Brandenburgische Technische Universität Cottbus - Senftenberg
Platz der Deutschen Einheit 1, 03046 Cottbus

Modulhandbuch für den Studiengang Environmental and Resource Management (universitäres Profil), Doppelabschluss, Master of Science, Prüfungsordnung 2021

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Module 11243 Master Thesis

assign to: Modules at the Brandenburg University of Technology Cottbus-Senftenberg (Environmental Sciences)
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11243	Mandatory

Modul Title	**Master Thesis** Master-Arbeit
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	30
Learning Outcome	The Master Thesis is an examination in which the student must show that he or she can independently and successfully deal with an assignment within a set deadline and contribute scientifically founded theoretical and practical knowledge to the solving of a problem. The Master-thesis should correspond to the advanced knowledge base of the subject. The Master Thesis consists of written work and its defence.
Contents	The Master Thesis can be practical as well as theoretical. It should relate the advanced standard of knowledge in the scientific field. The Master thesis consists of the written work and its defence.
Recommended Prerequisites	none
Mandatory Prerequisites	Successful completion of the modules (except for students with UTP as home university): • 41514 Study Project • 41421 Introduction to Environmental and Resource Management II **Additionally for Examination and Study Regulation of 2021 (including Double Degree):** • an achievement of an overall minimum amount of 72 credit points. **Additionally for Examination and Study Regulation of 2011:** • an achievement of an overall minimum amount of 78 credit points.
Forms of Teaching and Proportion	Self organised studies - 900 hours

Teaching Materials and Literature	It depends on the individual subject. Corresponding material will be named and provided by the supervisor.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	The grade of the Master thesis results from the thesis, which accounts for 75 percent, and its defense, which accounts for 25 percent.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The academic supervisor is responsible for the topic and the content of the thesis.
Module Components	None
Components to be offered in the Current Semester	No assignment

Module 41421 Introduction to Environmental and Resource Management II

assign to: Mandatory Modules

Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41421	Mandatory

Modul Title	**Introduction to Environmental and Resource Management II** Einführung in den Studiengang Umwelt- und Ressourcenmanagement II
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After attendance students will have a better understanding how the ERM master programme works, what distinguishes the specialization fields of ERM and how to find a topic for their master thesis. In addition they will be able to understand the basics of good scientific practice and have learned the foundation for conceptualizing, structuring and writing their master thesis.
Contents	The module will be structured into two major topics: 1. How to study the master programme of Environmental Resource Management at BTU 2. The basics of working scientifically at an European University. This part may include the following sub-topics: · Scientific writing (with a focus on master theses) · Working with scientific literature and publishing of scientific work · Presenting at scientific conferences and networking in the scientific community · Grant writing and funding proposals · Ethics and integrity in scientific work; Intellectual property and patents · Interdisciplinary collaboration · Science communication · Career paths in science Due to a change in teaching personnel, changes to structure, timing and topics of the module will be made during the semester.

Recommended Prerequisites	None
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	to be announced
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	Final module examination: 90 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	None
Module Components	• 240230 Lecture/Exercise Introduction to ERM II
Components to be offered in the Current Semester	**240321** Lecture/Exercise Introduction to ERM II - 4 Hours per Term

Module 41514 Study Project

assign to: Mandatory Modules
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41514	Mandatory

Modul Title	**Study Project** Studienprojekt
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	12
Learning Outcome	Within a study project the students work in details on a selected topic of preferably interdisciplinary nature. The main scope is the development of problem-solving skills by means of information gathering as well as the application of theoretical knowledge acquired in more formal classes. Students will organize their scientific research related to data acquisition, data analysis.
Contents	A study includes a project report with all factual information about the work in the project.
Recommended Prerequisites	Depending on the project topic knowledge in mathematics/statistics and/ or social as well as natural sciences is advantageous.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Consultation - 1 hours per week per semester Self organised studies - 345 hours
Teaching Materials and Literature	To be named by supervisor.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Written project report with all factual information about the work (as hard copy and digital form) and a presentation. • Written report, 20-30 pages (75%) • Presentation of results (25%)
Evaluation of Module Examination	Performance Verification – graded

Limited Number of Participants	none
Remarks	None
Module Components	• 240215 Study project Study Project
Components to be offered in the Current Semester	**240215** Study project Study Project

Module 12261 Ecological Excursion

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12261	Compulsory elective

Modul Title	**Ecological Excursion** Ökologische Exkursion
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Birkhofer, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	12
Learning Outcome	The Ecological Excursion module provides hands-on experience of biodiversity threats and conflicts and basic ecological adaptations to dryland conditions. **Part "Ecological Excursion: Seminar"** The seminar introduces students to the main components of terrestrial dryland ecosystems and provides a forum for discussion of topics relevant to the field trip. Students will learn about: • biodiversity crisis and threats • human-wildlife conflicts • German colonial history • competent use of English **Part "Ecological Excursion: Excursion"** The Ecological Excursions provide a hands-on experience that combines elements of scientific expeditions, teamwork projects and taxonomic identification of organisms. Students will learn about: • independent and team-oriented ecological project work • adaptations of animals and plants to local conditions • poverty alleviation and food security • geological and hydrological conditions and processes • ecological concepts such as food webs, species inventories, sampling theory
Contents	**Part "Ecological Excursion: Seminar"** • Fauna and Flora (plants, vertebrates, invertebrates)

- contemporary ecological challenges (biodiversity conservation, climate change, invasive species, ecosystem services)
- contemporary social challenges (human wildlife conflicts, poaching, food security, colonial history)

The seminar classes are organised as 8 double blocks of lectures by the lecturer and seminar presentations by the students during the semester. Lectures will be complemented by discussions and individual contributions from students. Self-organised work is required, in particular the preparation of seminar presentations and the acquisition of previously discussed content for the field trip.

Part "Ecological Excursion: Excursion"

- study design and hypothesis testing
- multidisciplinary teamwork
- communication skills

The field trip will last up to 16 days.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 1 hours per week per semester
Seminar - 2 hours per week per semester
Excursion - 10 hours per week per semester
Self organised studies - 165 hours

Teaching Materials and Literature

Relevant literature and equipment needed during the field trip will be provided to the participants.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

Part "Ecological Excursion: Seminar"
One oral presentation, 15 min followed by discussion (50%)

Part "Ecological Excursion: Excursion"
An individual log of a pre-assigned field day (25%) and a species list of a pre-assigned taxonomic group after the field day (25%, one list for every two students participating).

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

8

Remarks

The excursion to Namibia is associated with costs for participants (around 2.500 €). In previous years, stipends were available for qualified students to reduce the costs.
PLEASE NOTE: The module can only be offered with a minimum number of 8 participants! If fewer than 8 participants register for the module, the module must be cancelled.

Module Components

- 240708 Lecture/Seminar Ecological Excursion: Seminar
- 240709 Excursion Ecological Excursion: Excursion

Components to be offered in the Current Semester	**240709** Excursion Ecological Excursion: Excursion **240708** Lecture/Seminar Ecological Excursion: Seminar - 3 Hours per Term

Module 12826 Mathematical Data Science

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12826	Compulsory elective

Modul Title	**Mathematical Data Science** Mathematische Grundlagen der Data Science
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Hartmann, Carsten
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	8
Learning Outcome	After successfully completing the module, students have deepened their knowledge of stochastics acquired in the basic modules. They know the mathematical and statistical methods from data analysis. They have acquired basic skills for in-depth modules in stochastics or optimization. They have gained experience in doing independent research.
Contents	Choice of the following topics • Concentration of random vectors in high dimensions • Concentration inequalities • Linear and nonlinear principal component analysis (PCA) • Random matrices • Sparse recovery (compressed sensing) and LASSO regression • Introduction to statistical learning • Kernel methods and Gaussian processes • Applications in signal and image processing, random networks, …
Recommended Prerequisites	Knowledge of the content of the modules • 11103 : Analysis I • 11104 : Analysis II • 11101 : Lineare Algebra und analytische Geometrie I • 11217 : Wahrscheinlichkeitstheorie or very good knowledge of the content of the modules • 11113: Mathematics IT-2 (Linear Algebra) • 11213: Mathematics IT-3 (Analysis) • as well as of the content one of the modules

	- 11917 : Mathematik W-3 (Statistik) - 11926 : Statistik für Anwender - 11212 : Statistics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• C.M. Bishop. Pattern Recognition and Machine Learning. Springer, 2006. • D.P. Dubhashi, A. Panconesi. Concentration of Measure for the Analysis of Randomized Algorithms, Cambridge University Press, 2009. • R. van Handel. Probability in High Dimension. Lecture Notes, Princeton University, 2016. • R. Vershynin. High-Dimensional Probability: An Introduction with Applications in Data Science, Cambridge University Press, 2018
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of a semester project **Final module examination:** • Project presentation, 45 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Stochastics“ or in complex „Optimization “ • Study programme Mathematik B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend • Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“ • Study programme Informatik B.Sc.: Compulsory elective module in „Applied Mathematics“ or in field of application „Mathematics“ • Study programme Informatik M.Sc.: Compulsory elective module in „Mathematics“ or in field of application „Mathematics“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“
Module Components	• Lecture: Mathematical Data Science • Accompanying exercise
Components to be offered in the Current Semester	No assignment

Module 12942 Introduction to Climate Variability and Climate Change Projections

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12942	Compulsory elective

Modul Title	**Introduction to Climate Variability and Climate Change Projections** Einführung in Klimavariabilität und Klimaänderungsprojektionen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. rer. nat. Will, Andreas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The students shall be made familiar with natural climate variability and the expected climate change in selected regions. They shall be enabled to understand and to use the results of Climate System Models. In this way a sound basis for climate impact assessment in different regions will be provided.
Contents	Part Lecture: 1. Climate state and climate variables 2. Physical basis of • 1. climate system dynamics • 2. anthropogenic climate change 3. Observational evidence of anthropogenic climate change 4. Design and history of climate system models • 1. Global Climate System Models • 2. Regional Climate System Models • 3. Statistical Climate Change Signal Models 5. Evaluation of climate system models 6. Emission Scenarios and Climate Change Projections 7. Climate Change Signal Assessment • 1. Climate Change Signal in selected regions • 2. Uncertainties of Climate Change Signals • 3. Climate sensitivity • 4. Reliability of climate projections

	8. Climate System Model bias correction and Climate impact modelling Part Exercise: Exercises supporting the understanding of the lectures and the ability to use Climate System Model results are introduced by the lecturer. These exercises are to be solved by the students in form of self-organized studies. The solutions will be presented and discussed by the students during the exercise.
Recommended Prerequisites	Basic skills in mathematics, classical mechanics and thermodynamics are expected, Advanced skills in vector calculus and tensor analysis, statistics and discrete mathematics, in fluid mechanics and thermodynamics are very helpful in gaining understanding of the lectures and provide a sound basis for solving the exercises.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Climate Change 2013: The Physical Science Basis, Working Group 1 Contribution to the fifth Assessment Report of the IPCC, Editor: IPCC. Further literature together with lecture and exercise materials are made available in electronic form during the semester.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Solution of 3 exercises (50%) • Written examination, 45 Min. (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	**No offer in winter semester 2024/2025.**
Module Components	none
Components to be offered in the Current Semester	**240158** Lecture Physical basis of climate change - 2 Hours per Term **240159** Exercise Physical basis of climate change - 2 Hours per Term

Module 12949 Geoecology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12949	Compulsory elective

Modul Title	**Geoecology** Geoökologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr.-Ing. Repmann, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	**Rationale** Geoecology is an interdisciplinary science that integrates the geosciences with the life sciences. The purpose of this module is to extend the basic knowledge of geoecology with respect to anthropogenically induced challenges. Selected issues of soil science and applied soil protection, and related ecological problems will be reflected. Furthermore, the fundamentals of environmental toxicology with regard to adverse effects of chemicals on living systems will be taught. **Lecture:** The lecture of ecotoxicology deals with the potentially harmful impact of chemicals, present as pollutants in the environment, to living organisms with particular focus on soil. In this course students will learn about: - aspects of geoecology - basic concept of ecotoxicology - existing natural and synthetic chemicals - influence of industrial and agricultural development/processes with regard to chemicals in the environment - fate of chemicals (distribution, uptake, accumulation and possible degradation) - detection and risk assessment of contamination **Exercise/Practical training:**

The exercise/practical training offers a practical approach, which is necessary to understand the fundamentals of geoecological research. Students will learn about:
- study design and planning
-field sampling
-laboratory analyses
-preparing a scientific report

Contents

Part 1: Lecture:
- goals and definitions
- classes/groups of chemicals and their potential negative impacts on the environment
- routes of entry of these chemicals into the environment and relevance
- fate of chemicals
- general principles of ecotoxicology -> toxicity -> dose-response relationships -> reception
- factors that can possibly influence the toxicity of environmental chemicals
- investigation methods

o measurement and assessment of basic site/soil parameters
o selected toxicity tests
o risk assessment
· special investigation methods and selected case studies
· phytoremediation
· two short tests (approx. 30 minutes each)

Part 2: Exercise/Practical training, practical work in the field and laboratory:
· study design/problem formulation
· sampling in the field
· laboratory analysis
· writing a technical report

Recommended Prerequisites

Knowledge in chemistry, biology and soil science

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Exercise - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Huggett, Richard J. (1995): Geoecology: An evolutionary approach. New York, Routledge.
- Dickinson, G. & Murphy, K. (1997): Ecosystems, A Functional Approach. Routledge Introductions to Environment, ISBN: 0-203-13248-3.
- Ballantyne, B. (Ed.) (1999): General and Applied Toxicology. Macmillan, London.
- Walker, C. H., Sibly, R. M., Hopkin, S. P. & Peakall, D.B. (2012): Principles of Ecotoxicology -4th ed. Boca Raton, CRC Taylor & Francis.
- Fent, K. (2007): Ökotoxikologie, Umweltchemie, Toxikologie, Ökologie. 3. Auflage. Stuttgart, New York, Thieme.

	• Newman, M. C. & Unger, M. A. (2003): Fundamentals of Ecotoxicology. 2nd ed., Boca Raton, Lewis Publishers. • Crosby, D. G. (1998): Environmental Toxicology and Chemistry, Oxford University Press, New York. McBride, M. B. (1994): Environmental chemistry of soils. Oxford University Press.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Lecture: two tests; each of the two written tests lasts approximately 60 minutes (25% each, together 50% of final grade), • Exercise/Practical training: written laboratory report, 20-25 pages (50% of final grade)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	7
Remarks	none
Module Components	• 240437 Lecture Ecotoxicology • 240411 Exercise/Practical training Geoecology
Components to be offered in the Current Semester	**240437** Lecture Ecotoxicology - 2 Hours per Term **240411** Exercise/Practical training Geoecology

Module 12959 Geopedology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12959	Compulsory elective

Modul Title	**Geopedology** Geopedologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. phil. Raab, Thomas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Geopedology deals with an integrative approach of soil science, geomorphology and geology. Students will learn the main factors and processes controlling soil formation and soil properties as well as landform evolution. The significance of both past and modern human impacts for ecosystems will be shown. Attention is paid to natural and anthropogenic processes of landscapes development in the mid-latitudes during the Late Pleistocene and Holocene.
Contents	Fundamentals in Pedology Fundamentals in Geomorphology Soil-landscape relationships Methods in Geopedology
Recommended Prerequisites	Knowledge in Quaternary Science, Geology, Soil Science or Physical Geography
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	none
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Lecture: 2 Exams, each 45 min. for 25 points each • Seminar: 4 Exams, each 45 min. for 12,5 points each

Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240421 Seminar Geopedology • 240401 Lecture Geopedology
Components to be offered in the Current Semester	**240401** Lecture Geopedology - 2 Hours per Term **240421** Seminar Geopedology - 2 Hours per Term

Module 13046 Microclimates

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13046	Compulsory elective

Modul Title	**Microclimates** Mikroklimate
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Trachte, Katja
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The module offers in-depth insight into spatio-temporal atmospheric phenomena with special reference to urban areas and their periphery. Students acquire a basic knowledge of cross-scale processes and mechanisms related to local (topo-) climates, get the competence to carry out climatological analysis in space and time applying IT-based methodologies such as statistical analyses and machine learning approaches.
Contents	In the lecture professional aspects of microclimates are addressed, such as: • definition of microclimates • physical systems • differences in atmospheric conditions • influence of elevation and land use types • radiation budget • UHI • local scale wind systems and ventilation • ABL and NBL The exercise consists of two parts: Part 1 Exercises • analysis of spatio-temporal atmospheric data, e.g. in-situ measurements and spatial-explicit data • IT-based training using GIS and programming languages such as Python • Statistical analysis and machine learning approaches

	Part 2 Field campaign: • one coherent field campaign including measurements of microclimatological conditions
Recommended Prerequisites	Basic knowledge in atmospheric sciences and climatology, basic knowledge in statistics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Excursion - 12 hours Self organised studies - 108 hours
Teaching Materials and Literature	Recommended literature: Thomas Foken: Micrometeorology. Springer, Berlin, 2017. Roger G. Barry: Microclimate and Local Climate. Cambridge University Press, 2016.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1. Weekly exercises in form of data analyses and visualization (30%) 2. Submission of a research project (70%), 8-10 pages; c. 2000-3000 words
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	Lecture – Microclimates Exercise - Microclimates Field campaign - Microclimates
Components to be offered in the Current Semester	No assignment

Module 13221 Land surface - Atmosphere Interactions

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13221	Compulsory elective

Modul Title	**Land surface - Atmosphere Interactions** Landoberflächen - Atmosphären Interaktion
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Trachte, Katja
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The module offers fundamental knowledge of physical processes and methodologies related to land surface – atmosphere interactions and its relevance in the context of climate change, e.g. carbon and water cycle, factors of changes in surface energy fluxes, soil-vegetation-atmosphere transport, ecophysiological interactions. Students get the competence to assess relevant aspects related to global change as well as to apply IT-based approaches.
Contents	In the lecture professional aspects of land surface – atmosphere interactions are addressed, such as: · turbulence and the development of PBL structure · carbon cycle · water availability · water use efficiency · ecophysiology · measurement techniques, e.g. eddy-covariance · remote sensing · modeling approaches In the exercise the knowledge gained will be applied using the programming language Python to trainee statistical data analyses (e.g. spatial data mining, machine learning approaches, GLM) and visualization in the field of atmospheric / environmental sciences.
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	none
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1. Weekly exercises in form of data analyses and visualization (30%) 2. Submission encompass 8-10 pages including approx. 2000-3000 words. A group submission is scheduled. Individual grading can be achieved according to the uploaded program code. (70%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	Lecture – Land surface – Atmosphere Interaction Exercise - Land surface – Atmosphere Interaction
Components to be offered in the Current Semester	**240126** Lecture Land surface - Atmosphere Interactions - 2 Hours per Term **240128** Exercise Land surface - Atmosphere Interactions - 2 Hours per Term

Module 13234 Communication of Science and Technology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13234	Compulsory elective

Modul Title	**Communication of Science and Technology** Wissenschafts- und Technikkommunikation
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Students will know about different techniques, tools and formats for communication of science & technology. They will develop skills to break down complex issues at the nexus of science, technology and society to communicate science/technical information in a clear, understandable and engaging way to different stakeholders. On completion of the module, students will be able to: • Articulate the key issues and challenges in communicating about science & technology; • Understand the nature of different audiences for better stakeholder engagement; • Demonstrate awareness of and ability to use a variety of different techniques and media for targeted audience; • Improve their skills in communication of scientific/technical information in both written and oral forms; • work as part of a team to develop effective measures for communication of science & technology; • Provide constructive feedback to other students on their communication skills.
Contents	Course coverage: • Key issues in communication of science & technology; • Identify and knowing your audiences (mental models, risk perception, heuristics and biases, …); • Getting your audience's attention (Types of framing); • Communicating risk and uncertainty; • Formats for communication of science & technology.

	Students will also be given opportunities to receive feedback and improve their own written and oral skills. They will also work in small teams on team projects to further their skills for communicating about sustainability issues. These projects will focus on communicating about a given scientific topic to a particular audience using spoken, visual, written or web-based communication.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Center for Research on Environmental Decisions (CRED). 2009. *The Psychology of Climate Change Communication: A guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public.* New York. • Nisbet, M.C., Scheufele, D.A. 2009. What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, 96(10): 1767-1778. • Bubela, T., Nisbet, M., Borchelt, R. *et al.* 2009. Science communication reconsidered. Nature Biotechnology, 27, 514–518. • Nelkin, D. 1989. Communicating technological risk: The social construction of risk perception. *Annual Review Public Health*, 10, 95-113. • Tversky, A., Kahneman, D. 1974. Judgment under Uncertainty: Heuristics and Biases. Science, New Series, 185(4157), 1124-1131. Further material (including lecture slides and additional materials including videos, readings etc.) might be announced during the first class meeting.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Individual E-Assessment – 60 min (40%) • Group project - Part 1: Science Communication Material e.g., poster, video, etc. (30%) • Group project - Part 2: Group presentation– 15min oral presentation (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture / Seminar
Components to be offered in the Current Semester	**510601** Lecture/Seminar Communication of Science & Technology - 4 Hours per Term

Module 13298 Basics for Freshwater Management

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13298	Compulsory elective

Modul Title	**Basics for Freshwater Management** Grundlagen des Gewässermanagements
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. habil. Martin-Creuzburg, Dominik
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students understand freshwaters as ecosystems and know the ecological principles underlying ecological management and how to differentiate between naturally and anthropogenically introduced variability in freshwater ecosystems. They know the main groups of freshwater organisms, and understand the functioning and biogeochemical role of lake and stream ecosystems and their role in landscapes. Specifically, students understand how freshwater organisms achieve the freshwater ecosystem services that humans require. Students know the main anthropogenic impacts on freshwater resources. They understand the consequences of these impacts through their interaction with ecological processes. Students will thus be able to evaluate the consequences of major impacts to aquatic organisms and ecosystem functioning and related those to the European Water Framework Directive as the base for evaluation and management of freshwater resources.
Contents	Physical and chemical properties of water. Running water ecosystems: Characteristics, variability and typology, connected functional compartments and main groups of organisms, ecosystem functioning, matter transformation and ecosystem services. Ponds and lakes: Genesis and typology, biogeochemistry of water and sediment, habitats and organisms; lake shores and macrophyte ecology. Main water quality problems related to agriculture, forestry, urbanization and mining; eutrophication, acidification, salinization, siltation, contamination, effects of neobiota; hydromorphological degradation of streams and rivers; loss of ecosystem services in degraded freshwaters; expected impacts of climate change. Principles of sustainable water

	management; principles of lake diagnosis, quality assessment and evaluation as prerequisites for mitigation and restoration; EU Water Framework Directive; overview on strategies to conserve and improve impacted freshwaters.
Recommended Prerequisites	Basics in environmental sciences, ecology or similar.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	All course materials (lectures and video-based learning materials, as well as assignments, exercises, and self-tests) are made available on Moodle on a weekly basis.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Three written exams during the semester. Each partial exam counts for 25% of the module grade. • Students earn the remaining 25% of points via continued assessment through five work portfolios (ca. 1000 words each), five self-assessments, two exercises (4 questions/calculations each) and an oral exam (10 min). An opportunity to re-write a partial exam in the second examination period is only offered to students on sick leave.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module is taught as online course via Moodle. The course follows a blended learning concept in a strict weekly rhythm. It consists of A) self-organized study of the learning material of the week (learning and lecture videos, reading material, exercises) and B) live meetings in the online classroom for clarification of open questions and discussions to reflect and consolidate the understanding of the past week's learning material. The blended learning in weekly rhythm requires continuous participation. Enrolment in the Moodle course is mandatory for this module. The module starts with an online meeting on the first Monday of the semester. All three partial exams will be closed book exams and take place in presence in the course of the semester. The module is a mandatory prerequisite for the course Freshwater Restoration Ecology (module 42505) which is offered in summer semester.
Module Components	Basics for Freshwater Management (e-learning course)
Components to be offered in the Current Semester	**240501** Lecture/Exercise

Basics for Freshwater Management (e-learning module) - 4 Hours per Term
240503 Examination
Examination Basics for Freshwater Management

Module 13300 Environmental Data Science

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13300	Compulsory elective

Modul Title	**Environmental Data Science** Umweltdatenwissenschaft
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. Ryo, Masahiro
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After the course, students will acquire both hard and soft data science skills essential for solving issues in environmental science, such as data handling, data visualization, data analysis, data interpretation, and data communication. These practical skills will be supported by fundamental statistical and programming knowledge. The students will be fluent in the R programming language beyond the basic level.
Contents	Part 1. Introduction to environmental data science Part 2. Data handling - Coding Basics in R, data import & data transformation Part 3. Data visualization - Various types of data visualization Part 4. Data analysis - Basic statistics - Statistical modelling: classification and regression - Machine learning modelling: Classification and regression Part 5. Data interpretation - Model interpretation - Common pitfalls Part 6. Data communication - Storytelling with data: Basic rules & practical tips
Recommended Prerequisites	• Experience in R programming language • Basic knowledge of statistics (probability theory, hypothesis testing, correlation, linear model)
Mandatory Prerequisites	None

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Most of the textbooks are freely available from the links thanks to the fantastic authors: • H. Wickham & G. Grolemund: R for Data Science (https://r4ds.had.co.nz/index.html) • R. A. Irizarry: Introduction to Data Science (https://rafalab.github.io/dsbook/) • Hands-On Programming with R (https://rstudio-education.github.io/hopr/index.html) • C.O.Wilke: Fundamentals of Data Visualization (https://clauswilke.com/dataviz/) • B. Boehmke & B. Greenwell: Hands-On Machine Learning with R (https://bradleyboehmke.github.io/HOML/) • C. Molnar: Interpretable Machine Learning (https://christophm.github.io/interpretable-ml-book/) • C. N. Knaflic: Storytelling with Data (https://www.storytellingwithdata.com/)
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Exercises during course (10 small programming exercises; 6% each; 60% in total) • Oral presentation based on self-organized project: 15 min incl. discussion (40%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	15
Remarks	This module will be offered as a block course. Please bring your laptop.
Module Components	242100 Lecture/Exercise: Environmental Data Science
Components to be offered in the Current Semester	**242100** Lecture/Exercise Environmental Data Science - 4 Hours per Term

Module 13371 ERM-Research-Module

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13371	Compulsory elective

Modul Title	**ERM-Research-Module** ERM-Research-Modul
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	18
Learning Outcome	For students with a strong interest and capability in research, the ERM-Research-Module is an advanced study alternative in the Master's programme. This variant includes in particular the independent preparation of a two-semester research project. The students learn how to work on scientific problem formulation, the target-oriented implementation of experimental approaches and the scientific evaluation and presentation of the results. The students carry out research-orientated tasks which they work on increasingly independently and in exchange with other project participants under the intensive supervision of experienced researchers. The main scope is the development of scientific problem-solving skills by means of information gathering as well as the application of theoretical knowledge acquired in small group advanced seminars.
Contents	The supervising lecturers select suitable topics from their subject areas and intensively support the students in learning the necessary subject-specific and interdisciplinary skills. The contents of the module are regularly adapted in line with ongoing research projects in the participating disciplines.
Recommended Prerequisites	Depending on the topic excellent knowledge in mathematics/statistics, chemistry, biology and/or social as well as environmental sciences is required.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Exercise - 2 hours per week per semester Self organised studies - 480 hours
Teaching Materials and Literature	To be named by supervisor.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Written project report with all factual information about the work (as hard copy and digital form) and a presentation. Written report, 20-30 pages (75%) Presentation of results, 30 min. (25%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module "ERM Research Module" can only be repeated once if it is not passed. It is one of the practical study sections and is therefore excluded from the free trial regulation.
Module Components	• ERM-Research Lecture • ERM-Research Excercise
Components to be offered in the Current Semester	**242100** Lecture/Exercise Environmental Data Science - 4 Hours per Term

Module 13580 Systems and Process Hydrology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13580	Compulsory elective

Modul Title	**Systems and Process Hydrology** System- und Prozesshydrologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Kästner, Karl
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students are able to analyse hydrological processes and to obtain and interpret hydrological data from hydrological annuals and internet sources. They can use standard procedures for hydrological dimensioning, probability analysis and extreme value statistics (especially flood statistics). They are furthermore able to apply basic methods of deterministic simulation of hydrological processes, modelling and modelling.
Contents	Description of hydrological processes as well as evaluation and presentation of associated data; adaptation of distribution functions to runoff data, derivation of flood design values with different data; design precipitation. Basic system hydrological description approaches; application of system hydrology for river basin modelling. Deepening of the methods in exercises with practical examples.
Recommended Prerequisites	knowledge of hydrology
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Lecture presentations, scripts for the exercises, literature references and questionnaires are made available via the online portal Moodle. Further literature:

	• Maniak, 2010: Hydrologie und Wasserwirtschaft. Eine Einführung für Ingenieure, e-book. https://katalog.ub.b-tu.de/search?bvnr=BV036607172 • DYCK, S. u.a.: Angewandte Hydrologie, Teil 1, VEB Verlag für Bauwesen, Berlin 1980 • DYCK, S. u.a.: Angewandte Hydrologie, Teil 2, VEB Verlag für Bauwesen, Berlin 1980 • SCHÖNWIESE, C. D.: Praktische Statistik für Meteorologen und Geowissenschaftler, Gebrüder Bornträger Berlin • Nützmann, G., Moser, H.: Elemente einer analytischen Hydrologie, Prozesse - Wechselwirkungen - Modelle, Springer, e-book: https://katalog.ub.b-tu.de/search?bvnr=BV043210734
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	Written exam at the end of the lecture period (90 min.)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• *Lecture System- and Process Hydrology* • *Seminar System- and Process Hydrology* • *Exam System- and Process Hydrology*
Components to be offered in the Current Semester	**240673** Lecture Systems and Process Hydrology - 2 Hours per Term **240674** Seminar Systems and Process Hydrology - 2 Hours per Term **240675** Examination Systems and Process Hydrology

Module 13653 Atmospheric Water

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13653	Compulsory elective

Modul Title	**Atmospheric Water** Atmosphärisches Wasser
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Trachte, Katja
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The module offers fundamental knowledge of physical processes and methodologies related to the atmospheric water cycle and its relevance in the context of climate change, e.g. water vapor fluxes and pathways, cloud microphysical processes, precipitation. Students get the competence to assess relevant aspects related to atmospheric water transport and availability, water use efficiency and cloud – albedo feedbacks as well as to apply IT-based approaches.
Contents	In the lecture professional aspects of atmospheric water processes: · Atmospheric water fluxes · Water vapor pathways · Cloud microphysics · Cloud-albedo feedbacks · Precipitation processes · Water availability · Water use efficiency · Remote sensing · Modeling approaches In the exercise the knowledge gained will be applied using programming languages such as R and Python to trainee atmospheric remote sensing, data assimilation and modelling approaches in the field of atmospheric / environmental sciences.
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours Exercise - 2 hours
Teaching Materials and Literature	Recommended literature: H.R. Pruppacher & J.D. Klett: Microphysics of Clouds and Precipitation. Springer, 2010, Vol 18. R.A. Jr. Houze: Cloud Dynamics, 2014, 2nd Ed., Elsevier/Academic Press, Oxford
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1. Weekly exercises in form of data analyses and visualization (30%) 2. Submission of a project (70%) Submission encompass 8-10 pages including approx. 2000-3000 words. A group submission is scheduled. Individual grading can be achieved according to the uploaded program code.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	Lecture – Atmospheric Water Exercise - Atmospheric Water
Components to be offered in the Current Semester	**240161** Lecture Atmospheric Water - 2 Hours per Term **240162** Seminar/Exercise Atmospheric Water - 2 Hours per Term

Module 13655 Un/Disciplining Knowledge: Technology, Science, and Society in Transformation

assign to: Modules with the Focus on Environmental Sciences

Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13655	Compulsory elective

Modul Title	**Un/Disciplining Knowledge: Technology, Science, and Society in Transformation** Epistemischer Ungehorsam: Technik, Wissenschaft und Gesellschaft im Wandel
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. nat. phil. habil. Schwarz, Astrid
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	By the end of the module students are able to develop a research question within the academic field of Science and Technology Studies and create and present a research design, as well as identify and make use of appropriate sources of empirical material for your analysis, furthermore to identifiy, select and compare appropriate concepts and methods relating to an interdisciplinary research field and analyse changes in fields of science and technology with respect to knowledge forms.
Contents	This module presents central theories and approaches developed in Science and Technology Studies. The module focuses on questions about disciplining and undisciplining knowledge, the corresponding epistemic and ontological perspectives and the political economy of science. It explores concepts being concerned about shifting concepts of disciplinarity, such as interdisciplinarity, transdisciplinarity or postdisciplinarity.
Recommended Prerequisites	Knowledge from the courses • Technik in Wissenschaft und Gesellschaft • Philosophy of Science in Practice
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature and learning materials are given in the course description.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• short scientific essay, max. 4000 words (45%) • scientific review, max. 2500 words (40%) • presentation, max. 15 minutes (15%) The oral part of the examination can be done digitally or as a virtual meeting if the conditions for an examination in presence are not given.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	German-speaking teachers are available if required. Further information on this can be found in the course description.
Module Components	• Seminar - 4 SWS
Components to be offered in the Current Semester	**510151** Seminar Un/disciplining Knowledge - 4 Hours per Term

Module 13657 How to Talk about Nature?

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13657	Compulsory elective

Modul Title	**How to Talk about Nature?** Wie über Natur sprechen?
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. nat. phil. habil. Schwarz, Astrid
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After passing the module, students understand main philosophical theories of “nature”, interrogate the concept of “nature” and expose its numerous ideological and cultural manifestations. They identify the main ethical dimensions of “nature”, and its crosscultural and political dimensions. Additionally they understand the power of narratives and storytelling to shape our environmental present and future by insight into reading, writing, and visual practices about “nature”.
Contents	“How to talk about nature?” is closely linked to the question of what “nature” is, how it is construed and in which way we act with, in or against it. It is a question that is ontological and epistemological at the same time, it is about how we imagine nature “to be” and how we conceive knowledge about nature. The ideas about this entwinement are manifold over time and in space, different cultures have developed different ways of thinking and also practices of how to deal with a culture/nature distinction. Another important conceptual issue is how nature and technology are related, in contemporary debates for instance, "nature" is often identified with "environment" and as such inescapably entangled with its cultural, political, and technological context. Is the use of technology in “nature” then a threat or an opportunity to build a genuinely sustainable world? This module seeks to answer these and other questions, by approaching “nature” with variously grounded historical and contemporary theoretical approaches. For example, the concept of “nature” was differently interpreted in ancient times, compared to modern contemporary cultures. We will probe the different usage, the scope of historical and cross-cultural depth, the semantics, the images/

	imaginaries, and finally, the logical coherence of “nature” concepts. This variety of topics means that the assigned readings will draw from a wide range of sources. With respect to handle current ecological and technocultural problems, a conscious reflection about “nature” seems to be required. Thus, the module should be also seen, in part, as a way to gain insight into contemporary reading, writing, and visual practices about “nature”. Participation in the accompanying excursion is encouraged.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature and learning materials are given in the course description.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• One short essay, max 1500 words (25%) • Two reviews, each max. 2000 words (each 30%) • 2 oral (group) presentations, about 15 min **OR** weekly submitted written answers to one short question per week on the topical readings to be determined by the instructor (15%) The oral part of the examination can be done digitally or as a virtual meeting if the conditions for an examination in presence are not given.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	60
Remarks	none
Module Components	• Seminar, lecture - 4 hours per week per semester
Components to be offered in the Current Semester	**510112** Lecture/Seminar How to talk about "Nature"? / Ethik und Handeln / Philosophy of Technology and Nature / Natur und Technik / Wissenschaftstheorie, Logik und Naturphilosophie - 4 Hours per Term

Module 13663 Environmental Soil Science and Plant Nutrition

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13663	Compulsory elective

Modul Title	**Environmental Soil Science and Plant Nutrition** Umweltbezogene Bodenkunde und Pflanzenernährung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Ph. D. Rütting, Louise
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After completing this course, the student will be able to understand: • fundamental chemical properties and processes in soil • scientific methods employed for the remediation of contaminated soils • natural and anthropogenic factors and processes in soil and plant systems • basic principles of plant nutrient uptake • nutrient assimilation of plants with focus on the nitrogen and phosphate cycle • main sources and sinks of greenhouse gases
Contents	**Part 1: Soil Science/Soil Chemistry** Introduction to the principles of soil chemistry, including properties of soil minerals and their interactions with essential plant nutrients. We will focus on soil solution dynamics, sorption processes, and redox reactions. In addition, students will gain insights into soil water dynamics and the importance of soil organic matter. **Part 2: Plant Nutrition** The student learns about the importance of mineral nutrition in plants, including essentiality, availability, and applications, as well as their management and control strategies. We have a focus on plant nutrient uptake, the rhizosphere and nutrient starvation. The student will gain insight into the different processes of bioremediation and phytoremediation dealing with contamination problems in a scientific and ecological way. In a seminar we will discuss numerous remediation approaches.

	An excursion followed by a laboratory practical will combine the plant nutrition and soil sections.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Excursion - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The class is organized as lectures complemented by discussions and individual contributions. All slides and schedules are available in Moodle. Recommended literature: • Blume et al. (2016): Scheffer/Schachtschabel Soil Science. Springer, Berlin. • Naeem, M.; Ansari, A. A.; Gill, S.S. [Eds.] (2017): Essential Plant Nutrients. Uptake, Use Efficiency, and Management. Springer, Berlin. • Malik, J. A. (2022): Advances in Bioremediation and Phytoremediation for Sustainable Soil Management. Principles, Monitoring and Remediation. Springer International Publishing, Cham. • Flores, J. C. (2021): The Future of Phytoremediation. Nova Science Publishers Inc., Hauppauge.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• written mid-term assessment on lecture Part 1, 60 min. (30 %) • written final assessment on lecture Part 2, 60 min. (30 %) • written protocol on excursion and laboratory exercise (40 %)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	25
Remarks	The excursion and the laboratory practical will take place in March.
Module Components	*Lecture/Seminar Environmental Soil Science and Plant Nutrition* *Excursion Environmental Soil Science and Plant Nutrition*
Components to be offered in the Current Semester	**240262** Excursion Excursion Environmental Soil Science and Plant Nutrition - 2 Hours per Term **240261** Lecture/Seminar Soil Chemistry/Plant Nutrition - 2 Hours per Term

Module 13735 Biodiversity of Terrestrial Invertebrates

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13735	Compulsory elective

Modul Title	**Biodiversity of Terrestrial Invertebrates** Biodiversität terrestrischer Wirbelloser
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Birkhofer, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The module Biodiversity of Terrestrial Invertebrates provides an overview of the taxonomy and ecology of invertebrates in terrestrial ecosystems with mandatory half-day excursions and student projects. **Part "Biodiversity: Lecture"** The lectures introduce the taxonomy of terrestrial invertebrates with diagnostics for major orders and highlight the ecology of selected case taxa. Students will learn about • Phylogenetic relationships of major terrestrial invertebrate orders • Identification and diagnostics of major terrestrial invertebrate orders • Ecology of major terrestrial invertebrate orders **Part "Biodiversity: Seminar"** The seminars are based on student presentations of an assigned scientific publication focusing on the ecology of selected terrestrial invertebrate taxa. Students will learn about • Interpretation of scientific articles • Ecology of a selected case taxon • Summarizing and presenting scientific results **Part "Biodiversity: Excursion"** The two excursions will take students to habitats in and around Cottbus to study terrestrial invertebrate communities including some laboratory course work to identify invertebrates. Students will learn about • Ecological field work with a focus on biodiversity assessment • Identification of major terrestrial invertebrate orders in the field and laboratory

Contents	**Part "Biodiversity: Lecture"** • Terrestrial invertebrate taxonomy • Terrestrial invertebrate ecology **Part "Biodiversity: Seminar"** • Threats to terrestrial invertebrate biodiversity • Status of terrestrial invertebrate biodiversity • Solutions to biodiversity loss in terrestrial invertebrates **Part "Biodiversity: Excursion"** • Field methods to sample terrestrial invertebrates • Diagnostic criteria to identify major terrestrial invertebrate orders in the field and laboratory
Recommended Prerequisites	For international study programs and master students module “41217 General and Applied Ecology” or for BSc students module “41102 Ecology”. For German study programs module „14324 Terrestrische Ökologie“ or module „41203 Allgemeine Ökologie“.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Seminar - 1 hours per week per semester Excursion - 10 hours Exercise - 10 hours Self organised studies - 130 hours
Teaching Materials and Literature	**Part "Biodiversity: Lecture"** The class is organized as a weekly lecture introducing major orders of terrestrial invertebrates. Lecture-like presentations are complemented by discussions. Self-organized work, in particular acquiring more detailed knowledge of the taxonomic groups is required. E-books Piper R What Insects Do, and Why Schowalter TD Insect ecology: an ecosystem approach Beutel RG & Friedrich F Insect morphology and phylogeny Resh VH Encyclopaedia of insects New TR Insect species conservation: Ecology, biodiversity, and conservation Samways MJ Insect diversity conservation **Part "Biodiversity: Seminar"** A scientific paper focusing on the ecology of a major order of terrestrial invertebrates is assigned to students. The content of the paper will then be presented as an oral presentation in the seminar by the students following the lecture. All seminar topics and material are provided. **Part " Biodiversity: Excursion"** Participation in the two half-day ecological excursions is mandatory. All material for the excursions is provided. E-books

	Brock PD Britain's Insects: A Field Guide to the Insects of Great Britain and Ireland Santos JC Measuring arthropod biodiversity: a handbook of sampling methods
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	**Part "Biodiversity: Seminar"** One oral presentation, 25 min + 20 min discussion (50%) **Part " Biodiversity: Lecture"** One written examination, 80 min. (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240795 Biodiversity: Lecture/Seminar • 240796 Biodiversity: Excursion • 240797 Biodiversity: Exercise
Components to be offered in the Current Semester	No assignment

Module 13737 Practical Course Aquatic Ecology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13737	Compulsory elective

Modul Title	**Practical Course Aquatic Ecology** Praktikum Gewässerökologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. habil. Martin-Creuzburg, Dominik
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The students know basic methods for the investigation of standing and running waters and can apply them independently. They can effectively use different data and information in order to answer research questions or develop hypotheses. The students can compare and assess the possibilities and limitations of methods and data in aquatic ecology.
Contents	Recording and evaluation of abiotic and biotic water quality parameters within the framework of a case study on a watercourse and a standing water body. Field measurements with different probes, limnological sampling techniques and laboratory analyses, process measurements, experimental approaches, microscopy of aquatic organisms, data analyses and preparation of reports.
Recommended Prerequisites	13298 Basics for Freshwater Management or/and 42505 Freshwater Restoration Ecology. Commitment and willingness for active participation, self-organized work, teamwork and self-study.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Practical training - 80 hours Self organised studies - 100 hours
Teaching Materials and Literature	The necessary materials for the practical part will be provided.
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	Oral presentations and written reports of the results for each part, Running Waters and Standing Waters. **Part Running Waters:** • 15 min presentation on one of the methods to be applied (10%) • Course participation (10%) • Presentation of results and written report (ca. 3 - 5 pages without figures and/or tables, 11 pt font, line spacing no more than 1.2) (30%) **Part Standing Waters:** • 15 min presentation on one of the methods to be applied (10%) • Course participation (10%) • Presentation of results and written report (ca. 3 - 5 pages without figures and/or tables, 11 pt font, line spacing no more than 1.2) (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	12
Remarks	The course will take place as a block course during the lecture-free period of the 2026 summer semester from August 17 to September 4, 2026. The number of participants is limited to 12 students. The Standing water part will take place from August 17 to 21, 2026, at the Research Station of the Department of Aquatic Ecology in Bad Saarow. This requires all students to stay overnight in a youth hostel in Bad Saarow. The accommodation costs of ~€150 will be paid by the students themselves. In order to process the booking and deposit for the accommodation and to guarantee binding participation in the module, a deposit of €100 is required. The payment terms will be communicated to students by the Department of Aquatic Ecology after they have registered for the module with the Examination Office. The Department of Aquatic Ecology will decide on final admission to the module. This depends on the student's qualifications and receipt of the deposit for accommodation. Only after receiving a positive decision from the Department of Aquatic Ecology will the student be given access to the course page on Moodle.
Module Components	240506 Practical course aquatic ecology
Components to be offered in the Current Semester	No assignment

Module 13822 Biodiversity of Terrestrial Arthropods

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13822	Compulsory elective

Modul Title	**Biodiversity of Terrestrial Arthropods** Biodiversität terrestrischer Arthropoden
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Birkhofer, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The module Biodiversity of Terrestrial **Arthropods** provides an overview of the taxonomy and ecology of **arthropods** in terrestrial ecosystems with a mandatory 5-day excursion during the semesters excursion week and student projects. **Part "Biodiversity: Lecture"** The lectures introduce the taxonomy of terrestrial invertebrates with diagnostics for major orders and highlight the ecology of selected case taxa. Students will learn about • Phylogenetic relationships of major terrestrial invertebrate orders • Identification and diagnostics of major terrestrial invertebrate orders • Ecology of major terrestrial invertebrate orders **Part "Biodiversity: Seminar"** The seminars are based on student presentations of an assigned scientific publication focusing on the ecology of selected terrestrial invertebrate taxa. Students will learn about • Interpretation of scientific articles • Ecology of a selected case taxon • Summarizing and presenting scientific results **Part "Biodiversity: Excursion"** Students will learn:

- Ecological field work methods with a focus on biodiversity assessment
- Identification of arthropods and use of taxonomic determination keys

Contents

The courses will take students to an ecological field station in Brandenburg for five days during the semesters excursion week. A small fee of 10€ will be collected from all participating students to cover some of the costs.

