (15h +7.5 h): Transport of pollutants - Monitoring of pollutants (biomarkers and bioindicators) - Emerging Pollutants - Contamination of foodstuffs - Endocrine Disruptors - Effects of pollutants on populations and communities - Risk assessment in ecotoxicology

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook.
- Demonstrate independence and be proactive in acquiring new knowledge and developing new skills in order to adapt to changing or uncertain situations and to grow, to build a professional project within a continuing development approach.

At the end of this course, the student:

- knows and understands the basic principles of toxicology (dose, exposure, hazard, danger, indicator, biomarker) ;
- is able to describe the epidemiological and experimental methods used to assess the toxicity of chemicals ;
- knows the main routes of absorption, metabolism and elimination of toxic substances ;
- is able to compare the toxicity of major pollutants and contaminants to which humans may be exposed according to their lifestyle (heavy metals, air pollutants, pesticides, dioxins, industrial pollutants, hydrocarbons ')

After the section " Environmental Toxicology ", the student :

- knows and understands the modes of contamination of the environment;
- is able to describe the technical monitoring of pollutants in the environment (eg through the use of bio-indicators);
- knows and understands the impact of pollutants on individuals (including humans) , communities and ecosystems (among others through the use of biomarkers);
- masters the techniques of " risk assessment " in ecotoxicology;

Human and Environmental Toxicology

- understands the specificities related to the toxicity of endocrine disruptors and is able to make comparisons with other toxic substances;
- knows emerging pollutants, including their toxic effects, and is able to compare it with older pollutants;
- demonstrates critical thinking towards the impact of human activities on environmental contamination and ultimately on human health.

Content

The course is divided in different chapters :

Ch 1 Principles of Toxicology
- Introduction to toxicology
- Characteristics of exposure
- Interactions of chemicals
- Dose-response
- Variation in toxic responses

Ch 2 Absorption, Distribution and Excretion of toxicants
Ch 3 Biotransformation of Xenobiotics
Ch 4 Heavy metals
Ch 5 Pesticides
Ch 6 Poisonous gases
Ch 7 Persistent organic pollutants
Ch 8 Plastics and microplastics
Ch 9 Endocrine disruptors
Ch 10 Environmental Toxicology
- Transport and fate of toxicants in the environment
- Environmental monitoring
- Environmental risk assessment

The practical section includes seminars given by experts and exercises on risk assessment in ecotoxicology

Entry requirements

Basics of chemistry, biochemistry and physiology

Teaching and learning approach

Coordinated package of lectures with audio-visual aids (slides and videos) given by the teachers - concrete examples
Exercises on risk assessment in ecotoxicology and seminars given by invited experts
Most of the activity requires the presence of the students.

Time allocation in hours per activity

Lecture [contact]	30
Supervised practical [contact]	7.5
Sum	**37.5**

Assessment

Examiners	**Cathy Debier, Phillippe Hantson**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam		Individual

Master Thesis	
Course code	S1, Q1 / S2, Q2
Course type	Compulsory
Period	September 2022 – May 2023
Credits	27
Coordinator	
Keywords	Research | work | presentation

Description

The master thesis is a personal work that each student must complete during his master cycle. This thesis is an initiation to scientific research that allows the future engineer to study a topic of his own preference. As a future engineer, the student must identify and address a specific question by respecting the following general approach :

- Summarize the current knowledge about the chosen topic ;
- Set an experimental protocol (in a wide meaning of the term) ;
- Do observations (in the field or in a laboratory) ;
- Analyze and interpret these observations ;
- Draw appropriate conclusions ;
- Present this material in a scientific document ;
- Publicly defend their work

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of the master thesis, the student is able to :

- analyze scientific publications that are related to his master thesis topic, master and discuss the corresponding content and present this content in a summarized way ;
- design a consistent and sound approach in order to answer a scientific question by using a state-of-the-art knowledge about the question ;
- set up an experimental protocol (in a wide meaning of the term), analyze and interpret the corresponding results by the light of the scientific literature at hand and by taking into account the corresponding limitations ;
- communicate the results and justify them using a rigourous scientific language, both in a printed document and during a public oral presentation in front of a jury.

Content

Entry requirements

Teaching and learning approach

Master Thesis		
Typically, possible topics for the master thesis are proposed by promoters. A student can however suggest a new topic and thus can look for a potential promoter that would accept to supervise him. Upon acceptance by the Faculty, a part of the master thesis can be done outside of the university, in Belgium or abroad. This applies for example to Erasmus master theses and internships master theses. The master thesis supervision is under the responsability of a promoter (possible two copromoters). The (co)promoter(s) is in charge of supervising the quality and the timing of the work that must be done by the student. These aspects are evaluated as a specific item, i.e. the 'Evaluation of the personal work made the student', which is part of the final score. It is advised that students choose both the topic and the promoter for their master thesis during the second semester of the first year in the master cycle. All the way long during their master thesis, students must fulfill the master thesis regulation as described in the document that can be found here.		
Time allocation in hours per activity		
Lecture [contact]	0	
Supervised practical [contact]	0	
Tutorial [contact]	0	
Study trip [contact]	0	
Written/oral test	0	
Individual assignment	0	
Group assignment	0	
Self-study	0	
Sum	**0**	
Assessment		
Examiners		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Work during the year	30	Individual
Printed Document	50	Individual
Public Defense	20	Individual

Land monitoring by advanced Earth Observation

Course code	S2, Q2
Course type	Compulsory
Period	February 2023 – May 2023
Credits	3
Coordinator	Pierre Defourny
Keywords	Earth observation | detection | monitoring

Description

This course aims to develop in-depth understanding and professional skills to process and interpret very high resolution UAV (drone) imagery and Earth Observation satellite time series. Advanced concepts related to signal acquisition, time series quality control and uncertainty characterization are introduced. Radiative transfer modelling and methods for biophysical variables estimation (Leaf Area Index, biomass, nitrogen status, surface temperature, evapotranspiration, soil moisture, height, etc.) and change detection methods are explained and illustrated through practical applications and the European Copernicus Services. Finally, open source tools and systems supporting already operational and forthcoming monitoring systems, including flood monitoring, fire monitoring, forest monitoring and crop monitoring, are discussed in details. The objective of this course is to develop the necessary knowledge and technical skills to use advanced image processing methods (including machine learning and artificial intelligence) and to implement workflow for UAV or satellite monitoring applications in the field of agriculture, forestry, land use land cover change, and water resources management.

Learning outcomes

- Build an integrated body of scientific knowledge (knowledge, methods and techniques, models and processes) in environmental and human sciences which serves as the foundation from which to operate with expertise in the field of geoinformation and Earth Observation
- Master highly specialised skills in geoinformation science and Earth Observation which serves as the foundation from which to operate with expertise in the field of environmental, agricultural and land use management
- Formulate and resolve a complex environmental problem with appropriate, sustainable and innovative solutions, the problem being related to the impact of human activities or natural processes on the capacity of the environment to provide goods and services to the population
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors

At the end of this activity, the student is able to:

- practically mobilize the advanced concepts and methods of airborne and satellite remote sensing applied to the monitoring and the management of natural resources, to regional planning and to the environment in general;
- understand and critize in depth the operational services, the available products and the existing tools to get the best out of each;
- mastering specialized open source remote sensing softwares and developping processing chains including several tools;
- design and conduct rigorous digital analyzes of optical and radar time series to respond to specific issues belonging to the bioengineer fields and to formulate the related hypotheses and limits;
- be able to grasp technological developments in the field of remote sensing applied to the fields of the bioengineers.

Land monitoring by advanced Earth Observation		
Content		

The course combines lessons and practicals in computing lab mainly based on open source softwares used in the professional sector.
The lessons address the following topics:

- signal acquisition and pre-processing steps, including quality flags and uncertainty management;
- radiative transfer modelling and retrieval of various biophysical variables;
- optical and SAR time series analysis, features extraction and pixel-based / object-based metrics;
- advanced radar processing including polarimetric and interferometric variables;
- introduction to machine learning and artificial intelligence algorithms for Earth observation mapping, monitoring and change detection;
- critical review of operational monitoring systems (drought, flooding, fire, forest, crop, locust) and of Copernicus Services freely available.
- EO applications related to the environment, agriculture, forestry, water resources and land use planning.

Entry requirements

Introductory class in remote sensing; Programming skills (R, python)

Teaching and learning approach

The teaching introduces the concepts and advanced methods while the practicals in computer lab mobilise them in the context of specific applications. The lessons are quite interactive and partly relies on an inductive approach.
The course and the practicals aims to develop on one hand advanced technical skills in Earth observation data processing and on the other hand, the ability of critical analysis with regards existing solutions, services and products. The student learns not only to use open source packages and Google Earth Engine environment but also to assess the quality and to review the validity of the proposed algorithms and datasets for a given application.
The practical training is closely linked to the course and includes the use of several open source libraries (including QGIS, SNAP, GDAL, ORFEO, Sen4CAP), the exploitation of the Jupyter notebook environment for quality control et time series analysis, and the workflow coding in Python or R.

Time allocation in hours per activity

Lecture [contact]	22.5	
Supervised practical [contact]	15	
Sum	**37.5**	
Assessment		
Examiners	**Pierre Defourny**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam based on Case study	100	Individual

Spatial Modelling of land dynamics	
Course code	S2, Q2
Course type	Compulsory
Period	February 2023 – May 2023
Credits	3
Coordinator	Pierre Defourny
Keywords	Land use | model

Description

The course introduces with a critical perspective a representative set of methods of spatial analysis and land use/land cover modelling, addressing both conceptual and numerical aspects. The course primarily aims to train to the conceptualization of a spatial modelling approach on the one hand, and the development of a critical analysis of existing models and simulations on the other hand. Advanced geomatics methods and dynamic modelling tools supporting a multidisciplinary approach to territorial dynamics are privileged, including functional network modelling using geographic information system, dynamic simulation by cellular automata and spatiotemporal modelling using a multi-agent system. Learning at least one macro language opens the student to the development of special tools. Finally, the contribution of simulations and modelling expertise to decision-making process in spatial planning is discussed.

Learning outcomes

- Build an integrated body of scientific knowledge (knowledge, methods and techniques, models and processes) in environmental and human sciences which serves as the foundation from which to operate with expertise in the field of geoinformation and Earth Observation
- Master highly specialised skills in geoinformation science and Earth Observation which serves as the foundation from which to operate with expertise in the field of environmental, agricultural and land use management.
- Formulate and resolve a complex environmental problem with appropriate, sustainable and innovative solutions, the problem being related to the impact of human activities or natural processes on the capacity of the environment to provide goods and services to the population

At the end of the course, students are able to:

- mobilize the concepts and methods of spatial modelling and simulation of land dynamics;
- thoroughly analyse a complex territorial dynamic, to conceptualize a modelling approach and justify the proposed methodological choices;
- develop a critical analysis of operational models and spatial simulation methods in order to clearly determine their relevance and limitations.

Content

The different modelling and numerical simulation approaches for land use/land cover change and other territorial dynamics are presented according to an increasing level of complexity through concrete examples. The concepts and underlying assumptions are presented and put into perspective in relation to potential applications. During the lectures as well as in the computer lab, the student is invited to conceptualize rigorously his modelling approach and to discuss its implementation.

Entry requirements

Applied Geomatics; Basics in statistics

Teaching and learning approach

The course alternates theoretical module in the form of an interactive lecture and practical work module in the computer room (GIS software and modelling tools).

Time allocation in hours per activity

Spatial Modelling of land dynamics		
Lecture [contact]	15	
Supervised practical [contact]	15	
Sum	**30**	
Assessment		
Examiners	**Pierre Defourny**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam	100	Individual

Master thesis' accompanying seminar	
Course code	S2, Q2
Course type	Compulsory
Period	
Credits	3
Coordinator	Patrick Bogaert
Keywords	Research | work | presentation

Description

The master thesis is an initiation to research work. It is a personal approach that, under the guidance of a teacher, develops the capacity to master experimental approaches, to interpret results on the basis of state-of-the-art knowledge and to identify the perspectives of future investigations. In addition to this methodology, the student should be able to communicate clearly and orally the results of his work. He should also keep a critical mind on the correspondence between the followed approach and the pursued objectives.
In order to make them more visible, these communication activities and critical analysis exercises are valorized through seminars focused on the educational aspects of scientific communication. English must be used for the communication.

Learning outcomes

- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of this activity, the student is able to:

- masters computer tools to prepare and present slideshows, as well as tools to prepare scientific graphics ;
- present in English the context and state-of-the-art in the field of his work by defining the objectives and the followed methodology and /or experimental approach ;
- present orally and in English the results that were obtained and the scientific interpretations that can be made from them, both to peers and experts in the field of bioengineering ;
- identify the main achievements of his work and the prospects for future developments;
- answer to open questions and justify his claims in a scientifically rigorous, balanced and critical way.

Content

The oral presentation presented at the public defense of the dissertation is the final outcome of the seminars given during the academic year. The note for this course corresponds to the evaluation of the oral presentation of the dissertation by the jury. This evaluation will focus on 2 points, with equivalent weights: 1. Clarity of the presentation (quality of the slideshow, voice modulation, time allocation between the different parts of the presentation, keeping the public attention, etc.) 2. Scientific rigor of the presentation (terminology, slide content, synthetic capacity, etc.). This rule applies to all students, including those whose promoter is not a teacher of the faculty. Coordinators verify with the responsible teacher in each team (or with the supervisor when the student completes his dissertation outside the Faculty) before the June session that all students have actually presented two seminars. Any student who do not meet the requirements of this course may be sanctioned (0/20) whatever the quality of the oral presentation during the master thesis defense.

Entry requirements

Teaching and learning approach

Master thesis' accompanying seminar		
Time allocation in hours per activity		
Lecture [contact]	0	
Supervised practical [contact]	0	
Tutorial [contact]	0	
Study trip [contact]	0	
Written/oral test	0	
Individual assignment	0	
Group assignment	0	
Self-study	0	
Sum	**0**	
Assessment		
Examiners		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Public Defense	100	Individual

Process-based modelling in bioscience engineering	
Course code	S1, Q1
Course type	Elective
Period	September 2022 – December 2022
Credits	5
Coordinator	Emmanuel Hanert
Keywords	Model

Description

This module will help students to develop a thorough knowledge of the different steps required to setup a model and learn how to use simulation tools. The students will be able to setup a complete modelling approach in order to forecast and anticipate the behaviour of complex systems. This module considers the propagation of errors and uncertainties in models and hence allows estimating the risk associated to a particular decision.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

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

- Name, describe, explain the theoretical concepts related to the mechanistic approach to analyse and model environmental processes;
- Explain mathematical concepts and use computational tools to model the space-time dynamics of these processes;
- Use these concepts and tools in an operational fashion in order to model the processes that drive realistic environmental systems in the context of an individual project;
- Present a detailed justification of the methodological choices that have been made to analyse the system under study;
- Write a brief report, with a solid discussion based on the modelling results and appropriately illustrated with graphs and charts, using accurate and appropriate scientific vocabulary.

Content

The course covers the following elements and illustrates them with examples modelled with Matlab and/or Python:

- Application of mathematical models in ecology : logistic growth - predator-prey models and general Lotka-Volterra models applied to multi-populations systems.
- Application of mathematical models in epidemiology: compartments models - population dynamics (epidemics vs endemic states) - reproduction number (R_0).
- Transport models in 1D and 2D, and numerical discretization of the advection, diffusion and reaction terms.
- Application of transport models in ecology, epidemiology and hydrodynamics.
  Cellular automata models and their application to simulate outbreaks and invasive species.

Process-based modelling in bioscience engineering		
Entry requirements		
Basic courses in mathematics and some knowledge of Matlab		
Teaching and learning approach		
Teaching is based on a two-hour lecture each week. The lecture format is very "hands-on" with many practical examples and illustrations. Students are encouraged to take their laptop in the classroom. Practical sessions with a research assistant are also scheduled to help the students apply the concepts presented during the lectures.		
Time allocation in hours per activity		
Lecture [contact]	30	
Supervised practical [contact]	15	
Sum	**45**	
Assessment		
Examiners	**Emmanuel Hanert**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Individual report on a personal project		Individual
Written exam		Individual

Data Science in bioscience engineering - Part 1: Spatial and temporal data	
Course code	S1, Q1
Course type	Elective
Period	September 2022 - December 2022
Credits	3
Coordinator	
Keywords	Data | model

Description

- Notions of spatial/temporal dependency and its effect on statistical estimation.
- Quantification and modelling of dependencies through space and time.
- Random fields theory.
- Prediction and simulation of correlated data.
- Mapping and forecasting methods.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of this activity, the student is able to :

- Name, describe and explain the theoretical concepts underlying the stochastic approach for the analysis and the modeling of spatial and temporal data in an environmental framework;
- Explain the mathematical concepts and use the mathematical tools that are relevant for statistical exploratory analyses and inferential estimations from environmental data;
- Use these concepts and tools in an operational framework in order to make statistical analyses and modeling from a real environmental data set in the framework of a group project;
- Explain and justify the methodological choices that are made for the analyses and the modeling steps by integrating the relevant underlying theoretical concepts that have been presented and used during the practical exercises;
- Write a concise report based on the main findings for this analysis and modeling work by using a relevant and accurate mathematical language and appropriate figures.

Content

- This course will complete the basic notions already presented during the courses Probability and Statistics (I) and (II).
- The student will be able to analyze data that are correlated through space and time, as frequently encountered in the agro-environmental context.
- The course will emphasize the link between the general theory and the practical specificities of environmental data.
- It should allow the student to model such kind of processes and to use them in a mapping or forecasting context.