Part "Biodiversity: Lecture"

- Terrestrial arthropod taxonomy
- Terrestrial arthropod ecology

Part "Biodiversity: Seminar"

- Threats to terrestrial arthropod biodiversity
- Status of terrestrial arthropod biodiversity
- Solutions to biodiversity loss in terrestrial arthropod communities

Part "Biodiversity: Excursion"

- Field methods to sample biodiversity with a focus on terrestrial arthropods
- Diagnostic criteria to identify major terrestrial arthropod orders in the field and laboratory

Recommended Prerequisites

For international study programmes and master students module ”41217 General and Applied Ecology” or for BSc students module ”41102 Ecology”. For German study programmes module „14324 Terrestrische Ökologie” or module „41203 Allgemeine Ökologie".

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 1 hours per week per semester
Seminar - 1 hours per week per semester
Excursion - 32 hours
Self organised studies - 118 hours

Teaching Materials and Literature

Part "Biodiversity: Lecture"
The class is organized as a weekly lecture introducing major orders of terrestrial arthropods. Lecture-like presentations are complemented by discussions. Self-organized work, in particular acquiring more detailed knowledge of the taxonomic groups is required.

E-books
Piper R, What Insects Do, and Why
Schowalter TD, Insect ecology: an ecosystem approach
Beutel RG & Friedrich F, Insect morphology and phylogeny
Resh VH, Encyclopaedia of insects
New TR, Insect species conservation: Ecology, biodiversity, and conservation
Samways MJ, Insect diversity conservation

	Part "Biodiversity: Seminar" A scientific paper focusing on the ecology of a major order of terrestrial invertebrates is assigned to students. The content of the paper will then be presented as an oral presentation in the seminar by the students following the lecture. All seminar topics and material is provided. **Part " Biodiversity: Excursion"** Students will write a report on an assigned excursion. Participation in these half-day ecological excursions is mandatory. All material for the excursions is provided. E-books Brock PD, Britain's Insects: A Field Guide to the Insects of Great Britain and Ireland Santos JC, Measuring arthropod biodiversity: a handbook of sampling methods
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	**Part "Biodiversity: Seminar"** One oral presentation, 25 min + 20 min discussion (50%) **Part " Biodiversity: Excursion "** One written report summarising the results from the 5-day excursion (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The courses will take students to an ecological field station in Brandenburg for five days during the semesters excursion week. A small fee of **10 €** will be collected from all participating students to cover some of the costs.
Module Components	• 240795 Lecture/Seminar Biodiversity • 240798 Excursion Biodiversity
Components to be offered in the Current Semester	No assignment

Module 13837 Agro-Ecosystems Analysis and Modelling

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13837	Compulsory elective

Modul Title	**Agro-Ecosystems Analysis and Modelling** Analyse und Modellierung von Agrarökosystemen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. Webber, Heidi
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	• describe and analyze agricultural systems using system analysis terms and concepts; • develop a simple dynamic model of a process affecting crop development or growth using the R programming language; • conduct model calibration, evaluation and sensitivity analysis; • design a model based assessment of the performance and sustainability of a cropping system; and • critically reflect on scientific studies reporting simulation results.
Contents	With the range of challenges facing crop production systems, systems analysis and simulation modelling are frequently applied analytical tools to assess improved crop management and improve understanding of how crop systems functioning. Systems approaches represent a scientific concept in which the real world is divided into systems. These systems are captured into models Applied at a range of scales (canopy, (sub-) field, agroecosystem, regional or global), they can be used as scientific tools to test hypothesis of crop behavior, informing and aiding in experimental interpretation. The course consists of three main learning areas: systems dynamics and model development; model performance & model evaluation; model applications.
Recommended Prerequisites	Good quantitative skills, basic knowledge of statistics, basic knowledge of scripting in R
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	TBD
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	 - Report of the project #1, model development: description and schematic of the conceptual model, R-script, discussion (40%) 8 pages an appendix showing R-codes (draft description attached); working in groups of 2 or 3 students - Report of the project #2, model application: description and schematic of the topic selected, R-sript, discussion (40%) 7 pages an appendix showing R-codes (draft description attached); working in groups of 2 or 3 students - Preparation and leading of one group seminar: 30 min discussion on an assigned article presenting a model simulation study (20%) working in groups of 3 or 4 students
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	30
Remarks	The module will take place in Summer Semester 2025!
Module Components	*Lectures, seminars and computer based exercises*
Components to be offered in the Current Semester	No assignment

Module 13955 Geomorphology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13955	Compulsory elective

Modul Title	**Geomorphology** Geomorphologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. phil. Raab, Thomas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	At the end of the module, the students will be able • to understand and remember the fundamentals of geomorphology • to explain the factors and processes of landform development • to describe the morphology of landforms and explain its formation • to understand and apply methods for quantitative landform description and analysis • to apply and evaluate different types of digital elevation data • to process and analyze digital elevation data in GIS software • to create maps of landform structures and relief features
Contents	Part 1 Lecture – Geomorphology • Fundamentals and concepts of geomorphology • Geomorphic agents and processes • Landforms and landform • Anthropogenic geomorphology • Characteristic landforms of the mid latitudes Part 2 Seminar – Digital Terrain Analysis • Concept of Geomorphometry and basic geomorphometric parameters • Digital elevation models (DEMs) – types and data sources • Software for elevation data processing and analysis • Visualization methods • Advanced geomorphometric indices • Exemplary practical applications (hydrology, archaeology, soil erosion modelling,…)

	Part 3 Seminar/Exercise - Processing and analysis of digital landform data • Practical exercises for exemplary study areas of an ongoing research project • import and processing of DEMs in GIS database • computation of basic geomorphometric parameters (slope, curvature, exposition,…) • digital landform classification • computation of advanced morphometric indices (TWI, SPI, …) • visualization of relief structures • digitization of relief structures, analysis of spatial distribution patterns • creation of maps
Recommended Prerequisites	Basics of physical geography
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Exercise - 2 hours per week per semester Seminar - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Anderson, R.S., Anderson, S.P. (2010): Geomorphology. The Mechanics and Chemistry of Landscapes. Cambridge University Press. 637 p. • Goudie, A., Viles, H. (2016): Geomorphology in the Anthropocene. Cambridge University Press. 324 p. • Gutiérrez Elorza, M. (2005): Climatic geomorphology. Elsevier, 760 p. • Hengl, T. (ed., 2009): Geomorphometry. Concepts, Software, Applications. Elsevier, 765 p. • Slaymaker, O., (ed., 2011): Geomorphology and global environmental change. Cambridge University Press, 434 p. • Wilson, J.P. (2000): Terrain Analysis. Principles and Applications. Wiley, 479 p. • Teaching material and further recommended literature will be provided in the specific courses
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• written assessment on Lecture Geomorphology, approx. 8 questions, 2 pages (20%) • 4 seminar exercises to be solved independently or in groups, 4 protocols (1 page each) and 4 presentations (10 min each) (40%) • final integrative presentation (20 min) and discussion of exercise results (15 min) (40%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture *Geomorphology* (1SWS) • Exercise *Processing and analysis of digital landform data* (2SWS) • Seminar *Digital Terrain Analysis* (1SWS)

Components to be offered in the Current Semester	No assignment

Module 14132 Multidimensional Approaches for Technology Assessment

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14132	Compulsory elective

Modul Title	**Multidimensional Approaches for Technology Assessment** Multidimensionale Ansätze für Technikfolgenabschätzung
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students know about a range of technology assessment approaches, methodologies and tools to facilitate the evaluation of decarbonization & sustainability transformation options along socio-technological-economical-ecological-political (*STEEP*) dimensions. On completion of the module, students are able to: • Demonstrate a deep understanding of the multidimensional aspects and systemic interactions in the transformation of energy- and carbon-intensive industries; • Gain familiarity with a range of qualitative and quantitative methodologies in conducting technology assessment; • Design and conduct studies to analyze the opportunities and challenges which will be associated with the transformation of energy- and carbon-intensive industries along multiple dimensions; • Identify, assess and evaluate appropriate sources of information and critically reflect on the methodologies commonly implemented for technology assessment and their usefulness/weaknesses.
Contents	Course coverage: • Relevance and development of technology assessment; • Common methodological approaches and their usefulness/weakness; • Data and approaches for assessment (e.g., primary vs. secondary; qualitative vs. quantitative); • Methodologies for socio-political evaluations, techno-economic evaluations and ecological evaluations;

- Application on a case study to assess multidimensional opportunities and challenges associated with the transformation of a specific sector and derive implications along the *STEEP* dimensions based on assessment results.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 1 hours per week per semester
Exercise - 1 hours per week per semester
Study project - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Lee, R.P., Meyer, B., Huang, Q.L, Voss, R. 2020. Sustainable waste management for zero waste cities in China: potential, challenges and opportunities. *Clean Energy*, 4(3): 169 – 201.
- Lee, R.P. 2019. Alternative carbon feedstock for the chemical industry? – Assessing the challenges posed by the human dimension in the carbon transition, *Journal of Cleaner Production*, 219: 786-796.
- Lee, R. P., Tschoepe, M., Voss, R. 2021. Perception of chemical recycling and its role in the transition towards a circular carbon economy: A case study in Germany. *Waste Management*, 125: 280-292.
- Voss, R., Lee, R.P., Seidl, L., Keller, F., Fröhling, M. 2021. Global warming potential and economic performance of gasification-based chemical recycling and incineration pathways for residual municipal solid waste treatment in Germany. *Waste Management*, 134: 206 – 219.
- Keller, F., Lee, R.P., Meyer, B. 2020. Life cycle assessment of global warming potential, resource depletion and acidification potential of fossil, renewable and secondary feedstock for olefin production in Germany. *Journal of Cleaner Production*, 250: 119484.
- Lee, R.P., Scheibe, A. 2020. The politics of a carbon transition: An analysis of political indicators for a transformation in the German chemical industry*, Journal of Cleaner Production*, 244: 118629.

Further materials are provided via Moodle (including lecture slides and additional materials including videos, readings etc.)

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Individual component (E-assessment), 60-90 min - 50%
- Group Project - Part 1: Create a scientific poster (Analysis of e.g., a scientific article, industry report, case study, ...) - 25%
- Group Project - Part 2: Presentation, 15min - 25%

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

- Lectures & Exercises
- Projects

Components to be offered in the Current Semester	No assignment

Module 14299 Advances in Biogeochemistry and Pedology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14299	Compulsory elective

Modul Title	**Advances in Biogeochemistry and Pedology** Aktuelle Forschungen in Biogeochemie und Bodenkunde
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. phil. Raab, Thomas Prof. Ph. D. Rütting, Louise
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	Students will learn scientific method application, hypothesis formulation, critical reflection of results and academic discussion in fields of Soil-Plant-Systems and Geopedology.
Contents	Recent developments in the field of soil-ecosystem-landscape related research. Invited external speakers, as well as BTU PostDocs, PhD and Master students, present advances in scientific investigations in natural and human-made ecosystems. The focus is on the evolution, properties, and functions of the pedosphere and interacting processes with the biosphere. Research topics cover soil organic matter, biogeochemistry, plant nutrient uptake, stable isotope tracing, phosphorus and nitrogen cycling, soils in space and time, soil morphology and classification, and the impact of past and modern land use on soil landscapes.
Recommended Prerequisites	Basic knowledge in Biogeochemistry and Soil Science
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Consultation - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	will be announced at the beginning of the event
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	Students must write a series of short tests at the end of each seminar presentation (25 % of the module grade), they must ask weekly questions on each seminar topic (25 % of the module grade) and they must give a short poster presentation (5 minutes) at the end of the seminar (50 % of the module grade).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	24
Remarks	No offer in Summer 2026 and Winter 2026/27
Module Components	240499 Biogeochemistry and Pedology Research Seminar, 2 SWS 240498 Biogeochemistry and Pedology Research Consultation, 2 SWS
Components to be offered in the Current Semester	**240499** Seminar Biogeochemistry and Pedology Research Seminar - 2 Hours per Term

Module 14355 Hydrogeology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14355	Compulsory elective

Modul Title	**Hydrogeology** Hydrogeologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. PD Dr. habil. Neukum, Christoph
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students will acquire fundamental knowledge about hydrogeology involving physical principles and major ion chemistry. The course considers the elements of the hydrological cycle, hydrogeological properties of geological media, principle of groundwater flow, water chemistry and quality, basics of solute transport in groundwater, groundwater management, field methods and model applications.
Contents	Part 1. Introduction to hydrogeology Part 2. Water and the hydrological cycle Part 3. Geology and groundwater Part 4. Groundwater flow Part 5. Groundwater chemistry Part 6. Solute transport Part 7. Groundwater management The lectures are accomplished by practical exercises.
Recommended Prerequisites	• Basics in environmental science, Geology, Hydrology
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Franklin W. Schwartz, Patrick A. Domenico: Physical and Chemical Hydrogeology, ISBN: 978-0-471-59762-9

	• C.W. Fetter: Applied Hydrogeology, Print-ISBN: 978-1-292-02290-1, E-ISBN: 978-1-292-03608-3 • Bernward Hölting , Wilhelm Georg Coldewey: Hydrogeologie, Einführung in die Allgemeine und Angewandte Hydrogeologie
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written exam at the end of the lecture period (90 min)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture “Introduction to Hydrogeology” • Exercise “Applied Hydrogeology”
Components to be offered in the Current Semester	**242601** Lecture Introduction to Hydrogeology - 2 Hours per Term **242602** Exercise Applied Hydrogeology - 2 Hours per Term **242603** Examination Introduction to Hydrogeology

Module 14387 Applied Limnology, Management and Modelling of Lakes and Reservoirs

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14387	Compulsory elective

Modul Title	**Applied Limnology, Management and Modelling of Lakes and Reservoirs** Angewandte Limnologie, Management und Modellierung von Seen und Stauseen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Rinke, Karsten
Language of Teaching / Examination	English
Duration	2 semesters
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	· Ecosystem services and anthropogenic uses of lakes and reservoirs · Translating scientific knowledge into tailored water management concepts for standing waters · Assessment methods and systems analysis of lakes and reservoirs · Stressors of lakes and reservoirs, dominant drivers, and potential solution approaches
Contents	This module puts basic knowledge in natural sciences in general and aquatic ecology and biogeochemistry in particular into context with state of the art management concepts for lakes and reservoirs. This includes also an analysis of major ecosystem services and anthropogenic uses of standing waters as wel as dominant stressors and drivers of deterioration. We will employ quantitative methods including modelling and explicitly adress the unit of water body and catchment. The following main topics are in the focus of the module: · Human uses and ecosystem services of lakes and reservoirs · Morphology and physikal structure · Ecosystem dynamics and productivity · Nutrient cycles and biogeochemical processes · Eutrophication

	· Climate Change · Other stressors: Acidification, dryout,invasive species…. · Assessment and monitoring of lakes and reservoirs · Water quality prediction and management
Recommended Prerequisites	Basics for Freshwater Management (13298) or comparable knowledge in limnology, Expertise in R is very helpful
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Excursion - 20 hours Self organised studies - 100 hours
Teaching Materials and Literature	Literature and excercise materials are provided via Moodle.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Four selected excercises of our weekly seminars are used for calculating a grade (80%) • Seminar presentation (10 minutes) (20%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Wintersemester: Lecture (2 SWS) + excercise (2SWS) Summersemester: Excursion (20 Std insgesamt)
Module Components	• Lecture • Exercise • Excursion
Components to be offered in the Current Semester	**242401** Lecture Applied Limnology, Management and Modelling of Lakes and Reservoirs - 2 Hours per Term **242402** Exercise Applied Limnology, Management and Modelling of Lakes and Reservoirs - 2 Hours per Term

Module 14496 Applied Biostatistics for Environmental Data

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14496	Compulsory elective

Modul Title	**Applied Biostatistics for Environmental Data** Angewandte Biostatistik für Umweltdaten
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Djoudi, El Aziz
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	This module will provides a theoretical introduction to data analysis and results interpretation, statistical methods and tools for environmental and biological sciences, as well as applied tools with a particular focus on R programming (R software).
Contents	Part 1. Introduction to experimental design Design principles Random sampling, block design, nested design, split-plot… Replication and Pseudoreplication Part 2. Introduction to R Introduction to the essentials of R Basics: Syntax, packages, writing codes & functions Data handling, analysis and visualisation (graphs and tables) Exercises Part 3. Distributions, Parameters and Estimators Data classification & distribution Measures of central tendency: mean, median … Measures of variability: variance and standard deviation Likelihood and Akaike Information Criterion Exercises Part 4. Univariate analysis T-test and ANOVA (Analysis of variance) Correlation and regression analysis Non parametric analysis (Wilcoxon, Mann-Witney-U, Kruskal-Wallis) linear models & introduction to mixed models Exercises

	Part 5. Multivariate analysis Principal component analysis (PCA) Non-metric multidimensional scaling (NMDS) Redundancy analysis (RDA) & Canonical correspondence analysis (CCA) Exercises
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Zuur, A. F., Ieno, E. N. & Smith, G. M. 2007 Analysing ecological data. New York Gotelli, N. J. & Ellison A. M. 2013 A primer of ecological statistics. Sunderland Dormann, C. 2020 Environmental Data Analysis: An Introduction with Examples in R. Cham Lakicevic, M., Povak, N. & Reynolds, K. M. 2020 Introduction to R for terrestrial ecology: basics of numerical analysis, mapping, statistical tests and advanced application of R, Cham Wilke C.O. 2019 Fundamentals of Data Visualization, O'Reilly Wickham H& Grolemund G, 2017 R for Data Science, O'Reilly
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	- 10 Exercises during the courses (50%)) - Individual project presentation, 15 min. (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	25
Remarks	Please bring your laptop!
Module Components	240740 Lecture/Exercise: Applied Biostatistics for environmental data
Components to be offered in the Current Semester	**240740** Lecture/Exercise Applied Biostatistics for environmental data - 4 Hours per Term

Module 14781 Biological Methods for Biomass and Waste Treatment

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14781	Compulsory elective

Modul Title	**Biological Methods for Biomass and Waste Treatment** Biologische Verfahren der Biomasse- und Abfallbehandlung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. habil. Abendroth, Christian
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	<p data-start="0" data-end="990">Students are introduced to ecologically and economically viable alternatives to conventional waste treatment, with integrated and system-oriented solutions at the core. Particular emphasis is placed on anaerobic microbiomes and their central role in biological conversion processes such as anaerobic digestion, composting, and other innovative approaches to residual waste valorization. Building on microbiological and biochemical fundamentals, functional principles, process dynamics, and efficiencies are analyzed and transferred to real-world applications. In addition to established technologies, current research approaches, international developments, and novel process combinations—including contributions from the instructor’s own research—are addressed. The aim is to develop an in-depth understanding of the material and energy recovery of residuals within the context of a sustainable circular economy, and to foster the ability to independently design system-oriented solutions. <p data-start="992" data-end="1542" data-is-last-node="" data-is-only-node="">An interactive teaching format forms the didactic core: during the sessions, students continuously work on tasks whose results contribute to the overall assessment. This supports an active learning process that promotes analytical thinking, applied competence, and scientific discussion.
Contents	<p data-start="0" data-end="361">The course provides a solid yet practice-oriented introduction to the biological utilization of residual materials within the context of a sustainable circular economy. Starting from the fundamentals of biology and photosynthesis, it first examines the ”food vs. fuel” debate in order to critically assess conflicts

between food production and bioenergetic use. <p data-start="363" data-end="906">Subsequently, key processes of biological waste treatment are covered, including composting, biogas production, and dark fermentation. These processes are considered not only from a technological perspective, but particularly from the viewpoint of anaerobic microbiomes, which are understood as the driving force behind material transformations. An introduction to microbiomes and their analysis—from taxonomic profiling to functional approaches such as proteomics—enables a deeper understanding of microbial communities and their performance. <p data-start="908" data-end="1251">Building on this, central metabolic processes such as fermentation and methanogenesis are examined in detail and placed in the context of technical applications. In addition, innovative and less established approaches—such as the use of insects, bioleaching, remediation strategies, and novel materials and systems (e.g., SLMs)—are introduced. <p data-start="1253" data-end="1504" data-is-last-node="" data-is-only-node="">The course combines current research with application-oriented knowledge and offers an interdisciplinary perspective on biological transformation processes, with the aim of developing sustainable and creative solutions for future resource utilization.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 4 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

Kranert M. Einführung in die Kreislaufwirtschaft, Springer Vieweg Wiesbaden, 2017, https://doi.org/10.1007/978-3-8348-2257-4
Bischofsberger, Dichtl, Rosenwinkel, Seyfried, Böhnke. Anaerobtechnik. Springer-Verlag Berlin Heidelberg 2005, ISBN: 3-540-06850-3
Further literature will be announced during the course
<p data-start="0" data-end="129">

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

<div id="meta-origin" data-coolorigin="https%3A%2F%2Fwww.b-tu.de%2Forgcloud%2Fapps%2Frichdocumentscode%2Fproxy.php%3Freq%3D%2Fcool%2Fclipboard%3FWOPISrc%3Dhttps%253A%252F%252Fwww.b-tu.de%252Forgcloud%252Findex.php%252Fapps%252Frichdocuments%252Fwopi%252Ffiles%252F11244624_ochtzup9yafk%26ServerId%3DF84FA4B4%26ViewId%3D7%26Tag%3D58C29858B529DFEC"> Assessment in this module follows a continuous, dialogue-based oral approach. Students are asked to demonstrate their understanding of the course content by answering subject-specific questions and by formulating questions for their peers. The assessment takes place regularly throughout the semester and aims to evaluate subject-specific knowledge, understanding, and the ability to engage in academic discussion. <p> oral assessment generally after every second lecture approximately 15–20 minutes per assessment session 1–2 questions per student approximately every two weeks approximately 10 assessed questions per student

	over the semester 1 point for each successfully completed question assessment of answers based on subject-specific correctness and demonstrated understanding assessment of student-formulated questions based on scientific relevance, clarity, and appropriateness All assessed questions/tasks are weighted equally. The overall assessment result is calculated based on the proportion of points achieved out of the total number of points available (100%). comparable number and level of assessment opportunities for all students
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	238117 Lecture / Seminar: Biological Processes in Biomass and Waste Treatment <p><br data-start="84" data-end="87" />
Components to be offered in the Current Semester	**238117** Lecture/Seminar Biologische Verfahren der Biomasse und Abfallbehandlung - 4 Hours per Term

Module 14824 Automated Biodiversity Surveying Tools and Methods

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14824	Compulsory elective

Modul Title	**Automated Biodiversity Surveying Tools and Methods** Automatisierte Instrumente und Methoden zur Erfassung der biologischen Vielfalt
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	By the end of this course, students will be able to: - Demonstrate knowledge of the principles and methods of surveying different aspects of biodiversity. - Apply key concepts of survey design to ecological studies. - Apply AI tools (e.g. Birdnet) to automatically classify species from recordings Practical learning outcomes - Design a biodiversity survey for a given taxa using automated monitoring tools, from setup through data collection and analysis to scientific presentation. - Give a presentation on the proposed biodiversity study, including a background on the chosen taxon and region and justification of the experimental design.
Contents	This course combines lectures and hands-on sessions (with automated monitoring devices such as Audiomoth and InsectDetect) in groups to provide a basic introduction to the different methods used to survey and monitor biodiversity. These lectures and hands-on sessions introduce the students to the most common (and some emerging) methods to survey terrestrial biodiversity. This should provide students with a basic understanding of the methods they might use in future industrial (e.g. ecological consultancy) or research work. This includes methods such as audio recording of bats and birds, insect monitoring with pan traps and pitfall traps or camera trapping for larger mammals. The advantages, disadvantages and challenges of each method will be introduced.

	Practical examples using audio recorders (including deployment and data analysis) will be undertaken.
Recommended Prerequisites	Basic knowledge of ecology
Mandatory Prerequisites	None
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Excursion - 15 hours Self organised studies - 150 hours per week per semester
Teaching Materials and Literature	Teaching materials will be uploaded in Moodle. Scientific papers: A selection of scientific papers will be decided prior to course start. https://doi.org/10.1016/j.baae.2025.03.004 https://doi.org/10.1371/journal.pone.0295474 https://doi.org/10.1016/j.mambio.2019.11.003 https://doi.org/10.1002/ece3.11157 https://doi.org/10.1111/j.2041-210X.2010.00062.x
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1. continuous assessment of activities during class (50 %) ; Regular in-class quizzes and/or reflections (appr. 10 minutes each time) Presentation of selected readings or practical activities conducted during the course. 2. Final written exam, 90 min (50 %)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	15
Remarks	none
Module Components	• 240323 Lecture: Biodiversity surveying tools and methods • 240324 Practical work: Biodiversity recording and analysis with Audiomoth and/or other tools. Analysing audio (or other) data.
Components to be offered in the Current Semester	**240323** Lecture Biodiversity surveying tools and methods - 1 Hours per Term **240324** Practical training Biodiversity recording and analysis with Audiomoth and/or other tools. Analysing audio (or other) data. - 3 Hours per Term

Module 14884 Automated Biodiversity Surveying Tools: Field Methods

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14884	Compulsory elective

Modul Title	**Automated Biodiversity Surveying Tools: Field Methods** Automatisierte Werkzeuge zur Biodiversitätserfassung: Feldmethoden
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	By the end of this course, students will be able to: - Demonstrate understanding of major terrestrial organism groups relevant to automated biodiversity monitoring. - Describe and compare automated biodiversity monitoring tools, their methodological assumptions, strengths, limitations. - Apply principles of ecological survey design to the planning of automated biodiversity surveys. - Collect, manage, and prprocess biodiversity data generated by automated field methods. - Apply AI-based tools (e.g. BirdNET) to automatically identify species from acoustic or image data. - Conduct field surveys during the excursion using automated and non lethal methods - Interpret biodiveristy patterns across different habitat types and land-use-contexts

Contents	This course combines lectures, hands-on sessions, and a compulsory field excursion to introduce automated methods for surveying and monitoring terrestrial biodiversity. Students work in small groups with modern monitoring tools such as passive acoustic recorders, camera traps, insect monitoring systems, and drones. Lectures provide an overview of the ecological, taxonomic, and methodological foundations of automated biodiversity monitoring, with a focus on birds, bats, and sonant insects. Common and emerging survey methods are presented and critically discussed with respect to their advantages, limitations, and practical challenges. The practical components emphasize non-lethal field methods, including the planning and implementation of monitoring campaigns, device deployment, standardized data collection, and the application of AI-based tools (e.g. BirdNET) for automated species identification. During the field excursion, students conduct independent surveys across different habitat types and analyze the collected data in an ecological and conservation context.
Recommended Prerequisites	Basic knowledge of ecology
Mandatory Prerequisites	None
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Excursion - 3 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Teaching materials will be uploaded in Moodle. Scientific papers: A selection of scientific papers will be decided prior to course start. https://doi.org/10.1016/j.baae.2025.03.004 https://doi.org/10.1371/journal.pone.0295474 https://doi.org/10.1016/j.mambio.2019.11.003 https://doi.org/10.1002/ece3.11157 https://doi.org/10.1111/j.2041-210X.2010.00062.x
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Student presentation (10 min) during the excursion and at the regular classes (25%), field exercises and practical method applications during the excursion (data collection) (25%), report created during the

	excursion (data analysis) (25%), discussions and other interactions facilitated by students during the excursion and at the regular classes (25%).
	Details about the filed exercises and data collection, the report and the interactions will be discussed and specified during the excursion.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	10
Remarks	none
Module Components	240325 Lecture/Seminar: Automated biodiversity surveying tools: field methods
	240326 Excursion: Biodiversity recording and analysis with Audiomoth and/or other tools. Analysing audio (or other) data.
Components to be offered in the Current Semester	No assignment

Module 14888 Invasion Ecology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14888	Compulsory elective

Modul Title	**Invasion Ecology** Invasionsökologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	By the end of this course, students will be able to: - Explain key concepts and definitions in invasion ecology, including distinctions between native, non-native, and invasive species. - Describe major pathways, stages, and mechanisms of biological invasions across terrestrial and aquatic ecosystems. - Summarize and compare central hypotheses and theoretical frameworks in invasion ecology from both invader and recipient community perspectives. - Analyze case studies of novel interactions between invasive and native species, including plant–insect, host–parasite, and predator–prey systems. - Evaluate ecological and socio-economic impacts of invasive species using empirical evidence. - Assess and compare management strategies for invasive species, including prevention, monitoring, risk assessment, and biological control.

Contents	This module introduces invasion ecology as a key field addressing the ecological, evolutionary, and socio-economic consequences of species introductions. It covers pathways and stages of biological invasions, definitions and classifications of invasive species, and major invasion hypotheses from both invader and recipient community perspectives. The course examines invasive species across terrestrial, freshwater, and marine ecosystems, with a focus on their impacts on biodiversity, ecosystem functioning, and human well-being. Special emphasis is placed on novel species interactions, including plant–insect, host–parasite, and predator–prey systems, and on evolutionary processes shaping invasions. Through lectures and case-study-based group projects, students engage with predictive models, risk assessment protocols, and management strategies such as eradication, monitoring, and biological control. The module also critically discusses potential benefits of introduced species and future challenges under global environmental change.
Recommended Prerequisites	Basic knowledge of ecology
Mandatory Prerequisites	None
Forms of Teaching and Proportion	Seminar - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Teaching materials will be uploaded in Moodle.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	<div id="meta-origin" data-coolorigin="https%3A%2F%2Fwww.b-tu.de%2Forgcloud%2Fapps%2Frichdocumentscode%2Fproxy.php%3Freq%3D%2Fcool%2Fclipboard%3FWOPISrc%3Dhttps%253A%252F%252Fwww.b-tu.de%252Forgcloud%252Findex.php%252Fapps%252Frichdocuments%252Fwopi%252Ffiles%252F9418674_ochtzup9yafk%26ServerId%3Dde63ef99%26ViewId%3D4%26Tag%3D898c6182c566bf05"> <p class="western">1) Continuous assessment of activities during class (50 %) 7 short tests, 20 minutes each <p class="western">2) final written exam (50%), 80 minutes <p>Regular attendance at the event is expected in order to achieve the modul's learning outcomes. <p class="western">
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	15
Remarks	none
Module Components	240327 Lecture/Seminar: Invasion ecology

Components to be offered in the Current Semester	No assignment

Module 41217 General and Applied Ecology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41217	Compulsory elective

Modul Title	**General and Applied Ecology** Allgemeine und Angewandte Ökologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Djoudi, El Aziz
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The Module General and Applied Ecology provides an overview of the basic and applied aspects of ecology. The lectures provide a comprehensive overview of modern concepts of ecology including ecophysiology, population and community ecology. Ecological research further requires a fundamental understanding of sampling techniques and designs. Students will learn about • basic concepts of ecology • analyses of simple and more complex ecological data • the diversity of ecosystems and organisms • contemporary challenges in ecology • basic concepts of study design • sampling techniques
Contents	• What is ecology? • Organisms in the environment • Ecophysiology • Population ecology • Community ecology • Understanding biodiversity • Analysing ecological data • Describing spatial distributions • Macroecology • Study design & hypothesis testing • Sampling organisms
Recommended Prerequisites	Bachelor Module 41102 Ecology, 12954 Biostatistics, 41106 Biology

Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The class is organized as lectures complemented by discussions and individual contributions. All slides and schedules are available in Moodle. Self-organized work, in particular independent acquisition of relevant ecological information, is required. Textbooks Begon, M., Townsend, C.R. & Harper, J.L. 2006. Ecology: from individuals to ecosystems. Blackwell Publ. Townsend, C.R., Begon, M. & Harper, J.L. 2008. Essentials of ecology. Blackwell Publ. Southwood, T. R. 1994. Ecological methods. Chapman & Hall MacGarigal, K., Cushman, S. & Stafford, S. 2000 Multivariate statistics for wildlife and ecology research. Springer Zuur, A.F., Ieno, E.N. & Smith, G.M. 2007 Analysing ecological data. Springer Scheiner, S.M. 2001 Design and analysis of ecological experiments. Oxford Univ. Press Quinn, G.P. & Keough, M.J. 2002 Experimental design and data analysis for biologists. Cambridge Univ. Press EBooks Jorgensen - Encyclopedia of Ecology Levin - Encyclopedia of Biodiversity Levin – The Princeton Guide to Ecology Pla - Quantifying Functional Biodiversity Adams – Species Richness
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	Written exam at the end of the lecture period (120 min.)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Complementary module WHS
Module Components	• 240745 Lecture/Seminar Fundamentals of Ecology • 240746 Lecture/Seminar Ecological Methods and Models
Components to be offered in the Current Semester	**240745** Lecture/Seminar Fundamentals of Ecology - 2 Hours per Term **240746** Lecture/Seminar Ecological Methods and Models - 2 Hours per Term **240748** Examination Exam General and Applied Ecology

Module 41406 Environmental Modelling

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41406	Compulsory elective

Modul Title	**Environmental Modelling** Umweltmodellierung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Kästner, Karl
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	**Part 1 Introduction Modelling of the Environment:** The lecture aims at providing basic understanding of dynamical modeling of the environment. Basic conceplts of systems analysis will be introduced. In particular the students will get familiar with basic concepts of modeling of Atmo-, Hydro-, Bio- and Pedosphere, learn about the relevant processes, main interactions, model sensitivities and uncertainties. **Part 2 Environmental modeling exercises:** In the numerical exercise the students will learn writing simplified models and apply more complex and state of the art numerical models of selected processes or subsystems of the environment. They will learn, how to analyse and to interpret the results. They will get familiar with multiprocessor computers and with the computational needs of environmental modelling.
Contents	**Part 1 Introduction to Modelling of the Environment:** An introduction to modeling of the environment will be given. Concepts of modeling of the Atmo-, Hydro-, Bio- and Pedosphere will be presented. In particular the identification of relevant processes within and interactions between the spheres and their modeling will be highlighted. The opportunities of making predictions will be demonstrated by application to environmental problems like hazards, climate change and pollution. The model sensitivities and uncertainties will be discussed. **Part 2 Environmental modeling exercises:** Each student gets the opportunity to write an own numerical model of selected processes in the environment. More complex state of the

	art numerical models describing the behavior of a whole subsystem of the environment shall be applied to answer some detailed questions. The numerical model results shall be presented and discussed with the course participants.
Recommended Prerequisites	Mathematics I and II, Basic knowledge in Physics, Biology and Chemistry, familiarity with a programming language, in particular with 'R' and with Linux computers
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Tutorial for R and shell-skript language. Documentation of the model COSMO-CLM Tutorial of the model COSMO-CLM Documentation of the hydrological model HYDRUS. Tutorial of the model HYDRUS. Will be offered at the beginning of the semester
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1. 15 minutes Presentation (discussion should be at least 5 minutes) of the results of model programming in form of a presentation or report, 9 pages including figures, tables, references, title page and list of content (35%) 2. 15 minutes Presentation (discussion should be at least 5 minutes) of the results of model application in form of a presentation or report, 9 pages including figures, tables, references, title page and list of content (35%) 3. Written exam, duration 60 min. or open book online exam if required (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	24
Remarks	The number of participants in the exercise (240114 and 240116) is limited. See the exercise description for details. Entrance test of basics in modelling and programming (with R). Needs to be passed before starting with model programming and model application exercise.
Module Components	**In summer semester:** • 240113 Lecture Introduction to Environmental Modelling • 240114 Exercise Environmental modeling exercises • 240116 Exercise Environmental modeling exercises
Components to be offered in the Current Semester	No assignment

Module 42505 Freshwater Restoration Ecology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Umweltwissenschaften

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	42505	Compulsory elective

Modul Title	**Freshwater Restoration Ecology** Ökologie der Gewässerrenaturierung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. habil. Martin-Creuzburg, Dominik
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students know the basic principles and main methods of freshwater restoration and are able to assess the potential, but also the limitations, of restoration measures to mitigate or reverse human impacts. Students will be familiar with current methods and guidelines for evaluating surface water quality and restoration, as well as eco-engineering approaches to water management. Students will know cases of best-practice restoration and management.
Contents	Anthropogenic impact and current state of lakes, reservoirs, streams and rivers, quality assessment. Ecosystem services as target of management and restoration, impact of climate change on water bodies, strategies and planning of freshwater restoration, stream system rehabilitation and its limits, measures for in-stream habitat and floodplain enhancement, rehabilitation measures in the catchment, costs and benefits of restoration projects. General concepts and guidelines of lake and reservoir management, restoration principles, eco-engineering measures and other aspects of modern management of natural and artifical standing waters. Case studies of restoration and best management practice will be presented and discussed.
Recommended Prerequisites	Participation at module: • 13298 Basics for Freshwater Management
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester

	Excursion - 20 hours Self organised studies - 100 hours
Teaching Materials and Literature	Materials supplied via Moodle: Lecture notes, learning videos, literature for additional reading, key scientific articles and book chapters.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Written examination (80 minutes) at the end of the semester covering the main topics of the lectures and the seminar talks. Students will need to perform a seminar on an individual topic (20 min presentation and 20 min discussion). The exam result will contribute 65%, the presentation and post-presentation discussion 25%, active seminar participation 10%. Handing in protocols of the two excursions will gain extra points (2,5% of the total score for each protocol).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	**In summer semester:** • 240513 Lecture Freshwater restoration ecology • 240538 Excursion Practical field course river Spree • 240517 Examination Freshwater restoration ecology
Components to be offered in the Current Semester	**240560** Examination Prüfung Freshwater restoration ecology

Module 11243 Master Thesis

assign to: Modules at the Brandenburg University of Technology Cottbus-Senftenberg (Environmental Economics, Planning and Law)
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11243	Mandatory

Modul Title	**Master Thesis** Master-Arbeit
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	30
Learning Outcome	The Master Thesis is an examination in which the student must show that he or she can independently and successfully deal with an assignment within a set deadline and contribute scientifically founded theoretical and practical knowledge to the solving of a problem. The Master-thesis should correspond to the advanced knowledge base of the subject. The Master Thesis consists of written work and its defence.
Contents	The Master Thesis can be practical as well as theoretical. It should relate the advanced standard of knowledge in the scientific field. The Master thesis consists of the written work and its defence.
Recommended Prerequisites	none
Mandatory Prerequisites	Successful completion of the modules (except for students with UTP as home university): • 41514 Study Project • 41421 Introduction to Environmental and Resource Management II **Additionally for Examination and Study Regulation of 2021 (including Double Degree):** • an achievement of an overall minimum amount of 72 credit points. **Additionally for Examination and Study Regulation of 2011:** • an achievement of an overall minimum amount of 78 credit points.
Forms of Teaching and Proportion	Self organised studies - 900 hours

Teaching Materials and Literature	It depends on the individual subject. Corresponding material will be named and provided by the supervisor.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	The grade of the Master thesis results from the thesis, which accounts for 75 percent, and its defense, which accounts for 25 percent.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The academic supervisor is responsible for the topic and the content of the thesis.
Module Components	None
Components to be offered in the Current Semester	No assignment

Module 41421 Introduction to Environmental and Resource Management II

assign to: Mandatory Modules

Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41421	Mandatory

Modul Title	**Introduction to Environmental and Resource Management II** Einführung in den Studiengang Umwelt- und Ressourcenmanagement II
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After attendance students will have a better understanding how the ERM master programme works, what distinguishes the specialization fields of ERM and how to find a topic for their master thesis. In addition they will be able to understand the basics of good scientific practice and have learned the foundation for conceptualizing, structuring and writing their master thesis.
Contents	The module will be structured into two major topics: 1. How to study the master programme of Environmental Resource Management at BTU 2. The basics of working scientifically at an European University. This part may include the following sub-topics: · Scientific writing (with a focus on master theses) · Working with scientific literature and publishing of scientific work · Presenting at scientific conferences and networking in the scientific community · Grant writing and funding proposals · Ethics and integrity in scientific work; Intellectual property and patents · Interdisciplinary collaboration · Science communication · Career paths in science Due to a change in teaching personnel, changes to structure, timing and topics of the module will be made during the semester.