Entry requirements

Data Science in bioscience engineering - Part 1: Spatial and temporal data		
Knowledge of probability and statistics		
Teaching and learning approach		
Regular course and supervised practical exercises. Practical exercises will take place in a computer room using the Matlab or R software. Students will work in groups and will process a specific spatial data set. This personal work will be part of a printed report that must be defended during the examination		
Time allocation in hours per activity		
Lecture [contact]	22.5	
Supervised practical [contact]	15	
Sum	**37.5**	
Assessment		
Examiners		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam		Individual
Oral defense of team project		Group

Data Science in bioscience engineering - Part 2 : Seminars and case studies	
Course code	S1, Q1
Course type	Elective
Period	September 2022 – December 2022
Credits	2
Coordinator	
Keywords	Information

Description

Through a series of assignments, seminars and visits introducing in detail the concrete problems and solutions in the field of information management, students will be exposed to a variety of methodological, organizational and technical approaches. Depending on their orientation, students will have the opportunity to deepen a particular issue and to present a critical analysis based on conceptual, organizational and technical matters. Particular attention will be paid to the analysis of issues related to information reliability, security, confidentiality and ownership. This module highlights the technical solutions put in place to manage various sources of information and introduces the students to the issues associated with them at the institutional and societal level. In some cases, the review of solutions will also include a cost-benefit analysis and a review of the the strategy put in place to implement and integrate the information system in the decision-making process.

Learning outcomes

- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook.
- Demonstrate independence and be proactive in acquiring new knowledge and developing new skills in order to adapt to changing or uncertain situations and to grow, to build a professional project within a continuing development approach.

At the end of the course, the student will be able to:

- Link advanced technical courses in information management with real situations related to their implementation;
- Manage the entire process of solving a real engineering problem in information management;
- Understand how companies manage information and how they handle a stream of information from the input to the output;
- Critically evaluate the solutions implemented by companies or institutions to manage information and determine their impact in relation to an economic and environmental context;
- Identify new knowledge and skills required in order to understand issues specific to the management of information in a professional context.

Content

This course consists of assignments, seminars by external speakers and visits to companies and institutions.

Data Science in bioscience engineering - Part 2 : Seminars and case studies		
Entry requirements		
Teaching and learning approach		
Teaching is in the form of assignments, seminars given by external speakers and visits to companies or institutions that are active in the field of information analysis and management.		
Time allocation in hours per activity		
Lecture [contact]	30	
Sum	**30**	
Assessment		
Examiners		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Evaluation of reports produced	100	

Algorithms in data science	
Course code	S1, Q1
Course type	Elective
Period	September 2022 – December 2022
Credits	5
Coordinator	Jean-Charles Delvenne
Keywords	Data | algorithm

Description

The course explores questions, mainly of an algorithmic nature, regarding the challenges offered by the emergence of Big Data.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.

More specifically, at the end of the course the student will be able to :

- read a general or specialized literature on a specific cutting-edge theme of discrete mathematics, and summarize the key messages and results
- explain those messages to their peers in a clear and precise way
- solve mathematical problems in application to those results
- identify the possible caveats of those results and criticize the exposition chosen by the references
- relate the concepts encountered in the literature to concepts covered in other course, despite different notations or viewpoints

The mathematical objectives can change from year to year.

Content

The course contents may vary from one year to another and can tackle various algorithmic questions related to analysis, storage, or broadcast of large datasets. E.g., data anonymisation, plagiarism detection, social networks analysis, principles of peer-to-peer networks, etc.

Entry requirements

Some familiarity with linear algebra and discrete mathematics is required

Teaching and learning approach

Ex cathedra lectures and projects with written and/or oral reports.

Time allocation in hours per activity

Algorithms in data science		
Lecture [contact]	30	
Supervised practical [contact]	22.5	
Sum	**52.5**	
Assessment		
Examiners	Jean-Charles Delvenne, Vincent Blondel, Gautier Krings	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Oral and written presentation during the term		Individual
Written or oral exam		Individual

Advanced Hydrology for Engineers	
Course code	S1, Q1
Course type	Elective
Period	September 2022 – December 2022
Credits	3
Coordinator	Mathieu Javaux
Keywords	Hydrology | river

Description

Main themes of the course:

- Open-channel hydraulics
- stochastic modelling for hydrology
- Model optimization and parameterization

Learning outcomes

- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of the course and of the practicals, the students will be able:

- to characterize the type of flow in channels/rivers.
- to understand and be able to apply the theory on gradually varying flow and rapid varying flow;
- to measure the river discharge with different techniques
- to use modelling approaches to simulate river discharge and design methods to control flood risks.
- to estimate hydrological model parameters by different methods
- to understand stochastic hydrology concepts
- to use stochastic models to calibrate and simulate river discharge

Content

Theory :

- Open channel hydraulics (8 hours)
- Stochastic modeling in hydrology (8 hours)
- Parameter estimation (4 hours)

Practicals:

- Flow discharge measurements in situ (3 hours)
- Modeling exercises in computer room :
    - HEC-RAS (6 hours)
    - Stochastic modeling (6 hours)

Entry requirements

General Hydrology

Teaching and learning approach

- The lectures can be given in English but illustrated by slides in French. A reference textbook in French supports the lectures.
- Field practical work for river discharge measurements
- Practical work in the computer room allow students to use advanced methods of hydrological modelling
- The practical work and the reports are executed in teams

Advanced Hydrology for Engineers		
Time allocation in hours per activity		
Lecture [contact]	22.5	
Supervised practical [contact]	15	
Sum	**37.5**	
Assessment		
Examiners	**Mathieu Javaux**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Oral evaluation of the theory	50	Individual
Practical reports	50	Individual

Decision tools and project management - Part 2: Project management	
Course code	S1, Q1
Course type	Elective
Period	
Credits	1
Coordinator	Frédéric Gaspart
Keywords	Project | management

Description

- Mastering the project approach as an intervention mean in industrialized and developing countries, linked to their specific social, political and environmental context
- Mastering the successive steps of the life cycle of the project, integrating all these elements in a systematic pattern with a view to a feasibility analysis.
- Mastering the methods of project follow-up and assessment, including financial and economic assessment.
- Knowing the basics of planning methods and human resource management.

Learning outcomes

- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook.

Content

Stemming from the professional activity of the bio-engineer, the course outlines the project-based approach in a context of rural development or environmental management by public or private actors. The project-based approach is defined in contrast with other modes of intervention and outlined through the project life-cycle (identification, design, feasibility, programming, funding, implementation, follow-up, assessment). The incentives of various actors (fund raisers, field workers, target groups, etc.) and institutional partnerships are analysed.
Lectures emphasize the criteria and the methods for an impact assessment, and the practical implementation thereof. Critical analyses are performed by the students on case studies in the realms of rural development and the environment, so that they develop a professional attitude towards these problems. Finally, drawing from practical examples, lectures describe the methods for the identification, the design and the study of feasibility at the technical, environmental, organisational, social, financial and economic levels. Some legal and normative aspects are discussed.

Methods and tools are presented on the basis of the following schedule :

- basic definitions and concepts : project, program, project management, project life-cycle, strategies, stakeholders, resources, etc.

Decision tools and project management - Part 2: Project management		
▪ Strategic planning and programming ▪ Identification of projects, the idea of a project, the problem tree, the target tree ▪ Planning : strategies, indices, WBS organigram, GANTT diagram, risk analysis, budget, quality planning, organisational and managerial aspects, monitoring ▪ Implementation : launch, actor roles, organisational modes, risk/conflict/change management, communication ▪ Follow-up, monitoring, reporting ▪ Ex-post assessment		
Entry requirements		
Knowledge and know-how in basic courses of the bio-enginering programme		
Teaching and learning approach		
Time allocation in hours per activity		
Lecture [contact]	15	
Sum	**15**	
Assessment		
Examiners	Frédéric Gaspart	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Take-home exam	100	Individual

Soil erosion and conservation	
Course code	S2, Q2
Course type	Elective
Period	February 2023 – May 2023
Credits	4
Coordinator	Charles Bielders
Keywords	Soil | erosion | conservation

Description

Main themes of the course:
- Water, wind and tillage erosion : physical processes and quantification
- Modeling of water erosion at plot and watershed scale
- Principles of soil conservation in temperate and tropical environments
- Soil conservation techniques and practices : physical, agronomical, vegetative, and management practices

Learning outcomes

- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of the course and practicals, the students:
- Will master the main mechanisms involved in the degradation of soil by water , wind and tillage erosion;
- Will be able to propose a methodology on an experimental basis to quantify land degradation by water erosion at the plot scale or watershed ;
- Will be able to implement a simple model of water erosion in a GIS to assess the risk of erosion at the scale of the plot or watershed ;
- Will master the principles of soil conservation and will be able to propose practices, technologies or devices adapted to the socio-economic and technical context of operators and aiming at reducing erosion at the plot and watershed scale;
- Be able to communicate the results and conclusions of the simulations and experiments in the form of tables, graphs and scientific diagrams in a written report reflecting mastery of software tools essential for effective professional communication.
- be able to position himself with respect to the management of soil erosion and muddy floods

Content

Soil erosion and conservation		
Lectures ▪ Definitions, on- and off-site consequences of water erosion ▪ Forms of water erosion : interrill, rill, gully ▪ Factors of water erosion : rain, soil, terrain, cultural practices, crop ▪ Processes: detachment, transportation, storage ▪ Measurement of erosion ▪ Empirical (RUSLE) and deterministic modelling ▪ Principles and methods of soil conservation - Wind erosion (2h) - Tillage erosion (2h) As part of the section on water erosion, a collective brainstorming will be conducted around the fictional development of a site subject to muddy floods. The discussion will focus on the challenges of mastering soil erosion, actors and levers. Through role play, students will be encouraged to think about the complexity of managing an environmental issue. **Practicals** Soil Conservation ▪ Use of the RUSLE model on simple and complex slopes, and management of a small virtual watershed ▪ Evaluation of a grass strip ▪ Measurement of saltation (wind erosion) ▪ Estimation of tillage erosion on complex slope (spreadsheet)		
Entry requirements		
Spreadsheet management (ExcelTM) Basic use of Geographical information system Basic knowledge in soil science		
Teaching and learning approach		
▪ The lectures are given in English, but always illustrated by slides in French. ▪ Reference book in English. ▪ Practical work in the computer room lead the student to operational use of the RUSLE model. ▪ Practical work in the laboratory (grass strip, wind erosion) ▪ Exercise sessions (tillage erosion) ▪ The practicals, to be carried out in a team, and report writing stimulate collective work and the development of skills related to professional communication; ▪ Role play regarding the management of soil erosion for a fictitious site		
Time allocation in hours per activity		
Lecture [contact]	22.5	
Supervised practical [contact]	22.5	
Sum	**45**	
Assessment		
Examiners	**Charles Bielders**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Oral exam with written preparation	40	Individual
Evaluation of practicals based on written reports	40	Individual
Participation in role play	40	Group

Databases	
Course code	S2, Q2
Course type	Elective
Period	February 2023 – May 2023
Credits	6
Coordinator	Siegfried Nijssen
Keywords	Data | model

Description

- Data Base Management Systems (objectives, requirements, architecture).
- The Relational data model (formal theory, first-order logic, constraints).
- Conceptual models (entity-relationship, object role modeling).
- Logical database design (normal forms & normalization, ER-To-Relational)
- Physical database design and storage (tables and keys, indexes, file structures).
- Querying databases (Relational Algebra, Relational Calculus, data structures, query optimization, SQL)
- ACID properties (Atomicity, Consistency, Isolation, Durability), Concurrency Control, Recovery techniques.
- Programming database applications (JDBC, Database Cursors, Object-Relational Mapping).
- Recent or more advanced trends in the database field (object-oriented databases, Big Data, NoSQL, NewSQL)

Learning outcomes

Students completing this course successfully will be able to :

- explain the scenarios in which using a database is more convenient than programming with data files;
- explain the characteristics of the database approach, where they come from and contrast them with current trends in the database field
- identify and describe the main functions of a database management system;
- categorize conceptual, logical and physical data models based on the concepts they provide to describe the database structure;
- understand the main principles and mathematical theory of the relational approach to database management;
- design databases using a systematic approach, from a conceptual model through a logical level (i.e., a relational schema) into a physical model (i.e., tables and indexes);
- Use SQL (DDL) to implement a relational database schema and distinguish from SQL facilities with respect to the logical vs. physical distinction.
- query relational databases using SQL (DML) and contrast SQL with relational theory .
- optimize the performance of databases.
- understand the benefits and drawbacks of NoSQL databases.
- use relational databases either directly or from a conventional programming language.

Content

- Introduction to the entity-relationship model,
- Bases of the relational model: data structures and algebra,
- Logic-based relational languages to define and manipulate data,
- Critical study of the SQL language,
- Query optimization,
- Database application programming,

Databases

- Functions and architecture of database management systems,
- Management of concurrent database accesses and associated techniques of recovery after failures,
- NoSQL databases: graph databases, key-value stores, document stores,
- Overview of other databases: spatio-temporal databases, data warehouses, OLAP

Entry requirements

Basic knowledge of database management; Good abilities in programming

Teaching and learning approach

The objectives are organized along three main axes:

- Understand: both the historical context, and recent challenges and developments in the database field; relational theory, why is has been invented and how it fits in practice; implementation techniques and major algorithms for data organization, query and transaction processing.
- Design: from conceptual modeling (e.g. Entity-Relationship, UML) down to physical database tuning (e.g. indexes, query plans), through logical database design (e.g. functional dependencies, normal forms, normalization algorithms) and reasoning (relational algebra, views and constraints).
- Use: installing and configuring database management systems, creating and tuning databases, using query languages in practice (e.g. SQL), connecting to databases (e.g. call interfaces, ORMs), integrating database systems in software designs.

Theory and practice are acquired by students along those three axes as follows:

- Theory is dispensed in the traditional way, through lectures during the second quarter. The theoretical course follows Elmasri & Navathe's textbook [EN10].
- Practice is obtained by participating in 4 projects. These projects are either done individually, in groups of 2 or in larger groups.
- Both theory and pratical missions are dispensed in English.
- Even though preference will be given to face-to-face teaching sessions, depending on the health situation and the number of students enrolled, other forms of teaching (online, co-modal or hybrid) may be considered.

Time allocation in hours per activity

Lecture [contact]	30
Supervised practical [contact]	30
Sum	**60**

Assessment

Examiners	**Siegfried Nijssen**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam	75	Individual
Practical missions	25	Individual

Field trip – Forest, natural areas and land use	
Course code	S2, Q2
Course type	Elective
Period	February 2023 – May 2023
Credits	2
Coordinator	Quentin Ponette
Keywords	Forest | Field trip

Description

This course consists in a one week field trip in a foreign country (or in Belgium) during which students may compare their theoretical knowledge to field cases and current practices in their overall complexity. During this field trip, students are encouraged to consider the topics in an integrated manner, to use an inter-disciplinarity approach and to reason in a long term perspective. The visits cover numerous fields such as forest ecology, silviculture, forest planning, wood industry, nature conservation, habitat restoration and management.
Each visit is organized with an expert able to give valuable information on the presented subject. Topics are complementary to those seen during the two study years. A special attention is given to the choice of stakeholders to enable students to meet the wide range of stakeholders active in the professional world.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook.

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

- understand the overall functioning of the sector related to the management of forests and natural areas in terms of actors and interactions with other sectors, based on a chain and systemic approach;
- analyze, compare and criticize different techniques or strategies in forest planning and in habitat restoration and management, integrating all technical, economic, ecological and legal constraints;

Field trip – Forest, natural areas and land use		
▪ develop interactions with professionals, discuss about divergent point of views and ensure an original and personal synthesis ; ▪ reason complex management problems at various time and spatial scales.		
Content		
Concrete situations are presented to students by field experts (or teachers), covering topics related to silviculture, timber industries, nature conservation and environmental protection issues. Students actively participate in the exchange.		
Entry requirements		
Precursory courses: core courses of the Master in Forests and natural Areas Engineering		
Teaching and learning approach		
The one-week trip allows to analyze a set of case studies covering the diversity of themes and achievements related to the management of forests and natural areas, including valorization by the wood chain industries. Active participation of students is highly encouraged (observations, surveys, measures, planning). The students are invited to interview the experts and to participate to the debates.		
Time allocation in hours per activity		
Study trip [contact]	30	
Sum	**30**	
Assessment		
Examiners	Quentin Ponette, Anne-Laure Jacquemart, Caroline Vincke	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Individual contribution to a field-trip booklet		Individual
Oral Presentations during field trip		Individual
Oral discussion		Individual

Courses in year 2 at Université catholique de Louvain, Belgium

Track 4 - GEM4 Food Security

Elements of Agro-ecology	
Course code	S1, Q1
Course type	Compulsory
Period	September 2022 – December 2022
Credits	3
Coordinator	Phillippe Baret
Keywords	Atmosphere | climate | water

Description

- Emergence of the concept of Agroecology and historical process.
- Diversity of world food systems.
- Foresight approaches of Agriculture (Agrimonde, Afterres 2050)
- The principles of agroecology: ecological, socio-economic and methodological principles.
- Comparative approach for alternative agricultures: industrial agriculture, conventional farming, organic farming, sustainable agriculture, ecologically intensive agriculture.
- Examples of applications of agroecology in production and consumption systems in North and South.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.