Recommended Prerequisites	None
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	to be announced
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	Final module examination: 90 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	None
Module Components	• 240230 Lecture/Exercise Introduction to ERM II
Components to be offered in the Current Semester	**240321** Lecture/Exercise Introduction to ERM II - 4 Hours per Term

Module 41514 Study Project

assign to: Mandatory Modules
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41514	Mandatory

Modul Title	**Study Project** Studienprojekt
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	12
Learning Outcome	Within a study project the students work in details on a selected topic of preferably interdisciplinary nature. The main scope is the development of problem-solving skills by means of information gathering as well as the application of theoretical knowledge acquired in more formal classes. Students will organize their scientific research related to data acquisition, data analysis.
Contents	A study includes a project report with all factual information about the work in the project.
Recommended Prerequisites	Depending on the project topic knowledge in mathematics/statistics and/ or social as well as natural sciences is advantageous.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Consultation - 1 hours per week per semester Self organised studies - 345 hours
Teaching Materials and Literature	To be named by supervisor.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Written project report with all factual information about the work (as hard copy and digital form) and a presentation. • Written report, 20-30 pages (75%) • Presentation of results (25%)
Evaluation of Module Examination	Performance Verification – graded

Limited Number of Participants	none
Remarks	None
Module Components	• 240215 Study project Study Project
Components to be offered in the Current Semester	**240215** Study project Study Project

Module 11284 Advanced Studies of International Environmental Law

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11284	Compulsory elective

Modul Title	**Advanced Studies of International Environmental Law** Internationales Umweltrecht für Fortgeschrittene
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. jur. Albrecht, Eike
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After completing the module, students should be able to: • Understand international environmental law and its role in the management of global environmental problems, • Identify and critically analyse issues pertaining to international environmental disputes, • Apply international environmental law in specific concrete cases, • Comprehend and evaluate the significance of international environmental law in protecting the environment and fostering international relations. After completing the seminar, students will: • Understand the way in which international agreements are achieved, • Understand the role various international actors play in decision making, • Have an understanding of the relevant actors who contribute to the outcome of international agreements, • Be able to make clear and convincing statements (orally and in written form), • Understand international decision-making procedures after playing an active role in a (simulated) negotiation process, • Have improved their skills in effectively arguing their case in relation to the topics discussed in class.
Contents	Lecture: Advanced Studies of International Environmental Law • Introduction to international law and international environmental law • Creation and development of international environmental law

- Implementation and enforcement strategies of international environmental agreements
- International environmental agreements with respect to the following topics:
  - Biodiversity (Biodiversity Convention/CITES/WHC).
  - Marine environment (Convention on the Law of the Sea)
  - Climate change (Climate Change Convention/Kyoto Protocol/Paris Agreement)
  - Ozone depletion (Convention for Protecting Ozone Layer/Montreal Protocol)
  - Toxic/hazardous substances (Basel Convention on Hazardous Waste)
  - Citizens rights to information, public participation and access to Justice

Seminar: International Negotiations and Environmental Decision-Making
- Challenges of international negotiations with a focus on climate change
- Actors of global environmental governance and international environmental decision-making
- State participation in global environmental governance
- The role of non-state actors in environmental decision-making and negotiations
- Simulation (role play) of an international conference (2 groups with maximum 35 students)

At the beginning of the semester, the students will we be prepared to participate in a simulation of a multilateral negotiation process. (Climate Conference Simulation Groups). Each student in the simulation group will take the role of a relevant international player such as a country, an NGO, the private sector, or a subsidiary body. Participants will be required to prepare (in written and oral form) an assigned country/ organisation engaged in the international environmental negotiation process to actively participate in the final role-play.

Recommended Prerequisites

Knowledge of the content of module:
- 41201 *International Environmental Law*

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Seminar - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Birnie/Boyle/Redgwell, International Law and the Environment, 4th edition, Oxford University Press, 2021
- Knopp/Epstein/Hoffmann, International and European Environmental Law with Reference to German Environmental Law – A Guide for International Study Programs, 2nd edition, Berlin 2019

- Albrecht, Egute, Wanki, Ezeamama (Eds.), International environmental law (IEL) – Agreements and introduction. 6th expanded and updated edition, 2022.
- IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.001.
- IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24 https://doi.org/10.1017/9781009157940.001.

Additional literature will be announced in class and made available on the Moodle page of the course.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- **Written Exam, 120 minutes** (maximum 40 points)

And

Climate Conference Simulation Group:
- Paper for preparation of the climate conference, 2 pages (maximum 15 points)
- Simulation of a climate conference, 10 SWS (maximum 25 points)

or
Weekly seminars Group:
- 10 pages essay submission on topics related to environmental negotiations and decision-making (maximum 40 points)

To pass (grade 4,0) the module, students need to earn a minimum of 40 points.

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

- Lecture: Advanced Studies in International Environmental Law
- Seminar: International Negotiations and Environmental Decision-Making (including COTTCOP blocked seminars)

	• Examination: Advanced Studies in International Environmental Law
Components to be offered in the Current Semester	No assignment

Module 11463 Urban and Regional Planning

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11463	Compulsory elective

Modul Title	**Urban and Regional Planning** Stadt- und Regionalplanung
Department	Faculty 6 - Architecture, Civil Engineering and Urban Planning
Responsible Staff Member	Prof. Dr. phil. Gribat, Nina
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	This module will allow students: • to understand the main strategic concepts, analytical methods and planning tools required in urban and regional planning • to analyse urban structures and functions • to understand the concept of historic urban landscapes • to identify the factors influencing urban change • to understand the impact of urban development on heritage sites and local communities • to develop urban strategies for the protection and valorisation of archaeological heritage.
Contents	The module will focus on the following contents: • main concepts and approaches to urban and regional planning • identification of the urban/regional profile (environmental, physical, social, demographic, economic, cultural setting) • stakeholder analysis and participatory approaches to urban and regional planning • historic urban landscape approach • urban and regional planning tools and methodologies • urban change and trends in urban development • impact of urban development on heritage sites • models for successful integration of archaeological sites in urban and regional plans.
Recommended Prerequisites	none

Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The bibliography will be presented in class.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• active participation (20%) assignment 1: oral presentation 15 minutes (30%) assignment 2: oral presentation 25 minutes plus written abstract of 500 words (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Module Code: HCSM - 213 In the event that the module cannot be taught or tested according to the present description (e.g. for reasons of infection protection), the alternatives communicated on relevant platforms (e.g. homepage or Moodle) apply.
Module Components	Lecture/Seminar Urban and Regional Planning
Components to be offered in the Current Semester	No assignment

Module 11693 Ecological-Economic Modelling for Biodiversity Conservation

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11693	Compulsory elective

Modul Title	**Ecological-Economic Modelling for Biodiversity Conservation** Ökologisch-ökonomische Modellierung für den Schutz der biologischen Vielfalt
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. rer. pol. Drechsler, Martin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	Student shall • acquire knowledge about the ecological modelling of populations • acquire knowledge about the economic modelling of conservation instruments • acquire knowledge about the ecological-economic modelling of land use and conservation instruments • be able to write simple simulation programs • be able to analyse an ecological-economic model to assess a conservation instrument
Contents	• Ecological modelling of populations • Economic modelling of conservation instruments • Ecological-economic modelling of land use and conservation instruments • Programming with the (free) software Netlogo • Development and analysis of an ecological-economic model
Recommended Prerequisites	• Good math grades at school and/or successful completion of modules in quantitative analysis such as statistics • Interest to learn some computer programming • It is recommended to take the modules 41427 Economics of Land Use and Biodiversity Conservation.
Mandatory Prerequisites	None

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	To be announced in class.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Homework exercises (40 out of 90 points) • Paper about analysis of ecological-economic model developed in course, 2000 - 2500 words (50 out of 90 points)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Complementary Module ERM Master
Module Components	• 240911 Lecture/Practical Training Ecological-Economic Modelling for Biodiversity Conservation
Components to be offered in the Current Semester	No assignment

Module 12032 Statistics for Economic Analysis of Ecosystem Service Provision and Biodiversity Conservation

assign to: Modules with the Focus on Environmental Economics, Planning and Law

Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12032	Compulsory elective

Modul Title	**Statistics for Economic Analysis of Ecosystem Service Provision and Biodiversity Conservation** Statistik für die ökonomische Analyse des Biodiversitätsschutzes und der Bereitstellung von Ökosystem-Dienstleistungen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. rer. pol. Drechsler, Martin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Understanding the main statistical concepts and methods used in the economic analysis of ecosystem service provision and biodiversity conservation
Contents	- Basics of statistics (probability theory, exploratory data analysis, testing of hypotheses, statistical modelling) - Economic applications: econometric analysis of land-use dynamics, contingent valuation of environmental goods - Ecological applications: habitat suitability modelling, population viability analysis
Recommended Prerequisites	Basic knowledge of mathematics and the use of MS-Excel / Open Office Calc
Mandatory Prerequisites	None
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	Seltman, H.J., 2018. Experimental Design and Analysis (URL: http://www.stat.cmu.edu/~hseltman/309/Book/Book.pdf)
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• 6 Exercises (home work) during course, each 1-2 h (each 5,5 %) • Written examination, 80 minutes (67 %)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	None
Module Components	Lecture Statistics for Economic Analysis of Ecosystem Service Provision and Biodiversity Conservation
Components to be offered in the Current Semester	**240919** Examination Statistics for Economic Analysis of Ecosystem Service Provision and Biodiversity Conservation **240920** Examination Statistics for Economic Analysis of Ecosystem Service Provision and Biodiversity Conservation

Module 12983 Climate Change and Migration

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12983	Compulsory elective

Modul Title	**Climate Change and Migration** Klimawandel und Migration
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Associate Prof. (Univ. Damaskus) Dr. agr. Ibrahim, Bachar
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After completion of this module, students will have a solid understanding of Climate Change and its impacts, especially on vulnerable countries. Students will further have the knowledge about various concepts and logical arguments linking climate change and migration.
Contents	**Part "Climate Change"** • Observations of change in the climate system • Critically assess the role of human activities in modern climate change • Assess future climate change scenarios and their potential impact on the Earth • climate change agenda and how this agenda impact on policy • Identify the Impacts and related Adaptation masures **Part "Migration"** • The potential link between climate change, migration, • The Task of defining 'climate refugee' • climate change contribution to the refugee problems • Gaps in the international legal framework • Individual and Collective Action on Mitigation Lectures will be given live online and afterwards uploaded as a PDF on the moodle For the exercise, students have to solve a given problem. Students have to select a topic on moodle and register in the given table (maximum of 4 students per group).
Recommended Prerequisites	none

Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Environment, forced migration and social vulnerability, T. Afifi, J. Jäger - 2010 - Springer • Climate change, human security and violent conflict: challenges for societal stability, J. Scheffran, M. Brzoska, H.G. Brauch, P.M. Link… - 2012 • People on the move in a changing climate: The regional impact of environmental change on migration, E. Piguet, F. Laczko - 2013 • Global migration governance, A. Betts - 2011 • Disentangling migration and climate change, T. Faist, J. Schade - 2013 - Springer • Climate change and migration: security and borders in a warming world, G. White – 2011- Oxford University Press
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Oral Exam, 30 min. (50%) • Two presentations on the a scientific topic (each 25%) A pass mark is only achieved by obtaining at least 50% of the grade for each part of the module. The examination as well as the seminar part have to be passed (at least 50% in each) to pass the module.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	An annual excursion pertaining to the module may be organised. ***Complementary Module in Master Environmental and Resource Management.***
Module Components	• Lecture • Seminar • Examination
Components to be offered in the Current Semester	No assignment

Module 13234 Communication of Science and Technology

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13234	Compulsory elective

Modul Title	**Communication of Science and Technology** Wissenschafts- und Technikkommunikation
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Students will know about different techniques, tools and formats for communication of science & technology. They will develop skills to break down complex issues at the nexus of science, technology and society to communicate science/technical information in a clear, understandable and engaging way to different stakeholders. On completion of the module, students will be able to: • Articulate the key issues and challenges in communicating about science & technology; • Understand the nature of different audiences for better stakeholder engagement; • Demonstrate awareness of and ability to use a variety of different techniques and media for targeted audience; • Improve their skills in communication of scientific/technical information in both written and oral forms; • work as part of a team to develop effective measures for communication of science & technology; • Provide constructive feedback to other students on their communication skills.
Contents	Course coverage: • Key issues in communication of science & technology; • Identify and knowing your audiences (mental models, risk perception, heuristics and biases, …); • Getting your audience's attention (Types of framing); • Communicating risk and uncertainty; • Formats for communication of science & technology.

Students will also be given opportunities to receive feedback and improve their own written and oral skills. They will also work in small teams on team projects to further their skills for communicating about sustainability issues. These projects will focus on communicating about a given scientific topic to a particular audience using spoken, visual, written or web-based communication.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Seminar - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Center for Research on Environmental Decisions (CRED). 2009. *The Psychology of Climate Change Communication: A guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public.* New York.
- Nisbet, M.C., Scheufele, D.A. 2009. What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, 96(10): 1767-1778.
- Bubela, T., Nisbet, M., Borchelt, R. *et al.* 2009. Science communication reconsidered. Nature Biotechnology, 27, 514–518.
- Nelkin, D. 1989. Communicating technological risk: The social construction of risk perception. *Annual Review Public Health*, 10, 95-113.
- Tversky, A., Kahneman, D. 1974. Judgment under Uncertainty: Heuristics and Biases. Science, New Series, 185(4157), 1124-1131.

Further material (including lecture slides and additional materials including videos, readings etc.) might be announced during the first class meeting.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Individual E-Assessment – 60 min (40%)
- Group project - Part 1: Science Communication Material e.g., poster, video, etc. (30%)
- Group project - Part 2: Group presentation– 15min oral presentation (30%)

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

- Lecture / Seminar

Components to be offered in the Current Semester

510601 Lecture/Seminar
Communication of Science & Technology - 4 Hours per Term

Module 13371 ERM-Research-Module

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13371	Compulsory elective

Modul Title	**ERM-Research-Module** ERM-Research-Modul
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	18
Learning Outcome	For students with a strong interest and capability in research, the ERM-Research-Module is an advanced study alternative in the Master's programme. This variant includes in particular the independent preparation of a two-semester research project. The students learn how to work on scientific problem formulation, the target-oriented implementation of experimental approaches and the scientific evaluation and presentation of the results. The students carry out research-orientated tasks which they work on increasingly independently and in exchange with other project participants under the intensive supervision of experienced researchers. The main scope is the development of scientific problem-solving skills by means of information gathering as well as the application of theoretical knowledge acquired in small group advanced seminars.
Contents	The supervising lecturers select suitable topics from their subject areas and intensively support the students in learning the necessary subject-specific and interdisciplinary skills. The contents of the module are regularly adapted in line with ongoing research projects in the participating disciplines.
Recommended Prerequisites	Depending on the topic excellent knowledge in mathematics/statistics, chemistry, biology and/or social as well as environmental sciences is required.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Exercise - 2 hours per week per semester Self organised studies - 480 hours
Teaching Materials and Literature	To be named by supervisor.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Written project report with all factual information about the work (as hard copy and digital form) and a presentation. Written report, 20-30 pages (75%) Presentation of results, 30 min. (25%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module "ERM Research Module" can only be repeated once if it is not passed. It is one of the practical study sections and is therefore excluded from the free trial regulation.
Module Components	• ERM-Research Lecture • ERM-Research Excercise
Components to be offered in the Current Semester	**242100** Lecture/Exercise Environmental Data Science - 4 Hours per Term

Module 13657 How to Talk about Nature?

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13657	Compulsory elective

Modul Title	**How to Talk about Nature?** Wie über Natur sprechen?
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. nat. phil. habil. Schwarz, Astrid
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After passing the module, students understand main philosophical theories of “nature”, interrogate the concept of “nature” and expose its numerous ideological and cultural manifestations. They identify the main ethical dimensions of “nature”, and its crosscultural and political dimensions. Additionally they understand the power of narratives and storytelling to shape our environmental present and future by insight into reading, writing, and visual practices about “nature”.
Contents	“How to talk about nature?” is closely linked to the question of what “nature” is, how it is construed and in which way we act with, in or against it. It is a question that is ontological and epistemological at the same time, it is about how we imagine nature “to be” and how we conceive knowledge about nature. The ideas about this entwinement are manifold over time and in space, different cultures have developed different ways of thinking and also practices of how to deal with a culture/nature distinction. Another important conceptual issue is how nature and technology are related, in contemporary debates for instance, "nature" is often identified with "environment" and as such inescapably entangled with its cultural, political, and technological context. Is the use of technology in “nature” then a threat or an opportunity to build a genuinely sustainable world? This module seeks to answer these and other questions, by approaching “nature” with variously grounded historical and contemporary theoretical approaches. For example, the concept of “nature” was differently interpreted in ancient times, compared to modern contemporary cultures. We will probe the different usage, the scope of historical and cross-cultural depth, the semantics, the images/

	imaginaries, and finally, the logical coherence of “nature” concepts. This variety of topics means that the assigned readings will draw from a wide range of sources. With respect to handle current ecological and technocultural problems, a conscious reflection about “nature” seems to be required. Thus, the module should be also seen, in part, as a way to gain insight into contemporary reading, writing, and visual practices about “nature”. Participation in the accompanying excursion is encouraged.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature and learning materials are given in the course description.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• One short essay, max 1500 words (25%) • Two reviews, each max. 2000 words (each 30%) • 2 oral (group) presentations, about 15 min **OR** weekly submitted written answers to one short question per week on the topical readings to be determined by the instructor (15%) The oral part of the examination can be done digitally or as a virtual meeting if the conditions for an examination in presence are not given.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	60
Remarks	none
Module Components	• Seminar, lecture - 4 hours per week per semester
Components to be offered in the Current Semester	**510112** Lecture/Seminar How to talk about "Nature"? / Ethik und Handeln / Philosophy of Technology and Nature / Natur und Technik / Wissenschaftstheorie, Logik und Naturphilosophie - 4 Hours per Term

Module 13669 Law and Policy for Agricultural Resource Management

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13669	Compulsory elective

Modul Title	**Law and Policy for Agricultural Resource Management** Recht und Politik für die Bewirtschaftung landwirtschaftlicher Ressourcen
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. jur. Albrecht, Eike
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successful completion of the module, students will be able to: • Understand that sustainable management of agricultural resources is not just key to maintaining sustainable food supplies and food security – it is also necessary for supporting the proper functioning of the ecological systems that determine the conditions for life itself • Critically analyse and understand the main legal and policy frameworks aimed at protecting the ecological integrity of agricultural resources in the EU • Grasp a multitude of critical perspectives on the management of agricultural resources • Comprehend a number of carefully chosen areas of agricultural resources management, including specific topics and themes from international and comparative perspectives
Contents	The lectures will focus on a number of carefully chosen areas of agricultural resources management, which will be further contextualised in the seminars, where students will have the opportunity to engage more closely with specific topics and themes from international and comparative perspectives. Key lecture topics - Sustainable agriculture and food security - Protection of water resources from agricultural over-use and pollution (pesticides and phosphorous) - Agriculture, land use and biodiversity protection

	- Agriculture and climate change (livestock production, soils, forestry, mitigation and adaptation) Seminars topics to be announced in class.
Recommended Prerequisites	Knowledge of the content of module • 41201 International Environmental Law
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Birnie/Boyle/Redgwell, International Law and the Environment, 4th edition, Oxford University Press, 2021 • Knopp/Epstein/Hoffmann, International and European Environmental Law with Reference to German Environmental Law – A Guide for International Study Programs, 2nd edition, Berlin 2019 Additional literature will be announced in class and made available on the course Moodle page.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Essay: Written individual course work, maximum 3000 words including footnotes (50 %) • Presentation: (individual) 'Visual' form of assessment critiquing specific areas of law and policy, maximum 20 minutes per student (50 %) To pass (grade 4,0) the module, students need to earn a minimum of 50 points
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Not offered in the winter semester 2026/27.
Module Components	• Lecture: Law and policy for agricultural resource management • Seminar: International perspectives on agricultural resource management and implementation of regulatory frameworks
Components to be offered in the Current Semester	No assignment

Module 13705 Sociology of Sustainable Development

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13705	Compulsory elective

Modul Title	**Sociology of Sustainable Development** Soziologie der nachhaltigen Entwicklung
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Jaeger-Erben, Melanie
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students overview sociological approaches, theories and research topics in the context of sustainable development. After completing the module, they will have a sound knowledge on various approaches of social-ecological transformation and will be able to critically discuss current concepts such as the Anthropocene, Green Growth or Circular Economy. They have expertise in the reception and presentation of scientific texts.
Contents	Sustainable development promises to meet human needs of present and future generations while maintaining the integrity and stability of natural systems. However, this concept has been criticised on various grounds. Some argue that more fundamental changes are required to solve the multiple, accelerating crises of our times. Under the umbrella term ‘socio-ecological transformation’, scholars discuss various political, socio-economic, socio-technical and cultural changes aimed at responding appropriately to the socio-ecological crisis. This module critically engages with current sustainability debates from a sociological perspective, thereby discussing concepts such as Green Growth, Degrowth, Circular Economy or the Anthropocene. It explores how we can move to a society and economy in which human needs are met within planetary boundaries.
Recommended Prerequisites	41421: Introduction to Environmental and Resource Management II
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Exercise - 2 hours per week per semester

	Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Eisenmenger et al. (2020). The Sustainable Development Goals prioritize economic growth over sustainable resource use: a citrical refection onthe SDGs from a socio-ecological perspective. Sustainability Science, 15:1101-1110. • Haberl, H. et al. (2011). A Socio-metabolic Transition towards Sustainability? Challenges for Another Great Transformation. Sustainable Development 19, 1-14 • Gough, I., 2017. Recomposing consumption: defining necessities for sustainable and equitable well-being. Phil. Trans. R. Soc. A. 375, 20160379. • Hickel, J., Kallis, G., 2020. Is Green Growth Possible? New Political Economy 25, 469–486. • Malm, A., Hornborg, A., 2014. The geology of mankind? A critique of the Anthropocene narrative. The Anthropocene Review 1, 62–69. Further literature will be announced in the module.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Reading assignments, 1.500-2000 words (20%) • Reflections on sessions, 1.500-2000 words (20%) • Pecha Kucha presentation, (7 Min.) oder Podcast (20Min.) (30%) • Written Test (multiple choice, 30 Min.) (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	50
Remarks	none
Module Components	• Exercise: Research and methods of a Sociology of Sustainability - 2 Hours per Week per Semester • Seminar: Theories of Social-Ecological Transformation - 2 Hours per Week per Semester
Components to be offered in the Current Semester	No assignment

Module 13706 Justice and Diversity in Environmental Change

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13706	Compulsory elective

Modul Title	**Justice and Diversity in Environmental Change** Gerechtigkeit und Diversität im Kontext von Umweltveränderungen
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Jaeger-Erben, Melanie
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	• Acquiring a profound understanding of different concepts on social justice and diversity in the context of environmental change, climate change and sustainable development. • Discussing and critically reflecting upon current issues related to environmental justice, such as resource conflicts, land-use change or environmental movements. • Methodological skills in reading and discussing academic texts, preparing Pecha Kucha presentations, and recording scientific podcasts.
Contents	Environmental problems have the capacity to affect all of us. However, certain communities are disproportionally exposed to environmental hazards, such as air pollution. Also, some regions of the world (will) suffer much more from the implications of climate change. Environmental problems thus do not affect us all equally, or in the same way. Nor do we have equal power to decide solutions to these problems, or to take the necessary action to solve them. This unequal positioning, which often impose the greatest burdens upon marginalised, disadvantaged and less powerful populations, forms the central premise of environmental justice research and activism. The goal of this module is to gain a comprehensive understanding of social justice, environmental justice and diversity in environmentalism. The course introduces concepts such as environmental racism, climate justice, ecofeminism, and indigenous perspectives on environmental change. The theoretical perspectives introduced are applied to various environmental movements and resource conflicts all over the world.

Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Exercise - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Bell, K. (Ed.) (2021). Diversity and Inclusion in Environmentalism, Routledge. • Holifield, R., Chakraborty, J., Walker, G. (Eds.) (2018). The Routledge Handbook of Environmental Justice, Routledge. • Lele, S. et al. (Eds.) (2019). Rethinking environmentalism: Linking justice, sustainability, and diversity (Vol. 23). MIT Press. • Williams, J. (2021). Climate change is racist. Race, privilege and struggle for climate justice. Icon Books. Further literature will be announced during class.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Reading assignments, 1.500-2.000 words (20%) • Reflections on sessions, 1.500-2.000 words (20%) • Pecha Kucha presentation, 6:40 Min (30%) • written test (multiple choice) (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	50
Remarks	none
Module Components	• Exercise Theoretical approaches to Justice and Diversity in Environmental Change • Seminar Justice and Diversity research and methods in the context of Environmental Change
Components to be offered in the Current Semester	**510535** Seminar Justice and Diversity research and methods in the context of Environmental Change - 2 Hours per Term **510530** Lecture/Exercise Theoretical approaches to Justice and Diversity in Environmental Change - 2 Hours per Term

Module 13796 Just Energy Transition

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13796	Compulsory elective

Modul Title	**Just Energy Transition** Energiewende gerecht gestalten
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Hirschl, Bernd
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	On completion of this unit, students will be able to demonstrate the main conceptual debates surrounding just energy transitions. Students will be equipped with in-depth critical theoretical and empirical knowledge of the patterns of energy transition governance. After attending the module, students are able to conduct case analyses. The module is designed for Master students to develop their research, argumentation and presentation skills, as well as their capacities for collaborative work and group learning.
Contents	This module will discuss key opportunities and challenges of transitioning towards climate neutral energy systems, primarily through a social science lens. “Leaving no one behind” is a catchphrase used in contemporary climate and energy policies, that we will explore in more detail with texts from political science (policy analysis and political economy), philosophy, economics and sociology. We will discuss the dynamics of capitalism, questions of culture and everyday life, the role of the state, and international governance structures. The course is guided by the following questions: • What are the *conceptual foundations* of just energy transitions? • What are *universal and country-specific challenges* to just energy transitions? • What are *national and international responses* from society, politics and businesses to these challenges?
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Seminar - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	There are no core texts for this course. Essential readings for the seminars will be indicated with the course start. The following literature can be used for preparation: • Scoones, I., Leach, M., and Newell, P., eds. 2015. The politics of green transformations. Abingdon: Routledge • Unruh, G. C. (2000) 'Understanding carbon lock-in', Energy Policy, Vol 28, no 12, pp 817–830 • Peter Newell & Andrew Simms (2021) How Did We Do That? Histories and Political Economies of Rapid and Just Transitions, New Political Economy, 26:6, 907-922
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Case study, about 2,500 words (50 %) Empirical case study with theoretical underpinnings of a region/ country of the student's choice (not restricted to Global North): What are specific opportunities and challenges of a just energy transition and which responses have been implemented/are lacking? • Presentation, 15 min + 5 min Disscussion (topics to be announced) (40 %) topics to be announced • Class Participation (10 %)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	***Module with limited number of participants - Registration two weeks prior to the commencement of lectures!***
Module Components	• Seminar
Components to be offered in the Current Semester	No assignment

Module 13833 Analysis and Modelling of Human-Environment Systems

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13833	Compulsory elective

Modul Title	**Analysis and Modelling of Human-Environment Systems** Analyse und Modellierung von Mensch-Umwelt-Systemen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. Müller, Birgit
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Upon completing the course, students will be able to: • Identify key features of coupled human-environment systems and apply this knowledge to interdisciplinary case studies. • Understand core principles of complex adaptive systems. • Design, implement, and analyse agent-based models to investigate human-environment interactions.
Contents	How do deforestation, urban expansion, or climate policies impact ecosystems and communities? Understanding these complex interactions is key to tackling today's urgent environmental challenges. This course provides an introduction to modelling human-environment systems, emphasizing the intricate feedback loops between human activities and the biophysical world—across local, regional, and global scales. The module has two main focus areas. First, students will explore the key characteristics of coupled socio-environmental systems. We will read and discuss interdisciplinary research papers on applied case studies and theoretical considerations and examine how models can bridge science and real-world decision-making — whether in climate change adaptation, land-use planning, or resource management. Specific topics include to understand how human behaviour is represented in models, which role play social networks and how common pool resource management can support sustainable outcomes. Guest speakers will enrich the course with diverse perspectives and practical insights.

	Second, students will acquire hands-on experience in agent-based modelling using the NetLogo programming environment designed for beginners. They will learn how to conceptualize, build, and analyse computer models to simulate interactions within socio-environmental systems. Additionally, an introduction to statistical data analysis in R will provide essential tools for model evaluation and interpretation.
Recommended Prerequisites	None
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Marco Janssen (2020). Introduction to Agent-Based Modeling with applications to social, ecological and social-ecological systems. (ebook, 2n edition) • Further literature will be announced in the module.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 6 Exercises / homework a ca. 3h (Model conceptualisation tasks, programming tasks in NetLogo and short research paper presentations) 50%, • Realisation of a modelling project, conceptualisation and presentation (10-15 min) of its results on a scientific poster, 50%
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture / Exercise
Components to be offered in the Current Semester	**240921** Lecture/Exercise Analysis and Modelling of Human-Environment Systems - 4 Hours per Term

Module 13925 Alternative Economies

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13925	Compulsory elective

Modul Title	**Alternative Economies** Alternative Ökonomien
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Jaeger-Erben, Melanie
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Upon successful completion, students will have a solid overview on heterodox economic theories (including feminist, post-Keynesian, ecological and political economy perspectives), and understand how they differ from neoclassical economics. They are skilled in discussing and critically reflecting upon the opportunities, limitations and the applicability of different economic concepts presented in class. Students will acquire methodological skills in researching, reading and discussing academic literature.
Contents	The multiple crises we are currently facing – in relation to climate, biodiversity, democracy, or social inequalities – require different economic perspectives and practices. In lectures and seminars, students will learn about the limits of the dominant neoclassical paradigm and gain an overview on heterodox economic schools. They will be introduced to concepts such as degrowth, care economy, economic democracy or social entrepreneurship. At the same time, this course will critically analyse fundamental aspects of current economies, such as money, growth, profits, work or the relation to nature, and discuss practical examples of alternative economies.
Recommended Prerequisites	Knowledge of the contents of module • 13922 *Introduction to Transformation Studies*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester

	Self organised studies - 120 hours
Teaching Materials and Literature	• Chang, H.-J. (2014). Economics: The User's Guide. Bloomsbury Publishing. • Bauhardt, C. (2014). Solutions to the crisis? The Green New Deal, Degrowth, and the Solidarity Economy: Alternatives to the capitalist growth economy from an ecofeminist economics perspective. Ecological Economics 102, 60-68. https://doi.org/10.1016/ j.ecolecon.2014.03.015 • The Foundational Economy Collective (2022). Foundational Economy. The infrastructure of everyday life. Manchester University Press. • Raworth, K. (2017). Doughnut economics: seven ways to think like a 21st-century economist. London: Random House Business Books. • Wellbeing Economy Alliance (2020). Wellbeing Economics for the COVID-19 recovery. Ten principles to build back better. Briefing Paper,https://serval.unil.ch/resource/ serval:BIB_C2D492EC73DF.P001/REF. • Kallis, G. et al. (2018). Research on Degrowth. Annual Review of Environment and Resources. 43:4.1–4.26.https://doi.org/10.1146/ annurev-environ-102017-025941
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Participation and reflection notebook, 1,500-2,000 words (30%) • 4 short tests in class, 10 min. each (40%) • Poster presentation in groups (15 min.) (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	40
Remarks	***Module with limited number of participants - Registration two weeks prior to the commencement of lectures!***
Module Components	none
Components to be offered in the Current Semester	No assignment

Module 13957 Behavioural Economics

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13957	Compulsory elective

Modul Title	**Behavioural Economics** Verhaltensökonomie
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. oec. habil. Schnellenbach, Jan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After completing this module, students will be able to apply behavioural economic models to analyse individual decisions. They can integrate psychological research approaches into economic models. They can independently develop and master advanced research approaches in the field of behavioural economics and have a solid understanding of the basics of empirical, including experimental, research methods in the field of behavioural economics. Furthermore, they will be able to critically analyse and evaluate economic policy proposals with a behavioral economics perspective.
Contents	• Homo Economicus: The economic concept of human behaviour • The economic theory of moral action • Behavioural anomalies: an overview • Bounded rationality • Dealing with risk and uncertainty • Prospect theory • Heuristics: Curse or blessing? • Fairness and social norms • Economic happiness research • Behavioural political economy • Behavioural public economics
Recommended Prerequisites	Good knowledge of microeconomics.
Mandatory Prerequisites	No successful participation in the corresponding discontinued module 11814 Behavioral Economics.

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Foundational literature: • Angner, E. (2012). A Course in Behavioral Economics, Houndmills: Palgrave Macmillan. • Additional literature will be announced during the lecture. In the exercise: • Wilkinson, N. and Klaes, M. (2012), An Introduction to Behavioral Economics. 2nd edition, Houndmills: Palgrave Macmillan.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Mid-term exam, 30 min. (30 points) • Final exam, 70 min. (70 points)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	This module is a successor module to the module „Behavioral Economics (11814)". Students who have already passed the module cannot take the module "Behavioral Economics (13957)" again.
Module Components	Behavioral Economics (Lecture) Behavioral Economics (Exercise)
Components to be offered in the Current Semester	**530631** Lecture Behavioral Economics - 2 Hours per Term **530632** Exercise Behavioral Economics - 2 Hours per Term

Module 13958 Economics of Innovation

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13958	Compulsory elective

Modul Title	**Economics of Innovation** Innovationsökonomik
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. oec. habil. Schnellenbach, Jan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Each winter semester even year
Credits	6
Learning Outcome	Students will understand how innovation can be explained from a microeconomic perspective. They will know the economic, institutional, and psychological prerequisites for entrepreneurial innovation. Upon successful completion of the module, students will be able to critically assess under which circumstances innovative entrepreneurial actions are positively evaluated and potentially eligible for economic policy support.
Contents	Innovation in the history of economic theory; Types of innovation; Competition and innovation; Organizational aspects of innovation; Political and institutional prerequisites for innovation; Diffusion of innovations; Innovation and economic growth; Innovations and societal welfare.
Recommended Prerequisites	Good knowledge of microeconomics.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	G.M. Swann, The Economics of Innovation: An Introduction, Elgar, 2013 as well as additional articles and book chapters announced during the lecture
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• exam, 30 min. (Mid-term, 30 points) • exam, 70 min. (Final, 70 points)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	No offer in the winter semester 2025/26.
Module Components	Innovation Economics Lecture - 2 hours per week Innovation Economics Exercise - 2 hours per week
Components to be offered in the Current Semester	**530634** Lecture Economics of Innovation - 2 Hours per Term **530635** Exercise Economics of Innovation - 2 Hours per Term

Module 13959 Law and Economics

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13959	Compulsory elective

Modul Title	**Law and Economics** Recht und Wirtschaft
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. oec. habil. Schnellenbach, Jan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Each winter semester odd year
Credits	6
Learning Outcome	Students will gain an overview of the field of economic analysis of law, which involves analyzing legal rules from the perspective of economic theory. It focuses on the interaction of legal norms with the actions of private households and companies, as well as the impact of constitutional law on government actions. Students should learn to analyze legal norms in terms of their efficiency and economic effects, including microeconomic efficiency, as well as growth and distribution effects. They should also be able to assess why specific legal norms have developed historically as we know them today.
Contents	1. Fundamentals of the theory of private property rights a) Historical development of private property b) Theories of the emergence of private property rights c) Economic analysis of common-pool resources d) Property rights in intangible assets 2. Economic analysis of contract law a) Complete and incomplete contracts b) Moral hazard and adverse selection c) Efficient responses to contract breaches 3. Economic analysis of tort law a) The Coase theorem b) Economic analysis of liability rules 4. Economic analysis of criminal law a) Differentiating between tort law and criminal law b) Deterrence effects of criminal law c) Optimal deterrence effects 5. Constitutional economics

	a) Fundamentals of the economic theory of public law b) Empirical analysis of the economic effects of constitutional rules
Recommended Prerequisites	Basic knowledge of microeconomics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	H. Schäfer and C. Ott, Lehrbuch der ökonomischen Analyse des Zivilrechts, 5th edition, Heidelberg: Springer, 2012 Additional articles and book chapters announced during the lecture
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• exam, 30 min. (mid-term, 30 points) • exam, 70 min. (final, 70 points)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	None
Module Components	Law & Economics Lecture - 2 hours per week Law & Economics Exercise - 2 hours per week
Components to be offered in the Current Semester	No assignment

Module 14132 Multidimensional Approaches for Technology Assessment

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14132	Compulsory elective

Modul Title	**Multidimensional Approaches for Technology Assessment** Multidimensionale Ansätze für Technikfolgenabschätzung
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students know about a range of technology assessment approaches, methodologies and tools to facilitate the evaluation of decarbonization & sustainability transformation options along socio-technological-economical-ecological-political (*STEEP*) dimensions. On completion of the module, students are able to: • Demonstrate a deep understanding of the multidimensional aspects and systemic interactions in the transformation of energy- and carbon-intensive industries; • Gain familiarity with a range of qualitative and quantitative methodologies in conducting technology assessment; • Design and conduct studies to analyze the opportunities and challenges which will be associated with the transformation of energy- and carbon-intensive industries along multiple dimensions; • Identify, assess and evaluate appropriate sources of information and critically reflect on the methodologies commonly implemented for technology assessment and their usefulness/weaknesses.
Contents	Course coverage: • Relevance and development of technology assessment; • Common methodological approaches and their usefulness/weakness; • Data and approaches for assessment (e.g., primary vs. secondary; qualitative vs. quantitative); • Methodologies for socio-political evaluations, techno-economic evaluations and ecological evaluations;

- Application on a case study to assess multidimensional opportunities and challenges associated with the transformation of a specific sector and derive implications along the *STEEP* dimensions based on assessment results.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 1 hours per week per semester
Exercise - 1 hours per week per semester
Study project - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Lee, R.P., Meyer, B., Huang, Q.L, Voss, R. 2020. Sustainable waste management for zero waste cities in China: potential, challenges and opportunities. *Clean Energy*, 4(3): 169 – 201.
- Lee, R.P. 2019. Alternative carbon feedstock for the chemical industry? – Assessing the challenges posed by the human dimension in the carbon transition, *Journal of Cleaner Production*, 219: 786-796.
- Lee, R. P., Tschoepe, M., Voss, R. 2021. Perception of chemical recycling and its role in the transition towards a circular carbon economy: A case study in Germany. *Waste Management*, 125: 280-292.
- Voss, R., Lee, R.P., Seidl, L., Keller, F., Fröhling, M. 2021. Global warming potential and economic performance of gasification-based chemical recycling and incineration pathways for residual municipal solid waste treatment in Germany. *Waste Management*, 134: 206 – 219.
- Keller, F., Lee, R.P., Meyer, B. 2020. Life cycle assessment of global warming potential, resource depletion and acidification potential of fossil, renewable and secondary feedstock for olefin production in Germany. *Journal of Cleaner Production*, 250: 119484.
- Lee, R.P., Scheibe, A. 2020. The politics of a carbon transition: An analysis of political indicators for a transformation in the German chemical industry*, Journal of Cleaner Production*, 244: 118629.

Further materials are provided via Moodle (including lecture slides and additional materials including videos, readings etc.)

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Individual component (E-assessment), 60-90 min - 50%
- Group Project - Part 1: Create a scientific poster (Analysis of e.g., a scientific article, industry report, case study, ...) - 25%
- Group Project - Part 2: Presentation, 15min - 25%

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

- Lectures & Exercises
- Projects

Components to be offered in the Current Semester	No assignment

Module 14288 Psychology of Entrepreneurship and Change

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14288	Compulsory elective

Modul Title	**Psychology of Entrepreneurship and Change** Psychologie des Unternehmertums und Wandels
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. Urbig, Diemo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	<p data-start="0" data-end="303">After sucessfully completing this module, students will understand how fundamental psychological theories of decision-making under uncertainty, complex interdependence, and intertemporal dynamics can help explain the behavior of individuals who drive change, such as entrepreneurs, innovators, and social activists. They will have developed a basic understanding of the key psychological and behavioral economics theories related to decision-making under risk, uncertainty, and with intertemporal consequences. Students will be able to identify and explain critical patterns of thinking and decision-making in workplace contexts. Students will also be able to apply these theories to real-world situations.
Contents	In this module, we venture into the specifics of a wide range of decision-making theories. We travel through a diverse collection of seminal theories, including many that have formed the basis of Nobel Prize-winning research. We emphasize the interdisciplinary application of insights to ensure that students from a variety of disciplines can absorb and apply the knowledge gained in this module to their own professional decision-making scenarios. The concepts and theories are presented in lectures. Students practice their theory application skills by presenting and discussing critical issues and applications of these theories in seminar.

The literature is presented in the lecuture and students can afterwards read the literature in depth.
The topics include:

- Satisficing and dual process theories
- Risk aversion and ambiguity aversion
- Prospect theory and loss aversion
- Mental accounting and choice bracketing
- Risk reduction strategies: Hedging, learning, and real options
- Time preferences
- Status-quo, escalation of commitment, and the not-invented-here effect
- Personal initiative, sensation seeking, and entrepreneurship
- Rational herding and individually irrational learning
- Nash equilibrium and individually irrational cooperation

In each session of the module, we will focus on one or two articles that present a specific theory or topic.

To collect data, all students take part in a survey that measures some of the constructs addressed in the module, allowing lectures and seminars to use student data as a basis for discussion.

Recommended Prerequisites

none

Mandatory Prerequisites

No successful participation in modules

- 13811 *Behavioral Resource Management*
- 13514 *Individuals in Transformation Processess*

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Seminar - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

In each session of the module, we will focus on one or two articles that present a specific theory or topic. The lecture will introduce the main ideas of the articles, highlight the sections students should focus on, and provide a foundation for reading the articles in greater detail. Please note that students are not expected to understand each of the articles entirely in depth.

- Bernardo, A. E., & Welch, I. (2001). On the evolution of overconfidence and entrepreneurs. *Journal of Economics & Management Strategy*, *10*(3), 301-330.
- Bönte, W., Urbig. D. (2019) *Connecting People and Knowledge: Knowledge Spillovers, Cognitive Biases, and Entrepreneurship* (Chapter 34). In: E. E. Lehmann, M. Keilbach (eds.), From Industrial Organization to Entrepreneurship. Springer, pp. 385-397.
- Crant, J. M. (2000). Proactive behavior in organizations. Journal of Management, 26(3), 435-462.
- Ellsberg, D. (1961). Risk, ambiguity, and the savage axioms. *The Quarterly Journal of Economics*, 75(4), 643-669.

- Evans, J. S. B., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. Perspectives on Psychological Science, 8(3), 223-241.
- Fehr, E., & Schmidt, K. M. (1999). A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics*, 114(3), 817-868.
- Fox, C. R., & Tversky, A. (1995). Ambiguity aversion and comparative ignorance. *The Quarterly Journal of Economics*, 110(3), 585-603.
- Frederick, S., Loewenstein, G., & O'donoghue, T. (2002). Time discounting and time preference: A critical review. *Journal of Economic Literature*, 40(2), 351-401.
- Kahneman, D., Tversky, A. (1979). Prospect theory: An analysis of decisions under risk. *Econometrica*, 47, 278.
- Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin,* 127(2), 267–286.
- Ostrom, E. (2000). Collective action and the evolution of social norms. *Journal of Economic Perspectives*, 14(3), 137-158.
- Read, D., Loewenstein, G., Rabin, M., Keren, G., & Laibson, D. (2000). Choice bracketing. In S. Barbera, P. Hammond, & C. Seidl (Eds.), *Elicitation of Preferences* (pp. 171–202). Springer.
- Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of Risk and Uncertainty*, *1*(1), 7-59.
- Simon, H. A. (1955). A behavioural model of rational choice. *The Quarterly Journal of Economics*, *69*(1), 99-118.
- Staw, B. M. (1981). The escalation of commitment to a course of action. *Academy of Management Review*, *6*(4), 577-587.
- Thaler, R. (1985). Mental accounting and consumer choice. *Marketing Science*, 4(3), 199-214.
- Trigeorgis, L., & Reuer, J. J. (2017). Real options theory in strategic management. *Strategic Management Journal*, 38(1), 42-63:
- Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology*, 5(2), 207-232.
- Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice: A reference-dependent model. *The Quarterly Journal of Economics*, *106*(4), 1039-1061.