At the end of this course, the student is able to:

- Understand the conceptual foundations and methods of agroecology including the concept of food systems.
- Discuss the diverse trajectories of agriculture
- Evaluate a system in its agro-ecological dimensions
- Position the various alternative modes of agriculture

Content

- Emergence of the concept of Agroecology and historical process.
- Diversity of world food systems
- Foresight approaches of Agriculture (Agrimonde, Afterres 2050)
- The principles of agroecology: ecological, socio-economic and methodological principles.
- Comparative approach for alternative agricultures: industrial agriculture, conventional farming, organic farming, sustainable agriculture, ecologically intensive agriculture.
- Examples of applications of agroecology in production and consumption systems in North and South.

Entry requirements

Engineering biosphere (or equivalent)

Teaching and learning approach

Elements of Agro-ecology		
The course is given in the form of lectures alternating theory and practical examples. It also makes use of video media.		
Time allocation in hours per activity		
Lecture [contact]	30	
Sum	**30**	
Assessment		
Examiners	**Phillippe Baret**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam with oral discussion	100	Individual

Economics of Rural Development	
Course code	S1, Q1
Course type	Compulsory
Period	September 2022 – December 2022
Credits	3
Coordinator	Frédéric Gaspart
Keywords	Economics | development

Description

Determinants that hamper or promote rural development are analyzed in their context. Some peculiarities of rural development lead to the identification of a list of missing markets. To fulfil the social functions that are thus left unattended, rural communities set up institutional solutions to problems of insurance, credit, labour exchange and land tenure.

A particular attention is devoted to the transition from a subsistence economy to a market-oriented economy with a focus on the structural adjustment of the agro-food sector: transfer of the agricultural surplus, investment in productivity and market, technological and institutional innovations, gains from international trade. Poverty and food insecurity are both issues that are analysed transversally through these topics.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook.

By the end of the course, students are able to:

- master economic theory on the development of the agricultural sector,
- analyze the transitions from a subsistence economy into a market-oriented economy,
- understand the opportunities and the limits of the contributions of the development of the agro-food sector to economic development as a whole,
- understand technological and institutional innovations to foster the development of the agro-food sector,
- understand opportunities and limits of policy instruments in favour of rural development,
- understand specific obstacles to rural development rural and their traditional, institutional solutions through economic models (game theory, political economics, partial and general equilibrium models).

Economics of Rural Development		
Content		
Part 1 : Students are exposed to the broad visions that have been framing the contemporary policies for the role of agriculture in structural transformation and rural development, with an historical and theoretical structure. Structural adjustment, the Commodity Boom and the so-called Great Recession (2007-2012) are described and analyzed critically, along with the underlying conceptions of economic development and the role attributed to the rural sectors in the development process. Students will write an essay on a question defined by the teacher. Part 2 : Students read a book or selected chapters of a book chosen by the teachers. Following a guidance sheet, they compile an operational summary of the book and raise two questions about the arguments put forward by the author (the type of relevant question is defined in the guidance sheet). Furthermore, with the occasional help of the teachers, each student must suggest an informed tentative answer to her own questions. The questions and answers are sent to the teachers before a debate organized at the end of the semester ; questions raised by the students are confronted and answered during the debate.		
Entry requirements		
General skills for a bio-engineering bachelor, micro-economics (e.g. Principles of Economics) and introduction to game theory (e.g. Decision tools).		
Teaching and learning approach		
Classes, directed reading, oriented questions and answers, debate		
Time allocation in hours per activity		
Lecture [contact]	30	
Sum	**30**	
Assessment		
Examiners	**Frédéric Gaspart, Goedele Van den Broeck**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Essay		Individual
Preparatory report		Individual
Participation in debates		Group

Smart Technologies for environmental engineering	
Course code	S1, Q1
Course type	Compulsory
Period	September 2022 - December 2022
Credits	3
Coordinator	
Keywords	Technology

Description

This course aims to teach technologies for characterization and monitoring of agroecosystems. In particular, geophysical imaging and characterization techniques of soil properties are presented, such as ground penetrating radar, electromagnetic induction or electrical tomography. Also, the course discusses the use of drones for environmental monitoring, including multispectral, thermal infrared, LiDAR sensors as well as photogrammetry. Fundamental concepts, instruments and methods of signal analysis will be particularly seen in-depth. The student will be made familiar with these tools through practical works and an integrated project.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
  - Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook
- Demonstrate independence and be proactive in acquiring new knowledge and developing new skills in order to adapt to changing or uncertain situations and to grow, to build a professional project within a continuing development approach.

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

- understand the concepts of the different environmental sensors (geophysics, remote sensing);
- understand and implement different signal processing methods;
- develop a critical analysis on the application of these technologies;
- to master the use of some of the instruments studied.

Content

Smart Technologies for environmental engineering

Theorical class :

- Geophysical techniques: ground penetrating radar, electromagnetic induction, radiometry, electrical tomography, seismic, reflectometry.
- Drone remote sensing techniques: thermal infrared sensor, multispectral sensor, LiDAR.
- Sensor networks
- Signal processing methods: inversion, tomography, photogrammetry, data fusion, artificial neural networks.

Practical work :

The main concepts presented during the courses will be applied during practical work sessions (operational mastery) and an integrated project carried out by group.

Seminars:

Students analyze, synthesize and present a scientific article dealing with a scientific question relating to environmental monitoring.

Entry requirements

Applied Geomatics; Soil Physics

Teaching and learning approach

Time allocation in hours per activity

Lecture [contact]	22.5
Supervised practical [contact]	15
Sum	**37.5**

Assessment

Examiners

Test type (descriptive)	Weight of the test (%)	Individual or Group test
Written Exam		Individual
Project Report		Group
Seminar		Group

Master Thesis	
Course code	S1, Q1 / S2, Q2
Course type	Compulsory
Period	September 2022 – May 2023
Credits	27
Coordinator	
Keywords	Research | work | presentation

Description

The master thesis is a personal work that each student must complete during his master cycle. This thesis is an initiation to scientific research that allows the future engineer to study a topic of his own preference. As a future engineer, the student must identify and address a specific question by respecting the following general approach :

- Summarize the current knowledge about the chosen topic ;
- Set an experimental protocol (in a wide meaning of the term) ;
- Do observations (in the field or in a laboratory) ;
- Analyze and interpret these observations ;
- Draw appropriate conclusions ;
- Present this material in a scientific document ;
- Publicly defend their work

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of the master thesis, the student is able to :

- analyze scientific publications that are related to his master thesis topic, master and discuss the corresponding content and present this content in a summarized way ;
- design a consistent and sound approach in order to answer a scientific question by using a state-of-the-art knowledge about the question ;
- set up an experimental protocol (in a wide meaning of the term), analyze and interpret the corresponding results by the light of the scientific literature at hand and by taking into account the corresponding limitations ;
- communicate the results and justify them using a rigourous scientific language, both in a printed document and during a public oral presentation in front of a jury.

Content

Entry requirements

Teaching and learning approach

Master Thesis		
Typically, possible topics for the master thesis are proposed by promoters. A student can however suggest a new topic and thus can look for a potential promoter that would accept to supervise him. Upon acceptance by the Faculty, a part of the master thesis can be done outside of the university, in Belgium or abroad. This applies for example to Erasmus master theses and internships master theses. The master thesis supervision is under the responsability of a promoter (possible two copromoters). The (co)promoter(s) is in charge of supervising the quality and the timing of the work that must be done by the student. These aspects are evaluated as a specific item, i.e. the 'Evaluation of the personal work made the student', which is part of the final score. It is advised that students choose both the topic and the promoter for their master thesis during the second semester of the first year in the master cycle. All the way long during their master thesis, students must fulfill the master thesis regulation as described in the document that can be found here.		
Time allocation in hours per activity		
Lecture [contact]	0	
Supervised practical [contact]	0	
Tutorial [contact]	0	
Study trip [contact]	0	
Written/oral test	0	
Individual assignment	0	
Group assignment	0	
Self-study	0	
Sum	0	
Assessment		
Examiners		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Work during the year	30	Individual
Printed Document	50	Individual
Public Defense	20	Individual

Land monitoring by advanced Earth Observation	
Course code	S2, Q2
Course type	Compulsory
Period	February 2023 – May 2023
Credits	3
Coordinator	Pierre Defourny
Keywords	Earth observation | detection | monitoring

Description

This course aims to develop in-depth understanding and professional skills to process and interpret very high resolution UAV (drone) imagery and Earth Observation satellite time series. Advanced concepts related to signal acquisition, time series quality control and uncertainty characterization are introduced. Radiative transfer modelling and methods for biophysical variables estimation (Leaf Area Index, biomass, nitrogen status, surface temperature, evapotranspiration, soil moisture, height, etc.) and change detection methods are explained and illustrated through practical applications and the European Copernicus Services. Finally, open source tools and systems supporting already operational and forthcoming monitoring systems, including flood monitoring, fire monitoring, forest monitoring and crop monitoring, are discussed in details. The objective of this course is to develop the necessary knowledge and technical skills to use advanced image processing methods (including machine learning and artificial intelligence) and to implement workflow for UAV or satellite monitoring applications in the field of agriculture, forestry, land use land cover change, and water resources management.