Module Examination

Prerequisite + Final Module Examination (MAP)

Assessment Mode for Module Examination

Prerequisite for the final module examination:

- Data collection (allowing lectures and seminars to use student data as a basis for discussion)

Final module examination:

- Written examination, 90 minutes

Bonus marks of up to 10 per cent for a theory-application paper (essay), 1,200 - 1,500 words

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants	none
Remarks	The module is open to both Bachelor's and Master's students.
Module Components	• Lecture Psychology of Entrepreneurship and Change - 2 SWS • Seminar Psychology of Entrepreneurship and Change - 2 SWS
Components to be offered in the Current Semester	**530960** Lecture Psychology of Entrepreneurship and Change - 2 Hours per Term **530961** Seminar Psychology of Entrepreneurship and Change - 2 Hours per Term **530962** Examination Psychology of Entrepreneurship and Change

Module 14466 Fit4Future Summer School

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14466	Compulsory elective

Modul Title	**Fit4Future Summer School** Fit4Future Sommerschule
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Jaeger-Erben, Melanie
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successful completion, students have in-depth knowledge of various transformation dynamics and forms. They are experienced in discussing and reflecting on various analytical and evaluation concepts of transformation dynamics. They can classify various theoretical and methodological approaches in the present day and discuss them in light of relevant evaluation criteria that apply to transformations in the face of pressing crises such as climate catastrophe, biodiversity loss or land overuse. They are also able to understand the complexity of the design challenges of a transformation on a global scale and to analyze the various roles, e.g. of the state or niche actors. They can apply conceptual perspectives such as the multi-level perspective, the ecosystem approach or evolutionary innovation theory.
Contents	The Fit4Future Summer School series provide a dynamic learning environment where students engage with challenges of tomorrow. Every year the thematic focus shifts towards current transition dynamics and transformaton processes. The Summer School provides a mix of online lecture and offline exercises, with a full-week course during September every year. Topics are: • Just Transitions to sustainable and clean energy • Circular Economy and Society • Digitalisation and Sustainability • Globalisation and Global Studies • De- and Prostgrowth

	Throughout the programme, participants will engage with the various aspects of the chosen topic, explore the role of different transformation paradigms and assess the transformative power of different pathways towards sustainable future in an interdisciplinary setting.Renowned international experts will provide participants with a comprehensive understanding of the latest developments through lectures, workshops and field trips, creating a dynamic learning environment that encourages critical thinking and collaborative problem-solving.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Haberl, H., Fischer-Kowalski, M., Krausmann, F., Martinez-Atlier, J., & Winiwarter, V. (2011). A socio-metabolic transition towards sustainability? Challenges for another Great Transformation. *Sustainable development*, 19(1), 1-14. • Voulvoulis, N., Giakoumis, T., Hunt, C., Kioupi, V., Petrou, N., Souliotis, I., & Vaghela, C.J.G.E.C. (2022). systems thinking as a paradigm shift for sustainability transformation. *Global Environmental Change*, 75, 102544. • Abson, D. J., Fischer, J., Leventon, J., Newig, J., Schomerus, T., Vilsmaier, U., ... & Lang, D. J. (2017). Leverage points for sustainablity transformation. *Ambio*, 46, 30-39
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Essay on selected transformation dynamics, 5000 words, (40%) • 2 protocols of two events during the summer school, 1500 words each (20% each) • Learning diary, 3000 words (20%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	- Summer School Fit4Future
Components to be offered in the Current Semester	No assignment

Module 14494 The Political Economy of Transformation

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14494	Compulsory elective

Modul Title	**The Political Economy of Transformation** Die politische Ökonomie der Transformation
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Berger, Wolfram
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	By the end of the semester, students will have a solid understanding of theoretical concepts tied to a critical political economy perspective. They will be able to apply these theoretical perspectives for analysing concrete empirical contexts. They will have skills for critical reflection and will be able to navigate and process complex conceptual texts. Students have inter- and transdisciplinary research competencies.
Contents	To deal with the major challenges our societies are facing – such as the climate crisis, demographic change, geopolitical tension as well as regional and global economic restructurings – we need a profound understanding of their underlying social conditions. This interdisciplinary course offers an introduction to critical political economy approaches that examine these issues through the lenses of power, social relations, and uneven development. We begin with discussing core concepts through which critical political economists seeks to understand how capitalist economies function and how their contradictions emerge. We then turn to the institutional arrangements that shape and mediate economic life — such as states, legal systems, and international governance — examining their roles not as neutral arbiters but as embedded in social struggles and historical formations. Building on this, we explore the concepts of power and hegemony. Drawing on theorists such as Antonio Gramsci and perspectives from Cultural Political Economy, we analyse how dominant economic and political ideas as well as practices become socialised, and how they are contested. Finally, the course investigates the spatial dimension of capitalism: we study how space is not merely a backdrop but actively

	produced through processes of uneven development, globalisation, and territorial differentiation. Throughout the course, we will engage with both classical texts and contemporary applications, and reflect critically on the relevance of critical political economy approaches for understanding today's transformations. Students are encouraged to bring in their own interests and regional expertise, and to relate theoretical insights to empirical phenomena across scales.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• Gramsci, A., 2011. Prison notebooks. Vol. 1. Columbia Univ. Press. • Harvey, D., 2019. Spaces of Global Capitalism: A Theory of Uneven Geographical Development. Verso. • Massey, D.B., 1984. Spatial Divisions of Labour. Macmillan. • Moisio, S. (2018). Geopolitics of the knowledge-based economy. Routledge. • Sum, N.-L., & Jessop, B. (2013). Towards a cultural political economy: Putting culture in its place in political economy. Edward Elgar Pub. Ltd. • Vidal, M., Smith, T., Rotta, T., Prew, P. (Eds.), 2019. The Oxford Handbook of Karl Marx, 1st ed. Oxford University Press.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Präsentation: 15 min (50 %) • Hausarbeit: 6.000 Wörter (50 %)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	Not offered in the WS 2026/27 Module with limited number of participants - Registration two weeks prior to the commencement of lectures!
Module Components	• Seminar (2 SWS)
Components to be offered in the Current Semester	No assignment

Module 14726 Mathematical Optimization Techniques and Applications

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14726	Compulsory elective

Modul Title	**Mathematical Optimization Techniques and Applications** Mathematische Optimierungstechniken und Anwendungen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fügenschuh, Armin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Upon successful completion of the module, students will have acquired an understanding of core mathematical tools used in modern optimization. They will be able to identify optimization structures in real-world problems, formalize these problems in mathematical terms, and apply suitable algorithms to obtain and interpret solutions.
Contents	Foundations of optimization theory, global vs. local optimality, geometry of optimization, optimization for graph problems, fundamentals of linear programming, duality principles, advanced simplex methods, discrete optimization, interior point and ellipsoid methods, nonlinear optimization, applied modeling. Emphasis is placed both on theoretical insights and algorithmic implementation.
Recommended Prerequisites	Knowledge of subject matters of the modules • 11103: Analysis I • 11104: Analysis II • 11101: Lineare Algebra und analytische Geometrie I or of the modules • 11112: Mathematik IT-1 (Diskrete Mathematik) • 11113: Mathematik IT-2 (Lineare Algebra) • 11213: Mathematik IT-3 (Analysis)

Mandatory Prerequisites	• No successful participation in module 13862 Optimierung und Operations Research.
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	• V. Chvatal, Linear Programming, Bedford St Martins Pr 3PL, 2016 • R.J. Vanderbei: Linear Programming - Foundations and Extensions, 5th Edition, Springer, 2020
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 4 intermediate tests of 30 minutes each, written during the lecture period. The best 3 count 1/3 each for the final grade.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Optimierung" • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Optimization" • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Advanced Mathematical Methods in Data Science" • Study programme Artificial Intelligence Science M.Sc.: Compulsory elective module in complex „Advanced Methods" • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Software-basierte Systeme" • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject"
Module Components	• Lecture: Optimization and Operations Research • Accompanying exercise
Components to be offered in the Current Semester	**130710** Lecture Mathematical Optimization Techniques and Applications - 4 Hours per Term **130711** Exercise Mathematical Optimization Techniques and Applications - 2 Hours per Term

Module 14781 Biological Methods for Biomass and Waste Treatment

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14781	Compulsory elective

Modul Title	**Biological Methods for Biomass and Waste Treatment** Biologische Verfahren der Biomasse- und Abfallbehandlung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. habil. Abendroth, Christian
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	<p data-start="0" data-end="990">Students are introduced to ecologically and economically viable alternatives to conventional waste treatment, with integrated and system-oriented solutions at the core. Particular emphasis is placed on anaerobic microbiomes and their central role in biological conversion processes such as anaerobic digestion, composting, and other innovative approaches to residual waste valorization. Building on microbiological and biochemical fundamentals, functional principles, process dynamics, and efficiencies are analyzed and transferred to real-world applications. In addition to established technologies, current research approaches, international developments, and novel process combinations—including contributions from the instructor’s own research—are addressed. The aim is to develop an in-depth understanding of the material and energy recovery of residuals within the context of a sustainable circular economy, and to foster the ability to independently design system-oriented solutions. <p data-start="992" data-end="1542" data-is-last-node="" data-is-only-node="">An interactive teaching format forms the didactic core: during the sessions, students continuously work on tasks whose results contribute to the overall assessment. This supports an active learning process that promotes analytical thinking, applied competence, and scientific discussion.
Contents	<p data-start="0" data-end="361">The course provides a solid yet practice-oriented introduction to the biological utilization of residual materials within the context of a sustainable circular economy. Starting from the fundamentals of biology and photosynthesis, it first examines the ”food vs. fuel” debate in order to critically assess conflicts

between food production and bioenergetic use. <p data-start="363" data-end="906">Subsequently, key processes of biological waste treatment are covered, including composting, biogas production, and dark fermentation. These processes are considered not only from a technological perspective, but particularly from the viewpoint of anaerobic microbiomes, which are understood as the driving force behind material transformations. An introduction to microbiomes and their analysis—from taxonomic profiling to functional approaches such as proteomics—enables a deeper understanding of microbial communities and their performance. <p data-start="908" data-end="1251">Building on this, central metabolic processes such as fermentation and methanogenesis are examined in detail and placed in the context of technical applications. In addition, innovative and less established approaches—such as the use of insects, bioleaching, remediation strategies, and novel materials and systems (e.g., SLMs)—are introduced. <p data-start="1253" data-end="1504" data-is-last-node="" data-is-only-node="">The course combines current research with application-oriented knowledge and offers an interdisciplinary perspective on biological transformation processes, with the aim of developing sustainable and creative solutions for future resource utilization.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 4 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

Kranert M. Einführung in die Kreislaufwirtschaft, Springer Vieweg Wiesbaden, 2017, https://doi.org/10.1007/978-3-8348-2257-4
Bischofsberger, Dichtl, Rosenwinkel, Seyfried, Böhnke. Anaerobtechnik. Springer-Verlag Berlin Heidelberg 2005, ISBN: 3-540-06850-3
Further literature will be announced during the course
<p data-start="0" data-end="129">

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

<div id="meta-origin" data-coolorigin="https%3A%2F%2Fwww.b-tu.de%2Forgcloud%2Fapps%2Frichdocumentscode%2Fproxy.php%3Freq%3D%2Fcool%2Fclipboard%3FWOPISrc%3Dhttps%253A%252F%252Fwww.b-tu.de%252Forgcloud%252Findex.php%252Fapps%252Frichdocuments%252Fwopi%252Ffiles%252F11244624_ochtzup9yafk%26ServerId%3DF84FA4B4%26ViewId%3D7%26Tag%3D58C29858B529DFEC"> Assessment in this module follows a continuous, dialogue-based oral approach. Students are asked to demonstrate their understanding of the course content by answering subject-specific questions and by formulating questions for their peers. The assessment takes place regularly throughout the semester and aims to evaluate subject-specific knowledge, understanding, and the ability to engage in academic discussion. <p> oral assessment generally after every second lecture approximately 15–20 minutes per assessment session 1–2 questions per student approximately every two weeks approximately 10 assessed questions per student

	over the semester 1 point for each successfully completed question assessment of answers based on subject-specific correctness and demonstrated understanding assessment of student-formulated questions based on scientific relevance, clarity, and appropriateness All assessed questions/tasks are weighted equally. The overall assessment result is calculated based on the proportion of points achieved out of the total number of points available (100%). comparable number and level of assessment opportunities for all students
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	238117 Lecture / Seminar: Biological Processes in Biomass and Waste Treatment <p><br data-start="84" data-end="87" />
Components to be offered in the Current Semester	**238117** Lecture/Seminar Biologische Verfahren der Biomasse und Abfallbehandlung - 4 Hours per Term

Module 14872 Design Science in Entrepreneurship and Management

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14872	Compulsory elective

Modul Title	**Design Science in Entrepreneurship and Management** Designwissenschaft in Unternehmertum und Management
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Scheidgen, Katharina
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Successfully completing this course means, students will be able to apply design science in both scientific and practical projects. They will understand how design science differs from traditional explanatory research and know how to develop practical, research-based solutions to pressing challenges. Students will be able to identify design problems worth solving and use qualitative methods such as interviews to understand real-world problems. Based on this, they will be able to derive design requirements and create useful solutions, such as tools, processes, or frameworks. They will be competent in how to co-design these solutions with relevant stakeholders as well as how to evaluate these solutions.
Contents	The course *Design Science in Entrepreneurship and Management* introduces students to an innovative, impact-oriented approach that bridges academic theorizing with real-world problem solving. Design science is a problem-solving and scientific research approach that focuses on designing and evaluating solutions to pressing, complex problems. Unlike traditional academic research, which typically aims to understand and explain phenomena (“how and why” things happen), design science aims to shape and improve reality, answering “how can” and “how should things be” questions. The students will work in small teams and engage with a real-world problem. This problem will be introduced through a design brief, which outlines the problem they are asked to solve. Each team will plan and conduct their own design science mini-project. They will derive design requirements, that are, insights into what a solution must achieve in order to be useful. Based on these design requirements,

they will co-create artifacts and evaluate them. Drawing on both their artifact evaluation and academic literature, students will formulate design principles, that are, prescriptive knowledge that explains how to change an existing situation into a preferred one. Throughout their project, students will engage with relevant stakeholders to collect data, for example to understand the problem better or evaluate their solutions.The results of the project will be presented in two formats: a written report and an oral presentation.
By completing their own mini design science projects, students will gain hands-on experience in planning and conducting such projects. They will also learn how to communicate with relevant stakeholders, both in written reports and in oral presentations.

Recommended Prerequisites

- Experience in reading and engaging with academic literature as well as
- an interest in problem-solving are advantageous.
- Basic knowledge of qualitative approaches such as case studies are helpful.

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Seminar - 4 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Denyer, D., Tranfield, D., & Van Aken, J. E. (2008). Developing design propositions through research synthesis. Organization studies, 29(3), 393-413.
- Gregor, S., Chandra Kruse, L., & Seidel, S. (2020). Research perspectives: the anatomy of a design principle. Journal of the Association for Information Systems, 21(6), 2.
- Opdenakker, R., & Cuijpers, C. (2025). Design Science Methodology for the Management Sciences. Springer Texts in Business and Economics.
- Seckler, C., Mauer, R., & vom Brocke, J. (2021). Design science in entrepreneurship: Conceptual foundations and guiding principles. Journal of Business Venturing Design, 1(1-2), 100004.
- Thuan, N. H., Drechsler, A., & Antunes, P. (2019). Construction of design science research questions. Communications of the Association for Information Systems, 44(1), 20.
- Romme, A. G. L., & Holmström, J. (2023). From theories to tools: calling for research on technological innovation informed by design science. Technovation, 121, 102692.
- Romme, A. G. L., & Reymen, I. M. (2018). Entrepreneurship at the interface of design and science: Toward an inclusive framework. Journal of Business Venturing Insights, 10, e00094.
- Venable, J., Pries-Heje, J., & Baskerville, R. (2016). FEDS: a framework for evaluation in design science research. European Journal of Information Systems, 25(1), 77-89.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Presentation including discussion, max. 10 minutes, group-based (40 %)
- Term paper, 15 pages, group-based (40 %)

	• Reflections on sessions, individual (20%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	30
Remarks	***Module with limited number of participants - Registration two weeks prior to the commencement of lectures!***
Module Components	• Seminar 530505
Components to be offered in the Current Semester	**530505** Seminar Design Science in Entrepreneurship and Management - 4 Hours per Term

Module 41404 Strategic Environmental Assessment and Environmental Impact Assessment

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41404	Compulsory elective

Modul Title	**Strategic Environmental Assessment and Environmental Impact Assessment** Strategische Umweltprüfung und Umweltverträglichkeitsprüfung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Palekhov, Dmitry
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	**Environmental Impact Assessment (EIA)** After completing the module, the students will be able: • to compare the origins and development of EIA in the USA, Europe and worldwide; • to critically review the EIA process, explaining its various steps; • to select appropriate impact identification and prediction methods for the use within the EIA process. **Strategic Environmental Assessment (SEA)** After completing the module, the students will be able: • to understand the key principles, procedure and application of SEA; • to discuss SEA as a policy instrument and a way to improve strategic actions; • to explore benefits and barriers to a successful SEA; • to highlight the links and differences between SEA and Project EIA; • to understand the importance of strategic objectives and their alternatives at SEA level.
Contents	The contents of lectures will be discussed in more detail and applied to different case studies during seminars. While the lecture provides theoretical background, the seminars utilise a more practice-oriented approach. Students will apply various methods explained during the lectures with the help of relevant case studies. **Environmental Impact Assessment (EIA)**

- The history and development of EIA in the USA and the European Union
- The legal context of EIA (NEPA and the European Union EIA Directive)
- EIA system in Germany
- The EIA process – screening, scoping, environmental baseline, impact assessment, environmental impact statement (EIS) and its review, public participation, decision making and monitoring
- Methods used for identification of impacts and assessing their significance (checklists, matrices, networks, map overlays etc.)

Strategic Environmental Assessment (SEA)

- Basic concept and understanding of SEA, its benefits and importance for transition towards sustainability
- The objectives and implementation of the EC's SEA Directive 2001/42/EC
- The differences and similarities between EIA and SEA
- The SEA procedure and its integration into the process of planning

Recommended Prerequisites

None

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Seminar - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

Lecture notes and presentations shown during seminars will be available for downloading from the BTU Moodle learning portal. For students interested in more in-depth study of lecture topics, optional advanced readings will be regularly uploaded to the BTU elearning portal Moodle.
Recommended Journals:

- Environmental Impact Assessment Review published by Elsevier
- Impact Assessment and Project Appraisal published by the International Association for Impact Assessment (IAIA)

Both journals are electronically available to all BTU students at the following web pages:

- http://www.sciencedirect.com/science/journal/01959255
- https://www.tandfonline.com/loi/tiap20

N.B.: to get full access for articles, these web pages have to be accessed from within BTU network or with the help of a VPN-Client.
Environmental Impact Assessment – recommended readings:

- Glasson J and Therivel R (2019) Introduction to environmental impact assessment: 5th Edition. Routledge, London

- Noble BF (2021) Introduction to Environmental Assessment: A Guide to Principles and Practice, 4th Edition.Oxford University Press, Toronto
- Morris P, Therivel R (eds.) (2001) Methods of Environmental Impact Assessment (2nd edition). Spon Press, London
- Petts J (ed.) (1999) Handbook of Environmental Impact Assessment. Volume 1. Environmental Impact Assessment: Process, Methods and Potential. Volume 2. Environmental Impact Assessment in Practice: Impact and Limitations. Blackwell Science Ltd., Oxford.
- Schmidt M et al. (Eds.) (2008) Standards and Thresholds for Impact Assessment. Environmental Protection in the European Union, Volume 3. Springer, Heidelberg.
- Wood C (2003) Environmental Impact Assessment. A Comparative Review: Second Edition. Pearson Education Limited, Harlow.

Strategic Environmental Assessment - recommended readings:

- Dalal-Clayton B, Sadler B (2005) Strategic environmental assessment: A sourcebook and reference guide to international experience. Earthscan, London.
- Fischer TB (2002) Strategic Environmental Assessment in Transport and Land Use Planning. Earthscan, London.
- Fischer TB (2007) Theory and Practice of Strategic Environmental Assessment: Towards a More Systematic Approach. Earthscan, London.
- Gühnemann A (2000) Methods for Strategic Environmental Assessment of Transport Infrastructure Plans. Nomos Verlagsgesellschaft, Baden-Baden.
- Jones C et al. (eds) Strategic Environmental Assessment and Land Use Planning – an international evaluation. Earthscan, London.
- Marsden S (2008) Strategic Environmental Assessment in International and European Law: A Practitioner's Guide. Earthscan, London.
- Partidario MR and Clark R (Eds.) (2000) Perspectives on Strategic Environmental Assessment. Lewis Publishers, Boca Raton.
- Schmidt M, João E and Albrecht E (Eds.) (2005) Implementing Strategic Environmental Assessment. Environmental Protection in the European Union, Volume 2. Springer, Heidelberg.
- Therivel R (2004) Strategic Environmental Assessment in Action. Earthscan, London.
- Therivel R, Partidario MR (eds.) (1996) The Practice of Strategic Environmental Assessment, Earthscan, London.
- Therivel R, Wilson E, Thompson S, Heaney D and Pritchard D (1992) Strategic Environmental Assessment. Earthscan, London.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Oral performance verification (duration 10 minutes, maximum 15 points)
- Presentation (duration 10 minutes, maximum 15 points)

To pass the module students need to gain a minimum of 12 points (the sum of points for the above mentioned module components).

Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Registering for Examination of the module SEA/EIA is mandatory! No registration means no final grade in the end.
Module Components	• 2403121 LE Environmental Impact Assessment and Strategic Environmental Assessment • 2403122 SE Environmental Impact Assessment and Strategic Environmental Assessment
Components to be offered in the Current Semester	**240334** Lecture Strategic Environmental Assessment and Environmental Impact Assessment - 2 Hours per Term **240335** Seminar Strategic Environmental Assessment and Environmental Impact Assessment - 2 Hours per Term

Module 41405 Cost-Benefit Analysis in Environmental Evaluation

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41405	Compulsory elective

Modul Title	**Cost-Benefit Analysis in Environmental Evaluation** Kosten-Nutzen-Analyse in der umweltökonomischen Bewertung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. pol. Wätzold, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	To be able to apply economic thinking to solve environmental and resource management problems with a focus on cost-benefit analysis (CBA) and on cost-effective management and policy solutions.
Contents	• Economic principles (for non-economists) • Why does market failure exist in the case of environmental goods? • Methodology of CBA • Theory of CBA • Cost Assessment • Theory and methods of benefit valuation • Risk and uncertainty in CBA
Recommended Prerequisites	None
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Boardman, A.E. (2011), Cost-benefit analysis: concepts and practice (The Pearson series in economics) • announced in class
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	

	• written examination, 80 minutes (50%) • presentation, 15 min. and discussion (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240905 LE Cost Benefit Analysis in Environmental Evaluation • 240901 Examination Cost Benefit Analysis in Environmental Evaluation • 240902 Examination Cost Benefit Analysis in Environmental Evaluation
Components to be offered in the Current Semester	**240905** Lecture/Seminar Cost Benefit Analysis in Environmental Evaluation - 4 Hours per Term **240901** Examination Cost Benefit Analysis in Environmental Evaluation **240902** Examination Cost Benefit Analysis in Environmental Evaluation

Module 41422 Measuring Sustainability

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41422	Compulsory elective

Modul Title	**Measuring Sustainability** Nachhaltigkeit messen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	**Lecture and Seminar on Measuring Sustainability** In the lecture fundamental knowledge regarding tools and approaches to measuring sustainability will be gained. **Learning outcome:** • Familiarisation with the concept of sustainable development. • Familiarisation with consequences of global challenges as threats to achieving sustainable development goals. • Understanding indicator systems for sustainable development. • Understanding voluntary sustainability standards (VSS). • Understanding various methods and tools for sustainability assessment.
Contents	• Historic development and current understanding of sustainable development; • International legal framework and policies for sustainable development; • Goals and targets for sustainable development; • Indicator systems for sustainable development; • Voluntary sustainability standards (VSS) as an instrument of sustainable development; • Tools and methods for assessing sustainability; • Sustainability in supply and value chains.
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Research paper/essay - 30 hours Self organised studies - 90 hours
Teaching Materials and Literature	Literature will be recommended at the beginning of the course. All presentations will be made available to students.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Series of MCQs during the lecture period (total duration 60minutes, 10points) • A final written examination (duration 90 minutes, 20 points) • To pass the module students need to gain a minimum of 12 points (the sum of points for the above mentioned module components).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	70
Remarks	Registering for examination of the module “Measuring Sustainability” is mandatory! No registration means no final grade in the end.
Module Components	• Lecture Measuring Sustainability • Seminar Measuring Sustainability
Components to be offered in the Current Semester	**240336** Lecture Measuring Sustainability - 2 Hours per Term **240337** Seminar Measuring Sustainability - 2 Hours per Term

Module 41427 Economics of Land Use and Biodiversity Conservation

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41427	Compulsory elective

Modul Title	**Economics of Land Use and Biodiversity Conservation** Ökonomische Analyse der Landnutzung und des Schutzes der biologischen Vielfalt
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. pol. Wätzold, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	• acquire knowledge about the economic analysis of sustainable land use and biodiversity conservation • get acquainted with an economic analysis of related policy instruments • be able to discuss related issues on a scientific level • be able to read scientific papers and discuss them critically
Contents	• optimal spatial allocation of land use • policy instruments for sustainable land use (PES, conservation banking) • institutions and governance structures, common pool resources • REDD (reducing emissions from deforestation and degradation)
Recommended Prerequisites	Basic economic knowledge.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Excursion - 8 hours Self organised studies - 112 hours
Teaching Materials and Literature	To be announced in class.
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• written examination, 70 minutes (50%) • oral presentation 15 min and hand-out (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Complementary module ERM Master 2006. *to Excursion - 8 hours (if possible) depending on the COVID-19 situation, the course may be offered online or in presence.
Module Components	• 240907 Lecture/Seminar Economics of land and biodiversity conservation management incl. excursion • 240912 Examination Economics of land and biodiversity conservation management • 240958 Examination Economics of land and biodiversity conservation management
Components to be offered in the Current Semester	**240907** Lecture/Seminar Economics of land and biodiversity conservation management - 4 Hours per Term **240912** Examination Economics of land and biodiversity conservation management **240958** Examination Economics of land and biodiversity conservation management

Module 42417 Methods of Water Resources Management

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Umweltökonomie, -planung und -recht

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	42417	Compulsory elective

Modul Title	**Methods of Water Resources Management** Methoden der Wasserbewirtschaftung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Kästner, Karl
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	At the end of the module the student are able to apply methods to assess and to balance the components of the water cylce and to derive properties of surface and subsurface catchments with respect to runoff generation and water yield. They can simulate hydrological responses of the water balance components to different inputs.
Contents	Elements of the water balance as a function of space and time; determination of available surface and groundwater resources; management practices for surface and groundwater resources: application of statistic, stochastic and deterministic methods in the fields of watershed modeling, system hydrology, reservoir management, flood prediction and integrative resources management, isotopic hydrology
Recommended Prerequisites	None
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Handouts and reading list • Manual and tutorial of the modeling programme
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Assessment report, max. 3 pages text without figures and tables - 40%

	• Exam, 80 minutes - 60%
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module will not be offered in the summer semester of 2026.
Module Components	**Summer semester:** • 240630 Lecture Methods of Water Resources Management - Lecture part • 240631 Seminar/Exercise Methods of Water Resources Management - Practical part
Components to be offered in the Current Semester	**240669** Examination Methods of Water Resources Management

Module 11243 Master Thesis

assign to: Modules at the Brandenburg University of Technology Cottbus-Senftenberg (Environmental Engineering)
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11243	Mandatory

Modul Title	**Master Thesis** Master-Arbeit
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	30
Learning Outcome	The Master Thesis is an examination in which the student must show that he or she can independently and successfully deal with an assignment within a set deadline and contribute scientifically founded theoretical and practical knowledge to the solving of a problem. The Master-thesis should correspond to the advanced knowledge base of the subject. The Master Thesis consists of written work and its defence.
Contents	The Master Thesis can be practical as well as theoretical. It should relate the advanced standard of knowledge in the scientific field. The Master thesis consists of the written work and its defence.
Recommended Prerequisites	none
Mandatory Prerequisites	Successful completion of the modules (except for students with UTP as home university): • 41514 Study Project • 41421 Introduction to Environmental and Resource Management II **Additionally for Examination and Study Regulation of 2021 (including Double Degree):** • an achievement of an overall minimum amount of 72 credit points. **Additionally for Examination and Study Regulation of 2011:** • an achievement of an overall minimum amount of 78 credit points.
Forms of Teaching and Proportion	Self organised studies - 900 hours

Teaching Materials and Literature	It depends on the individual subject. Corresponding material will be named and provided by the supervisor.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	The grade of the Master thesis results from the thesis, which accounts for 75 percent, and its defense, which accounts for 25 percent.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The academic supervisor is responsible for the topic and the content of the thesis.
Module Components	None
Components to be offered in the Current Semester	No assignment

Module 41421 Introduction to Environmental and Resource Management II

assign to: Mandatory Modules

Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41421	Mandatory

Modul Title	**Introduction to Environmental and Resource Management II** Einführung in den Studiengang Umwelt- und Ressourcenmanagement II
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After attendance students will have a better understanding how the ERM master programme works, what distinguishes the specialization fields of ERM and how to find a topic for their master thesis. In addition they will be able to understand the basics of good scientific practice and have learned the foundation for conceptualizing, structuring and writing their master thesis.
Contents	The module will be structured into two major topics: 1. How to study the master programme of Environmental Resource Management at BTU 2. The basics of working scientifically at an European University. This part may include the following sub-topics: · Scientific writing (with a focus on master theses) · Working with scientific literature and publishing of scientific work · Presenting at scientific conferences and networking in the scientific community · Grant writing and funding proposals · Ethics and integrity in scientific work; Intellectual property and patents · Interdisciplinary collaboration · Science communication · Career paths in science Due to a change in teaching personnel, changes to structure, timing and topics of the module will be made during the semester.

Recommended Prerequisites	None
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	to be announced
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	Final module examination: 90 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	None
Module Components	• 240230 Lecture/Exercise Introduction to ERM II
Components to be offered in the Current Semester	**240321** Lecture/Exercise Introduction to ERM II - 4 Hours per Term

Module 41514 Study Project

assign to: Mandatory Modules
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41514	Mandatory

Modul Title	**Study Project** Studienprojekt
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	12
Learning Outcome	Within a study project the students work in details on a selected topic of preferably interdisciplinary nature. The main scope is the development of problem-solving skills by means of information gathering as well as the application of theoretical knowledge acquired in more formal classes. Students will organize their scientific research related to data acquisition, data analysis.
Contents	A study includes a project report with all factual information about the work in the project.
Recommended Prerequisites	Depending on the project topic knowledge in mathematics/statistics and/ or social as well as natural sciences is advantageous.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Consultation - 1 hours per week per semester Self organised studies - 345 hours
Teaching Materials and Literature	To be named by supervisor.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Written project report with all factual information about the work (as hard copy and digital form) and a presentation. • Written report, 20-30 pages (75%) • Presentation of results (25%)
Evaluation of Module Examination	Performance Verification – graded

Limited Number of Participants	none
Remarks	None
Module Components	• 240215 Study project Study Project
Components to be offered in the Current Semester	**240215** Study project Study Project

Module 11225 Numerical Simulation: Free Surface and Groundwater Modelling

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11225	Compulsory elective

Modul Title	**Numerical Simulation: Free Surface and Groundwater Modelling** Numerische Simulation: Gewässer- und Grundwassermodellierung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. PD Dr.-Ing. habil. Molkenthin, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Understanding of numerical simulation methods for free-surface and groundwater flow and related processes.
Contents	• Hydrological and hydrodynamic modelling of free surface flow in rivers, lakes and coastal waters and related numerical schemes (FD, FV, FE) • Numerical and computational aspects for FD, FE and FV schemes • Setup, calibration, validation and application of models • Simulation result analysis • Exercises in 1D/2D model comparsion and 2D river modelling including flooding • Academic and real case studies from river modelling • Description of groundwater flow processes • Numerical modelling of groundwater flow in 1D, 2D and 3D and realted numerical schemes (FD, FE, FV) • Finite element and differences schemes for groundwater flow pollution transport, boundary conditions in 2D/3D • Exercise: 1D/2D/3D groundwater modelling project • Project presentation and journal paper writing
Recommended Prerequisites	• Successful participation in module Hydroloy & Hydraulics (11510 or 41414) with good result (ERM Module 11510 mark ≤2.3) • Advanced understanding of numerical methods, hydrological and hydrodynamic processes, computational hydraulics

	• Advanced data management and analysis skills (e.g. spatial data, time series) using GIS and data analysis software / modelling environments (R, Python, Matlab, SQL, ...).
Mandatory Prerequisites	No successful participation in associated phase-out module *41505 Coupling Free-Surface and Groundwater Modelling*.
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Practical training - 4 hours per week per semester Self organised studies - 60 hours
Teaching Materials and Literature	none
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• two assignments (each 15%) • poster presentation and discussion (10%) • journal paper and discussion (10%) • final written (120 min) or oral (30-45 min) examination (50%) The form in which the examinations will be carried out will be announced at the beginning of the course.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240636 Lecture/Exercise 2D Hydrodynamic numerical modelling • 240637 Lecture/Exercise Groundwater modelling
Components to be offered in the Current Semester	**240636** Lecture/Exercise 2D Hydrodynamic numerical modelling - 2 Hours per Term **240637** Lecture/Exercise Groundwater modelling - 2 Hours per Term

Module 11228 Modelling Process in Hydroengineering Projects

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11228	Compulsory elective

Modul Title	**Modelling Process in Hydroengineering Projects** Computergestützter Modellierungsprozess in Ingenieurprojekten des Wasserwesens
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. PD Dr.-Ing. habil. Molkenthin, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Understanding of modelling and information management methods in hydroengineering projects using simulation and data analysis tools.
Contents	Modelling Process • Modelling using hydroinformatics systems in hydroengineering projects • Physical understanding, data preparation • Model set-up, scenario definition, sensitivity analysis, result analysis • Application examples for real case studies (in combination with Module 11225)
Recommended Prerequisites	• Successful participation in module Hydroloy & Hydraulics (11510 or 41414) with good result (ERM Module 11510 mark ≤2.3) • Advanced understanding of computer based water related modelling techniques (data and processes), numerical methods (FDM, FEM, FVM), GIS and time series analysis. • Experiences in use of numerical simulation tools (esp. for 1D and 2D hydraulic modelling) • Hydroengineering knowlegde and skills
Mandatory Prerequisites	No successful participation in associated phase-out modules:

	• *41506 Modelling Business Processes, Workflow and Information Management* **OR** • *41507 Geometric Modelling and Presentation Methods*.
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Seminar - 4 hours per week per semester Practical training - 1 hours per week per semester Self organised studies - 60 hours
Teaching Materials and Literature	The current teaching materials including literature references are made available to students via the respective current websites (e.g. Moodle, Google site, HydroEurope server) for the current courses.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Assignments (30%) • Project reports (30%) • Seminar presentations and discussions (40%) The details and weighting of the different assessment elements are determined in the first lectures.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240640 Seminar Flood management • 240641 Seminar Groundwater management • 240639 Lecture/Practical training Modelling in Hydroengineering
Components to be offered in the Current Semester	**240640** Seminar Flood management - 1 Hours per Term **240641** Seminar Groundwater management - 1 Hours per Term **240639** Lecture/Practical training Modelling in Hydroengineering - 2 Hours per Term **248234** Lecture/Seminar Hydrogeology of large catchments

Module 11229 Information Management in Hydroinformatics Systems

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11229	Compulsory elective

Modul Title	**Information Management in Hydroinformatics Systems** Informationsmanagement in Systemen der Hydroinformatik
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. PD Dr.-Ing. habil. Molkenthin, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Skills and abilities for Hydroinformatics system design and development; Understanding of information management, data analysis and Web-technology in hydroinformatics systems
Contents	information modelling techniques, components of numerical models, numerical model design for hydrodynamic simulation, interfaces to software modules, implementation and application examples, information analysis and mining, Web-Technologies for hydroinformatics systems,application of Web-Technologies in hydroinformatics systems, application of R /Python/... in hydroinformatics
Recommended Prerequisites	• Successful participation in module Hydroloy & Hydraulics (11510 or 41414) with good result (ERM Module 11510 mark ≤2.3) • Advanced programming and software development skills • Understanding of data bases, numerical methods, data analysis and visualisation, GIS • Experiences in Web-technology, XML-Schemes and software interfacing for water related applications
Mandatory Prerequisites	No successful participation in associated phase-out module *41508 Monitoring, Data Acquisition and Documentation*.
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 90 hours

Teaching Materials and Literature	none
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Exercises/assignments (50%) • Written (120 min) or oral (30-45 min) examination (50%) The details and weighting of the different assessment elements are determined in the first lectures.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240638 Lecture Hydroinformatics Systems design and development • 240643 Exercise Information handling (field, laboratory, simulation) • 240645 Practical training Web-based hydroinformatics systems
Components to be offered in the Current Semester	**240638** Lecture Hydroinformatics Systems design and development - 2 Hours per Term **240643** Exercise Information handling (field, laboratory, simulation) - 2 Hours per Term **240645** Practical training Web-based hydroinformatics systems - 2 Hours per Term

Module 11510 Hydrology & Hydraulics

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11510	Compulsory elective

Modul Title	**Hydrology & Hydraulics** Hydrologie & Hydraulik
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. PD Dr.-Ing. habil. Molkenthin, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Understanding the typical modelling processes in hydrology & hydraulics such as GIS based catchment analysis, rainfall/runoff analysis, open channel hydraulics and hydrodynamic analysis of rivers. Practical experiences in application of related software tools. Basic ability to evaluate and present modelling results in respect to theoretical background, model assumptions and limits as well as uncertainties in data.
Contents	The module has four main parts. **First part** deals with the DEM based topographic analysis of a catchment as pre-processing for a hydrological analysis including catchment delinieation, rainfall interpolation, land-use and soil data analysis using GIS for a given case study. **Second part** deals with the hydrological rainfall/runoff analysis using different analysis methods. The lectures present the theoretical background of the analysis methods and their application in projects. Students will perform a EXCEL/Hec-HMS/Shetran based assignment for a given case study**.** **Third part** of the module deals with open channel hydraulics. The lecture presents the theoretical background including engineering assumptions and simplifications. Application examples with manual calculations in comparison to computer-based simulations are introduced and used for training. **Fourth part** of the module covers computer-based hydrodynamic simulation of river networks for flood management. The lectures present the theoretical background of the hydrodynamic simulation methods (basic differential equations, numerical methods, physical parameters,

	handling of structures such as weirs, calibration, validation, simulation scenarios …) and their application in projects. Students will perform a software-based assignment for a given case study. All assignments deal with the same case study data set and demonstrate the integrated application of different software tools within a project. Finally, the lectures will give an outlook for 2D flood modelling and related flood risk management.
Recommended Prerequisites	Advanced knowledge in mathematics/numerics, physics, fluid mechanics, GIS, ICT and water resource management on master level, experiences in computer based modelling, data management and data analysis
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Practical training - 3 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	Teaching material and a list of recommended literature will be published on the Web page / in Moodle, links will be provided to the participants during the lectures.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1) Four assignments during the semester (each 10% -> four assignments 40%) 2) Written exam (60%) The written exam will be offered two times during the semester (e.g. last week of lecture period and mid of September). Participants can participate in both written exams, in this case the mean value of the two results will be considered as written result for the final mark. To pass the module, participants needs at least 50% summing up the results from the assignments (max. 40%) and from the written exam(s) (max. 60%).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	This module is for ERM Master study programme.
Module Components	• 240608 Lecture Hydrology & Hydraulics • 240610 Practical training Hydrology & Hydraulics • 240621 Examination Hydrology & Hydraulics (1st written exam) • 240654 Examination Hydrology & Hydraulics (2nd written exam)
Components to be offered in the Current Semester	**240621** Examination Hydrology & Hydraulics

Modul 11591 Numerik in der Geotechnik

zugeordnet zu: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Studiengang Environmental and Resource Management

Akademischer Grad	Modulnummer	Modulform
	11591	Wahlpflicht

Modultitel	**Numerik in der Geotechnik** Numerics in Geotechnics
Einrichtung	Fakultät 6 - Architektur, Bauingenieurwesen und Stadtplanung
Verantwortlich	Prof. Dr.-Ing. Grandas Tavera, Carlos
Lehr- und Prüfungssprache	Deutsch
Dauer	1 Semester
Angebotsturnus	jedes Sommersemester
Leistungspunkte	6
Lernziele	Nach Abschluss des Moduls kennen die Studierenden numerische Methoden zur Lösung der typischen Differentialgleichungen in der Geotechnik. Sie sind in der Lage, die Modellierung üblicher geomechanischen Randwertprobleme mit der Methode der Finiten Differenzen und der Methode der Finiten Elementen nachzuvollziehen und ihre Lösung kritisch zu bewerten. Sie können geeignete Stoffgesetze für die numerische Berechnung begründet auswählen und ihren Einfluss auf die Ergebnisse einschätzen.
Inhalte	Nachfolgende Inhalte werden themenbezogen vermittelt: • Anfangs- und Randwertprobleme in der Bodenmechanik • Finite Differenzen: Zeitintegration, numerische Stabilität, Beispiele • Einführung in die zeitliche Integration von Stoffgesetze: Return-Mapping, explizite und semi-explizite Methode • Finite Elemente: schwache Form, Diskretisierung, Randbedingungen, numerische Lösung • Locking, reduzierte Integration, Hour-Glass-Modes • Einführung in die Diskrete Elemente Methode
Empfohlene Voraussetzungen	Grundkenntnisse in Mechanik, Grundbau und Bodenmechanik.
Zwingende Voraussetzungen	keine
Lehrformen und Arbeitsumfang	Vorlesung - 2 SWS Übung - 2 SWS Selbststudium - 120 Stunden

Unterrichtsmaterialien und Literaturhinweise	• Witt, K.J.: Grundbau-Taschenbuch Teil 1 bis 3, 8. Aufl., Ernst & Sohn, Berlin, 2016. • Deutsche Gesellschaft für Geotechnik e.V.: Empfehlungen des Arbeitskreises Baugruben EAB, 5. Aufl., Ernst & Sohn, Berlin, 2012. • Presss, W., e.a., Numerical Recipies, Cambridge Univ. Press, 1992. • Zienkewicz O.C. et.al.: The Finite Element Method, Vol. 1, Wiley, 2005. • Strang, G.: Wissenschaftliches Rechnen, Springer, 2007.
Modulprüfung	Modulabschlussprüfung (MAP)
Prüfungsleistung/en für Modulprüfung	• Mündliche Prüfung, 20 min
Bewertung der Modulprüfung	Prüfungsleistung - benotet
Teilnehmerbeschränkung	keine
Bemerkungen	Für den Fall, dass das Modul nicht gemäß der vorliegenden Beschreibung gelehrt bzw. geprüft werden kann (z.B. aus Gründen des Infektionsschutzes), gelten die auf einschlägigen Plattformen (z.B. Homepage bzw. Moodle) kommunizierten Alternativen.
Veranstaltungen zum Modul	• 630350 Vorlesung Numerik in der Geotechnik • 630351 Übung Numerik in der Geotechnik • 630355 Prüfung Numerik in der Geotechnik
Veranstaltungen im aktuellen Semester	**630355** Prüfung Numerik in der Geotechnik

Module 12165 Renewable Energy Technologies for Power Supply

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12165	Compulsory elective

Modul Title	**Renewable Energy Technologies for Power Supply** Energieerzeugung auf Basis erneuerbarer Energien
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. Röntzsch, Lars
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The participants of the module acquire advanced knowledge in the design, operation, and application of renewable energy systems, including solar energy (solar thermal and photovoltaics), wind energy, hydroelectric power, geothermal energy (both near-surface and deep), biomass, and energy storage technologies, with a focus on hydrogen technology. They can analyze and reflect on the interactions between these subfields, considering their technical and ecological implications, and are capable of making scientifically grounded judgments within the discipline. The participants of the module develop the ability to formulate their own research questions and address them using appropriate scientific methods. They can effectively engage in domain-specific and interdisciplinary discussions, presenting complex topics clearly and persuasively to diverse audiences. Additionally, they demonstrate the ability to independently acquire new knowledge and apply it to solve and critically evaluate application- or research-oriented challenges.
Contents	Design, operation and use of: • Solar energy (photovoltaics, solar thermal) • Wind energy • Geothermal energy (deep and near-surface) • Biomass • Hydroelectric power • Energy storage inclusive hydrogen technology
Recommended Prerequisites	<div class="" data-turn-id-container="request-WEB:a3431c09-7954-4939-889f-9a2bd9d2dbf2-3" data-is-

	intersecting="true"><section class="text-token-text-primary w-full focus:outline-none has-data-writing-block:pointer-events-none [&:has([data-writing-block])>*]:pointer-events-auto R6Vx5W_threadScrollVars scroll-mb-[calc(var(--scroll-root-safe-area-inset-bottom,0px)+var(--thread-response-height))] scroll-mt-[calc(var(--header-height)+min(200px,max(70px,20svh)))]" dir="auto" data-turn-id="request-WEB:a3431c09-7954-4939-889f-9a2bd9d2dbf2-3" data-turn-id-container="request-WEB:a3431c09-7954-4939-889f-9a2bd9d2dbf2-3" data-testid="conversation-turn-6" data-scroll-anchor="false" data-turn="assistant"><div class="text-base my-auto mx-auto pb-10 [--thread-content-margin:var(--thread-content-margin-xs,calc(var(--spacing)*4))] @w-sm/main:[--thread-content-margin:var(--thread-content-margin-sm,calc(var(--spacing)*6))] @w-lg/main:[--thread-content-margin:var(--thread-content-margin-lg,calc(var(--spacing)*16))] px-(--thread-content-margin)"><div class="[--thread-content-max-width:40rem] @w-lg/main:[--thread-content-max-width:48rem] mx-auto max-w-(--thread-content-max-width) flex-1 group/turn-messages focus-visible:outline-hidden relative flex w-full min-w-0 flex-col agent-turn"> <div class="min-h-8 text-message relative flex w-full flex-col items-end gap-2 text-start break-words whitespace-normal outline-none keyboard-focused:focus-ring [.text-message +&]:mt-1" dir="auto" tabindex="0" data-message-author-role="assistant" data-message-id="c4da9da5-dfdc-4888-9d7e-9396a38a3b90" data-message-model-slug="gpt-5-5" data-turn-start-message="true"> <p data-start="391" data-end="691" data-is-last-node="" data-is-only-node="">Completed Bachelor’s degree in a relevant field such as natural sciences, engineering, environmental engineering, energy engineering, process engineering, or a comparable degree programme. Very good knowledge and a solid understanding of engineering, physics, chemistry, and mathematics are required. </section>
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The course documents are provided in the learning management system Moodle.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Final written exam (120 min)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	60
Remarks	none
Module Components	Lectures, exam

Components to be offered in the Current Semester	**320461** Lecture Renewable Energy Technologies for Power Supply - 4 Hours per Term **320483** Examination Renewable Energy Technologies for Power Supply

Module 12989 Process System Technology II

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12989	Compulsory elective

Modul Title	**Process System Technology II** Prozesssystemtechnik II
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Arellano-Garcia, Harvey
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The students are able to describe dynamic and locally distributed systems of process engineering with the help of mathematical models. For this purpose, you can make suitable assumptions and neglects for the derivation of a model from the context of a task, then compile them on the basis of material, momentum, energy and property balances and complete them with kinetic approaches, thermodynamic equations of state and suitable boundary and initial conditions , In addition, students are able to apply systematic methods for model reduction, in particular for the reduction of spatial coordinates, for the introduction of quasi-stationarity assumptions and equilibrium assumptions. The students can use the finite-volume method to transform spatially distributed process models into systems of ordinary differential equations, to implement and solve them in a numerical simulation environment.
Contents	1. Modeling strategy: relevant scales, inputs / outputs, assumptions 2. Balancing: partial mass balances, total mass balances, momentum balance, energy balances. Substantive and local formulations 3. Entropy Balance: Source terms, drivers and rivers 4. Balancing of multiphase systems 5. Constitutive equations: Overview of kinetics (reaction, mass and heat transport, impulse transport), thermodynamic equations of state. Stefan Maxwell kinetics of mass transport. 6. Boundary and initial conditions: species, bad and well-posed problems 7. finite volume method 8. method of characteristics

	9. Model reduction: quasi stationarity, balance, integration 10. Differential Algebra Systems: Differential Index, Index Reduction, Solution Methods
Recommended Prerequisites	44303 Prozesssystemtechnik
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• M. Jischa, Konvektiver Impuls-, Wärme- und Stoffaustausch, Vieweg, 1982. • R. Taylor, R. Krishna, Multicomponent Mass Transfer, Wiley, 1993. • B. Bird, et al., Transport Phenomena, Wiley, 2002. • S. I. Sandler, Chemical, Biochemical and Engineering Thermodynamics, Wiley, 2006. • S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill, 1980. • A. Varma et al., Mathematical Methods in Chemical Engineering, Oxford U. Press, 1997.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	Examination 120 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	**Summer semester:** • Lesson/Exercise Process System Technology II • Examination Process System Technology II
Components to be offered in the Current Semester	**360381** Examination Process System Technology II

Module 13234 Communication of Science and Technology

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13234	Compulsory elective

Modul Title	**Communication of Science and Technology** Wissenschafts- und Technikkommunikation
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Students will know about different techniques, tools and formats for communication of science & technology. They will develop skills to break down complex issues at the nexus of science, technology and society to communicate science/technical information in a clear, understandable and engaging way to different stakeholders. On completion of the module, students will be able to: • Articulate the key issues and challenges in communicating about science & technology; • Understand the nature of different audiences for better stakeholder engagement; • Demonstrate awareness of and ability to use a variety of different techniques and media for targeted audience; • Improve their skills in communication of scientific/technical information in both written and oral forms; • work as part of a team to develop effective measures for communication of science & technology; • Provide constructive feedback to other students on their communication skills.
Contents	Course coverage: • Key issues in communication of science & technology; • Identify and knowing your audiences (mental models, risk perception, heuristics and biases, …); • Getting your audience's attention (Types of framing); • Communicating risk and uncertainty; • Formats for communication of science & technology.

Students will also be given opportunities to receive feedback and improve their own written and oral skills. They will also work in small teams on team projects to further their skills for communicating about sustainability issues. These projects will focus on communicating about a given scientific topic to a particular audience using spoken, visual, written or web-based communication.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Seminar - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Center for Research on Environmental Decisions (CRED). 2009. *The Psychology of Climate Change Communication: A guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public.* New York.
- Nisbet, M.C., Scheufele, D.A. 2009. What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, 96(10): 1767-1778.
- Bubela, T., Nisbet, M., Borchelt, R. *et al.* 2009. Science communication reconsidered. Nature Biotechnology, 27, 514–518.
- Nelkin, D. 1989. Communicating technological risk: The social construction of risk perception. *Annual Review Public Health*, 10, 95-113.
- Tversky, A., Kahneman, D. 1974. Judgment under Uncertainty: Heuristics and Biases. Science, New Series, 185(4157), 1124-1131.

Further material (including lecture slides and additional materials including videos, readings etc.) might be announced during the first class meeting.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Individual E-Assessment – 60 min (40%)
- Group project - Part 1: Science Communication Material e.g., poster, video, etc. (30%)
- Group project - Part 2: Group presentation– 15min oral presentation (30%)

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

- Lecture / Seminar

Components to be offered in the Current Semester

510601 Lecture/Seminar
Communication of Science & Technology - 4 Hours per Term

Module 13249 Introduction to Gas Dynamics

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13249	Compulsory elective

Modul Title	**Introduction to Gas Dynamics** Einführung in die Gasdynamik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successful participation the students are able to distinguish the physical properties of compressible and incompressible fluid flows. They have understood the governing equations, relevant phenomena, and control parameters, and they are able to perform a quantitative analysis of simple problems. In the exercise the students apply theoretical concepts to sample problems in order to develop analytical and numerical problem-solving skills.
Contents	• Conserved quantities and conservation laws • Nondimensional numbers • Sound speed and propagation • Flow regimes • Basics of aerostatics • Isentropic, barotropic, and polytropic flows • State change with entropy change • Steady compressible flows • Unsteady compressible flows • Stationary and propagating shocks
Recommended Prerequisites	Basic knowledge of continuum mechanics, fluid dynamics, and thermodynamics is an asset.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Liepmann & Roshko. Elements of Gas Dynamics. Dover, 2002. • Babu. Fundamentals of Gas Dynamics. Springer, 2011. • Achterberg. Gas Dynamics: An Introduction with Examples from Astrophysics and Geophysics. Atlantis, 2016. • Oswatitsch. Grundlagen der Gasdynamik. Springer, 1976.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• oral examination, approx. 40 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module aims at Bachelor students from all disciplines with interest in but no or little knowledge of gas and fluid flows.
Module Components	VL/ÜB/PRÜ Introduction to gas dynamics
Components to be offered in the Current Semester	**350472** Examination Introduction to gas dynamics

Module 13251 Introduction to Computational Thinking and Programming for CFD

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13251	Compulsory elective

Modul Title	**Introduction to Computational Thinking and Programming for CFD** Einführung in das rechnergestützte Denken und Programmieren für CFD
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Students learn to use the higher programming language Python for numerical problem solving, data analysis, and visualization with links to computational fluid dynamics (CFD). After successful completion of the course, participants are able to develop algorithms and computer programs for simple problems on their own. On this basis, students will be put in the position to understand and work themselves into more complex problems. This module provides basic programming experience, which is recommended, but not mandatory, for the sequence of CFD courses (CFD 1, 2, and 3) that is offered by the department.
Contents	• Fundamentals of Scientific Computing • Data types, conversions, input, and output • Branching and iteration • Root finding, maximization, and minimization • Numerical differentiation and integration • Numerical errors and their quantification • Random sampling, distribution functions, and statistical moments • Computational efficiency • Functional programming and recursion • Object-oriented programming • Plotting and visualization
Recommended Prerequisites	Interest in computer simulations and/or numerical methods.

Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Kong, Siauw & Bayen. Python Programming and Numerical Methods: A Guide for Engineers and Scientists. Academic Press, 2020. URL: https://pythonnumericalmethods.berkeley.edu/notebooks/Index.html • Guttag. Introduction to Computation and Programming Using Python: With Application to Understanding Data. Second Edition. MIT Press, 2016. ISBN: 9780262529624. URL (code): https://github.com/guttag/Intro-to-Computation-and-Programming • Chapra & Clough. Applied Numerical Methods with Python for Engineers and Scientists. McGraw-Hill Education, 2021. • Theis. Einstieg in Python, Galileo Press, 2011.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	The exam can be in written form or as an oral exam. • For a written examination: 90 minutes duration • For an oral exam: 30 min duration Until the end of the first three weeks of lectures it will be announced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module aims at students, primarily on the Bachelor level, from all disciplines with no or little programming experience.
Module Components	Lecture/Exercise
Components to be offered in the Current Semester	**350406** Lecture/Exercise Introduction to computational thinking and programming for CFD - 4 Hours per Term **350476** Examination Introduction to computational thinking and programming for CFD

Module 13371 ERM-Research-Module

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13371	Compulsory elective

Modul Title	**ERM-Research-Module** ERM-Research-Modul
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	18
Learning Outcome	For students with a strong interest and capability in research, the ERM-Research-Module is an advanced study alternative in the Master's programme. This variant includes in particular the independent preparation of a two-semester research project. The students learn how to work on scientific problem formulation, the target-oriented implementation of experimental approaches and the scientific evaluation and presentation of the results. The students carry out research-orientated tasks which they work on increasingly independently and in exchange with other project participants under the intensive supervision of experienced researchers. The main scope is the development of scientific problem-solving skills by means of information gathering as well as the application of theoretical knowledge acquired in small group advanced seminars.
Contents	The supervising lecturers select suitable topics from their subject areas and intensively support the students in learning the necessary subject-specific and interdisciplinary skills. The contents of the module are regularly adapted in line with ongoing research projects in the participating disciplines.
Recommended Prerequisites	Depending on the topic excellent knowledge in mathematics/statistics, chemistry, biology and/or social as well as environmental sciences is required.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Exercise - 2 hours per week per semester Self organised studies - 480 hours
Teaching Materials and Literature	To be named by supervisor.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Written project report with all factual information about the work (as hard copy and digital form) and a presentation. Written report, 20-30 pages (75%) Presentation of results, 30 min. (25%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module "ERM Research Module" can only be repeated once if it is not passed. It is one of the practical study sections and is therefore excluded from the free trial regulation.
Module Components	• ERM-Research Lecture • ERM-Research Excercise
Components to be offered in the Current Semester	**242100** Lecture/Exercise Environmental Data Science - 4 Hours per Term

Module 13515 Advanced Methods in Process, Energy and Systems Engineering

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13515	Compulsory elective

Modul Title	**Advanced Methods in Process, Energy and Systems Engineering** Erweiterte Methoden zur Prozessmodellierung und Optimierung in der Energie- und Verfahrenstechnik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Arellano-Garcia, Harvey
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	The module requires a basic background in calculus and linear algebra, thus allowing easy understanding of mathematical reasoning. In addition, numerous examples in process, energy, environmental and systems engineering will demonstrate key concepts and algorithms. The practical exercises will involve theoretical derivations and small-size numerical problems in modelling systems like matlab, python, octave, GAMS thus putting knowledge into practice. As part of the block course, students also gain an insight into German technical and everyday language, as well as into German culture.
Contents	This module will teach approaches to modelling and optimization frameworks to address the complex process and energy problems, which arise in design and operation of process and energy systems in an integrated way. Moreover, the presented theoretical and methodological concepts are joined conceptionally with optimal designed experiments to adjust the fundamental mathematical models and to validate the developed process concepts. The taught methods are of generic character, and thus, producing optimal design and operational plans for process and energy systems ranging from microscale to mega-scale stages over operative time horizons from milliseconds to years. The approaches to be discussed will mainly be around superstructure-based modelling, mixed-integer linear and nonlinear programming, multiobjective optimization, optimization under

	uncertainty, and life-cycle assessment. The presented case studies will be around advanced process systems for renewable energy conversion, separation and reaction systems as well as biotechnological production systems.
Recommended Prerequisites	• Basic backround in process engineering • calculus and linear algebra
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	• Script zur Vorlesung • Advanced Optimization for Process Systems Engineering. Ignacio E. Grossmann, Cambridge University Press • Optimization for Chemical and Biochemical Engineering: Theory, Algorithms, Modeling and Applications. Vassilios S. Vassiliadis, Walter Kähm, Ehecatl Antonio del Rio Chanona, Cambridge University Press • Systematic Methods of Chemical Process Design. Lorenz T. Biegler, Ignacio E. Grossmann, Arthur W. Westerberg, Prentince Hall • Nonlinear Programming: Concepts, Algorithms, and Applications to Chemical Processes. Lorenz T. Biegler, SIAM, 2010
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written Examination 90 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• The module takes place as a block course • The appointment will be announced in the current semester
Module Components	• VL Advance Methods in Process, Energy and systems Engineering • Ü Advance Methods in Process, Energy and systems Engineering • P Advance Methods in Process, Energy and systems Engineering
Components to be offered in the Current Semester	**360352** Seminar Advanced Methods in Process, Energy and Systems Engineering - 2 Hours per Term **360351** Lecture/Exercise Advanced Methods in Process, Energy and systems Engineering - 4 Hours per Term **360390** Examination Advanced Methods in Process, Energy and systems Engineering

Module 13517 CFD Seminar

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13517	Compulsory elective

Modul Title	**CFD Seminar** CFD-Seminar
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	After successful participation the students are able to evaluate distinguished fluid mechanical problems from a numerical point of view.
Contents	The numerically evaluated topics are: • Laminar, turbulent, compressible and incompressible flows in technical flows, geophysics, meteorology and reactive flows.
Recommended Prerequisites	• Basics of numeric and fluid mechanics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• Stephen B. Pope, Turbulent Flows, 2000 • Joel H. Ferziger, Numerische Strömungsmechanik, 2007
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Presentation; 20 min (1/3 of grade for the quality of the preparation and 1/3 oral presentation) and • written report; 10 pages (1/3 of grade).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none

Module Components	• SEM CFD Seminar
Components to be offered in the Current Semester	**350411** Seminar CFD Seminar - 2 Hours per Term

Module 13657 How to Talk about Nature?

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13657	Compulsory elective

Modul Title	**How to Talk about Nature?** Wie über Natur sprechen?
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. nat. phil. habil. Schwarz, Astrid
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After passing the module, students understand main philosophical theories of “nature”, interrogate the concept of “nature” and expose its numerous ideological and cultural manifestations. They identify the main ethical dimensions of “nature”, and its crosscultural and political dimensions. Additionally they understand the power of narratives and storytelling to shape our environmental present and future by insight into reading, writing, and visual practices about “nature”.
Contents	“How to talk about nature?” is closely linked to the question of what “nature” is, how it is construed and in which way we act with, in or against it. It is a question that is ontological and epistemological at the same time, it is about how we imagine nature “to be” and how we conceive knowledge about nature. The ideas about this entwinement are manifold over time and in space, different cultures have developed different ways of thinking and also practices of how to deal with a culture/nature distinction. Another important conceptual issue is how nature and technology are related, in contemporary debates for instance, "nature" is often identified with "environment" and as such inescapably entangled with its cultural, political, and technological context. Is the use of technology in “nature” then a threat or an opportunity to build a genuinely sustainable world? This module seeks to answer these and other questions, by approaching “nature” with variously grounded historical and contemporary theoretical approaches. For example, the concept of “nature” was differently interpreted in ancient times, compared to modern contemporary cultures. We will probe the different usage, the scope of historical and cross-cultural depth, the semantics, the images/

	imaginaries, and finally, the logical coherence of “nature” concepts. This variety of topics means that the assigned readings will draw from a wide range of sources. With respect to handle current ecological and technocultural problems, a conscious reflection about “nature” seems to be required. Thus, the module should be also seen, in part, as a way to gain insight into contemporary reading, writing, and visual practices about “nature”. Participation in the accompanying excursion is encouraged.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature and learning materials are given in the course description.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• One short essay, max 1500 words (25%) • Two reviews, each max. 2000 words (each 30%) • 2 oral (group) presentations, about 15 min **OR** weekly submitted written answers to one short question per week on the topical readings to be determined by the instructor (15%) The oral part of the examination can be done digitally or as a virtual meeting if the conditions for an examination in presence are not given.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	60
Remarks	none
Module Components	• Seminar, lecture - 4 hours per week per semester
Components to be offered in the Current Semester	**510112** Lecture/Seminar How to talk about "Nature"? / Ethik und Handeln / Philosophy of Technology and Nature / Natur und Technik / Wissenschaftstheorie, Logik und Naturphilosophie - 4 Hours per Term

Module 13664 Soil Reclamation and Landscape Restoration

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13664	Compulsory elective

Modul Title	**Soil Reclamation and Landscape Restoration** Bodensanierung und Landschaftsrenaturierung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. rer. nat. Badorreck, Annika
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After completing this course the student will be able to understand - the social need for management and protection of soils and ecosystems - prevention stragies of soil degradation and its crucial role in global food security - basic definitions and principles of sustainable and climate-smart agriculture, forestry and land management fundamental features and measures of soil reclamation and landscape restoration - deduction of restored soils functions, ecosystem functions and ecosystem services.
Contents	Scientific content: This course examines principles and strategies for soil reclamation and landscape restoration in tropical and subtropical regions of the Global South. It introduces climate-smart agriculture, forestry and livestock management. Emphasizing sustainable soil and land management, it explains how these practices can mitigate and adapt to climate change. The course also covers Sustainable Land Management (SLM) practices contributing to global goals, particularly SDG target 15.3 on achieving land degradation neutrality. It discusses urban forestry, its ecosystem benefits, and the challenges involved. Additionally, the course addresses soil salinization, proposing strategies for managing its effects on agriculture. Teaching concept: eLearning packages containing thematic lessons were provided to the students in order to engaging students through active self-paced learning. Four online certification tests within these packages account for in total 40% of the modul grade. Seminar: A

	scientific paper covering a topic of the modul is assigned to students. The content of the paper will then be presented as an oral presentation in the seminar at the end of the module by a group of students or as individual followed by a discussion (60% of modul grade).
Recommended Prerequisites	Knowledge of geology, soil science and renaturation
Mandatory Prerequisites	Module 13663 Environmental Soil Science and Plant Nutrition
Forms of Teaching and Proportion	Exercise - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The class is organized as seminar complemented by discussions and individual contributions. Online packages containing lesson materials were provided via moodle. All seminar topics and material is provided prior the seminar via moodle. Self-organized work, in particular independent acquisition of relevant information, is required.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Seminar: One oral presentation, 15 min including discussion (60%) • Excercise as "Flipped-classroom/eLearning": Four online certification tests (4 x 10%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	*Exercise (as eLearning) Soil Reclamation and Landscape Restoration* *Seminar Soil Reclamation and Landscape Restoration*
Components to be offered in the Current Semester	No assignment

Module 13831 Process Simulation in Chemical and Process Engineering

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13831	Compulsory elective

Modul Title	**Process Simulation in Chemical and Process Engineering** Prozesssimulation in der Chemie- und Verfahrenstechnik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Arellano-Garcia, Harvey
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After completing the module, students will be able to analyse physical and chemical phenomena involved in different processes, develop mathematical models and use different process simulation approaches using ASPEN PLUS.
Contents	• Fundamentals: Continuity equations, energy conservation, momentum conservation and state equations; Transport properties; Equilibrium and chemical kinetics; Thermodynamic correlations for estimating physical properties. • Use and scope of mathematical modelling; principles of model formulation; principles of steady-state and dynamic simulation; simulation of models; sequential modular approach; Equation-based approach; analysis of simulation data. • Introduction and use of process simulation software for flowchart simulation • Modelling and simulation of specific systems: e.g., heat conduction in a rod; laminar flow of Newtonian fluid in a pipe; heat exchanger; gravity tank, Power Engineering
Recommended Prerequisites	Physics, Mathematics, Thermodynamics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Handouts and reading list • Manual and tutorial of the modelling programs
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination (90 min)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	none
Components to be offered in the Current Semester	**360351** Lecture/Exercise Prozesssimulation/Process Simulation - 4 Hours per Term **360385** Examination Process Simulation in Chemical and Process Engineering

Module 13832 Optimisation in Process and Energy Systems Engineering

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13832	Compulsory elective

Modul Title	**Optimisation in Process and Energy Systems Engineering** Optimierung in der Verfahrens- und Energiesystemtechnik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Arellano-Garcia, Harvey
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After participating in this module, the students master the basic knowledge, in terms of mathematical optimization methods and tools. Relevant examples from Energy and Process Engineering are used to enhance the understanding of the various tools and methods taught. The focus is on the formulation of the problems and the approaches for their mathematical solution. The methods covered are applied in accompanying calculation exercises.
Contents	• Introduction: Definition, problem formulation, applications • Linear programming • Non-linear programming • Mixed integer non-linear programming • Dynamic optimization • Stochastic optimization
Recommended Prerequisites	• Chemical Engineering • Thermodynamics • Process Systems Engineering
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 135 hours

Teaching Materials and Literature	• T. F. Edgar, D. M. Himmelblau, Optimization of Chemical Processes, McGraw-Hill, New York, 2001 • L. T. Biegler, I. E. Grossmann, A. W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall, New Jersey, 1997 • C. A. Floudas, Nonlinear and Mixed-Integer Optimization, Oxford University Press, 1995 • J. Nocedal, S. J. Wright, Numerical Optimization, Springer, 2006 • R. Baldick, Applied Optimization, Formulation and Algorithms for Engineering Systems, Cambridge University Press, 2006
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination (90 min)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL + Ü + Prü Optimization in Process and Energy Systems Engineerin
Components to be offered in the Current Semester	**360331** Lecture/Exercise Optimierung in der Energie- und Verfahrenstechnik/Optimization in Process and Energy Systems Engineering - 3 Hours per Term **360386** Examination Optimization in Process and Energy Systems Engineering

Module 14069 Biomass and Bioenergy

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14069	Compulsory elective

Modul Title	**Biomass and Bioenergy** Biomasse und Bioenergie
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Hirschl, Bernd
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Students are able to understand the multifunctionality of biomass and know the various pathways of biomass conversion into energy. They are prepared to have critical knowledge regarding biomass cultivation for energy generation by discussing social and environmental concerns, like land use or the competition with food chains. After attending the module, students have expertise in interpreting and presenting scientific texts.
Contents	Sustainable energy generation is seen as one of the largest present challenges of our society. The module “Biomass and Bioenergy” will discuss climate neutral energy systems, where biomass is a sustainable carbon neutral source of energy. This module is highly interdisciplinary. Topics will include: • Overview on biomass production (agriculture and forestry) • Biomass residual waste • Energy conversion technologies • Social and ecological aspects of biomass use • Current bioenergy policies
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The following literature can be used for preparation:

	• Book: Kaltschmitt, M., ed. (2018) Energy from Organic Materials (Biomass). A Volume in the Encyclopedia of Sustainability Science and Technology, 1439 p. Springer DOI:https://doi.org/10.1007/978-1-4939-7813-7 • Book: Srivastava, N., Verma, B. & Mishra, P.K., eds. 2023. Agroindustrial Waste for Green Fuel Application. Springer DOI:https://doi.org/10.1007/978-981-19-6230-1 • Journal “Biomass and Bioenergy” (Elsevier) • Journal “Sustainable Energy Technologies and Assessments” (Elsevier)
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Presentation (15 minutes + discussion) **Final Module Examination:** • Written exam, 120 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Not offered in **summer semester 2026**.
Module Components	• Seminar: Biomass and Bioenergy • Examination: Biomass and Bioenergy
Components to be offered in the Current Semester	No assignment

Module 14132 Multidimensional Approaches for Technology Assessment

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14132	Compulsory elective

Modul Title	**Multidimensional Approaches for Technology Assessment** Multidimensionale Ansätze für Technikfolgenabschätzung
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students know about a range of technology assessment approaches, methodologies and tools to facilitate the evaluation of decarbonization & sustainability transformation options along socio-technological-economical-ecological-political (*STEEP*) dimensions. On completion of the module, students are able to: • Demonstrate a deep understanding of the multidimensional aspects and systemic interactions in the transformation of energy- and carbon-intensive industries; • Gain familiarity with a range of qualitative and quantitative methodologies in conducting technology assessment; • Design and conduct studies to analyze the opportunities and challenges which will be associated with the transformation of energy- and carbon-intensive industries along multiple dimensions; • Identify, assess and evaluate appropriate sources of information and critically reflect on the methodologies commonly implemented for technology assessment and their usefulness/weaknesses.
Contents	Course coverage: • Relevance and development of technology assessment; • Common methodological approaches and their usefulness/weakness; • Data and approaches for assessment (e.g., primary vs. secondary; qualitative vs. quantitative); • Methodologies for socio-political evaluations, techno-economic evaluations and ecological evaluations;

- Application on a case study to assess multidimensional opportunities and challenges associated with the transformation of a specific sector and derive implications along the *STEEP* dimensions based on assessment results.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 1 hours per week per semester
Exercise - 1 hours per week per semester
Study project - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Lee, R.P., Meyer, B., Huang, Q.L, Voss, R. 2020. Sustainable waste management for zero waste cities in China: potential, challenges and opportunities. *Clean Energy*, 4(3): 169 – 201.
- Lee, R.P. 2019. Alternative carbon feedstock for the chemical industry? – Assessing the challenges posed by the human dimension in the carbon transition, *Journal of Cleaner Production*, 219: 786-796.
- Lee, R. P., Tschoepe, M., Voss, R. 2021. Perception of chemical recycling and its role in the transition towards a circular carbon economy: A case study in Germany. *Waste Management*, 125: 280-292.
- Voss, R., Lee, R.P., Seidl, L., Keller, F., Fröhling, M. 2021. Global warming potential and economic performance of gasification-based chemical recycling and incineration pathways for residual municipal solid waste treatment in Germany. *Waste Management*, 134: 206 – 219.
- Keller, F., Lee, R.P., Meyer, B. 2020. Life cycle assessment of global warming potential, resource depletion and acidification potential of fossil, renewable and secondary feedstock for olefin production in Germany. *Journal of Cleaner Production*, 250: 119484.
- Lee, R.P., Scheibe, A. 2020. The politics of a carbon transition: An analysis of political indicators for a transformation in the German chemical industry*, Journal of Cleaner Production*, 244: 118629.

Further materials are provided via Moodle (including lecture slides and additional materials including videos, readings etc.)

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Individual component (E-assessment), 60-90 min - 50%
- Group Project - Part 1: Create a scientific poster (Analysis of e.g., a scientific article, industry report, case study, ...) - 25%
- Group Project - Part 2: Presentation, 15min - 25%

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

- Lectures & Exercises
- Projects

Components to be offered in the Current Semester	No assignment

Module 14462 Lightweight and Active Structures

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14462	Compulsory elective

Modul Title	**Lightweight and Active Structures** Leichte und Aktive Tragwerke
Department	Faculty 6 - Architecture, Civil Engineering and Urban Planning
Responsible Staff Member	Prof. Dr.-Ing. Bleicher, Achim
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	Knowledge / Skills: Bringing together theories, methods and tools from different fields for the optimal design of lightweight and active structures. Competencies: After successful participation in the module, students are able to design, model, optimate and simulate simple lightweight and active structures. The contents of the module are applied by working with the simulation software Sofistik and Matlab/ Simulink.
Contents	• Lightweight design principles • Concepts and Mechanisms for moveable and active structures • Optimization of lightweight structures • Systems for vibration control • Modeling and simulation of simple active structures as a basis for the design of adaptronic systems • Design of adaptronic systems (sensors, actuators, control)
Recommended Prerequisites	Vorgespannte Tragwerke (11694) Schwingungsanfällige Tragwerke (23503)
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Seminar - 1 hours per week per semester Consultation - 1 hours per week per semester Self organised studies - 135 hours
Teaching Materials and Literature	Otto, F., 1972. IL 5 Wandelbare Dächer Convertible Roofs. Karl Krämer,

	Wittenborn and Company, Stuttgart / Bern, New York. Wiedemann, J., 2007, 1996. Leichtbau I und II. Springer-Verlag Isermann, R., 2008. Mechatronische Systeme. Springer Berlin Heidelberg, Berlin, Heidelberg. Housner, Bergman, Caughey, Chassiakos, Claus, Masri, 1997. Structural Control: Past, Present and Future. Journal of Engineering Mechanics Vol. 123, 897–971. Janocha, H., 2007. Adaptronics and Smart Structures. Springer Berlin Heidelberg, Berlin, Heidelberg. Preumont, A., 2011. Vibration Control of Active Structures: An Introduction, Edition: 3rd. 2011. Springer, Berlin.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Preparation of a written project report (ca. 20000 signs) (70%) Presentation of the project results (15 Min.) (15%) Oral examination (15 Min.) (15%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	Lecture / Seminar Lightweight and Active Structures
Components to be offered in the Current Semester	No assignment

Module 14496 Applied Biostatistics for Environmental Data

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14496	Compulsory elective

Modul Title	**Applied Biostatistics for Environmental Data** Angewandte Biostatistik für Umweltdaten
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Djoudi, El Aziz
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	This module will provides a theoretical introduction to data analysis and results interpretation, statistical methods and tools for environmental and biological sciences, as well as applied tools with a particular focus on R programming (R software).
Contents	Part 1. Introduction to experimental design Design principles Random sampling, block design, nested design, split-plot… Replication and Pseudoreplication Part 2. Introduction to R Introduction to the essentials of R Basics: Syntax, packages, writing codes & functions Data handling, analysis and visualisation (graphs and tables) Exercises Part 3. Distributions, Parameters and Estimators Data classification & distribution Measures of central tendency: mean, median … Measures of variability: variance and standard deviation Likelihood and Akaike Information Criterion Exercises Part 4. Univariate analysis T-test and ANOVA (Analysis of variance) Correlation and regression analysis Non parametric analysis (Wilcoxon, Mann-Witney-U, Kruskal-Wallis) linear models & introduction to mixed models Exercises

	Part 5. Multivariate analysis Principal component analysis (PCA) Non-metric multidimensional scaling (NMDS) Redundancy analysis (RDA) & Canonical correspondence analysis (CCA) Exercises
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Zuur, A. F., Ieno, E. N. & Smith, G. M. 2007 Analysing ecological data. New York Gotelli, N. J. & Ellison A. M. 2013 A primer of ecological statistics. Sunderland Dormann, C. 2020 Environmental Data Analysis: An Introduction with Examples in R. Cham Lakicevic, M., Povak, N. & Reynolds, K. M. 2020 Introduction to R for terrestrial ecology: basics of numerical analysis, mapping, statistical tests and advanced application of R, Cham Wilke C.O. 2019 Fundamentals of Data Visualization, O'Reilly Wickham H& Grolemund G, 2017 R for Data Science, O'Reilly
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	- 10 Exercises during the courses (50%)) - Individual project presentation, 15 min. (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	25
Remarks	Please bring your laptop!
Module Components	240740 Lecture/Exercise: Applied Biostatistics for environmental data
Components to be offered in the Current Semester	**240740** Lecture/Exercise Applied Biostatistics for environmental data - 4 Hours per Term

Module 14506 Advanced Geophysical Methods in Natural Resource Investigation (ANRI)

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14506	Compulsory elective

Modul Title	**Advanced Geophysical Methods in Natural Resource Investigation (ANRI)** Fortgeschrittene geophysikalische Methoden zur Erkundung natürlicher Ressourcen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Bordon, Pablo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Understand advanced geophysical methods for subsurface exploration. Gain practical skills in applying geophysical methods in real fieldwork scenarios, including magnetometry, ground-penetrating radar (GPR), electrical resistivity tomography (ERT), and electromagnetics for data acquisition and interpretation Learn to process and interpret geophysical data including airborne data. Develop expertise in using specialized software. Evaluate the efficiency of different geophysical methods in various field conditions. Analyze and mitigate common issues encountered during geophysical surveys.
Contents	**Lecture:** The lecture component of this course will provide an overview of advanced geophysical investigation methods used in subsurface exploration. It will cover the principles of magnetometry, ground-penetrating radar (GPR), geoelectrics and electromagnetic methods, along with an introduction to radiometry and its applications in natural resource exploration. Students will learn about data acquisition techniques for both ground and airborne geophysical surveys, and explore the challenges associated with data interpretation. Additionally, the lecture will address typical workflows used in the processing of geophysical data to ensure accurate results.

	Practical Training: The practical training component will focus on providing hands-on experience in fieldwork, utilizing magnetometry, GPR, geoelectric, electromagnetic instruments. Students will actively participate in data acquisition and analysis using specialized software. They will gain experience in processing, and learn how to apply these methods effectively in real exploration scenarios. Practical training will also include the development of field reports and presentations based on data collected during field activities, helping students to refine their skills in communicating technical results.
Recommended Prerequisites	none
Mandatory Prerequisites	Successful completion of the NRI module 42421 – Natural Resource Investigation
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Material provided by the Chair
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Exam for the lecture (60 minutes) Presentation (15 minutes) and report for the practical training (10-15 pages)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	15
Remarks	none
Module Components	Lecture Practical training Exam
Components to be offered in the Current Semester	**240813** Lecture Advanced Geophysical Methods in Natural Resource Investigation (ANRI) - 2 Hours per Term **240814** Practical training Advanced Geophysical Methods in Natural Resource Investigation (ANRI) - 2 Hours per Term **240815** Examination Advanced Geophysical Methods in Natural Resource Investigation (ANRI)

Module 14781 Biological Methods for Biomass and Waste Treatment

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14781	Compulsory elective

Modul Title	**Biological Methods for Biomass and Waste Treatment** Biologische Verfahren der Biomasse- und Abfallbehandlung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. habil. Abendroth, Christian
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	<p data-start="0" data-end="990">Students are introduced to ecologically and economically viable alternatives to conventional waste treatment, with integrated and system-oriented solutions at the core. Particular emphasis is placed on anaerobic microbiomes and their central role in biological conversion processes such as anaerobic digestion, composting, and other innovative approaches to residual waste valorization. Building on microbiological and biochemical fundamentals, functional principles, process dynamics, and efficiencies are analyzed and transferred to real-world applications. In addition to established technologies, current research approaches, international developments, and novel process combinations—including contributions from the instructor’s own research—are addressed. The aim is to develop an in-depth understanding of the material and energy recovery of residuals within the context of a sustainable circular economy, and to foster the ability to independently design system-oriented solutions. <p data-start="992" data-end="1542" data-is-last-node="" data-is-only-node="">An interactive teaching format forms the didactic core: during the sessions, students continuously work on tasks whose results contribute to the overall assessment. This supports an active learning process that promotes analytical thinking, applied competence, and scientific discussion.
Contents	<p data-start="0" data-end="361">The course provides a solid yet practice-oriented introduction to the biological utilization of residual materials within the context of a sustainable circular economy. Starting from the fundamentals of biology and photosynthesis, it first examines the ”food vs. fuel” debate in order to critically assess conflicts

between food production and bioenergetic use. <p data-start="363" data-end="906">Subsequently, key processes of biological waste treatment are covered, including composting, biogas production, and dark fermentation. These processes are considered not only from a technological perspective, but particularly from the viewpoint of anaerobic microbiomes, which are understood as the driving force behind material transformations. An introduction to microbiomes and their analysis—from taxonomic profiling to functional approaches such as proteomics—enables a deeper understanding of microbial communities and their performance. <p data-start="908" data-end="1251">Building on this, central metabolic processes such as fermentation and methanogenesis are examined in detail and placed in the context of technical applications. In addition, innovative and less established approaches—such as the use of insects, bioleaching, remediation strategies, and novel materials and systems (e.g., SLMs)—are introduced. <p data-start="1253" data-end="1504" data-is-last-node="" data-is-only-node="">The course combines current research with application-oriented knowledge and offers an interdisciplinary perspective on biological transformation processes, with the aim of developing sustainable and creative solutions for future resource utilization.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 4 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

Kranert M. Einführung in die Kreislaufwirtschaft, Springer Vieweg Wiesbaden, 2017, https://doi.org/10.1007/978-3-8348-2257-4
Bischofsberger, Dichtl, Rosenwinkel, Seyfried, Böhnke. Anaerobtechnik. Springer-Verlag Berlin Heidelberg 2005, ISBN: 3-540-06850-3
Further literature will be announced during the course
<p data-start="0" data-end="129">

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

<div id="meta-origin" data-coolorigin="https%3A%2F%2Fwww.b-tu.de%2Forgcloud%2Fapps%2Frichdocumentscode%2Fproxy.php%3Freq%3D%2Fcool%2Fclipboard%3FWOPISrc%3Dhttps%253A%252F%252Fwww.b-tu.de%252Forgcloud%252Findex.php%252Fapps%252Frichdocuments%252Fwopi%252Ffiles%252F11244624_ochtzup9yafk%26ServerId%3DF84FA4B4%26ViewId%3D7%26Tag%3D58C29858B529DFEC"> Assessment in this module follows a continuous, dialogue-based oral approach. Students are asked to demonstrate their understanding of the course content by answering subject-specific questions and by formulating questions for their peers. The assessment takes place regularly throughout the semester and aims to evaluate subject-specific knowledge, understanding, and the ability to engage in academic discussion. <p> oral assessment generally after every second lecture approximately 15–20 minutes per assessment session 1–2 questions per student approximately every two weeks approximately 10 assessed questions per student

	over the semester 1 point for each successfully completed question assessment of answers based on subject-specific correctness and demonstrated understanding assessment of student-formulated questions based on scientific relevance, clarity, and appropriateness All assessed questions/tasks are weighted equally. The overall assessment result is calculated based on the proportion of points achieved out of the total number of points available (100%). comparable number and level of assessment opportunities for all students
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	238117 Lecture / Seminar: Biological Processes in Biomass and Waste Treatment <p><br data-start="84" data-end="87" />
Components to be offered in the Current Semester	**238117** Lecture/Seminar Biologische Verfahren der Biomasse und Abfallbehandlung - 4 Hours per Term

Module 42421 Natural Resource Investigation

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	42421	Compulsory elective

Modul Title	**Natural Resource Investigation** Rohstofferkundung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Herd, Rainer
Language of Teaching / Examination	English
Duration	2 semesters
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	• Get to know geological processes and to understand the role of these processes for the formation of natural resources • Become acquainted to the processes leading to the genesis of different raw materials • Study methods and techniques for investigation of natural resources • Use these investigation methods in the field and in the lab • Be able to present working results in an oral presentation and to defend them in an open discussion • Get an insight in the work of a professional exploration company during an excursion
Contents	**Lecture Prospection and Exploration of Natural Resources** The lectures provides an overview about the geological processes which are responsible for the formation of different natural resources including energy resources, metals, industrial minerals and ground water. Methods for the prospection and exploration of these resources are presented using geological, geophysical, geochemical and remote sensing techniques. Advantages and disadvantages of the methods are discussed. **Practical training Prospection and Exploration of Natural Resources** The focus of this course is the practical training of the prospection and exploration methods in the field and in the lab. Geological, geophysical and remote sensing techniques are used in order to detect e.g. raw material deposits. **Lecture/exercise Introduction to Coal Petrology** Lecture and practical training at the microscope.