Learning outcomes

- Build an integrated body of scientific knowledge (knowledge, methods and techniques, models and processes) in environmental and human sciences which serves as the foundation from which to operate with expertise in the field of geoinformation and Earth Observation
- Master highly specialised skills in geoinformation science and Earth Observation which serves as the foundation from which to operate with expertise in the field of environmental, agricultural and land use management
- Formulate and resolve a complex environmental problem with appropriate, sustainable and innovative solutions, the problem being related to the impact of human activities or natural processes on the capacity of the environment to provide goods and services to the population
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors

At the end of this activity, the student is able to:

- practically mobilize the advanced concepts and methods of airborne and satellite remote sensing applied to the monitoring and the management of natural resources, to regional planning and to the environment in general;
- understand and critize in depth the operational services, the available products and the existing tools to get the best out of each;
- mastering specialized open source remote sensing softwares and developping processing chains including several tools;
- design and conduct rigorous digital analyzes of optical and radar time series to respond to specific issues belonging to the bioengineer fields and to formulate the related hypotheses and limits;
- be able to grasp technological developments in the field of remote sensing applied to the fields of the bioengineers.

Land monitoring by advanced Earth Observation		
Content		
The course combines lessons and practicals in computing lab mainly based on open source softwares used in the professional sector. The lessons address the following topics: ▪ signal acquisition and pre-processing steps, including quality flags and uncertainty management; ▪ radiative transfer modelling and retrieval of various biophysical variables; ▪ optical and SAR time series analysis, features extraction and pixel-based / object-based metrics; ▪ advanced radar processing including polarimetric and interferometric variables; ▪ introduction to machine learning and artificial intelligence algorithms for Earth observation mapping, monitoring and change detection; ▪ critical review of operational monitoring systems (drought, flooding, fire, forest, crop, locust) and of Copernicus Services freely available. ▪ EO applications related to the environment, agriculture, forestry, water resources and land use planning.		
Entry requirements		
Introductory class in remote sensing; Programming skills (R, python)		
Teaching and learning approach		
The teaching introduces the concepts and advanced methods while the practicals in computer lab mobilise them in the context of specific applications. The lessons are quite interactive and partly relies on an inductive approach. The course and the practicals aims to develop on one hand advanced technical skills in Earth observation data processing and on the other hand, the ability of critical analysis with regards existing solutions, services and products. The student learns not only to use open source packages and Google Earth Engine environment but also to assess the quality and to review the validity of the proposed algorithms and datasets for a given application. The practical training is closely linked to the course and includes the use of several open source libraries (including QGIS, SNAP, GDAL, ORFEO, Sen4CAP), the exploitation of the Jupyter notebook environment for quality control et time series analysis, and the workflow coding in Python or R.		
Time allocation in hours per activity		
Lecture [contact]	22.5	
Supervised practical [contact]	15	
Sum	**37.5**	
Assessment		
Examiners	**Pierre Defourny**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam based on Case study	100	Individual

Soil erosion and conservation	
Course code	S2, Q2
Course type	Cpmpulsory
Period	February 2023 – May 2023
Credits	4
Coordinator	Charles Bielders
Keywords	Soil | erosion | conservation

Description

Main themes of the course:
- Water, wind and tillage erosion : physical processes and quantification
- Modeling of water erosion at plot and watershed scale
- Principles of soil conservation in temperate and tropical environments
- Soil conservation techniques and practices : physical, agronomical, vegetative, and management practices

Learning outcomes

- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of the course and practicals, the students:
- Will master the main mechanisms involved in the degradation of soil by water , wind and tillage erosion;
- Will be able to propose a methodology on an experimental basis to quantify land degradation by water erosion at the plot scale or watershed ;
- Will be able to implement a simple model of water erosion in a GIS to assess the risk of erosion at the scale of the plot or watershed ;
- Will master the principles of soil conservation and will be able to propose practices, technologies or devices adapted to the socio-economic and technical context of operators and aiming at reducing erosion at the plot and watershed scale;
- Be able to communicate the results and conclusions of the simulations and experiments in the form of tables, graphs and scientific diagrams in a written report reflecting mastery of software tools essential for effective professional communication.
- be able to position himself with respect to the management of soil erosion and muddy floods

Content

Soil erosion and conservation

Lectures

- Definitions, on- and off-site consequences of water erosion
- Forms of water erosion : interrill, rill, gully
- Factors of water erosion : rain, soil, terrain, cultural practices, crop
- Processes: detachment, transportation, storage
- Measurement of erosion
- Empirical (RUSLE) and deterministic modelling
- Principles and methods of soil conservation
  - Wind erosion (2h)
  - Tillage erosion (2h)

As part of the section on water erosion, a collective brainstorming will be conducted around the fictional development of a site subject to muddy floods. The discussion will focus on the challenges of mastering soil erosion, actors and levers. Through role play, students will be encouraged to think about the complexity of managing an environmental issue.

Practicals

Soil Conservation

- Use of the RUSLE model on simple and complex slopes, and management of a small virtual watershed
- Evaluation of a grass strip
- Measurement of saltation (wind erosion)
- Estimation of tillage erosion on complex slope (spreadsheet)

Entry requirements

Spreadsheet management (ExcelTM)
Basic use of Geographical information system
Basic knowledge in soil science

Teaching and learning approach

- The lectures are given in English, but always illustrated by slides in French.
- Reference book in English.
- Practical work in the computer room lead the student to operational use of the RUSLE model.
- Practical work in the laboratory (grass strip, wind erosion)
- Exercise sessions (tillage erosion)
- The practicals, to be carried out in a team, and report writing stimulate collective work and the development of skills related to professional communication;
- Role play regarding the management of soil erosion for a fictitious site

Time allocation in hours per activity

Lecture [contact]	22.5
Supervised practical [contact]	22.5
Sum	**45**

Assessment

Examiners	**Charles Bielders**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Oral exam with written preparation	40	Individual
Evaluation of practicals based on written reports	40	Individual
Participation in role play	40	Group

Master thesis' accompanying seminar	
Course code	S2, Q2
Course type	Compulsory
Period	
Credits	3
Coordinator	Patrick Bogaert
Keywords	Research | work | presentation

Description

The master thesis is an initiation to research work. It is a personal approach that, under the guidance of a teacher, develops the capacity to master experimental approaches, to interpret results on the basis of state-of-the-art knowledge and to identify the perspectives of future investigations. In addition to this methodology, the student should be able to communicate clearly and orally the results of his work. He should also keep a critical mind on the correspondence between the followed approach and the pursued objectives.
In order to make them more visible, these communication activities and critical analysis exercises are valorized through seminars focused on the educational aspects of scientific communication. English must be used for the communication.

Learning outcomes

- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of this activity, the student is able to:

- masters computer tools to prepare and present slideshows, as well as tools to prepare scientific graphics ;
- present in English the context and state-of-the-art in the field of his work by defining the objectives and the followed methodology and /or experimental approach ;
- present orally and in English the results that were obtained and the scientific interpretations that can be made from them, both to peers and experts in the field of bioengineering ;
- identify the main achievements of his work and the prospects for future developments;
- answer to open questions and justify his claims in a scientifically rigorous, balanced and critical way.

Content

The oral presentation presented at the public defense of the dissertation is the final outcome of the seminars given during the academic year. The note for this course corresponds to the evaluation of the oral presentation of the dissertation by the jury. This evaluation will focus on 2 points, with equivalent weights: 1. Clarity of the presentation (quality of the slideshow, voice modulation, time allocation between the different parts of the presentation, keeping the public attention, etc.) 2. Scientific rigor of the presentation (terminology, slide content, synthetic capacity, etc.). This rule applies to all students, including those whose promoter is not a teacher of the faculty. Coordinators verify with the responsible teacher in each team (or with the supervisor when the student completes his dissertation outside the Faculty) before the June session that all students have actually presented two seminars. Any student who do not meet the requirements of this course may be sanctioned (0/20) whatever the quality of the oral presentation during the master thesis defense.

Entry requirements

Master thesis' accompanying seminar		
Teaching and learning approach		
Time allocation in hours per activity		
Lecture [contact]	0	
Supervised practical [contact]	0	
Tutorial [contact]	0	
Study trip [contact]	0	
Written/oral test	0	
Individual assignment	0	
Group assignment	0	
Self-study	0	
Sum	**0**	
Assessment		
Examiners		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Public Defense	100	Individual

Data Science in bioscience engineering - Part 1: Spatial and temporal data	
Course code	S1, Q1
Course type	Elective
Period	September 2022 - December 2022
Credits	3
Coordinator	
Keywords	Data | model

Description

- Notions of spatial/temporal dependency and its effect on statistical estimation.
- Quantification and modelling of dependencies through space and time.
- Random fields theory.
- Prediction and simulation of correlated data.
- Mapping and forecasting methods.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.