	The lecture provides an overview about the genesis of coal seams and about the microscopic constituents of coal. The maceral concept is introduced. It is shown that coal is also a source of environmental information. The student will do a reconstruction of the paleoenvironment by using microscopic maceral analyses. **Excursion Prospex** Field trip to an active exploration site. Topics: Geological setting, exploration technology, efficiency and costs.
Recommended Prerequisites	• General high school knowledge in physics • Basics in geology
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 1 hours per week per semester Excursion - 8 hours Practical training - 3 hours per week per semester Self organised studies - 67 hours
Teaching Materials and Literature	Material provided by the Chair
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Written examination, 80 min. (50%) • Written essay, 8-10 pages (30%) • Short report about results of the microscopic analyses (20%) Excursion participation is mandatory.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	**Winter semester:** • 240809 Lecture Prospection and Exploration of Natural Resources • 240808 Excursion Raw Material Exploration • 240804 Lecture/Exercise Introduction to coal petrology • 240869 Examination Prospection and Exploration of Natural Resources **Summer semester:** • 420830 PR Prospection and Exploration of Natural Resources • 842090 Examination Prospection and Exploration of Natural Resources
Components to be offered in the Current Semester	**240809** Lecture Prospection and Exploration of Natural Resources (Modul 42421) - 2 Hours per Term **240808** Excursion Raw Material Exploration (Modul 42421) **240804** Lecture/Exercise Introduction to coal petrology (Modul 42-4-21) - 2 Hours per Term

240869 Examination
Prospection and Exploration of Natural Resources (Modul 42421)

Module 44107 Safety- and Risk-Analysis for Process Plants

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Umwelttechnik

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	44107	Compulsory elective

Modul Title	**Safety- and Risk-Analysis for Process Plants** Sicherheits- und Risikoanalyse für Prozessanlagen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Arellano-Garcia, Harvey
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After completing the module, students will be able to apply basic methods for performing and evaluating safety-related aspects for industrial plants. They learn methodical basics for the evaluation of probabilities of occurrence and the derivation of the resulting consequences. Using the methods taught for qualitative and quantitative risk assessment, students are able to independently develop sustainable concepts and solutions. They also have basic knowledge of safety-related plant optimization and can communicate this to plant operators, authorities, etc.
Contents	• Hazard identification methods (e.g. Checklists, FMEA, HAZOP) • Frequency evaluation methods (event tree, fault tree) • Consequence evaluation methods (e.g. one- and two phase flow (critical, sub-critical), dispersion of neutral and dense gas, fire, explosion and toxic hazards) • Qualitative and quantitative risk assessment methods • Safety related plant optimization Exercise: • Realization of safety and risk studies (method, case study)
Recommended Prerequisites	None
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester

	Practical training - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Lecture notes • Lees,F.P.: Loss prevention in the process industries, Butterworth 1996, Oxford • Guidelines for chemical process quantitative risk analysis AICHE,1989, New York • Guidelines for hazard evaluation procedures AICHE , 1992, New York • W.F.Kenney: Process risk management systems, VCH 1993, New York • D. A. Crowl;J. F. Louvar: Chemical process safety, Prentice Hall, Inc., 2002, New Jersey
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of the exercises within the practical training **Final module examination:** • Written examination, 90 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	None
Module Components	• 238227 Lecture Safety and risk analysis • 238231 Examination Safety- and risk-analysis
Components to be offered in the Current Semester	**360375** Examination Safety- and Risk-Analysis for Process Plants

Module 11243 Master Thesis

assign to: Modules at the Brandenburg University of Technology Cottbus-Senftenberg (Home at Technological University of Pereira)
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11243	Mandatory

Modul Title	**Master Thesis** Master-Arbeit
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	30
Learning Outcome	The Master Thesis is an examination in which the student must show that he or she can independently and successfully deal with an assignment within a set deadline and contribute scientifically founded theoretical and practical knowledge to the solving of a problem. The Master-thesis should correspond to the advanced knowledge base of the subject. The Master Thesis consists of written work and its defence.
Contents	The Master Thesis can be practical as well as theoretical. It should relate the advanced standard of knowledge in the scientific field. The Master thesis consists of the written work and its defence.
Recommended Prerequisites	none
Mandatory Prerequisites	Successful completion of the modules (except for students with UTP as home university): • 41514 Study Project • 41421 Introduction to Environmental and Resource Management II **Additionally for Examination and Study Regulation of 2021 (including Double Degree):** • an achievement of an overall minimum amount of 72 credit points. **Additionally for Examination and Study Regulation of 2011:** • an achievement of an overall minimum amount of 78 credit points.
Forms of Teaching and Proportion	Self organised studies - 900 hours

Teaching Materials and Literature	It depends on the individual subject. Corresponding material will be named and provided by the supervisor.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	The grade of the Master thesis results from the thesis, which accounts for 75 percent, and its defense, which accounts for 25 percent.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The academic supervisor is responsible for the topic and the content of the thesis.
Module Components	None
Components to be offered in the Current Semester	No assignment

Module 12261 Ecological Excursion

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12261	Compulsory elective

Modul Title	**Ecological Excursion** Ökologische Exkursion
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Birkhofer, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	12
Learning Outcome	The Ecological Excursion module provides hands-on experience of biodiversity threats and conflicts and basic ecological adaptations to dryland conditions. **Part "Ecological Excursion: Seminar"** The seminar introduces students to the main components of terrestrial dryland ecosystems and provides a forum for discussion of topics relevant to the field trip. Students will learn about: • biodiversity crisis and threats • human-wildlife conflicts • German colonial history • competent use of English **Part "Ecological Excursion: Excursion"** The Ecological Excursions provide a hands-on experience that combines elements of scientific expeditions, teamwork projects and taxonomic identification of organisms. Students will learn about: • independent and team-oriented ecological project work • adaptations of animals and plants to local conditions • poverty alleviation and food security • geological and hydrological conditions and processes • ecological concepts such as food webs, species inventories, sampling theory
Contents	**Part "Ecological Excursion: Seminar"** • Fauna and Flora (plants, vertebrates, invertebrates)

- contemporary ecological challenges (biodiversity conservation, climate change, invasive species, ecosystem services)
- contemporary social challenges (human wildlife conflicts, poaching, food security, colonial history)

The seminar classes are organised as 8 double blocks of lectures by the lecturer and seminar presentations by the students during the semester. Lectures will be complemented by discussions and individual contributions from students. Self-organised work is required, in particular the preparation of seminar presentations and the acquisition of previously discussed content for the field trip.

Part "Ecological Excursion: Excursion"

- study design and hypothesis testing
- multidisciplinary teamwork
- communication skills

The field trip will last up to 16 days.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 1 hours per week per semester
Seminar - 2 hours per week per semester
Excursion - 10 hours per week per semester
Self organised studies - 165 hours

Teaching Materials and Literature

Relevant literature and equipment needed during the field trip will be provided to the participants.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

Part "Ecological Excursion: Seminar"
One oral presentation, 15 min followed by discussion (50%)

Part "Ecological Excursion: Excursion"
An individual log of a pre-assigned field day (25%) and a species list of a pre-assigned taxonomic group after the field day (25%, one list for every two students participating).

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

8

Remarks

The excursion to Namibia is associated with costs for participants (around 2.500 €). In previous years, stipends were available for qualified students to reduce the costs.
PLEASE NOTE: The module can only be offered with a minimum number of 8 participants! If fewer than 8 participants register for the module, the module must be cancelled.

Module Components

- 240708 Lecture/Seminar Ecological Excursion: Seminar
- 240709 Excursion Ecological Excursion: Excursion

Components to be offered in the Current Semester	**240709** Excursion Ecological Excursion: Excursion **240708** Lecture/Seminar Ecological Excursion: Seminar - 3 Hours per Term

Module 12826 Mathematical Data Science

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12826	Compulsory elective

Modul Title	**Mathematical Data Science** Mathematische Grundlagen der Data Science
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. Hartmann, Carsten
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	8
Learning Outcome	After successfully completing the module, students have deepened their knowledge of stochastics acquired in the basic modules. They know the mathematical and statistical methods from data analysis. They have acquired basic skills for in-depth modules in stochastics or optimization. They have gained experience in doing independent research.
Contents	Choice of the following topics • Concentration of random vectors in high dimensions • Concentration inequalities • Linear and nonlinear principal component analysis (PCA) • Random matrices • Sparse recovery (compressed sensing) and LASSO regression • Introduction to statistical learning • Kernel methods and Gaussian processes • Applications in signal and image processing, random networks, …
Recommended Prerequisites	Knowledge of the content of the modules • 11103 : Analysis I • 11104 : Analysis II • 11101 : Lineare Algebra und analytische Geometrie I • 11217 : Wahrscheinlichkeitstheorie or very good knowledge of the content of the modules • 11113: Mathematics IT-2 (Linear Algebra) • 11213: Mathematics IT-3 (Analysis) • as well as of the content one of the modules

	- 11917 : Mathematik W-3 (Statistik) - 11926 : Statistik für Anwender - 11212 : Statistics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• C.M. Bishop. Pattern Recognition and Machine Learning. Springer, 2006. • D.P. Dubhashi, A. Panconesi. Concentration of Measure for the Analysis of Randomized Algorithms, Cambridge University Press, 2009. • R. van Handel. Probability in High Dimension. Lecture Notes, Princeton University, 2016. • R. Vershynin. High-Dimensional Probability: An Introduction with Applications in Data Science, Cambridge University Press, 2018
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of a semester project **Final module examination:** • Project presentation, 45 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Stochastics“ or in complex „Optimization “ • Study programme Mathematik B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend • Study programme Wirtschaftsmathematik B.Sc.: Compulsory elective module in complex „Specialisation“, in limited extend • Study programme Artificial Intelligence M.Sc.: Compulsory elective module in complex „Learning and Reasoning“ • Study programme Informatik B.Sc.: Compulsory elective module in „Applied Mathematics“ or in field of application „Mathematics“ • Study programme Informatik M.Sc.: Compulsory elective module in „Mathematics“ or in field of application „Mathematics“ • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject“
Module Components	• Lecture: Mathematical Data Science • Accompanying exercise
Components to be offered in the Current Semester	No assignment

Module 12942 Introduction to Climate Variability and Climate Change Projections

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12942	Compulsory elective

Modul Title	**Introduction to Climate Variability and Climate Change Projections** Einführung in Klimavariabilität und Klimaänderungsprojektionen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. rer. nat. Will, Andreas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The students shall be made familiar with natural climate variability and the expected climate change in selected regions. They shall be enabled to understand and to use the results of Climate System Models. In this way a sound basis for climate impact assessment in different regions will be provided.
Contents	Part Lecture: 1. Climate state and climate variables 2. Physical basis of • 1. climate system dynamics • 2. anthropogenic climate change 3. Observational evidence of anthropogenic climate change 4. Design and history of climate system models • 1. Global Climate System Models • 2. Regional Climate System Models • 3. Statistical Climate Change Signal Models 5. Evaluation of climate system models 6. Emission Scenarios and Climate Change Projections 7. Climate Change Signal Assessment • 1. Climate Change Signal in selected regions • 2. Uncertainties of Climate Change Signals • 3. Climate sensitivity • 4. Reliability of climate projections

	8. Climate System Model bias correction and Climate impact modelling Part Exercise: Exercises supporting the understanding of the lectures and the ability to use Climate System Model results are introduced by the lecturer. These exercises are to be solved by the students in form of self-organized studies. The solutions will be presented and discussed by the students during the exercise.
Recommended Prerequisites	Basic skills in mathematics, classical mechanics and thermodynamics are expected, Advanced skills in vector calculus and tensor analysis, statistics and discrete mathematics, in fluid mechanics and thermodynamics are very helpful in gaining understanding of the lectures and provide a sound basis for solving the exercises.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Climate Change 2013: The Physical Science Basis, Working Group 1 Contribution to the fifth Assessment Report of the IPCC, Editor: IPCC. Further literature together with lecture and exercise materials are made available in electronic form during the semester.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Solution of 3 exercises (50%) • Written examination, 45 Min. (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	**No offer in winter semester 2024/2025.**
Module Components	none
Components to be offered in the Current Semester	**240158** Lecture Physical basis of climate change - 2 Hours per Term **240159** Exercise Physical basis of climate change - 2 Hours per Term

Module 12949 Geoecology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12949	Compulsory elective

Modul Title	**Geoecology** Geoökologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr.-Ing. Repmann, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	**Rationale** Geoecology is an interdisciplinary science that integrates the geosciences with the life sciences. The purpose of this module is to extend the basic knowledge of geoecology with respect to anthropogenically induced challenges. Selected issues of soil science and applied soil protection, and related ecological problems will be reflected. Furthermore, the fundamentals of environmental toxicology with regard to adverse effects of chemicals on living systems will be taught. **Lecture:** The lecture of ecotoxicology deals with the potentially harmful impact of chemicals, present as pollutants in the environment, to living organisms with particular focus on soil. In this course students will learn about: - aspects of geoecology - basic concept of ecotoxicology - existing natural and synthetic chemicals - influence of industrial and agricultural development/processes with regard to chemicals in the environment - fate of chemicals (distribution, uptake, accumulation and possible degradation) - detection and risk assessment of contamination **Exercise/Practical training:**

The exercise/practical training offers a practical approach, which is necessary to understand the fundamentals of geoecological research. Students will learn about:
- study design and planning
-field sampling
-laboratory analyses
-preparing a scientific report

Contents

Part 1: Lecture:
- goals and definitions
- classes/groups of chemicals and their potential negative impacts on the environment
- routes of entry of these chemicals into the environment and relevance
- fate of chemicals
- general principles of ecotoxicology -> toxicity -> dose-response relationships -> reception
- factors that can possibly influence the toxicity of environmental chemicals
- investigation methods

o measurement and assessment of basic site/soil parameters
o selected toxicity tests
o risk assessment
· special investigation methods and selected case studies
· phytoremediation
· two short tests (approx. 30 minutes each)

Part 2: Exercise/Practical training, practical work in the field and laboratory:
· study design/problem formulation
· sampling in the field
· laboratory analysis
· writing a technical report

Recommended Prerequisites

Knowledge in chemistry, biology and soil science

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Exercise - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Huggett, Richard J. (1995): Geoecology: An evolutionary approach. New York, Routledge.
- Dickinson, G. & Murphy, K. (1997): Ecosystems, A Functional Approach. Routledge Introductions to Environment, ISBN: 0-203-13248-3.
- Ballantyne, B. (Ed.) (1999): General and Applied Toxicology. Macmillan, London.
- Walker, C. H., Sibly, R. M., Hopkin, S. P. & Peakall, D.B. (2012): Principles of Ecotoxicology -4th ed. Boca Raton, CRC Taylor & Francis.
- Fent, K. (2007): Ökotoxikologie, Umweltchemie, Toxikologie, Ökologie. 3. Auflage. Stuttgart, New York, Thieme.

	• Newman, M. C. & Unger, M. A. (2003): Fundamentals of Ecotoxicology. 2nd ed., Boca Raton, Lewis Publishers. • Crosby, D. G. (1998): Environmental Toxicology and Chemistry, Oxford University Press, New York. McBride, M. B. (1994): Environmental chemistry of soils. Oxford University Press.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Lecture: two tests; each of the two written tests lasts approximately 60 minutes (25% each, together 50% of final grade), • Exercise/Practical training: written laboratory report, 20-25 pages (50% of final grade)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	7
Remarks	none
Module Components	• 240437 Lecture Ecotoxicology • 240411 Exercise/Practical training Geoecology
Components to be offered in the Current Semester	**240437** Lecture Ecotoxicology - 2 Hours per Term **240411** Exercise/Practical training Geoecology

Module 12959 Geopedology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12959	Compulsory elective

Modul Title	**Geopedology** Geopedologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. phil. Raab, Thomas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Geopedology deals with an integrative approach of soil science, geomorphology and geology. Students will learn the main factors and processes controlling soil formation and soil properties as well as landform evolution. The significance of both past and modern human impacts for ecosystems will be shown. Attention is paid to natural and anthropogenic processes of landscapes development in the mid-latitudes during the Late Pleistocene and Holocene.
Contents	Fundamentals in Pedology Fundamentals in Geomorphology Soil-landscape relationships Methods in Geopedology
Recommended Prerequisites	Knowledge in Quaternary Science, Geology, Soil Science or Physical Geography
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	none
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Lecture: 2 Exams, each 45 min. for 25 points each • Seminar: 4 Exams, each 45 min. for 12,5 points each

Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240421 Seminar Geopedology • 240401 Lecture Geopedology
Components to be offered in the Current Semester	**240401** Lecture Geopedology - 2 Hours per Term **240421** Seminar Geopedology - 2 Hours per Term

Module 13046 Microclimates

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13046	Compulsory elective

Modul Title	**Microclimates** Mikroklimate
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Trachte, Katja
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The module offers in-depth insight into spatio-temporal atmospheric phenomena with special reference to urban areas and their periphery. Students acquire a basic knowledge of cross-scale processes and mechanisms related to local (topo-) climates, get the competence to carry out climatological analysis in space and time applying IT-based methodologies such as statistical analyses and machine learning approaches.
Contents	In the lecture professional aspects of microclimates are addressed, such as: • definition of microclimates • physical systems • differences in atmospheric conditions • influence of elevation and land use types • radiation budget • UHI • local scale wind systems and ventilation • ABL and NBL The exercise consists of two parts: Part 1 Exercises • analysis of spatio-temporal atmospheric data, e.g. in-situ measurements and spatial-explicit data • IT-based training using GIS and programming languages such as Python • Statistical analysis and machine learning approaches

	Part 2 Field campaign: • one coherent field campaign including measurements of microclimatological conditions
Recommended Prerequisites	Basic knowledge in atmospheric sciences and climatology, basic knowledge in statistics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Excursion - 12 hours Self organised studies - 108 hours
Teaching Materials and Literature	Recommended literature: Thomas Foken: Micrometeorology. Springer, Berlin, 2017. Roger G. Barry: Microclimate and Local Climate. Cambridge University Press, 2016.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1. Weekly exercises in form of data analyses and visualization (30%) 2. Submission of a research project (70%), 8-10 pages; c. 2000-3000 words
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	Lecture – Microclimates Exercise - Microclimates Field campaign - Microclimates
Components to be offered in the Current Semester	No assignment

Module 13221 Land surface - Atmosphere Interactions

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13221	Compulsory elective

Modul Title	**Land surface - Atmosphere Interactions** Landoberflächen - Atmosphären Interaktion
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Trachte, Katja
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The module offers fundamental knowledge of physical processes and methodologies related to land surface – atmosphere interactions and its relevance in the context of climate change, e.g. carbon and water cycle, factors of changes in surface energy fluxes, soil-vegetation-atmosphere transport, ecophysiological interactions. Students get the competence to assess relevant aspects related to global change as well as to apply IT-based approaches.
Contents	In the lecture professional aspects of land surface – atmosphere interactions are addressed, such as: · turbulence and the development of PBL structure · carbon cycle · water availability · water use efficiency · ecophysiology · measurement techniques, e.g. eddy-covariance · remote sensing · modeling approaches In the exercise the knowledge gained will be applied using the programming language Python to trainee statistical data analyses (e.g. spatial data mining, machine learning approaches, GLM) and visualization in the field of atmospheric / environmental sciences.
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	none
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1. Weekly exercises in form of data analyses and visualization (30%) 2. Submission encompass 8-10 pages including approx. 2000-3000 words. A group submission is scheduled. Individual grading can be achieved according to the uploaded program code. (70%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	Lecture – Land surface – Atmosphere Interaction Exercise - Land surface – Atmosphere Interaction
Components to be offered in the Current Semester	**240126** Lecture Land surface - Atmosphere Interactions - 2 Hours per Term **240128** Exercise Land surface - Atmosphere Interactions - 2 Hours per Term

Module 13234 Communication of Science and Technology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13234	Compulsory elective

Modul Title	**Communication of Science and Technology** Wissenschafts- und Technikkommunikation
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Students will know about different techniques, tools and formats for communication of science & technology. They will develop skills to break down complex issues at the nexus of science, technology and society to communicate science/technical information in a clear, understandable and engaging way to different stakeholders. On completion of the module, students will be able to: • Articulate the key issues and challenges in communicating about science & technology; • Understand the nature of different audiences for better stakeholder engagement; • Demonstrate awareness of and ability to use a variety of different techniques and media for targeted audience; • Improve their skills in communication of scientific/technical information in both written and oral forms; • work as part of a team to develop effective measures for communication of science & technology; • Provide constructive feedback to other students on their communication skills.
Contents	Course coverage: • Key issues in communication of science & technology; • Identify and knowing your audiences (mental models, risk perception, heuristics and biases, …); • Getting your audience's attention (Types of framing); • Communicating risk and uncertainty; • Formats for communication of science & technology.

	Students will also be given opportunities to receive feedback and improve their own written and oral skills. They will also work in small teams on team projects to further their skills for communicating about sustainability issues. These projects will focus on communicating about a given scientific topic to a particular audience using spoken, visual, written or web-based communication.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Center for Research on Environmental Decisions (CRED). 2009. *The Psychology of Climate Change Communication: A guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public.* New York. • Nisbet, M.C., Scheufele, D.A. 2009. What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, 96(10): 1767-1778. • Bubela, T., Nisbet, M., Borchelt, R. *et al.* 2009. Science communication reconsidered. Nature Biotechnology, 27, 514–518. • Nelkin, D. 1989. Communicating technological risk: The social construction of risk perception. *Annual Review Public Health*, 10, 95-113. • Tversky, A., Kahneman, D. 1974. Judgment under Uncertainty: Heuristics and Biases. Science, New Series, 185(4157), 1124-1131. Further material (including lecture slides and additional materials including videos, readings etc.) might be announced during the first class meeting.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Individual E-Assessment – 60 min (40%) • Group project - Part 1: Science Communication Material e.g., poster, video, etc. (30%) • Group project - Part 2: Group presentation– 15min oral presentation (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture / Seminar
Components to be offered in the Current Semester	**510601** Lecture/Seminar Communication of Science & Technology - 4 Hours per Term

Module 13298 Basics for Freshwater Management

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13298	Compulsory elective

Modul Title	**Basics for Freshwater Management** Grundlagen des Gewässermanagements
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. habil. Martin-Creuzburg, Dominik
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students understand freshwaters as ecosystems and know the ecological principles underlying ecological management and how to differentiate between naturally and anthropogenically introduced variability in freshwater ecosystems. They know the main groups of freshwater organisms, and understand the functioning and biogeochemical role of lake and stream ecosystems and their role in landscapes. Specifically, students understand how freshwater organisms achieve the freshwater ecosystem services that humans require. Students know the main anthropogenic impacts on freshwater resources. They understand the consequences of these impacts through their interaction with ecological processes. Students will thus be able to evaluate the consequences of major impacts to aquatic organisms and ecosystem functioning and related those to the European Water Framework Directive as the base for evaluation and management of freshwater resources.
Contents	Physical and chemical properties of water. Running water ecosystems: Characteristics, variability and typology, connected functional compartments and main groups of organisms, ecosystem functioning, matter transformation and ecosystem services. Ponds and lakes: Genesis and typology, biogeochemistry of water and sediment, habitats and organisms; lake shores and macrophyte ecology. Main water quality problems related to agriculture, forestry, urbanization and mining; eutrophication, acidification, salinization, siltation, contamination, effects of neobiota; hydromorphological degradation of streams and rivers; loss of ecosystem services in degraded freshwaters; expected impacts of climate change. Principles of sustainable water

	management; principles of lake diagnosis, quality assessment and evaluation as prerequisites for mitigation and restoration; EU Water Framework Directive; overview on strategies to conserve and improve impacted freshwaters.
Recommended Prerequisites	Basics in environmental sciences, ecology or similar.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	All course materials (lectures and video-based learning materials, as well as assignments, exercises, and self-tests) are made available on Moodle on a weekly basis.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Three written exams during the semester. Each partial exam counts for 25% of the module grade. • Students earn the remaining 25% of points via continued assessment through five work portfolios (ca. 1000 words each), five self-assessments, two exercises (4 questions/calculations each) and an oral exam (10 min). An opportunity to re-write a partial exam in the second examination period is only offered to students on sick leave.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module is taught as online course via Moodle. The course follows a blended learning concept in a strict weekly rhythm. It consists of A) self-organized study of the learning material of the week (learning and lecture videos, reading material, exercises) and B) live meetings in the online classroom for clarification of open questions and discussions to reflect and consolidate the understanding of the past week's learning material. The blended learning in weekly rhythm requires continuous participation. Enrolment in the Moodle course is mandatory for this module. The module starts with an online meeting on the first Monday of the semester. All three partial exams will be closed book exams and take place in presence in the course of the semester. The module is a mandatory prerequisite for the course Freshwater Restoration Ecology (module 42505) which is offered in summer semester.
Module Components	Basics for Freshwater Management (e-learning course)
Components to be offered in the Current Semester	**240501** Lecture/Exercise

Basics for Freshwater Management (e-learning module) - 4 Hours per Term
240503 Examination
Examination Basics for Freshwater Management

Module 13300 Environmental Data Science

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13300	Compulsory elective

Modul Title	**Environmental Data Science** Umweltdatenwissenschaft
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. Ryo, Masahiro
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After the course, students will acquire both hard and soft data science skills essential for solving issues in environmental science, such as data handling, data visualization, data analysis, data interpretation, and data communication. These practical skills will be supported by fundamental statistical and programming knowledge. The students will be fluent in the R programming language beyond the basic level.
Contents	Part 1. Introduction to environmental data science Part 2. Data handling - Coding Basics in R, data import & data transformation Part 3. Data visualization - Various types of data visualization Part 4. Data analysis - Basic statistics - Statistical modelling: classification and regression - Machine learning modelling: Classification and regression Part 5. Data interpretation - Model interpretation - Common pitfalls Part 6. Data communication - Storytelling with data: Basic rules & practical tips
Recommended Prerequisites	• Experience in R programming language • Basic knowledge of statistics (probability theory, hypothesis testing, correlation, linear model)
Mandatory Prerequisites	None

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Most of the textbooks are freely available from the links thanks to the fantastic authors: • H. Wickham & G. Grolemund: R for Data Science (https://r4ds.had.co.nz/index.html) • R. A. Irizarry: Introduction to Data Science (https://rafalab.github.io/dsbook/) • Hands-On Programming with R (https://rstudio-education.github.io/hopr/index.html) • C.O.Wilke: Fundamentals of Data Visualization (https://clauswilke.com/dataviz/) • B. Boehmke & B. Greenwell: Hands-On Machine Learning with R (https://bradleyboehmke.github.io/HOML/) • C. Molnar: Interpretable Machine Learning (https://christophm.github.io/interpretable-ml-book/) • C. N. Knaflic: Storytelling with Data (https://www.storytellingwithdata.com/)
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Exercises during course (10 small programming exercises; 6% each; 60% in total) • Oral presentation based on self-organized project: 15 min incl. discussion (40%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	15
Remarks	This module will be offered as a block course. Please bring your laptop.
Module Components	242100 Lecture/Exercise: Environmental Data Science
Components to be offered in the Current Semester	**242100** Lecture/Exercise Environmental Data Science - 4 Hours per Term

Module 13580 Systems and Process Hydrology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13580	Compulsory elective

Modul Title	**Systems and Process Hydrology** System- und Prozesshydrologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Kästner, Karl
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students are able to analyse hydrological processes and to obtain and interpret hydrological data from hydrological annuals and internet sources. They can use standard procedures for hydrological dimensioning, probability analysis and extreme value statistics (especially flood statistics). They are furthermore able to apply basic methods of deterministic simulation of hydrological processes, modelling and modelling.
Contents	Description of hydrological processes as well as evaluation and presentation of associated data; adaptation of distribution functions to runoff data, derivation of flood design values with different data; design precipitation. Basic system hydrological description approaches; application of system hydrology for river basin modelling. Deepening of the methods in exercises with practical examples.
Recommended Prerequisites	knowledge of hydrology
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Lecture presentations, scripts for the exercises, literature references and questionnaires are made available via the online portal Moodle. Further literature:

	• Maniak, 2010: Hydrologie und Wasserwirtschaft. Eine Einführung für Ingenieure, e-book. https://katalog.ub.b-tu.de/search?bvnr=BV036607172 • DYCK, S. u.a.: Angewandte Hydrologie, Teil 1, VEB Verlag für Bauwesen, Berlin 1980 • DYCK, S. u.a.: Angewandte Hydrologie, Teil 2, VEB Verlag für Bauwesen, Berlin 1980 • SCHÖNWIESE, C. D.: Praktische Statistik für Meteorologen und Geowissenschaftler, Gebrüder Bornträger Berlin • Nützmann, G., Moser, H.: Elemente einer analytischen Hydrologie, Prozesse - Wechselwirkungen - Modelle, Springer, e-book: https://katalog.ub.b-tu.de/search?bvnr=BV043210734
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	Written exam at the end of the lecture period (90 min.)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• *Lecture System- and Process Hydrology* • *Seminar System- and Process Hydrology* • *Exam System- and Process Hydrology*
Components to be offered in the Current Semester	**240673** Lecture Systems and Process Hydrology - 2 Hours per Term **240674** Seminar Systems and Process Hydrology - 2 Hours per Term **240675** Examination Systems and Process Hydrology

Module 13653 Atmospheric Water

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13653	Compulsory elective

Modul Title	**Atmospheric Water** Atmosphärisches Wasser
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Trachte, Katja
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The module offers fundamental knowledge of physical processes and methodologies related to the atmospheric water cycle and its relevance in the context of climate change, e.g. water vapor fluxes and pathways, cloud microphysical processes, precipitation. Students get the competence to assess relevant aspects related to atmospheric water transport and availability, water use efficiency and cloud – albedo feedbacks as well as to apply IT-based approaches.
Contents	In the lecture professional aspects of atmospheric water processes: · Atmospheric water fluxes · Water vapor pathways · Cloud microphysics · Cloud-albedo feedbacks · Precipitation processes · Water availability · Water use efficiency · Remote sensing · Modeling approaches In the exercise the knowledge gained will be applied using programming languages such as R and Python to trainee atmospheric remote sensing, data assimilation and modelling approaches in the field of atmospheric / environmental sciences.
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours Exercise - 2 hours
Teaching Materials and Literature	Recommended literature: H.R. Pruppacher & J.D. Klett: Microphysics of Clouds and Precipitation. Springer, 2010, Vol 18. R.A. Jr. Houze: Cloud Dynamics, 2014, 2nd Ed., Elsevier/Academic Press, Oxford
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1. Weekly exercises in form of data analyses and visualization (30%) 2. Submission of a project (70%) Submission encompass 8-10 pages including approx. 2000-3000 words. A group submission is scheduled. Individual grading can be achieved according to the uploaded program code.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	Lecture – Atmospheric Water Exercise - Atmospheric Water
Components to be offered in the Current Semester	**240161** Lecture Atmospheric Water - 2 Hours per Term **240162** Seminar/Exercise Atmospheric Water - 2 Hours per Term

Module 13655 Un/Disciplining Knowledge: Technology, Science, and Society in Transformation

assign to: Modules with the Focus on Environmental Sciences

Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13655	Compulsory elective

Modul Title	**Un/Disciplining Knowledge: Technology, Science, and Society in Transformation** Epistemischer Ungehorsam: Technik, Wissenschaft und Gesellschaft im Wandel
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. nat. phil. habil. Schwarz, Astrid
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	By the end of the module students are able to develop a research question within the academic field of Science and Technology Studies and create and present a research design, as well as identify and make use of appropriate sources of empirical material for your analysis, furthermore to identifiy, select and compare appropriate concepts and methods relating to an interdisciplinary research field and analyse changes in fields of science and technology with respect to knowledge forms.
Contents	This module presents central theories and approaches developed in Science and Technology Studies. The module focuses on questions about disciplining and undisciplining knowledge, the corresponding epistemic and ontological perspectives and the political economy of science. It explores concepts being concerned about shifting concepts of disciplinarity, such as interdisciplinarity, transdisciplinarity or postdisciplinarity.
Recommended Prerequisites	Knowledge from the courses • Technik in Wissenschaft und Gesellschaft • Philosophy of Science in Practice
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature and learning materials are given in the course description.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• short scientific essay, max. 4000 words (45%) • scientific review, max. 2500 words (40%) • presentation, max. 15 minutes (15%) The oral part of the examination can be done digitally or as a virtual meeting if the conditions for an examination in presence are not given.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	German-speaking teachers are available if required. Further information on this can be found in the course description.
Module Components	• Seminar - 4 SWS
Components to be offered in the Current Semester	**510151** Seminar Un/disciplining Knowledge - 4 Hours per Term

Module 13657 How to Talk about Nature?

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13657	Compulsory elective

Modul Title	**How to Talk about Nature?** Wie über Natur sprechen?
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. nat. phil. habil. Schwarz, Astrid
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After passing the module, students understand main philosophical theories of “nature”, interrogate the concept of “nature” and expose its numerous ideological and cultural manifestations. They identify the main ethical dimensions of “nature”, and its crosscultural and political dimensions. Additionally they understand the power of narratives and storytelling to shape our environmental present and future by insight into reading, writing, and visual practices about “nature”.
Contents	“How to talk about nature?” is closely linked to the question of what “nature” is, how it is construed and in which way we act with, in or against it. It is a question that is ontological and epistemological at the same time, it is about how we imagine nature “to be” and how we conceive knowledge about nature. The ideas about this entwinement are manifold over time and in space, different cultures have developed different ways of thinking and also practices of how to deal with a culture/nature distinction. Another important conceptual issue is how nature and technology are related, in contemporary debates for instance, "nature" is often identified with "environment" and as such inescapably entangled with its cultural, political, and technological context. Is the use of technology in “nature” then a threat or an opportunity to build a genuinely sustainable world? This module seeks to answer these and other questions, by approaching “nature” with variously grounded historical and contemporary theoretical approaches. For example, the concept of “nature” was differently interpreted in ancient times, compared to modern contemporary cultures. We will probe the different usage, the scope of historical and cross-cultural depth, the semantics, the images/

	imaginaries, and finally, the logical coherence of “nature” concepts. This variety of topics means that the assigned readings will draw from a wide range of sources. With respect to handle current ecological and technocultural problems, a conscious reflection about “nature” seems to be required. Thus, the module should be also seen, in part, as a way to gain insight into contemporary reading, writing, and visual practices about “nature”. Participation in the accompanying excursion is encouraged.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature and learning materials are given in the course description.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• One short essay, max 1500 words (25%) • Two reviews, each max. 2000 words (each 30%) • 2 oral (group) presentations, about 15 min **OR** weekly submitted written answers to one short question per week on the topical readings to be determined by the instructor (15%) The oral part of the examination can be done digitally or as a virtual meeting if the conditions for an examination in presence are not given.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	60
Remarks	none
Module Components	• Seminar, lecture - 4 hours per week per semester
Components to be offered in the Current Semester	**510112** Lecture/Seminar How to talk about "Nature"? / Ethik und Handeln / Philosophy of Technology and Nature / Natur und Technik / Wissenschaftstheorie, Logik und Naturphilosophie - 4 Hours per Term

Module 13663 Environmental Soil Science and Plant Nutrition

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13663	Compulsory elective

Modul Title	**Environmental Soil Science and Plant Nutrition** Umweltbezogene Bodenkunde und Pflanzenernährung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Ph. D. Rütting, Louise
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After completing this course, the student will be able to understand: • fundamental chemical properties and processes in soil • scientific methods employed for the remediation of contaminated soils • natural and anthropogenic factors and processes in soil and plant systems • basic principles of plant nutrient uptake • nutrient assimilation of plants with focus on the nitrogen and phosphate cycle • main sources and sinks of greenhouse gases
Contents	**Part 1: Soil Science/Soil Chemistry** Introduction to the principles of soil chemistry, including properties of soil minerals and their interactions with essential plant nutrients. We will focus on soil solution dynamics, sorption processes, and redox reactions. In addition, students will gain insights into soil water dynamics and the importance of soil organic matter. **Part 2: Plant Nutrition** The student learns about the importance of mineral nutrition in plants, including essentiality, availability, and applications, as well as their management and control strategies. We have a focus on plant nutrient uptake, the rhizosphere and nutrient starvation. The student will gain insight into the different processes of bioremediation and phytoremediation dealing with contamination problems in a scientific and ecological way. In a seminar we will discuss numerous remediation approaches.

	An excursion followed by a laboratory practical will combine the plant nutrition and soil sections.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Excursion - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The class is organized as lectures complemented by discussions and individual contributions. All slides and schedules are available in Moodle. Recommended literature: • Blume et al. (2016): Scheffer/Schachtschabel Soil Science. Springer, Berlin. • Naeem, M.; Ansari, A. A.; Gill, S.S. [Eds.] (2017): Essential Plant Nutrients. Uptake, Use Efficiency, and Management. Springer, Berlin. • Malik, J. A. (2022): Advances in Bioremediation and Phytoremediation for Sustainable Soil Management. Principles, Monitoring and Remediation. Springer International Publishing, Cham. • Flores, J. C. (2021): The Future of Phytoremediation. Nova Science Publishers Inc., Hauppauge.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• written mid-term assessment on lecture Part 1, 60 min. (30 %) • written final assessment on lecture Part 2, 60 min. (30 %) • written protocol on excursion and laboratory exercise (40 %)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	25
Remarks	The excursion and the laboratory practical will take place in March.
Module Components	*Lecture/Seminar Environmental Soil Science and Plant Nutrition* *Excursion Environmental Soil Science and Plant Nutrition*
Components to be offered in the Current Semester	**240262** Excursion Excursion Environmental Soil Science and Plant Nutrition - 2 Hours per Term **240261** Lecture/Seminar Soil Chemistry/Plant Nutrition - 2 Hours per Term

Module 13735 Biodiversity of Terrestrial Invertebrates

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13735	Compulsory elective

Modul Title	**Biodiversity of Terrestrial Invertebrates** Biodiversität terrestrischer Wirbelloser
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Birkhofer, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The module Biodiversity of Terrestrial Invertebrates provides an overview of the taxonomy and ecology of invertebrates in terrestrial ecosystems with mandatory half-day excursions and student projects. **Part "Biodiversity: Lecture"** The lectures introduce the taxonomy of terrestrial invertebrates with diagnostics for major orders and highlight the ecology of selected case taxa. Students will learn about • Phylogenetic relationships of major terrestrial invertebrate orders • Identification and diagnostics of major terrestrial invertebrate orders • Ecology of major terrestrial invertebrate orders **Part "Biodiversity: Seminar"** The seminars are based on student presentations of an assigned scientific publication focusing on the ecology of selected terrestrial invertebrate taxa. Students will learn about • Interpretation of scientific articles • Ecology of a selected case taxon • Summarizing and presenting scientific results **Part "Biodiversity: Excursion"** The two excursions will take students to habitats in and around Cottbus to study terrestrial invertebrate communities including some laboratory course work to identify invertebrates. Students will learn about • Ecological field work with a focus on biodiversity assessment • Identification of major terrestrial invertebrate orders in the field and laboratory

Contents	**Part "Biodiversity: Lecture"** • Terrestrial invertebrate taxonomy • Terrestrial invertebrate ecology **Part "Biodiversity: Seminar"** • Threats to terrestrial invertebrate biodiversity • Status of terrestrial invertebrate biodiversity • Solutions to biodiversity loss in terrestrial invertebrates **Part "Biodiversity: Excursion"** • Field methods to sample terrestrial invertebrates • Diagnostic criteria to identify major terrestrial invertebrate orders in the field and laboratory
Recommended Prerequisites	For international study programs and master students module “41217 General and Applied Ecology” or for BSc students module “41102 Ecology”. For German study programs module „14324 Terrestrische Ökologie“ or module „41203 Allgemeine Ökologie“.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Seminar - 1 hours per week per semester Excursion - 10 hours Exercise - 10 hours Self organised studies - 130 hours
Teaching Materials and Literature	**Part "Biodiversity: Lecture"** The class is organized as a weekly lecture introducing major orders of terrestrial invertebrates. Lecture-like presentations are complemented by discussions. Self-organized work, in particular acquiring more detailed knowledge of the taxonomic groups is required. E-books Piper R What Insects Do, and Why Schowalter TD Insect ecology: an ecosystem approach Beutel RG & Friedrich F Insect morphology and phylogeny Resh VH Encyclopaedia of insects New TR Insect species conservation: Ecology, biodiversity, and conservation Samways MJ Insect diversity conservation **Part "Biodiversity: Seminar"** A scientific paper focusing on the ecology of a major order of terrestrial invertebrates is assigned to students. The content of the paper will then be presented as an oral presentation in the seminar by the students following the lecture. All seminar topics and material are provided. **Part " Biodiversity: Excursion"** Participation in the two half-day ecological excursions is mandatory. All material for the excursions is provided. E-books

	Brock PD Britain's Insects: A Field Guide to the Insects of Great Britain and Ireland Santos JC Measuring arthropod biodiversity: a handbook of sampling methods
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	**Part "Biodiversity: Seminar"** One oral presentation, 25 min + 20 min discussion (50%) **Part " Biodiversity: Lecture"** One written examination, 80 min. (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240795 Biodiversity: Lecture/Seminar • 240796 Biodiversity: Excursion • 240797 Biodiversity: Exercise
Components to be offered in the Current Semester	No assignment

Module 13737 Practical Course Aquatic Ecology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13737	Compulsory elective

Modul Title	**Practical Course Aquatic Ecology** Praktikum Gewässerökologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. habil. Martin-Creuzburg, Dominik
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The students know basic methods for the investigation of standing and running waters and can apply them independently. They can effectively use different data and information in order to answer research questions or develop hypotheses. The students can compare and assess the possibilities and limitations of methods and data in aquatic ecology.
Contents	Recording and evaluation of abiotic and biotic water quality parameters within the framework of a case study on a watercourse and a standing water body. Field measurements with different probes, limnological sampling techniques and laboratory analyses, process measurements, experimental approaches, microscopy of aquatic organisms, data analyses and preparation of reports.
Recommended Prerequisites	13298 Basics for Freshwater Management or/and 42505 Freshwater Restoration Ecology. Commitment and willingness for active participation, self-organized work, teamwork and self-study.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Practical training - 80 hours Self organised studies - 100 hours
Teaching Materials and Literature	The necessary materials for the practical part will be provided.
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	Oral presentations and written reports of the results for each part, Running Waters and Standing Waters. **Part Running Waters:** • 15 min presentation on one of the methods to be applied (10%) • Course participation (10%) • Presentation of results and written report (ca. 3 - 5 pages without figures and/or tables, 11 pt font, line spacing no more than 1.2) (30%) **Part Standing Waters:** • 15 min presentation on one of the methods to be applied (10%) • Course participation (10%) • Presentation of results and written report (ca. 3 - 5 pages without figures and/or tables, 11 pt font, line spacing no more than 1.2) (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	12
Remarks	The course will take place as a block course during the lecture-free period of the 2026 summer semester from August 17 to September 4, 2026. The number of participants is limited to 12 students. The Standing water part will take place from August 17 to 21, 2026, at the Research Station of the Department of Aquatic Ecology in Bad Saarow. This requires all students to stay overnight in a youth hostel in Bad Saarow. The accommodation costs of ~€150 will be paid by the students themselves. In order to process the booking and deposit for the accommodation and to guarantee binding participation in the module, a deposit of €100 is required. The payment terms will be communicated to students by the Department of Aquatic Ecology after they have registered for the module with the Examination Office. The Department of Aquatic Ecology will decide on final admission to the module. This depends on the student's qualifications and receipt of the deposit for accommodation. Only after receiving a positive decision from the Department of Aquatic Ecology will the student be given access to the course page on Moodle.
Module Components	240506 Practical course aquatic ecology
Components to be offered in the Current Semester	No assignment

Module 13822 Biodiversity of Terrestrial Arthropods

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13822	Compulsory elective

Modul Title	**Biodiversity of Terrestrial Arthropods** Biodiversität terrestrischer Arthropoden
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Birkhofer, Klaus
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The module Biodiversity of Terrestrial **Arthropods** provides an overview of the taxonomy and ecology of **arthropods** in terrestrial ecosystems with a mandatory 5-day excursion during the semesters excursion week and student projects. **Part "Biodiversity: Lecture"** The lectures introduce the taxonomy of terrestrial invertebrates with diagnostics for major orders and highlight the ecology of selected case taxa. Students will learn about • Phylogenetic relationships of major terrestrial invertebrate orders • Identification and diagnostics of major terrestrial invertebrate orders • Ecology of major terrestrial invertebrate orders **Part "Biodiversity: Seminar"** The seminars are based on student presentations of an assigned scientific publication focusing on the ecology of selected terrestrial invertebrate taxa. Students will learn about • Interpretation of scientific articles • Ecology of a selected case taxon • Summarizing and presenting scientific results **Part "Biodiversity: Excursion"** Students will learn:

- Ecological field work methods with a focus on biodiversity assessment
- Identification of arthropods and use of taxonomic determination keys

Contents

The courses will take students to an ecological field station in Brandenburg for five days during the semesters excursion week. A small fee of 10€ will be collected from all participating students to cover some of the costs.

Part "Biodiversity: Lecture"

- Terrestrial arthropod taxonomy
- Terrestrial arthropod ecology

Part "Biodiversity: Seminar"

- Threats to terrestrial arthropod biodiversity
- Status of terrestrial arthropod biodiversity
- Solutions to biodiversity loss in terrestrial arthropod communities

Part "Biodiversity: Excursion"

- Field methods to sample biodiversity with a focus on terrestrial arthropods
- Diagnostic criteria to identify major terrestrial arthropod orders in the field and laboratory

Recommended Prerequisites

For international study programmes and master students module ”41217 General and Applied Ecology” or for BSc students module ”41102 Ecology”. For German study programmes module „14324 Terrestrische Ökologie” or module „41203 Allgemeine Ökologie".

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 1 hours per week per semester
Seminar - 1 hours per week per semester
Excursion - 32 hours
Self organised studies - 118 hours

Teaching Materials and Literature

Part "Biodiversity: Lecture"
The class is organized as a weekly lecture introducing major orders of terrestrial arthropods. Lecture-like presentations are complemented by discussions. Self-organized work, in particular acquiring more detailed knowledge of the taxonomic groups is required.

E-books
Piper R, What Insects Do, and Why
Schowalter TD, Insect ecology: an ecosystem approach
Beutel RG & Friedrich F, Insect morphology and phylogeny
Resh VH, Encyclopaedia of insects
New TR, Insect species conservation: Ecology, biodiversity, and conservation
Samways MJ, Insect diversity conservation

	Part "Biodiversity: Seminar" A scientific paper focusing on the ecology of a major order of terrestrial invertebrates is assigned to students. The content of the paper will then be presented as an oral presentation in the seminar by the students following the lecture. All seminar topics and material is provided. **Part " Biodiversity: Excursion"** Students will write a report on an assigned excursion. Participation in these half-day ecological excursions is mandatory. All material for the excursions is provided. E-books Brock PD, Britain's Insects: A Field Guide to the Insects of Great Britain and Ireland Santos JC, Measuring arthropod biodiversity: a handbook of sampling methods
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	**Part "Biodiversity: Seminar"** One oral presentation, 25 min + 20 min discussion (50%) **Part " Biodiversity: Excursion "** One written report summarising the results from the 5-day excursion (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The courses will take students to an ecological field station in Brandenburg for five days during the semesters excursion week. A small fee of **10 €** will be collected from all participating students to cover some of the costs.
Module Components	• 240795 Lecture/Seminar Biodiversity • 240798 Excursion Biodiversity
Components to be offered in the Current Semester	No assignment

Module 13837 Agro-Ecosystems Analysis and Modelling

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13837	Compulsory elective

Modul Title	**Agro-Ecosystems Analysis and Modelling** Analyse und Modellierung von Agrarökosystemen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. Webber, Heidi
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	• describe and analyze agricultural systems using system analysis terms and concepts; • develop a simple dynamic model of a process affecting crop development or growth using the R programming language; • conduct model calibration, evaluation and sensitivity analysis; • design a model based assessment of the performance and sustainability of a cropping system; and • critically reflect on scientific studies reporting simulation results.
Contents	With the range of challenges facing crop production systems, systems analysis and simulation modelling are frequently applied analytical tools to assess improved crop management and improve understanding of how crop systems functioning. Systems approaches represent a scientific concept in which the real world is divided into systems. These systems are captured into models Applied at a range of scales (canopy, (sub-) field, agroecosystem, regional or global), they can be used as scientific tools to test hypothesis of crop behavior, informing and aiding in experimental interpretation. The course consists of three main learning areas: systems dynamics and model development; model performance & model evaluation; model applications.
Recommended Prerequisites	Good quantitative skills, basic knowledge of statistics, basic knowledge of scripting in R
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	TBD
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	 - Report of the project #1, model development: description and schematic of the conceptual model, R-script, discussion (40%) 8 pages an appendix showing R-codes (draft description attached); working in groups of 2 or 3 students - Report of the project #2, model application: description and schematic of the topic selected, R-sript, discussion (40%) 7 pages an appendix showing R-codes (draft description attached); working in groups of 2 or 3 students - Preparation and leading of one group seminar: 30 min discussion on an assigned article presenting a model simulation study (20%) working in groups of 3 or 4 students
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	30
Remarks	The module will take place in Summer Semester 2025!
Module Components	*Lectures, seminars and computer based exercises*
Components to be offered in the Current Semester	No assignment

Module 13955 Geomorphology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13955	Compulsory elective

Modul Title	**Geomorphology** Geomorphologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. phil. Raab, Thomas
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	At the end of the module, the students will be able • to understand and remember the fundamentals of geomorphology • to explain the factors and processes of landform development • to describe the morphology of landforms and explain its formation • to understand and apply methods for quantitative landform description and analysis • to apply and evaluate different types of digital elevation data • to process and analyze digital elevation data in GIS software • to create maps of landform structures and relief features
Contents	Part 1 Lecture – Geomorphology • Fundamentals and concepts of geomorphology • Geomorphic agents and processes • Landforms and landform • Anthropogenic geomorphology • Characteristic landforms of the mid latitudes Part 2 Seminar – Digital Terrain Analysis • Concept of Geomorphometry and basic geomorphometric parameters • Digital elevation models (DEMs) – types and data sources • Software for elevation data processing and analysis • Visualization methods • Advanced geomorphometric indices • Exemplary practical applications (hydrology, archaeology, soil erosion modelling,…)

	Part 3 Seminar/Exercise - Processing and analysis of digital landform data • Practical exercises for exemplary study areas of an ongoing research project • import and processing of DEMs in GIS database • computation of basic geomorphometric parameters (slope, curvature, exposition,…) • digital landform classification • computation of advanced morphometric indices (TWI, SPI, …) • visualization of relief structures • digitization of relief structures, analysis of spatial distribution patterns • creation of maps
Recommended Prerequisites	Basics of physical geography
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Exercise - 2 hours per week per semester Seminar - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Anderson, R.S., Anderson, S.P. (2010): Geomorphology. The Mechanics and Chemistry of Landscapes. Cambridge University Press. 637 p. • Goudie, A., Viles, H. (2016): Geomorphology in the Anthropocene. Cambridge University Press. 324 p. • Gutiérrez Elorza, M. (2005): Climatic geomorphology. Elsevier, 760 p. • Hengl, T. (ed., 2009): Geomorphometry. Concepts, Software, Applications. Elsevier, 765 p. • Slaymaker, O., (ed., 2011): Geomorphology and global environmental change. Cambridge University Press, 434 p. • Wilson, J.P. (2000): Terrain Analysis. Principles and Applications. Wiley, 479 p. • Teaching material and further recommended literature will be provided in the specific courses
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• written assessment on Lecture Geomorphology, approx. 8 questions, 2 pages (20%) • 4 seminar exercises to be solved independently or in groups, 4 protocols (1 page each) and 4 presentations (10 min each) (40%) • final integrative presentation (20 min) and discussion of exercise results (15 min) (40%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture *Geomorphology* (1SWS) • Exercise *Processing and analysis of digital landform data* (2SWS) • Seminar *Digital Terrain Analysis* (1SWS)

Components to be offered in the Current Semester	No assignment

Module 14132 Multidimensional Approaches for Technology Assessment

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14132	Compulsory elective

Modul Title	**Multidimensional Approaches for Technology Assessment** Multidimensionale Ansätze für Technikfolgenabschätzung
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students know about a range of technology assessment approaches, methodologies and tools to facilitate the evaluation of decarbonization & sustainability transformation options along socio-technological-economical-ecological-political (*STEEP*) dimensions. On completion of the module, students are able to: • Demonstrate a deep understanding of the multidimensional aspects and systemic interactions in the transformation of energy- and carbon-intensive industries; • Gain familiarity with a range of qualitative and quantitative methodologies in conducting technology assessment; • Design and conduct studies to analyze the opportunities and challenges which will be associated with the transformation of energy- and carbon-intensive industries along multiple dimensions; • Identify, assess and evaluate appropriate sources of information and critically reflect on the methodologies commonly implemented for technology assessment and their usefulness/weaknesses.
Contents	Course coverage: • Relevance and development of technology assessment; • Common methodological approaches and their usefulness/weakness; • Data and approaches for assessment (e.g., primary vs. secondary; qualitative vs. quantitative); • Methodologies for socio-political evaluations, techno-economic evaluations and ecological evaluations;

- Application on a case study to assess multidimensional opportunities and challenges associated with the transformation of a specific sector and derive implications along the *STEEP* dimensions based on assessment results.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 1 hours per week per semester
Exercise - 1 hours per week per semester
Study project - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Lee, R.P., Meyer, B., Huang, Q.L, Voss, R. 2020. Sustainable waste management for zero waste cities in China: potential, challenges and opportunities. *Clean Energy*, 4(3): 169 – 201.
- Lee, R.P. 2019. Alternative carbon feedstock for the chemical industry? – Assessing the challenges posed by the human dimension in the carbon transition, *Journal of Cleaner Production*, 219: 786-796.
- Lee, R. P., Tschoepe, M., Voss, R. 2021. Perception of chemical recycling and its role in the transition towards a circular carbon economy: A case study in Germany. *Waste Management*, 125: 280-292.
- Voss, R., Lee, R.P., Seidl, L., Keller, F., Fröhling, M. 2021. Global warming potential and economic performance of gasification-based chemical recycling and incineration pathways for residual municipal solid waste treatment in Germany. *Waste Management*, 134: 206 – 219.
- Keller, F., Lee, R.P., Meyer, B. 2020. Life cycle assessment of global warming potential, resource depletion and acidification potential of fossil, renewable and secondary feedstock for olefin production in Germany. *Journal of Cleaner Production*, 250: 119484.
- Lee, R.P., Scheibe, A. 2020. The politics of a carbon transition: An analysis of political indicators for a transformation in the German chemical industry*, Journal of Cleaner Production*, 244: 118629.

Further materials are provided via Moodle (including lecture slides and additional materials including videos, readings etc.)

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Individual component (E-assessment), 60-90 min - 50%
- Group Project - Part 1: Create a scientific poster (Analysis of e.g., a scientific article, industry report, case study, ...) - 25%
- Group Project - Part 2: Presentation, 15min - 25%

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

- Lectures & Exercises
- Projects

Components to be offered in the Current Semester	No assignment

Module 14299 Advances in Biogeochemistry and Pedology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14299	Compulsory elective

Modul Title	**Advances in Biogeochemistry and Pedology** Aktuelle Forschungen in Biogeochemie und Bodenkunde
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. phil. Raab, Thomas Prof. Ph. D. Rütting, Louise
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	Students will learn scientific method application, hypothesis formulation, critical reflection of results and academic discussion in fields of Soil-Plant-Systems and Geopedology.
Contents	Recent developments in the field of soil-ecosystem-landscape related research. Invited external speakers, as well as BTU PostDocs, PhD and Master students, present advances in scientific investigations in natural and human-made ecosystems. The focus is on the evolution, properties, and functions of the pedosphere and interacting processes with the biosphere. Research topics cover soil organic matter, biogeochemistry, plant nutrient uptake, stable isotope tracing, phosphorus and nitrogen cycling, soils in space and time, soil morphology and classification, and the impact of past and modern land use on soil landscapes.
Recommended Prerequisites	Basic knowledge in Biogeochemistry and Soil Science
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Consultation - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	will be announced at the beginning of the event
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	Students must write a series of short tests at the end of each seminar presentation (25 % of the module grade), they must ask weekly questions on each seminar topic (25 % of the module grade) and they must give a short poster presentation (5 minutes) at the end of the seminar (50 % of the module grade).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	24
Remarks	No offer in Summer 2026 and Winter 2026/27
Module Components	240499 Biogeochemistry and Pedology Research Seminar, 2 SWS 240498 Biogeochemistry and Pedology Research Consultation, 2 SWS
Components to be offered in the Current Semester	**240499** Seminar Biogeochemistry and Pedology Research Seminar - 2 Hours per Term

Module 14355 Hydrogeology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14355	Compulsory elective

Modul Title	**Hydrogeology** Hydrogeologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. PD Dr. habil. Neukum, Christoph
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Students will acquire fundamental knowledge about hydrogeology involving physical principles and major ion chemistry. The course considers the elements of the hydrological cycle, hydrogeological properties of geological media, principle of groundwater flow, water chemistry and quality, basics of solute transport in groundwater, groundwater management, field methods and model applications.
Contents	Part 1. Introduction to hydrogeology Part 2. Water and the hydrological cycle Part 3. Geology and groundwater Part 4. Groundwater flow Part 5. Groundwater chemistry Part 6. Solute transport Part 7. Groundwater management The lectures are accomplished by practical exercises.
Recommended Prerequisites	• Basics in environmental science, Geology, Hydrology
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Franklin W. Schwartz, Patrick A. Domenico: Physical and Chemical Hydrogeology, ISBN: 978-0-471-59762-9

	• C.W. Fetter: Applied Hydrogeology, Print-ISBN: 978-1-292-02290-1, E-ISBN: 978-1-292-03608-3 • Bernward Hölting , Wilhelm Georg Coldewey: Hydrogeologie, Einführung in die Allgemeine und Angewandte Hydrogeologie
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written exam at the end of the lecture period (90 min)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture “Introduction to Hydrogeology” • Exercise “Applied Hydrogeology”
Components to be offered in the Current Semester	**242601** Lecture Introduction to Hydrogeology - 2 Hours per Term **242602** Exercise Applied Hydrogeology - 2 Hours per Term **242603** Examination Introduction to Hydrogeology

Module 14387 Applied Limnology, Management and Modelling of Lakes and Reservoirs

assign to: Modules with the Focus on Environmental Sciences

Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14387	Compulsory elective

Modul Title	**Applied Limnology, Management and Modelling of Lakes and Reservoirs** Angewandte Limnologie, Management und Modellierung von Seen und Stauseen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Rinke, Karsten
Language of Teaching / Examination	English
Duration	2 semesters
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	· Ecosystem services and anthropogenic uses of lakes and reservoirs · Translating scientific knowledge into tailored water management concepts for standing waters · Assessment methods and systems analysis of lakes and reservoirs · Stressors of lakes and reservoirs, dominant drivers, and potential solution approaches
Contents	This module puts basic knowledge in natural sciences in general and aquatic ecology and biogeochemistry in particular into context with state of the art management concepts for lakes and reservoirs. This includes also an analysis of major ecosystem services and anthropogenic uses of standing waters as wel as dominant stressors and drivers of deterioration. We will employ quantitative methods including modelling and explicitly adress the unit of water body and catchment. The following main topics are in the focus of the module: · Human uses and ecosystem services of lakes and reservoirs · Morphology and physikal structure · Ecosystem dynamics and productivity · Nutrient cycles and biogeochemical processes · Eutrophication

	· Climate Change · Other stressors: Acidification, dryout,invasive species…. · Assessment and monitoring of lakes and reservoirs · Water quality prediction and management
Recommended Prerequisites	Basics for Freshwater Management (13298) or comparable knowledge in limnology, Expertise in R is very helpful
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Excursion - 20 hours Self organised studies - 100 hours
Teaching Materials and Literature	Literature and excercise materials are provided via Moodle.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Four selected excercises of our weekly seminars are used for calculating a grade (80%) • Seminar presentation (10 minutes) (20%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Wintersemester: Lecture (2 SWS) + excercise (2SWS) Summersemester: Excursion (20 Std insgesamt)
Module Components	• Lecture • Exercise • Excursion
Components to be offered in the Current Semester	**242401** Lecture Applied Limnology, Management and Modelling of Lakes and Reservoirs - 2 Hours per Term **242402** Exercise Applied Limnology, Management and Modelling of Lakes and Reservoirs - 2 Hours per Term

Module 14496 Applied Biostatistics for Environmental Data

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14496	Compulsory elective

Modul Title	**Applied Biostatistics for Environmental Data** Angewandte Biostatistik für Umweltdaten
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Djoudi, El Aziz
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	This module will provides a theoretical introduction to data analysis and results interpretation, statistical methods and tools for environmental and biological sciences, as well as applied tools with a particular focus on R programming (R software).
Contents	Part 1. Introduction to experimental design Design principles Random sampling, block design, nested design, split-plot… Replication and Pseudoreplication Part 2. Introduction to R Introduction to the essentials of R Basics: Syntax, packages, writing codes & functions Data handling, analysis and visualisation (graphs and tables) Exercises Part 3. Distributions, Parameters and Estimators Data classification & distribution Measures of central tendency: mean, median … Measures of variability: variance and standard deviation Likelihood and Akaike Information Criterion Exercises Part 4. Univariate analysis T-test and ANOVA (Analysis of variance) Correlation and regression analysis Non parametric analysis (Wilcoxon, Mann-Witney-U, Kruskal-Wallis) linear models & introduction to mixed models Exercises

	Part 5. Multivariate analysis Principal component analysis (PCA) Non-metric multidimensional scaling (NMDS) Redundancy analysis (RDA) & Canonical correspondence analysis (CCA) Exercises
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Zuur, A. F., Ieno, E. N. & Smith, G. M. 2007 Analysing ecological data. New York Gotelli, N. J. & Ellison A. M. 2013 A primer of ecological statistics. Sunderland Dormann, C. 2020 Environmental Data Analysis: An Introduction with Examples in R. Cham Lakicevic, M., Povak, N. & Reynolds, K. M. 2020 Introduction to R for terrestrial ecology: basics of numerical analysis, mapping, statistical tests and advanced application of R, Cham Wilke C.O. 2019 Fundamentals of Data Visualization, O'Reilly Wickham H& Grolemund G, 2017 R for Data Science, O'Reilly
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	- 10 Exercises during the courses (50%)) - Individual project presentation, 15 min. (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	25
Remarks	Please bring your laptop!
Module Components	240740 Lecture/Exercise: Applied Biostatistics for environmental data
Components to be offered in the Current Semester	**240740** Lecture/Exercise Applied Biostatistics for environmental data - 4 Hours per Term

Module 14781 Biological Methods for Biomass and Waste Treatment

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14781	Compulsory elective

Modul Title	**Biological Methods for Biomass and Waste Treatment** Biologische Verfahren der Biomasse- und Abfallbehandlung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. habil. Abendroth, Christian
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	<p data-start="0" data-end="990">Students are introduced to ecologically and economically viable alternatives to conventional waste treatment, with integrated and system-oriented solutions at the core. Particular emphasis is placed on anaerobic microbiomes and their central role in biological conversion processes such as anaerobic digestion, composting, and other innovative approaches to residual waste valorization. Building on microbiological and biochemical fundamentals, functional principles, process dynamics, and efficiencies are analyzed and transferred to real-world applications. In addition to established technologies, current research approaches, international developments, and novel process combinations—including contributions from the instructor’s own research—are addressed. The aim is to develop an in-depth understanding of the material and energy recovery of residuals within the context of a sustainable circular economy, and to foster the ability to independently design system-oriented solutions. <p data-start="992" data-end="1542" data-is-last-node="" data-is-only-node="">An interactive teaching format forms the didactic core: during the sessions, students continuously work on tasks whose results contribute to the overall assessment. This supports an active learning process that promotes analytical thinking, applied competence, and scientific discussion.
Contents	<p data-start="0" data-end="361">The course provides a solid yet practice-oriented introduction to the biological utilization of residual materials within the context of a sustainable circular economy. Starting from the fundamentals of biology and photosynthesis, it first examines the ”food vs. fuel” debate in order to critically assess conflicts

between food production and bioenergetic use. <p data-start="363" data-end="906">Subsequently, key processes of biological waste treatment are covered, including composting, biogas production, and dark fermentation. These processes are considered not only from a technological perspective, but particularly from the viewpoint of anaerobic microbiomes, which are understood as the driving force behind material transformations. An introduction to microbiomes and their analysis—from taxonomic profiling to functional approaches such as proteomics—enables a deeper understanding of microbial communities and their performance. <p data-start="908" data-end="1251">Building on this, central metabolic processes such as fermentation and methanogenesis are examined in detail and placed in the context of technical applications. In addition, innovative and less established approaches—such as the use of insects, bioleaching, remediation strategies, and novel materials and systems (e.g., SLMs)—are introduced. <p data-start="1253" data-end="1504" data-is-last-node="" data-is-only-node="">The course combines current research with application-oriented knowledge and offers an interdisciplinary perspective on biological transformation processes, with the aim of developing sustainable and creative solutions for future resource utilization.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 4 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

Kranert M. Einführung in die Kreislaufwirtschaft, Springer Vieweg Wiesbaden, 2017, https://doi.org/10.1007/978-3-8348-2257-4
Bischofsberger, Dichtl, Rosenwinkel, Seyfried, Böhnke. Anaerobtechnik. Springer-Verlag Berlin Heidelberg 2005, ISBN: 3-540-06850-3
Further literature will be announced during the course
<p data-start="0" data-end="129">

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

<div id="meta-origin" data-coolorigin="https%3A%2F%2Fwww.b-tu.de%2Forgcloud%2Fapps%2Frichdocumentscode%2Fproxy.php%3Freq%3D%2Fcool%2Fclipboard%3FWOPISrc%3Dhttps%253A%252F%252Fwww.b-tu.de%252Forgcloud%252Findex.php%252Fapps%252Frichdocuments%252Fwopi%252Ffiles%252F11244624_ochtzup9yafk%26ServerId%3DF84FA4B4%26ViewId%3D7%26Tag%3D58C29858B529DFEC"> Assessment in this module follows a continuous, dialogue-based oral approach. Students are asked to demonstrate their understanding of the course content by answering subject-specific questions and by formulating questions for their peers. The assessment takes place regularly throughout the semester and aims to evaluate subject-specific knowledge, understanding, and the ability to engage in academic discussion. <p> oral assessment generally after every second lecture approximately 15–20 minutes per assessment session 1–2 questions per student approximately every two weeks approximately 10 assessed questions per student

	over the semester 1 point for each successfully completed question assessment of answers based on subject-specific correctness and demonstrated understanding assessment of student-formulated questions based on scientific relevance, clarity, and appropriateness All assessed questions/tasks are weighted equally. The overall assessment result is calculated based on the proportion of points achieved out of the total number of points available (100%). comparable number and level of assessment opportunities for all students
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	238117 Lecture / Seminar: Biological Processes in Biomass and Waste Treatment <p><br data-start="84" data-end="87" />
Components to be offered in the Current Semester	**238117** Lecture/Seminar Biologische Verfahren der Biomasse und Abfallbehandlung - 4 Hours per Term

Module 14824 Automated Biodiversity Surveying Tools and Methods

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14824	Compulsory elective

Modul Title	**Automated Biodiversity Surveying Tools and Methods** Automatisierte Instrumente und Methoden zur Erfassung der biologischen Vielfalt
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	By the end of this course, students will be able to: - Demonstrate knowledge of the principles and methods of surveying different aspects of biodiversity. - Apply key concepts of survey design to ecological studies. - Apply AI tools (e.g. Birdnet) to automatically classify species from recordings Practical learning outcomes - Design a biodiversity survey for a given taxa using automated monitoring tools, from setup through data collection and analysis to scientific presentation. - Give a presentation on the proposed biodiversity study, including a background on the chosen taxon and region and justification of the experimental design.
Contents	This course combines lectures and hands-on sessions (with automated monitoring devices such as Audiomoth and InsectDetect) in groups to provide a basic introduction to the different methods used to survey and monitor biodiversity. These lectures and hands-on sessions introduce the students to the most common (and some emerging) methods to survey terrestrial biodiversity. This should provide students with a basic understanding of the methods they might use in future industrial (e.g. ecological consultancy) or research work. This includes methods such as audio recording of bats and birds, insect monitoring with pan traps and pitfall traps or camera trapping for larger mammals. The advantages, disadvantages and challenges of each method will be introduced.

	Practical examples using audio recorders (including deployment and data analysis) will be undertaken.
Recommended Prerequisites	Basic knowledge of ecology
Mandatory Prerequisites	None
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Excursion - 15 hours Self organised studies - 150 hours per week per semester
Teaching Materials and Literature	Teaching materials will be uploaded in Moodle. Scientific papers: A selection of scientific papers will be decided prior to course start. https://doi.org/10.1016/j.baae.2025.03.004 https://doi.org/10.1371/journal.pone.0295474 https://doi.org/10.1016/j.mambio.2019.11.003 https://doi.org/10.1002/ece3.11157 https://doi.org/10.1111/j.2041-210X.2010.00062.x
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1. continuous assessment of activities during class (50 %) ; Regular in-class quizzes and/or reflections (appr. 10 minutes each time) Presentation of selected readings or practical activities conducted during the course. 2. Final written exam, 90 min (50 %)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	15
Remarks	none
Module Components	• 240323 Lecture: Biodiversity surveying tools and methods • 240324 Practical work: Biodiversity recording and analysis with Audiomoth and/or other tools. Analysing audio (or other) data.
Components to be offered in the Current Semester	**240323** Lecture Biodiversity surveying tools and methods - 1 Hours per Term **240324** Practical training Biodiversity recording and analysis with Audiomoth and/or other tools. Analysing audio (or other) data. - 3 Hours per Term

Module 14884 Automated Biodiversity Surveying Tools: Field Methods

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14884	Compulsory elective

Modul Title	**Automated Biodiversity Surveying Tools: Field Methods** Automatisierte Werkzeuge zur Biodiversitätserfassung: Feldmethoden
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	By the end of this course, students will be able to: - Demonstrate understanding of major terrestrial organism groups relevant to automated biodiversity monitoring. - Describe and compare automated biodiversity monitoring tools, their methodological assumptions, strengths, limitations. - Apply principles of ecological survey design to the planning of automated biodiversity surveys. - Collect, manage, and prprocess biodiversity data generated by automated field methods. - Apply AI-based tools (e.g. BirdNET) to automatically identify species from acoustic or image data. - Conduct field surveys during the excursion using automated and non lethal methods - Interpret biodiveristy patterns across different habitat types and land-use-contexts

Contents	This course combines lectures, hands-on sessions, and a compulsory field excursion to introduce automated methods for surveying and monitoring terrestrial biodiversity. Students work in small groups with modern monitoring tools such as passive acoustic recorders, camera traps, insect monitoring systems, and drones. Lectures provide an overview of the ecological, taxonomic, and methodological foundations of automated biodiversity monitoring, with a focus on birds, bats, and sonant insects. Common and emerging survey methods are presented and critically discussed with respect to their advantages, limitations, and practical challenges. The practical components emphasize non-lethal field methods, including the planning and implementation of monitoring campaigns, device deployment, standardized data collection, and the application of AI-based tools (e.g. BirdNET) for automated species identification. During the field excursion, students conduct independent surveys across different habitat types and analyze the collected data in an ecological and conservation context.
Recommended Prerequisites	Basic knowledge of ecology
Mandatory Prerequisites	None
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Excursion - 3 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Teaching materials will be uploaded in Moodle. Scientific papers: A selection of scientific papers will be decided prior to course start. https://doi.org/10.1016/j.baae.2025.03.004 https://doi.org/10.1371/journal.pone.0295474 https://doi.org/10.1016/j.mambio.2019.11.003 https://doi.org/10.1002/ece3.11157 https://doi.org/10.1111/j.2041-210X.2010.00062.x
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Student presentation (10 min) during the excursion and at the regular classes (25%), field exercises and practical method applications during the excursion (data collection) (25%), report created during the

	excursion (data analysis) (25%), discussions and other interactions facilitated by students during the excursion and at the regular classes (25%).
	Details about the filed exercises and data collection, the report and the interactions will be discussed and specified during the excursion.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	10
Remarks	none
Module Components	240325 Lecture/Seminar: Automated biodiversity surveying tools: field methods
	240326 Excursion: Biodiversity recording and analysis with Audiomoth and/or other tools. Analysing audio (or other) data.
Components to be offered in the Current Semester	No assignment

Module 14888 Invasion Ecology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14888	Compulsory elective

Modul Title	**Invasion Ecology** Invasionsökologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	By the end of this course, students will be able to: - Explain key concepts and definitions in invasion ecology, including distinctions between native, non-native, and invasive species. - Describe major pathways, stages, and mechanisms of biological invasions across terrestrial and aquatic ecosystems. - Summarize and compare central hypotheses and theoretical frameworks in invasion ecology from both invader and recipient community perspectives. - Analyze case studies of novel interactions between invasive and native species, including plant–insect, host–parasite, and predator–prey systems. - Evaluate ecological and socio-economic impacts of invasive species using empirical evidence. - Assess and compare management strategies for invasive species, including prevention, monitoring, risk assessment, and biological control.

Contents	This module introduces invasion ecology as a key field addressing the ecological, evolutionary, and socio-economic consequences of species introductions. It covers pathways and stages of biological invasions, definitions and classifications of invasive species, and major invasion hypotheses from both invader and recipient community perspectives. The course examines invasive species across terrestrial, freshwater, and marine ecosystems, with a focus on their impacts on biodiversity, ecosystem functioning, and human well-being. Special emphasis is placed on novel species interactions, including plant–insect, host–parasite, and predator–prey systems, and on evolutionary processes shaping invasions. Through lectures and case-study-based group projects, students engage with predictive models, risk assessment protocols, and management strategies such as eradication, monitoring, and biological control. The module also critically discusses potential benefits of introduced species and future challenges under global environmental change.
Recommended Prerequisites	Basic knowledge of ecology
Mandatory Prerequisites	None
Forms of Teaching and Proportion	Seminar - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Teaching materials will be uploaded in Moodle.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	<div id="meta-origin" data-coolorigin="https%3A%2F%2Fwww.b-tu.de%2Forgcloud%2Fapps%2Frichdocumentscode%2Fproxy.php%3Freq%3D%2Fcool%2Fclipboard%3FWOPISrc%3Dhttps%253A%252F%252Fwww.b-tu.de%252Forgcloud%252Findex.php%252Fapps%252Frichdocuments%252Fwopi%252Ffiles%252F9418674_ochtzup9yafk%26ServerId%3Dde63ef99%26ViewId%3D4%26Tag%3D898c6182c566bf05"> <p class="western">1) Continuous assessment of activities during class (50 %) 7 short tests, 20 minutes each <p class="western">2) final written exam (50%), 80 minutes <p>Regular attendance at the event is expected in order to achieve the modul's learning outcomes. <p class="western">
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	15
Remarks	none
Module Components	240327 Lecture/Seminar: Invasion ecology

Components to be offered in the Current Semester	No assignment

Module 41217 General and Applied Ecology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41217	Compulsory elective

Modul Title	**General and Applied Ecology** Allgemeine und Angewandte Ökologie
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Djoudi, El Aziz
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The Module General and Applied Ecology provides an overview of the basic and applied aspects of ecology. The lectures provide a comprehensive overview of modern concepts of ecology including ecophysiology, population and community ecology. Ecological research further requires a fundamental understanding of sampling techniques and designs. Students will learn about • basic concepts of ecology • analyses of simple and more complex ecological data • the diversity of ecosystems and organisms • contemporary challenges in ecology • basic concepts of study design • sampling techniques
Contents	• What is ecology? • Organisms in the environment • Ecophysiology • Population ecology • Community ecology • Understanding biodiversity • Analysing ecological data • Describing spatial distributions • Macroecology • Study design & hypothesis testing • Sampling organisms
Recommended Prerequisites	Bachelor Module 41102 Ecology, 12954 Biostatistics, 41106 Biology

Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The class is organized as lectures complemented by discussions and individual contributions. All slides and schedules are available in Moodle. Self-organized work, in particular independent acquisition of relevant ecological information, is required. Textbooks Begon, M., Townsend, C.R. & Harper, J.L. 2006. Ecology: from individuals to ecosystems. Blackwell Publ. Townsend, C.R., Begon, M. & Harper, J.L. 2008. Essentials of ecology. Blackwell Publ. Southwood, T. R. 1994. Ecological methods. Chapman & Hall MacGarigal, K., Cushman, S. & Stafford, S. 2000 Multivariate statistics for wildlife and ecology research. Springer Zuur, A.F., Ieno, E.N. & Smith, G.M. 2007 Analysing ecological data. Springer Scheiner, S.M. 2001 Design and analysis of ecological experiments. Oxford Univ. Press Quinn, G.P. & Keough, M.J. 2002 Experimental design and data analysis for biologists. Cambridge Univ. Press EBooks Jorgensen - Encyclopedia of Ecology Levin - Encyclopedia of Biodiversity Levin – The Princeton Guide to Ecology Pla - Quantifying Functional Biodiversity Adams – Species Richness
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	Written exam at the end of the lecture period (120 min.)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Complementary module WHS
Module Components	• 240745 Lecture/Seminar Fundamentals of Ecology • 240746 Lecture/Seminar Ecological Methods and Models
Components to be offered in the Current Semester	**240745** Lecture/Seminar Fundamentals of Ecology - 2 Hours per Term **240746** Lecture/Seminar Ecological Methods and Models - 2 Hours per Term **240748** Examination Exam General and Applied Ecology

Module 41406 Environmental Modelling

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41406	Compulsory elective

Modul Title	**Environmental Modelling** Umweltmodellierung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Kästner, Karl
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	**Part 1 Introduction Modelling of the Environment:** The lecture aims at providing basic understanding of dynamical modeling of the environment. Basic conceplts of systems analysis will be introduced. In particular the students will get familiar with basic concepts of modeling of Atmo-, Hydro-, Bio- and Pedosphere, learn about the relevant processes, main interactions, model sensitivities and uncertainties. **Part 2 Environmental modeling exercises:** In the numerical exercise the students will learn writing simplified models and apply more complex and state of the art numerical models of selected processes or subsystems of the environment. They will learn, how to analyse and to interpret the results. They will get familiar with multiprocessor computers and with the computational needs of environmental modelling.
Contents	**Part 1 Introduction to Modelling of the Environment:** An introduction to modeling of the environment will be given. Concepts of modeling of the Atmo-, Hydro-, Bio- and Pedosphere will be presented. In particular the identification of relevant processes within and interactions between the spheres and their modeling will be highlighted. The opportunities of making predictions will be demonstrated by application to environmental problems like hazards, climate change and pollution. The model sensitivities and uncertainties will be discussed. **Part 2 Environmental modeling exercises:** Each student gets the opportunity to write an own numerical model of selected processes in the environment. More complex state of the

	art numerical models describing the behavior of a whole subsystem of the environment shall be applied to answer some detailed questions. The numerical model results shall be presented and discussed with the course participants.
Recommended Prerequisites	Mathematics I and II, Basic knowledge in Physics, Biology and Chemistry, familiarity with a programming language, in particular with 'R' and with Linux computers
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Tutorial for R and shell-skript language. Documentation of the model COSMO-CLM Tutorial of the model COSMO-CLM Documentation of the hydrological model HYDRUS. Tutorial of the model HYDRUS. Will be offered at the beginning of the semester
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1. 15 minutes Presentation (discussion should be at least 5 minutes) of the results of model programming in form of a presentation or report, 9 pages including figures, tables, references, title page and list of content (35%) 2. 15 minutes Presentation (discussion should be at least 5 minutes) of the results of model application in form of a presentation or report, 9 pages including figures, tables, references, title page and list of content (35%) 3. Written exam, duration 60 min. or open book online exam if required (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	24
Remarks	The number of participants in the exercise (240114 and 240116) is limited. See the exercise description for details. Entrance test of basics in modelling and programming (with R). Needs to be passed before starting with model programming and model application exercise.
Module Components	**In summer semester:** • 240113 Lecture Introduction to Environmental Modelling • 240114 Exercise Environmental modeling exercises • 240116 Exercise Environmental modeling exercises
Components to be offered in the Current Semester	No assignment

Module 42505 Freshwater Restoration Ecology

assign to: Modules with the Focus on Environmental Sciences
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	42505	Compulsory elective

Modul Title	**Freshwater Restoration Ecology** Ökologie der Gewässerrenaturierung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. habil. Martin-Creuzburg, Dominik
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students know the basic principles and main methods of freshwater restoration and are able to assess the potential, but also the limitations, of restoration measures to mitigate or reverse human impacts. Students will be familiar with current methods and guidelines for evaluating surface water quality and restoration, as well as eco-engineering approaches to water management. Students will know cases of best-practice restoration and management.
Contents	Anthropogenic impact and current state of lakes, reservoirs, streams and rivers, quality assessment. Ecosystem services as target of management and restoration, impact of climate change on water bodies, strategies and planning of freshwater restoration, stream system rehabilitation and its limits, measures for in-stream habitat and floodplain enhancement, rehabilitation measures in the catchment, costs and benefits of restoration projects. General concepts and guidelines of lake and reservoir management, restoration principles, eco-engineering measures and other aspects of modern management of natural and artifical standing waters. Case studies of restoration and best management practice will be presented and discussed.
Recommended Prerequisites	Participation at module: • 13298 Basics for Freshwater Management
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester

	Excursion - 20 hours Self organised studies - 100 hours
Teaching Materials and Literature	Materials supplied via Moodle: Lecture notes, learning videos, literature for additional reading, key scientific articles and book chapters.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Written examination (80 minutes) at the end of the semester covering the main topics of the lectures and the seminar talks. Students will need to perform a seminar on an individual topic (20 min presentation and 20 min discussion). The exam result will contribute 65%, the presentation and post-presentation discussion 25%, active seminar participation 10%. Handing in protocols of the two excursions will gain extra points (2,5% of the total score for each protocol).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	**In summer semester:** • 240513 Lecture Freshwater restoration ecology • 240538 Excursion Practical field course river Spree • 240517 Examination Freshwater restoration ecology
Components to be offered in the Current Semester	**240560** Examination Prüfung Freshwater restoration ecology

Module 11284 Advanced Studies of International Environmental Law

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11284	Compulsory elective

Modul Title	**Advanced Studies of International Environmental Law** Internationales Umweltrecht für Fortgeschrittene
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. jur. Albrecht, Eike
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After completing the module, students should be able to: • Understand international environmental law and its role in the management of global environmental problems, • Identify and critically analyse issues pertaining to international environmental disputes, • Apply international environmental law in specific concrete cases, • Comprehend and evaluate the significance of international environmental law in protecting the environment and fostering international relations. After completing the seminar, students will: • Understand the way in which international agreements are achieved, • Understand the role various international actors play in decision making, • Have an understanding of the relevant actors who contribute to the outcome of international agreements, • Be able to make clear and convincing statements (orally and in written form), • Understand international decision-making procedures after playing an active role in a (simulated) negotiation process, • Have improved their skills in effectively arguing their case in relation to the topics discussed in class.
Contents	Lecture: Advanced Studies of International Environmental Law • Introduction to international law and international environmental law • Creation and development of international environmental law

- Implementation and enforcement strategies of international environmental agreements
- International environmental agreements with respect to the following topics:
  - Biodiversity (Biodiversity Convention/CITES/WHC).
  - Marine environment (Convention on the Law of the Sea)
  - Climate change (Climate Change Convention/Kyoto Protocol/Paris Agreement)
  - Ozone depletion (Convention for Protecting Ozone Layer/Montreal Protocol)
  - Toxic/hazardous substances (Basel Convention on Hazardous Waste)
  - Citizens rights to information, public participation and access to Justice

Seminar: International Negotiations and Environmental Decision-Making
- Challenges of international negotiations with a focus on climate change
- Actors of global environmental governance and international environmental decision-making
- State participation in global environmental governance
- The role of non-state actors in environmental decision-making and negotiations
- Simulation (role play) of an international conference (2 groups with maximum 35 students)

At the beginning of the semester, the students will we be prepared to participate in a simulation of a multilateral negotiation process. (Climate Conference Simulation Groups). Each student in the simulation group will take the role of a relevant international player such as a country, an NGO, the private sector, or a subsidiary body. Participants will be required to prepare (in written and oral form) an assigned country/ organisation engaged in the international environmental negotiation process to actively participate in the final role-play.

Recommended Prerequisites

Knowledge of the content of module:
- 41201 *International Environmental Law*

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Seminar - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Birnie/Boyle/Redgwell, International Law and the Environment, 4th edition, Oxford University Press, 2021
- Knopp/Epstein/Hoffmann, International and European Environmental Law with Reference to German Environmental Law – A Guide for International Study Programs, 2nd edition, Berlin 2019

- Albrecht, Egute, Wanki, Ezeamama (Eds.), International environmental law (IEL) – Agreements and introduction. 6th expanded and updated edition, 2022.
- IPCC, 2022: Summary for Policymakers. In: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi: 10.1017/9781009157926.001.
- IPCC, 2018: Summary for Policymakers. In: Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 3-24 https://doi.org/10.1017/9781009157940.001.

Additional literature will be announced in class and made available on the Moodle page of the course.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- **Written Exam, 120 minutes** (maximum 40 points)

And

Climate Conference Simulation Group:
- Paper for preparation of the climate conference, 2 pages (maximum 15 points)
- Simulation of a climate conference, 10 SWS (maximum 25 points)

or
Weekly seminars Group:
- 10 pages essay submission on topics related to environmental negotiations and decision-making (maximum 40 points)

To pass (grade 4,0) the module, students need to earn a minimum of 40 points.