At the end of this activity, the student is able to :

- Name, describe and explain the theoretical concepts underlying the stochastic approach for the analysis and the modeling of spatial and temporal data in an environmental framework;
- Explain the mathematical concepts and use the mathematical tools that are relevant for statistical exploratory analyses and inferential estimations from environmental data;
- Use these concepts and tools in an operational framework in order to make statistical analyses and modeling from a real environmental data set in the framework of a group project;
- Explain and justify the methodological choices that are made for the analyses and the modeling steps by integrating the relevant underlying theoretical concepts that have been presented and used during the practical exercises;
- Write a concise report based on the main findings for this analysis and modeling work by using a relevant and accurate mathematical language and appropriate figures.

Content

- This course will complete the basic notions already presented during the courses Probability and Statistics (I) and (II).
- The student will be able to analyze data that are correlated through space and time, as frequently encountered in the agro-environmental context.
- The course will emphasize the link between the general theory and the practical specificities of environmental data.
- It should allow the student to model such kind of processes and to use them in a mapping or forecasting context.

Entry requirements

Data Science in bioscience engineering - Part 1: Spatial and temporal data		
Knowledge of probability and statistics		
Teaching and learning approach		
Regular course and supervised practical exercises. Practical exercises will take place in a computer room using the Matlab or R software. Students will work in groups and will process a specific spatial data set. This personal work will be part of a printed report that must be defended during the examination		
Time allocation in hours per activity		
Lecture [contact]	22.5	
Supervised practical [contact]	15	
Sum	**37.5**	
Assessment		
Examiners		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam		Individual
Oral defense of team project		Group

Data Science in bioscience engineering - Part 2 : Seminars and case studies	
Course code	S1, Q1
Course type	Elective
Period	September 2022 – December 2022
Credits	2
Coordinator	
Keywords	Information

Description

Through a series of assignments, seminars and visits introducing in detail the concrete problems and solutions in the field of information management, students will be exposed to a variety of methodological, organizational and technical approaches. Depending on their orientation, students will have the opportunity to deepen a particular issue and to present a critical analysis based on conceptual, organizational and technical matters. Particular attention will be paid to the analysis of issues related to information reliability, security, confidentiality and ownership. This module highlights the technical solutions put in place to manage various sources of information and introduces the students to the issues associated with them at the institutional and societal level. In some cases, the review of solutions will also include a cost-benefit analysis and a review of the the strategy put in place to implement and integrate the information system in the decision-making process.

Learning outcomes

- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook.
- Demonstrate independence and be proactive in acquiring new knowledge and developing new skills in order to adapt to changing or uncertain situations and to grow, to build a professional project within a continuing development approach.

At the end of the course, the student will be able to:

- Link advanced technical courses in information management with real situations related to their implementation;
- Manage the entire process of solving a real engineering problem in information management;
- Understand how companies manage information and how they handle a stream of information from the input to the output;
- Critically evaluate the solutions implemented by companies or institutions to manage information and determine their impact in relation to an economic and environmental context;
- Identify new knowledge and skills required in order to understand issues specific to the management of information in a professional context.

Content

This course consists of assignments, seminars by external speakers and visits to companies and institutions.

Data Science in bioscience engineering - Part 2 : Seminars and case studies		
Entry requirements		
Teaching and learning approach		
Teaching is in the form of assignments, seminars given by external speakers and visits to companies or institutions that are active in the field of information analysis and management.		
Time allocation in hours per activity		
Lecture [contact]	30	
Sum	**30**	
Assessment		
Examiners		
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Evaluation of reports produced	100	

Algorithms in data science	
Course code	S1, Q1
Course type	Elective
Period	September 2022 – December 2022
Credits	5
Coordinator	Jean-Charles Delvenne
Keywords	Data | algorithm

Description

The course explores questions, mainly of an algorithmic nature, regarding the challenges offered by the emergence of Big Data.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.

More specifically, at the end of the course the student will be able to :

- read a general or specialized literature on a specific cutting-edge theme of discrete mathematics, and summarize the key messages and results
- explain those messages to their peers in a clear and precise way
- solve mathematical problems in application to those results
- identify the possible caveats of those results and criticize the exposition chosen by the references
- relate the concepts encountered in the literature to concepts covered in other course, despite different notations or viewpoints

The mathematical objectives can change from year to year.

Content

The course contents may vary from one year to another and can tackle various algorithmic questions related to analysis, storage, or broadcast of large datasets. E.g., data anonymisation, plagiarism detection, social networks analysis, principles of peer-to-peer networks, etc.

Entry requirements

Some familiarity with linear algebra and discrete mathematics is required

Teaching and learning approach

Ex cathedra lectures and projects with written and/or oral reports.

Time allocation in hours per activity

Algorithms in data science		
Lecture [contact]	30	
Supervised practical [contact]	22.5	
Sum	**52.5**	
Assessment		
Examiners	Jean-Charles Delvenne, Vincent Blondel, Gautier Krings	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Oral and written presentation during the term		Individual
Written or oral exam		Individual

Climatology and hydrology applied to agronomy and the environment	
Course code	S1, Q1
Course type	Elective
Period	September 2022 – December 2022
Credits	6
Coordinator	Marnik Vanclooster
Keywords	Atmosphere | water | climate

Description

Bio-climatology:

- Exchange of heat and mass in the boundary layer of the atmosphere, inside plant communities and in the top layer of the soil.
- Mechanisms of climate formation: atmospheric structure, vertical profiles in the lower layers, lateral movement, atmospheric circulation, clouds and precipitation, greenhouse effect, effects of landscape elements, dynamic and thermal action of relief and vegetation.
- Influence of human activities on climate and impacts of global climate change.

Hydrology:

- Water management issues at the plot and watershed scale.
- The different components of the hydrological cycle (rain, infiltration, runoff, drainage, hypodermic flow, evapotranspiration): process, mathematical description, methods of measurement and interpretation.
- Hydrological modelling at the plot and watershed scale.
- Control structures for surface runoff and collection of runoff water.

Learning outcomes

Content

Bio-climatology:

- Exchange of heat and mass in the boundary layer of the atmosphere, inside plant communities and in the top layer of the soil.
- Mechanisms of climate formation: atmospheric structure, vertical profiles in the lower layers, lateral movement, atmospheric circulation, clouds and precipitation, greenhouse effect, effects of landscape elements, dynamic and thermal action of relief and vegetation.
- Influence of human activities on climate and impacts of global climate change.

Hydrology:

- Water management issues at the plot and watershed scale.
- The different components of the hydrological cycle (rain, infiltration, runoff, drainage, hypodermic flow, evapotranspiration): process, mathematical description, methods of measurement and interpretation.
- Hydrological modelling at the plot and watershed scale.
- Control structures for surface runoff and collection of runoff water.

Entry requirements

Wave, optical and modern physics

Teaching and learning approach

Theoretical course : Lectures in audience.

Exercises :

- Exercices in computer room
- Supervised exercise sessions

Climatology and hydrology applied to agronomy and the environment		
▪ Field excursion		
Time allocation in hours per activity		
Lecture [contact]	45	
Supervised practical [contact]	22.5	
Sum	**67.5**	
Assessment		
Examiners	Charles Bielders, Hugues Goosse, Marnik Vanclooster	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam	85	Individual
Written tests before practical sessions	15	Individual

Agriculture and rural policies	
Course code	S1, Q1
Course type	Elective
Period	September 2022 – December 2022
Credits	3
Coordinator	Bruno Henry de Frahan
Keywords	Policies | economics | trade | market

Description

The main topics of this course cover the socio-economic analysis of decisions made in terms of agricultural, food and trade policy, and rural development as well as their micro- and macro-economic effects. An emphasis is given to the study of the socio-economic and environmental implications of the Common Agricultural Policy of the European Union and its evolution towards a better targeted policy. This policy is compared to policies in place in other developed countries.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook.

By the end of this course, students are able to specify, explain and illustrate:

- the rationales and implications of supporting the agricultural and food sectors in developed countries,
- the institutional and political facts related to the evolution of agricultural policies, in particular the Common Agricultural Policy,
- the theoretical foundations and methodological frameworks for performing policy analysis.
  Students are able to :
- describe, quantify, and discuss the many socio-economic effects of the instruments of agricultural, food and rural policies, in particular the Common Agricultural Policy, using methods from the neo-classical economic and institutional theories.
- formulate a critical view on the most common instruments of agricultural, food and rural policies.
- develop and synthesise an analysis of the socio-economic effects of one particular policy instrument in one particular situation of their choice.

Students have acquired the skills to examine the socio-economic effects of the instruments of agricultural, food and rural food policies, in particular the Common Agricultural Policy, using methods

Agriculture and rural policies		
from the neo-classical economic and institutional theories and applying them for identifying the micro- and macro-economic effects.		
Content		
After a short introduction on the nature and the process of decision making for economic policy, this course examines the contribution of economics in formulating economic policy, in particular in the agricultural and food sector. The course identifies the keys problems of the agricultural and food sector through its industrial evolution and the current constraints of this sector in Europe. The governmental interventions progressively aimed at the agricultural and food sector and rural areas are then examined and compared among countries with a market economy. The objectives, the instruments and the effects of the Common Agricultural Policy and its successive reforms are emphasized. The food policy of the European Union is analysed within the framework of the Single Market. In parallel to these agricultural, food and rural policies, the effects of the trade policies of countries with a market economy on the international trade are analysed. This analysis introduces the preferential trade agreements of the European Union and the international negotiations of the World Trade Organisation. The course ends with the evolution of the agricultural, food and rural policies at the beginning of this millennium.		
Entry requirements		
Micro-economics (e.g. Principles of economics)		
Teaching and learning approach		
Teaching in class, lectures		
Time allocation in hours per activity		
Lecture [contact]	30	
Sum	**30**	
Assessment		
Examiners	**Bruno Henry de Frahan**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam	70	Individual
Term paper	30	Group

Decision tools and project management - Part 1: Decision tools for environmental management

Course code	S1, Q1
Course type	Elective
Period	September 2022 - December 2022
Credits	3
Coordinator	Frédéric Gaspart
Keywords	

Description

- Understanding decision processes and the various methods of decision making most commonly relied upon in agronomics, environmental sciences, economics and management.
- Taking into account risk and multi-criteria objectives.
- Formulating decision problems as they occur in agronomics and in natural resources management.
- Selecting adequate methods.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.

Content

- The course outlines, explains and compares various methods and decision making tools available in natural and social sciences. It distinguishes and shows the complementarities of statistics and economic analysis. Multi-criteria decisions and decisions under uncertainty in situations with several interacting decision-makers are illustrated with examples taken in fields relevant for the students.

Entry requirements

Knowledge and know-how in basic courses of the bio-enginering programme
Organization and planning (i.e. Course Design)

Teaching and learning approach

Time allocation in hours per activity

Lecture [contact]	22.5
Supervised practical [contact]	7.5
Sum	**30**

Assessment

Examiners	Frédéric Gaspart	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**

Decision tools and project management - Part 1: Decision tools for environmental management		
Written exam	100	Individual

Decision Tools and Farm Management – Part1: Farm management	
Course code	S2, Q2
Course type	Elective
Period	February 2023 – May 2023
Credits	3
Coordinator	
Keywords	Management | production | agriculture

Description

After an introduction on the agricultural production economy, the role of major production factors in the efficient management of agricultural firms is characterized. The main tools for analysis and decision making are explained and used in practical exercises. The main agricultural and food branches are outlined. The development of the agricultural sector in Belgium and in Europe is analysed.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Design and implement a multidisciplinary project, alone and in a team, with the stakeholders concerned while taking the objectives into account and incorporating the scientific, technical, environmental, economic and human factors.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook

Content

- Present discounted value
- The main agricultural production factors
- Decision making tools : global and partial budgets, linear programming, program planning, cluster and factorial analysis, risk analysis
- The main agricultural branches (including agro-food branches)
- Transversal issues : taxes, prices, energy costs, pollutions, animal feed, organic production,...

Entry requirements

General skills for a bio-engineering bachelor, animal and vegetal productions, introductory management, micro-economics and introduction to game theory

Teaching and learning approach

Classes and homeworks

Decision Tools and Farm Management – Part1: Farm management		
Time allocation in hours per activity		
Lecture [contact]	25	
Supervised practical [contact]	7.5	
Sum	**32.5**	
Assessment		
Examiners	**?**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam	100	Individual

Spatial Modelling of land dynamics	
Course code	S2, Q2
Course type	Elective
Period	February 2023 – May 2023
Credits	3
Coordinator	Pierre Defourny
Keywords	Land use | model

Description

The course introduces with a critical perspective a representative set of methods of spatial analysis and land use/land cover modelling, addressing both conceptual and numerical aspects. The course primarily aims to train to the conceptualization of a spatial modelling approach on the one hand, and the development of a critical analysis of existing models and simulations on the other hand. Advanced geomatics methods and dynamic modelling tools supporting a multidisciplinary approach to territorial dynamics are privileged, including functional network modelling using geographic information system, dynamic simulation by cellular automata and spatiotemporal modelling using a multi-agent system.
Learning at least one macro language opens the student to the development of special tools.
Finally, the contribution of simulations and modelling expertise to decision-making process in spatial planning is discussed.

Learning outcomes

- Build an integrated body of scientific knowledge (knowledge, methods and techniques, models and processes) in environmental and human sciences which serves as the foundation from which to operate with expertise in the field of geoinformation and Earth Observation
- Master highly specialised skills in geoinformation science and Earth Observation which serves as the foundation from which to operate with expertise in the field of environmental, agricultural and land use management.
- Formulate and resolve a complex environmental problem with appropriate, sustainable and innovative solutions, the problem being related to the impact of human activities or natural processes on the capacity of the environment to provide goods and services to the population

At the end of the course, students are able to:

- mobilize the concepts and methods of spatial modelling and simulation of land dynamics;
- thoroughly analyse a complex territorial dynamic, to conceptualize a modelling approach and justify the proposed methodological choices;
- develop a critical analysis of operational models and spatial simulation methods in order to clearly determine their relevance and limitations.

Content

The different modelling and numerical simulation approaches for land use/land cover change and other territorial dynamics are presented according to an increasing level of complexity through concrete examples. The concepts and underlying assumptions are presented and put into perspective in relation to potential applications. During the lectures as well as in the computer lab, the student is invited to conceptualize rigorously his modelling approach and to discuss its implementation.

Entry requirements

Applied Geomatics; Basics in statistics

Teaching and learning approach

The course alternates theoretical module in the form of an interactive lecture and practical work module in the computer room (GIS software and modelling tools).

Time allocation in hours per activity

Spatial Modelling of land dynamics		
Lecture [contact]	15	
Supervised practical [contact]	15	
Sum	**30**	
Assessment		
Examiners	**Pierre Defourny**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Written exam	100	Individual

Impact evaluation in agriculture	
Course code	S2, Q2
Course type	Elective
Period	February 2023 – May 2023
Credits	4
Coordinator	Goedele Van den Broeck
Keywords	Impact | agriculture | policies

Description

Importance of impact evaluation, different evaluation methods (randomized assignment of treatment, instrumental variable estimation, difference-in-difference estimation, propensity score matching, regression discontinuity design), implementation of impact evaluation. All illustrations and applications are drawn from agricultural policies, programs and projects.

Learning outcomes

- Explore an integrated body of knowledge (knowledge, methods and techniques, models and processes) which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Explore an integrated body of "engineering and management knowledge" which serves as the foundation from which to operate with expertise in the field of agricultural science and technology.
- Design and execute a research project, implementing an analytical scientific and, if applicable, systematic approach, to further understanding of an original research problem in their field of specialisation, incorporating several disciplines.
- Formulate and resolve a complex agricultural engineering problem related to new situations presenting a degree of uncertainty. The student will be able to design appropriate, sustainable and innovative solutions through a systematic approach incorporating scientific, economic and sociological aspects. This problem may be related to agricultural production and the quality of products, agricultural production systems and sectors, and to the transformation of agricultural products.
- Communicate, interact and convince in a professional manner, both verbally and in writing, adapting to their conversational partners and the context.
- Act critically and responsibly by taking account of sustainable development issues and operating with a humanistic outlook.
- Demonstrate independence and be proactive in acquiring new knowledge and developing new skills in order to adapt to changing or uncertain situations and to grow, to build a professional project within a continuing development approach

At the end of the course, students will be able :

- to understand the importance of impact evaluation for developing sound agricultural and food policy
- to know, understand and explain the different evaluation methods and how to construct a convincing counterfactual
- to critically compare the advantages and disadvantages associated with the different evaluation methods
- - to know, understand and explain how to implement an impact evaluation in agriculture, specifically how to collect data, design a farm survey and develop a sampling strategy

Content

Impact evaluation in agriculture		
▪ Students are exposed to the theory behind impact evaluation, illustrated by many real-life applications of agricultural policies, programs and projects. ▪ Students read and discuss selected scientific publications that use different evaluation methods to critically reflect about the implementation of impact evaluations in various contexts. ▪ - External guest speakers from various NGOs, development agencies and research institutes will share their professional expertise with impact evaluation to familiarize students with a non-academic perspective on impact evaluation.		
Entry requirements		
Micro-economics: Principles of Economics; Introduction to econometrics		
Teaching and learning approach		
Teaching in class room, directed reading, group discussions, presentations		
Time allocation in hours per activity		
Lecture [contact]	30	
Supervised practical [contact]	8	
Sum	**38**	
Assessment		
Examiners	**Goedele Van den Broeck**	
Test type (descriptive)	**Weight of the test (%)**	**Individual or Group test**
Discussion about evaluation plan submitted in advance by the student	100	Individual

GEM Study Guide

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