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

- Lecture: Advanced Studies in International Environmental Law
- Seminar: International Negotiations and Environmental Decision-Making (including COTTCOP blocked seminars)

- Examination: Advanced Studies in International Environmental Law

Components to be offered in the Current Semester

No assignment

Module 11463 Urban and Regional Planning

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11463	Compulsory elective

Modul Title	**Urban and Regional Planning** Stadt- und Regionalplanung
Department	Faculty 6 - Architecture, Civil Engineering and Urban Planning
Responsible Staff Member	Prof. Dr. phil. Gribat, Nina
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	This module will allow students: • to understand the main strategic concepts, analytical methods and planning tools required in urban and regional planning • to analyse urban structures and functions • to understand the concept of historic urban landscapes • to identify the factors influencing urban change • to understand the impact of urban development on heritage sites and local communities • to develop urban strategies for the protection and valorisation of archaeological heritage.
Contents	The module will focus on the following contents: • main concepts and approaches to urban and regional planning • identification of the urban/regional profile (environmental, physical, social, demographic, economic, cultural setting) • stakeholder analysis and participatory approaches to urban and regional planning • historic urban landscape approach • urban and regional planning tools and methodologies • urban change and trends in urban development • impact of urban development on heritage sites • models for successful integration of archaeological sites in urban and regional plans.
Recommended Prerequisites	none

Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The bibliography will be presented in class.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• active participation (20%) assignment 1: oral presentation 15 minutes (30%) assignment 2: oral presentation 25 minutes plus written abstract of 500 words (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Module Code: HCSM - 213 In the event that the module cannot be taught or tested according to the present description (e.g. for reasons of infection protection), the alternatives communicated on relevant platforms (e.g. homepage or Moodle) apply.
Module Components	Lecture/Seminar Urban and Regional Planning
Components to be offered in the Current Semester	No assignment

Module 11693 Ecological-Economic Modelling for Biodiversity Conservation

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11693	Compulsory elective

Modul Title	**Ecological-Economic Modelling for Biodiversity Conservation** Ökologisch-ökonomische Modellierung für den Schutz der biologischen Vielfalt
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. rer. pol. Drechsler, Martin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	Student shall • acquire knowledge about the ecological modelling of populations • acquire knowledge about the economic modelling of conservation instruments • acquire knowledge about the ecological-economic modelling of land use and conservation instruments • be able to write simple simulation programs • be able to analyse an ecological-economic model to assess a conservation instrument
Contents	• Ecological modelling of populations • Economic modelling of conservation instruments • Ecological-economic modelling of land use and conservation instruments • Programming with the (free) software Netlogo • Development and analysis of an ecological-economic model
Recommended Prerequisites	• Good math grades at school and/or successful completion of modules in quantitative analysis such as statistics • Interest to learn some computer programming • It is recommended to take the modules 41427 Economics of Land Use and Biodiversity Conservation.
Mandatory Prerequisites	None

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	To be announced in class.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Homework exercises (40 out of 90 points) • Paper about analysis of ecological-economic model developed in course, 2000 - 2500 words (50 out of 90 points)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Complementary Module ERM Master
Module Components	• 240911 Lecture/Practical Training Ecological-Economic Modelling for Biodiversity Conservation
Components to be offered in the Current Semester	No assignment

Module 12032 Statistics for Economic Analysis of Ecosystem Service Provision and Biodiversity Conservation

assign to: Modules with the Focus on Environmental Economics, Planning and Law

Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12032	Compulsory elective

Modul Title	**Statistics for Economic Analysis of Ecosystem Service Provision and Biodiversity Conservation** Statistik für die ökonomische Analyse des Biodiversitätsschutzes und der Bereitstellung von Ökosystem-Dienstleistungen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. rer. pol. Drechsler, Martin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Understanding the main statistical concepts and methods used in the economic analysis of ecosystem service provision and biodiversity conservation
Contents	- Basics of statistics (probability theory, exploratory data analysis, testing of hypotheses, statistical modelling) - Economic applications: econometric analysis of land-use dynamics, contingent valuation of environmental goods - Ecological applications: habitat suitability modelling, population viability analysis
Recommended Prerequisites	Basic knowledge of mathematics and the use of MS-Excel / Open Office Calc
Mandatory Prerequisites	None
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	Seltman, H.J., 2018. Experimental Design and Analysis (URL: http://www.stat.cmu.edu/~hseltman/309/Book/Book.pdf)
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• 6 Exercises (home work) during course, each 1-2 h (each 5,5 %) • Written examination, 80 minutes (67 %)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	None
Module Components	Lecture Statistics for Economic Analysis of Ecosystem Service Provision and Biodiversity Conservation
Components to be offered in the Current Semester	**240919** Examination Statistics for Economic Analysis of Ecosystem Service Provision and Biodiversity Conservation **240920** Examination Statistics for Economic Analysis of Ecosystem Service Provision and Biodiversity Conservation

Module 12983 Climate Change and Migration

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12983	Compulsory elective

Modul Title	**Climate Change and Migration** Klimawandel und Migration
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Associate Prof. (Univ. Damaskus) Dr. agr. Ibrahim, Bachar
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After completion of this module, students will have a solid understanding of Climate Change and its impacts, especially on vulnerable countries. Students will further have the knowledge about various concepts and logical arguments linking climate change and migration.
Contents	**Part "Climate Change"** • Observations of change in the climate system • Critically assess the role of human activities in modern climate change • Assess future climate change scenarios and their potential impact on the Earth • climate change agenda and how this agenda impact on policy • Identify the Impacts and related Adaptation masures **Part "Migration"** • The potential link between climate change, migration, • The Task of defining 'climate refugee' • climate change contribution to the refugee problems • Gaps in the international legal framework • Individual and Collective Action on Mitigation Lectures will be given live online and afterwards uploaded as a PDF on the moodle For the exercise, students have to solve a given problem. Students have to select a topic on moodle and register in the given table (maximum of 4 students per group).
Recommended Prerequisites	none

Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Environment, forced migration and social vulnerability, T. Afifi, J. Jäger - 2010 - Springer • Climate change, human security and violent conflict: challenges for societal stability, J. Scheffran, M. Brzoska, H.G. Brauch, P.M. Link… - 2012 • People on the move in a changing climate: The regional impact of environmental change on migration, E. Piguet, F. Laczko - 2013 • Global migration governance, A. Betts - 2011 • Disentangling migration and climate change, T. Faist, J. Schade - 2013 - Springer • Climate change and migration: security and borders in a warming world, G. White – 2011- Oxford University Press
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Oral Exam, 30 min. (50%) • Two presentations on the a scientific topic (each 25%) A pass mark is only achieved by obtaining at least 50% of the grade for each part of the module. The examination as well as the seminar part have to be passed (at least 50% in each) to pass the module.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	An annual excursion pertaining to the module may be organised. ***Complementary Module in Master Environmental and Resource Management.***
Module Components	• Lecture • Seminar • Examination
Components to be offered in the Current Semester	No assignment

Module 13234 Communication of Science and Technology

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13234	Compulsory elective

Modul Title	**Communication of Science and Technology** Wissenschafts- und Technikkommunikation
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Students will know about different techniques, tools and formats for communication of science & technology. They will develop skills to break down complex issues at the nexus of science, technology and society to communicate science/technical information in a clear, understandable and engaging way to different stakeholders. On completion of the module, students will be able to: • Articulate the key issues and challenges in communicating about science & technology; • Understand the nature of different audiences for better stakeholder engagement; • Demonstrate awareness of and ability to use a variety of different techniques and media for targeted audience; • Improve their skills in communication of scientific/technical information in both written and oral forms; • work as part of a team to develop effective measures for communication of science & technology; • Provide constructive feedback to other students on their communication skills.
Contents	Course coverage: • Key issues in communication of science & technology; • Identify and knowing your audiences (mental models, risk perception, heuristics and biases, …); • Getting your audience's attention (Types of framing); • Communicating risk and uncertainty; • Formats for communication of science & technology.

Students will also be given opportunities to receive feedback and improve their own written and oral skills. They will also work in small teams on team projects to further their skills for communicating about sustainability issues. These projects will focus on communicating about a given scientific topic to a particular audience using spoken, visual, written or web-based communication.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Seminar - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Center for Research on Environmental Decisions (CRED). 2009. *The Psychology of Climate Change Communication: A guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public.* New York.
- Nisbet, M.C., Scheufele, D.A. 2009. What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, 96(10): 1767-1778.
- Bubela, T., Nisbet, M., Borchelt, R. *et al.* 2009. Science communication reconsidered. Nature Biotechnology, 27, 514–518.
- Nelkin, D. 1989. Communicating technological risk: The social construction of risk perception. *Annual Review Public Health*, 10, 95-113.
- Tversky, A., Kahneman, D. 1974. Judgment under Uncertainty: Heuristics and Biases. Science, New Series, 185(4157), 1124-1131.

Further material (including lecture slides and additional materials including videos, readings etc.) might be announced during the first class meeting.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Individual E-Assessment – 60 min (40%)
- Group project - Part 1: Science Communication Material e.g., poster, video, etc. (30%)
- Group project - Part 2: Group presentation– 15min oral presentation (30%)

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

- Lecture / Seminar

Components to be offered in the Current Semester

510601 Lecture/Seminar
Communication of Science & Technology - 4 Hours per Term

Module 13655 Un/Disciplining Knowledge: Technology, Science, and Society in Transformation

assign to: Modules with the Focus on Environmental Economics, Planning and Law

Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13655	Compulsory elective

Modul Title	**Un/Disciplining Knowledge: Technology, Science, and Society in Transformation** Epistemischer Ungehorsam: Technik, Wissenschaft und Gesellschaft im Wandel
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. nat. phil. habil. Schwarz, Astrid
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	By the end of the module students are able to develop a research question within the academic field of Science and Technology Studies and create and present a research design, as well as identify and make use of appropriate sources of empirical material for your analysis, furthermore to identifiy, select and compare appropriate concepts and methods relating to an interdisciplinary research field and analyse changes in fields of science and technology with respect to knowledge forms.
Contents	This module presents central theories and approaches developed in Science and Technology Studies. The module focuses on questions about disciplining and undisciplining knowledge, the corresponding epistemic and ontological perspectives and the political economy of science. It explores concepts being concerned about shifting concepts of disciplinarity, such as interdisciplinarity, transdisciplinarity or postdisciplinarity.
Recommended Prerequisites	Knowledge from the courses • Technik in Wissenschaft und Gesellschaft • Philosophy of Science in Practice
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester

	Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature and learning materials are given in the course description.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• short scientific essay, max. 4000 words (45%) • scientific review, max. 2500 words (40%) • presentation, max. 15 minutes (15%) The oral part of the examination can be done digitally or as a virtual meeting if the conditions for an examination in presence are not given.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	German-speaking teachers are available if required. Further information on this can be found in the course description.
Module Components	• Seminar - 4 SWS
Components to be offered in the Current Semester	**510151** Seminar Un/disciplining Knowledge - 4 Hours per Term

Module 13657 How to Talk about Nature?

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13657	Compulsory elective

Modul Title	**How to Talk about Nature?** Wie über Natur sprechen?
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. nat. phil. habil. Schwarz, Astrid
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After passing the module, students understand main philosophical theories of “nature”, interrogate the concept of “nature” and expose its numerous ideological and cultural manifestations. They identify the main ethical dimensions of “nature”, and its crosscultural and political dimensions. Additionally they understand the power of narratives and storytelling to shape our environmental present and future by insight into reading, writing, and visual practices about “nature”.
Contents	“How to talk about nature?” is closely linked to the question of what “nature” is, how it is construed and in which way we act with, in or against it. It is a question that is ontological and epistemological at the same time, it is about how we imagine nature “to be” and how we conceive knowledge about nature. The ideas about this entwinement are manifold over time and in space, different cultures have developed different ways of thinking and also practices of how to deal with a culture/nature distinction. Another important conceptual issue is how nature and technology are related, in contemporary debates for instance, "nature" is often identified with "environment" and as such inescapably entangled with its cultural, political, and technological context. Is the use of technology in “nature” then a threat or an opportunity to build a genuinely sustainable world? This module seeks to answer these and other questions, by approaching “nature” with variously grounded historical and contemporary theoretical approaches. For example, the concept of “nature” was differently interpreted in ancient times, compared to modern contemporary cultures. We will probe the different usage, the scope of historical and cross-cultural depth, the semantics, the images/

	imaginaries, and finally, the logical coherence of “nature” concepts. This variety of topics means that the assigned readings will draw from a wide range of sources. With respect to handle current ecological and technocultural problems, a conscious reflection about “nature” seems to be required. Thus, the module should be also seen, in part, as a way to gain insight into contemporary reading, writing, and visual practices about “nature”. Participation in the accompanying excursion is encouraged.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature and learning materials are given in the course description.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• One short essay, max 1500 words (25%) • Two reviews, each max. 2000 words (each 30%) • 2 oral (group) presentations, about 15 min **OR** weekly submitted written answers to one short question per week on the topical readings to be determined by the instructor (15%) The oral part of the examination can be done digitally or as a virtual meeting if the conditions for an examination in presence are not given.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	60
Remarks	none
Module Components	• Seminar, lecture - 4 hours per week per semester
Components to be offered in the Current Semester	**510112** Lecture/Seminar How to talk about "Nature"? / Ethik und Handeln / Philosophy of Technology and Nature / Natur und Technik / Wissenschaftstheorie, Logik und Naturphilosophie - 4 Hours per Term

Module 13669 Law and Policy for Agricultural Resource Management

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13669	Compulsory elective

Modul Title	**Law and Policy for Agricultural Resource Management** Recht und Politik für die Bewirtschaftung landwirtschaftlicher Ressourcen
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. jur. Albrecht, Eike
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After successful completion of the module, students will be able to: • Understand that sustainable management of agricultural resources is not just key to maintaining sustainable food supplies and food security – it is also necessary for supporting the proper functioning of the ecological systems that determine the conditions for life itself • Critically analyse and understand the main legal and policy frameworks aimed at protecting the ecological integrity of agricultural resources in the EU • Grasp a multitude of critical perspectives on the management of agricultural resources • Comprehend a number of carefully chosen areas of agricultural resources management, including specific topics and themes from international and comparative perspectives
Contents	The lectures will focus on a number of carefully chosen areas of agricultural resources management, which will be further contextualised in the seminars, where students will have the opportunity to engage more closely with specific topics and themes from international and comparative perspectives. Key lecture topics - Sustainable agriculture and food security - Protection of water resources from agricultural over-use and pollution (pesticides and phosphorous) - Agriculture, land use and biodiversity protection

	- Agriculture and climate change (livestock production, soils, forestry, mitigation and adaptation) Seminars topics to be announced in class.
Recommended Prerequisites	Knowledge of the content of module • 41201 International Environmental Law
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Birnie/Boyle/Redgwell, International Law and the Environment, 4th edition, Oxford University Press, 2021 • Knopp/Epstein/Hoffmann, International and European Environmental Law with Reference to German Environmental Law – A Guide for International Study Programs, 2nd edition, Berlin 2019 Additional literature will be announced in class and made available on the course Moodle page.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Essay: Written individual course work, maximum 3000 words including footnotes (50 %) • Presentation: (individual) 'Visual' form of assessment critiquing specific areas of law and policy, maximum 20 minutes per student (50 %) To pass (grade 4,0) the module, students need to earn a minimum of 50 points
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Not offered in the winter semester 2026/27.
Module Components	• Lecture: Law and policy for agricultural resource management • Seminar: International perspectives on agricultural resource management and implementation of regulatory frameworks
Components to be offered in the Current Semester	No assignment

Module 13705 Sociology of Sustainable Development

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13705	Compulsory elective

Modul Title	**Sociology of Sustainable Development** Soziologie der nachhaltigen Entwicklung
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Jaeger-Erben, Melanie
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students overview sociological approaches, theories and research topics in the context of sustainable development. After completing the module, they will have a sound knowledge on various approaches of social-ecological transformation and will be able to critically discuss current concepts such as the Anthropocene, Green Growth or Circular Economy. They have expertise in the reception and presentation of scientific texts.
Contents	Sustainable development promises to meet human needs of present and future generations while maintaining the integrity and stability of natural systems. However, this concept has been criticised on various grounds. Some argue that more fundamental changes are required to solve the multiple, accelerating crises of our times. Under the umbrella term ‘socio-ecological transformation’, scholars discuss various political, socio-economic, socio-technical and cultural changes aimed at responding appropriately to the socio-ecological crisis. This module critically engages with current sustainability debates from a sociological perspective, thereby discussing concepts such as Green Growth, Degrowth, Circular Economy or the Anthropocene. It explores how we can move to a society and economy in which human needs are met within planetary boundaries.
Recommended Prerequisites	41421: Introduction to Environmental and Resource Management II
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Exercise - 2 hours per week per semester

	Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Eisenmenger et al. (2020). The Sustainable Development Goals prioritize economic growth over sustainable resource use: a citrical refection onthe SDGs from a socio-ecological perspective. Sustainability Science, 15:1101-1110. • Haberl, H. et al. (2011). A Socio-metabolic Transition towards Sustainability? Challenges for Another Great Transformation. Sustainable Development 19, 1-14 • Gough, I., 2017. Recomposing consumption: defining necessities for sustainable and equitable well-being. Phil. Trans. R. Soc. A. 375, 20160379. • Hickel, J., Kallis, G., 2020. Is Green Growth Possible? New Political Economy 25, 469–486. • Malm, A., Hornborg, A., 2014. The geology of mankind? A critique of the Anthropocene narrative. The Anthropocene Review 1, 62–69. Further literature will be announced in the module.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Reading assignments, 1.500-2000 words (20%) • Reflections on sessions, 1.500-2000 words (20%) • Pecha Kucha presentation, (7 Min.) oder Podcast (20Min.) (30%) • Written Test (multiple choice, 30 Min.) (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	50
Remarks	none
Module Components	• Exercise: Research and methods of a Sociology of Sustainability - 2 Hours per Week per Semester • Seminar: Theories of Social-Ecological Transformation - 2 Hours per Week per Semester
Components to be offered in the Current Semester	No assignment

Module 13706 Justice and Diversity in Environmental Change

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13706	Compulsory elective

Modul Title	**Justice and Diversity in Environmental Change** Gerechtigkeit und Diversität im Kontext von Umweltveränderungen
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Jaeger-Erben, Melanie
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	• Acquiring a profound understanding of different concepts on social justice and diversity in the context of environmental change, climate change and sustainable development. • Discussing and critically reflecting upon current issues related to environmental justice, such as resource conflicts, land-use change or environmental movements. • Methodological skills in reading and discussing academic texts, preparing Pecha Kucha presentations, and recording scientific podcasts.
Contents	Environmental problems have the capacity to affect all of us. However, certain communities are disproportionally exposed to environmental hazards, such as air pollution. Also, some regions of the world (will) suffer much more from the implications of climate change. Environmental problems thus do not affect us all equally, or in the same way. Nor do we have equal power to decide solutions to these problems, or to take the necessary action to solve them. This unequal positioning, which often impose the greatest burdens upon marginalised, disadvantaged and less powerful populations, forms the central premise of environmental justice research and activism. The goal of this module is to gain a comprehensive understanding of social justice, environmental justice and diversity in environmentalism. The course introduces concepts such as environmental racism, climate justice, ecofeminism, and indigenous perspectives on environmental change. The theoretical perspectives introduced are applied to various environmental movements and resource conflicts all over the world.

Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Exercise - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Bell, K. (Ed.) (2021). Diversity and Inclusion in Environmentalism, Routledge. • Holifield, R., Chakraborty, J., Walker, G. (Eds.) (2018). The Routledge Handbook of Environmental Justice, Routledge. • Lele, S. et al. (Eds.) (2019). Rethinking environmentalism: Linking justice, sustainability, and diversity (Vol. 23). MIT Press. • Williams, J. (2021). Climate change is racist. Race, privilege and struggle for climate justice. Icon Books. Further literature will be announced during class.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Reading assignments, 1.500-2.000 words (20%) • Reflections on sessions, 1.500-2.000 words (20%) • Pecha Kucha presentation, 6:40 Min (30%) • written test (multiple choice) (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	50
Remarks	none
Module Components	• Exercise Theoretical approaches to Justice and Diversity in Environmental Change • Seminar Justice and Diversity research and methods in the context of Environmental Change
Components to be offered in the Current Semester	**510535** Seminar Justice and Diversity research and methods in the context of Environmental Change - 2 Hours per Term **510530** Lecture/Exercise Theoretical approaches to Justice and Diversity in Environmental Change - 2 Hours per Term

Module 13796 Just Energy Transition

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13796	Compulsory elective

Modul Title	**Just Energy Transition** Energiewende gerecht gestalten
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Hirschl, Bernd
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	On completion of this unit, students will be able to demonstrate the main conceptual debates surrounding just energy transitions. Students will be equipped with in-depth critical theoretical and empirical knowledge of the patterns of energy transition governance. After attending the module, students are able to conduct case analyses. The module is designed for Master students to develop their research, argumentation and presentation skills, as well as their capacities for collaborative work and group learning.
Contents	This module will discuss key opportunities and challenges of transitioning towards climate neutral energy systems, primarily through a social science lens. “Leaving no one behind” is a catchphrase used in contemporary climate and energy policies, that we will explore in more detail with texts from political science (policy analysis and political economy), philosophy, economics and sociology. We will discuss the dynamics of capitalism, questions of culture and everyday life, the role of the state, and international governance structures. The course is guided by the following questions: • What are the *conceptual foundations* of just energy transitions? • What are *universal and country-specific challenges* to just energy transitions? • What are *national and international responses* from society, politics and businesses to these challenges?
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Seminar - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	There are no core texts for this course. Essential readings for the seminars will be indicated with the course start. The following literature can be used for preparation: • Scoones, I., Leach, M., and Newell, P., eds. 2015. The politics of green transformations. Abingdon: Routledge • Unruh, G. C. (2000) 'Understanding carbon lock-in', Energy Policy, Vol 28, no 12, pp 817–830 • Peter Newell & Andrew Simms (2021) How Did We Do That? Histories and Political Economies of Rapid and Just Transitions, New Political Economy, 26:6, 907-922
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Case study, about 2,500 words (50 %) Empirical case study with theoretical underpinnings of a region/ country of the student's choice (not restricted to Global North): What are specific opportunities and challenges of a just energy transition and which responses have been implemented/are lacking? • Presentation, 15 min + 5 min Disscussion (topics to be announced) (40 %) topics to be announced • Class Participation (10 %)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	***Module with limited number of participants - Registration two weeks prior to the commencement of lectures!***
Module Components	• Seminar
Components to be offered in the Current Semester	No assignment

Module 13833 Analysis and Modelling of Human-Environment Systems

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13833	Compulsory elective

Modul Title	**Analysis and Modelling of Human-Environment Systems** Analyse und Modellierung von Mensch-Umwelt-Systemen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. Müller, Birgit
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Upon completing the course, students will be able to: • Identify key features of coupled human-environment systems and apply this knowledge to interdisciplinary case studies. • Understand core principles of complex adaptive systems. • Design, implement, and analyse agent-based models to investigate human-environment interactions.
Contents	How do deforestation, urban expansion, or climate policies impact ecosystems and communities? Understanding these complex interactions is key to tackling today's urgent environmental challenges. This course provides an introduction to modelling human-environment systems, emphasizing the intricate feedback loops between human activities and the biophysical world—across local, regional, and global scales. The module has two main focus areas. First, students will explore the key characteristics of coupled socio-environmental systems. We will read and discuss interdisciplinary research papers on applied case studies and theoretical considerations and examine how models can bridge science and real-world decision-making — whether in climate change adaptation, land-use planning, or resource management. Specific topics include to understand how human behaviour is represented in models, which role play social networks and how common pool resource management can support sustainable outcomes. Guest speakers will enrich the course with diverse perspectives and practical insights.

	Second, students will acquire hands-on experience in agent-based modelling using the NetLogo programming environment designed for beginners. They will learn how to conceptualize, build, and analyse computer models to simulate interactions within socio-environmental systems. Additionally, an introduction to statistical data analysis in R will provide essential tools for model evaluation and interpretation.
Recommended Prerequisites	None
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Marco Janssen (2020). Introduction to Agent-Based Modeling with applications to social, ecological and social-ecological systems. (ebook, 2n edition) • Further literature will be announced in the module.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 6 Exercises / homework a ca. 3h (Model conceptualisation tasks, programming tasks in NetLogo and short research paper presentations) 50%, • Realisation of a modelling project, conceptualisation and presentation (10-15 min) of its results on a scientific poster, 50%
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture / Exercise
Components to be offered in the Current Semester	**240921** Lecture/Exercise Analysis and Modelling of Human-Environment Systems - 4 Hours per Term

Module 13925 Alternative Economies

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13925	Compulsory elective

Modul Title	**Alternative Economies** Alternative Ökonomien
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Jaeger-Erben, Melanie
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Upon successful completion, students will have a solid overview on heterodox economic theories (including feminist, post-Keynesian, ecological and political economy perspectives), and understand how they differ from neoclassical economics. They are skilled in discussing and critically reflecting upon the opportunities, limitations and the applicability of different economic concepts presented in class. Students will acquire methodological skills in researching, reading and discussing academic literature.
Contents	The multiple crises we are currently facing – in relation to climate, biodiversity, democracy, or social inequalities – require different economic perspectives and practices. In lectures and seminars, students will learn about the limits of the dominant neoclassical paradigm and gain an overview on heterodox economic schools. They will be introduced to concepts such as degrowth, care economy, economic democracy or social entrepreneurship. At the same time, this course will critically analyse fundamental aspects of current economies, such as money, growth, profits, work or the relation to nature, and discuss practical examples of alternative economies.
Recommended Prerequisites	Knowledge of the contents of module • 13922 *Introduction to Transformation Studies*
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester

	Self organised studies - 120 hours
Teaching Materials and Literature	• Chang, H.-J. (2014). Economics: The User's Guide. Bloomsbury Publishing. • Bauhardt, C. (2014). Solutions to the crisis? The Green New Deal, Degrowth, and the Solidarity Economy: Alternatives to the capitalist growth economy from an ecofeminist economics perspective. Ecological Economics 102, 60-68. https://doi.org/10.1016/ j.ecolecon.2014.03.015 • The Foundational Economy Collective (2022). Foundational Economy. The infrastructure of everyday life. Manchester University Press. • Raworth, K. (2017). Doughnut economics: seven ways to think like a 21st-century economist. London: Random House Business Books. • Wellbeing Economy Alliance (2020). Wellbeing Economics for the COVID-19 recovery. Ten principles to build back better. Briefing Paper,https://serval.unil.ch/resource/ serval:BIB_C2D492EC73DF.P001/REF. • Kallis, G. et al. (2018). Research on Degrowth. Annual Review of Environment and Resources. 43:4.1–4.26.https://doi.org/10.1146/ annurev-environ-102017-025941
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Participation and reflection notebook, 1,500-2,000 words (30%) • 4 short tests in class, 10 min. each (40%) • Poster presentation in groups (15 min.) (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	40
Remarks	***Module with limited number of participants - Registration two weeks prior to the commencement of lectures!***
Module Components	none
Components to be offered in the Current Semester	No assignment

Module 13957 Behavioural Economics

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13957	Compulsory elective

Modul Title	**Behavioural Economics** Verhaltensökonomie
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. oec. habil. Schnellenbach, Jan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After completing this module, students will be able to apply behavioural economic models to analyse individual decisions. They can integrate psychological research approaches into economic models. They can independently develop and master advanced research approaches in the field of behavioural economics and have a solid understanding of the basics of empirical, including experimental, research methods in the field of behavioural economics. Furthermore, they will be able to critically analyse and evaluate economic policy proposals with a behavioral economics perspective.
Contents	• Homo Economicus: The economic concept of human behaviour • The economic theory of moral action • Behavioural anomalies: an overview • Bounded rationality • Dealing with risk and uncertainty • Prospect theory • Heuristics: Curse or blessing? • Fairness and social norms • Economic happiness research • Behavioural political economy • Behavioural public economics
Recommended Prerequisites	Good knowledge of microeconomics.
Mandatory Prerequisites	No successful participation in the corresponding discontinued module 11814 Behavioral Economics.

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Foundational literature: • Angner, E. (2012). A Course in Behavioral Economics, Houndmills: Palgrave Macmillan. • Additional literature will be announced during the lecture. In the exercise: • Wilkinson, N. and Klaes, M. (2012), An Introduction to Behavioral Economics. 2nd edition, Houndmills: Palgrave Macmillan.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Mid-term exam, 30 min. (30 points) • Final exam, 70 min. (70 points)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	This module is a successor module to the module „Behavioral Economics (11814)". Students who have already passed the module cannot take the module "Behavioral Economics (13957)" again.
Module Components	Behavioral Economics (Lecture) Behavioral Economics (Exercise)
Components to be offered in the Current Semester	**530631** Lecture Behavioral Economics - 2 Hours per Term **530632** Exercise Behavioral Economics - 2 Hours per Term

Module 13958 Economics of Innovation

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13958	Compulsory elective

Modul Title	**Economics of Innovation** Innovationsökonomik
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. oec. habil. Schnellenbach, Jan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Each winter semester even year
Credits	6
Learning Outcome	Students will understand how innovation can be explained from a microeconomic perspective. They will know the economic, institutional, and psychological prerequisites for entrepreneurial innovation. Upon successful completion of the module, students will be able to critically assess under which circumstances innovative entrepreneurial actions are positively evaluated and potentially eligible for economic policy support.
Contents	Innovation in the history of economic theory; Types of innovation; Competition and innovation; Organizational aspects of innovation; Political and institutional prerequisites for innovation; Diffusion of innovations; Innovation and economic growth; Innovations and societal welfare.
Recommended Prerequisites	Good knowledge of microeconomics.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	G.M. Swann, The Economics of Innovation: An Introduction, Elgar, 2013 as well as additional articles and book chapters announced during the lecture
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• exam, 30 min. (Mid-term, 30 points) • exam, 70 min. (Final, 70 points)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	No offer in the winter semester 2025/26.
Module Components	Innovation Economics Lecture - 2 hours per week Innovation Economics Exercise - 2 hours per week
Components to be offered in the Current Semester	**530634** Lecture Economics of Innovation - 2 Hours per Term **530635** Exercise Economics of Innovation - 2 Hours per Term

Module 13959 Law and Economics

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13959	Compulsory elective

Modul Title	**Law and Economics** Recht und Wirtschaft
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. oec. habil. Schnellenbach, Jan
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Each winter semester odd year
Credits	6
Learning Outcome	Students will gain an overview of the field of economic analysis of law, which involves analyzing legal rules from the perspective of economic theory. It focuses on the interaction of legal norms with the actions of private households and companies, as well as the impact of constitutional law on government actions. Students should learn to analyze legal norms in terms of their efficiency and economic effects, including microeconomic efficiency, as well as growth and distribution effects. They should also be able to assess why specific legal norms have developed historically as we know them today.
Contents	1. Fundamentals of the theory of private property rights a) Historical development of private property b) Theories of the emergence of private property rights c) Economic analysis of common-pool resources d) Property rights in intangible assets 2. Economic analysis of contract law a) Complete and incomplete contracts b) Moral hazard and adverse selection c) Efficient responses to contract breaches 3. Economic analysis of tort law a) The Coase theorem b) Economic analysis of liability rules 4. Economic analysis of criminal law a) Differentiating between tort law and criminal law b) Deterrence effects of criminal law c) Optimal deterrence effects 5. Constitutional economics

	a) Fundamentals of the economic theory of public law b) Empirical analysis of the economic effects of constitutional rules
Recommended Prerequisites	Basic knowledge of microeconomics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	H. Schäfer and C. Ott, Lehrbuch der ökonomischen Analyse des Zivilrechts, 5th edition, Heidelberg: Springer, 2012 Additional articles and book chapters announced during the lecture
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• exam, 30 min. (mid-term, 30 points) • exam, 70 min. (final, 70 points)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	None
Module Components	Law & Economics Lecture - 2 hours per week Law & Economics Exercise - 2 hours per week
Components to be offered in the Current Semester	No assignment

Module 14132 Multidimensional Approaches for Technology Assessment

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14132	Compulsory elective

Modul Title	**Multidimensional Approaches for Technology Assessment** Multidimensionale Ansätze für Technikfolgenabschätzung
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students know about a range of technology assessment approaches, methodologies and tools to facilitate the evaluation of decarbonization & sustainability transformation options along socio-technological-economical-ecological-political (*STEEP*) dimensions. On completion of the module, students are able to: • Demonstrate a deep understanding of the multidimensional aspects and systemic interactions in the transformation of energy- and carbon-intensive industries; • Gain familiarity with a range of qualitative and quantitative methodologies in conducting technology assessment; • Design and conduct studies to analyze the opportunities and challenges which will be associated with the transformation of energy- and carbon-intensive industries along multiple dimensions; • Identify, assess and evaluate appropriate sources of information and critically reflect on the methodologies commonly implemented for technology assessment and their usefulness/weaknesses.
Contents	Course coverage: • Relevance and development of technology assessment; • Common methodological approaches and their usefulness/weakness; • Data and approaches for assessment (e.g., primary vs. secondary; qualitative vs. quantitative); • Methodologies for socio-political evaluations, techno-economic evaluations and ecological evaluations;

- Application on a case study to assess multidimensional opportunities and challenges associated with the transformation of a specific sector and derive implications along the *STEEP* dimensions based on assessment results.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 1 hours per week per semester
Exercise - 1 hours per week per semester
Study project - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Lee, R.P., Meyer, B., Huang, Q.L, Voss, R. 2020. Sustainable waste management for zero waste cities in China: potential, challenges and opportunities. *Clean Energy*, 4(3): 169 – 201.
- Lee, R.P. 2019. Alternative carbon feedstock for the chemical industry? – Assessing the challenges posed by the human dimension in the carbon transition, *Journal of Cleaner Production*, 219: 786-796.
- Lee, R. P., Tschoepe, M., Voss, R. 2021. Perception of chemical recycling and its role in the transition towards a circular carbon economy: A case study in Germany. *Waste Management*, 125: 280-292.
- Voss, R., Lee, R.P., Seidl, L., Keller, F., Fröhling, M. 2021. Global warming potential and economic performance of gasification-based chemical recycling and incineration pathways for residual municipal solid waste treatment in Germany. *Waste Management*, 134: 206 – 219.
- Keller, F., Lee, R.P., Meyer, B. 2020. Life cycle assessment of global warming potential, resource depletion and acidification potential of fossil, renewable and secondary feedstock for olefin production in Germany. *Journal of Cleaner Production*, 250: 119484.
- Lee, R.P., Scheibe, A. 2020. The politics of a carbon transition: An analysis of political indicators for a transformation in the German chemical industry*, Journal of Cleaner Production*, 244: 118629.

Further materials are provided via Moodle (including lecture slides and additional materials including videos, readings etc.)

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Individual component (E-assessment), 60-90 min - 50%
- Group Project - Part 1: Create a scientific poster (Analysis of e.g., a scientific article, industry report, case study, ...) - 25%
- Group Project - Part 2: Presentation, 15min - 25%

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

- Lectures & Exercises
- Projects

Components to be offered in the Current Semester	No assignment

Module 14288 Psychology of Entrepreneurship and Change

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14288	Compulsory elective

Modul Title	**Psychology of Entrepreneurship and Change** Psychologie des Unternehmertums und Wandels
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. Urbig, Diemo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	<p data-start="0" data-end="303">After sucessfully completing this module, students will understand how fundamental psychological theories of decision-making under uncertainty, complex interdependence, and intertemporal dynamics can help explain the behavior of individuals who drive change, such as entrepreneurs, innovators, and social activists. They will have developed a basic understanding of the key psychological and behavioral economics theories related to decision-making under risk, uncertainty, and with intertemporal consequences. Students will be able to identify and explain critical patterns of thinking and decision-making in workplace contexts. Students will also be able to apply these theories to real-world situations.
Contents	In this module, we venture into the specifics of a wide range of decision-making theories. We travel through a diverse collection of seminal theories, including many that have formed the basis of Nobel Prize-winning research. We emphasize the interdisciplinary application of insights to ensure that students from a variety of disciplines can absorb and apply the knowledge gained in this module to their own professional decision-making scenarios. The concepts and theories are presented in lectures. Students practice their theory application skills by presenting and discussing critical issues and applications of these theories in seminar.

The literature is presented in the lecuture and students can afterwards read the literature in depth.
The topics include:

- Satisficing and dual process theories
- Risk aversion and ambiguity aversion
- Prospect theory and loss aversion
- Mental accounting and choice bracketing
- Risk reduction strategies: Hedging, learning, and real options
- Time preferences
- Status-quo, escalation of commitment, and the not-invented-here effect
- Personal initiative, sensation seeking, and entrepreneurship
- Rational herding and individually irrational learning
- Nash equilibrium and individually irrational cooperation

In each session of the module, we will focus on one or two articles that present a specific theory or topic.

To collect data, all students take part in a survey that measures some of the constructs addressed in the module, allowing lectures and seminars to use student data as a basis for discussion.

Recommended Prerequisites

none

Mandatory Prerequisites

No successful participation in modules

- 13811 *Behavioral Resource Management*
- 13514 *Individuals in Transformation Processess*

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Seminar - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

In each session of the module, we will focus on one or two articles that present a specific theory or topic. The lecture will introduce the main ideas of the articles, highlight the sections students should focus on, and provide a foundation for reading the articles in greater detail. Please note that students are not expected to understand each of the articles entirely in depth.

- Bernardo, A. E., & Welch, I. (2001). On the evolution of overconfidence and entrepreneurs. *Journal of Economics & Management Strategy*, *10*(3), 301-330.
- Bönte, W., Urbig. D. (2019) *Connecting People and Knowledge: Knowledge Spillovers, Cognitive Biases, and Entrepreneurship* (Chapter 34). In: E. E. Lehmann, M. Keilbach (eds.), From Industrial Organization to Entrepreneurship. Springer, pp. 385-397.
- Crant, J. M. (2000). Proactive behavior in organizations. Journal of Management, 26(3), 435-462.
- Ellsberg, D. (1961). Risk, ambiguity, and the savage axioms. *The Quarterly Journal of Economics*, 75(4), 643-669.

- Evans, J. S. B., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. Perspectives on Psychological Science, 8(3), 223-241.
- Fehr, E., & Schmidt, K. M. (1999). A theory of fairness, competition, and cooperation. *The Quarterly Journal of Economics*, 114(3), 817-868.
- Fox, C. R., & Tversky, A. (1995). Ambiguity aversion and comparative ignorance. *The Quarterly Journal of Economics*, 110(3), 585-603.
- Frederick, S., Loewenstein, G., & O'donoghue, T. (2002). Time discounting and time preference: A critical review. *Journal of Economic Literature*, 40(2), 351-401.
- Kahneman, D., Tversky, A. (1979). Prospect theory: An analysis of decisions under risk. *Econometrica*, 47, 278.
- Loewenstein, G. F., Weber, E. U., Hsee, C. K., & Welch, N. (2001). Risk as feelings. *Psychological Bulletin,* 127(2), 267–286.
- Ostrom, E. (2000). Collective action and the evolution of social norms. *Journal of Economic Perspectives*, 14(3), 137-158.
- Read, D., Loewenstein, G., Rabin, M., Keren, G., & Laibson, D. (2000). Choice bracketing. In S. Barbera, P. Hammond, & C. Seidl (Eds.), *Elicitation of Preferences* (pp. 171–202). Springer.
- Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of Risk and Uncertainty*, *1*(1), 7-59.
- Simon, H. A. (1955). A behavioural model of rational choice. *The Quarterly Journal of Economics*, *69*(1), 99-118.
- Staw, B. M. (1981). The escalation of commitment to a course of action. *Academy of Management Review*, *6*(4), 577-587.
- Thaler, R. (1985). Mental accounting and consumer choice. *Marketing Science*, 4(3), 199-214.
- Trigeorgis, L., & Reuer, J. J. (2017). Real options theory in strategic management. *Strategic Management Journal*, 38(1), 42-63:
- Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology*, 5(2), 207-232.
- Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice: A reference-dependent model. *The Quarterly Journal of Economics*, *106*(4), 1039-1061.

Module Examination

Prerequisite + Final Module Examination (MAP)

Assessment Mode for Module Examination

Prerequisite for the final module examination:

- Data collection (allowing lectures and seminars to use student data as a basis for discussion)

Final module examination:

- Written examination, 90 minutes

Bonus marks of up to 10 per cent for a theory-application paper (essay), 1,200 - 1,500 words

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants	none
Remarks	The module is open to both Bachelor's and Master's students.
Module Components	• Lecture Psychology of Entrepreneurship and Change - 2 SWS • Seminar Psychology of Entrepreneurship and Change - 2 SWS
Components to be offered in the Current Semester	**530960** Lecture Psychology of Entrepreneurship and Change - 2 Hours per Term **530961** Seminar Psychology of Entrepreneurship and Change - 2 Hours per Term **530962** Examination Psychology of Entrepreneurship and Change

Module 14466 Fit4Future Summer School

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14466	Compulsory elective

Modul Title	**Fit4Future Summer School** Fit4Future Sommerschule
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Jaeger-Erben, Melanie
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successful completion, students have in-depth knowledge of various transformation dynamics and forms. They are experienced in discussing and reflecting on various analytical and evaluation concepts of transformation dynamics. They can classify various theoretical and methodological approaches in the present day and discuss them in light of relevant evaluation criteria that apply to transformations in the face of pressing crises such as climate catastrophe, biodiversity loss or land overuse. They are also able to understand the complexity of the design challenges of a transformation on a global scale and to analyze the various roles, e.g. of the state or niche actors. They can apply conceptual perspectives such as the multi-level perspective, the ecosystem approach or evolutionary innovation theory.
Contents	The Fit4Future Summer School series provide a dynamic learning environment where students engage with challenges of tomorrow. Every year the thematic focus shifts towards current transition dynamics and transformaton processes. The Summer School provides a mix of online lecture and offline exercises, with a full-week course during September every year. Topics are: • Just Transitions to sustainable and clean energy • Circular Economy and Society • Digitalisation and Sustainability • Globalisation and Global Studies • De- and Prostgrowth

	Throughout the programme, participants will engage with the various aspects of the chosen topic, explore the role of different transformation paradigms and assess the transformative power of different pathways towards sustainable future in an interdisciplinary setting.Renowned international experts will provide participants with a comprehensive understanding of the latest developments through lectures, workshops and field trips, creating a dynamic learning environment that encourages critical thinking and collaborative problem-solving.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Haberl, H., Fischer-Kowalski, M., Krausmann, F., Martinez-Atlier, J., & Winiwarter, V. (2011). A socio-metabolic transition towards sustainability? Challenges for another Great Transformation. *Sustainable development*, 19(1), 1-14. • Voulvoulis, N., Giakoumis, T., Hunt, C., Kioupi, V., Petrou, N., Souliotis, I., & Vaghela, C.J.G.E.C. (2022). systems thinking as a paradigm shift for sustainability transformation. *Global Environmental Change*, 75, 102544. • Abson, D. J., Fischer, J., Leventon, J., Newig, J., Schomerus, T., Vilsmaier, U., ... & Lang, D. J. (2017). Leverage points for sustainablity transformation. *Ambio*, 46, 30-39
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Essay on selected transformation dynamics, 5000 words, (40%) • 2 protocols of two events during the summer school, 1500 words each (20% each) • Learning diary, 3000 words (20%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	- Summer School Fit4Future
Components to be offered in the Current Semester	No assignment

Module 14494 The Political Economy of Transformation

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14494	Compulsory elective

Modul Title	**The Political Economy of Transformation** Die politische Ökonomie der Transformation
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Berger, Wolfram
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	By the end of the semester, students will have a solid understanding of theoretical concepts tied to a critical political economy perspective. They will be able to apply these theoretical perspectives for analysing concrete empirical contexts. They will have skills for critical reflection and will be able to navigate and process complex conceptual texts. Students have inter- and transdisciplinary research competencies.
Contents	To deal with the major challenges our societies are facing – such as the climate crisis, demographic change, geopolitical tension as well as regional and global economic restructurings – we need a profound understanding of their underlying social conditions. This interdisciplinary course offers an introduction to critical political economy approaches that examine these issues through the lenses of power, social relations, and uneven development. We begin with discussing core concepts through which critical political economists seeks to understand how capitalist economies function and how their contradictions emerge. We then turn to the institutional arrangements that shape and mediate economic life — such as states, legal systems, and international governance — examining their roles not as neutral arbiters but as embedded in social struggles and historical formations. Building on this, we explore the concepts of power and hegemony. Drawing on theorists such as Antonio Gramsci and perspectives from Cultural Political Economy, we analyse how dominant economic and political ideas as well as practices become socialised, and how they are contested. Finally, the course investigates the spatial dimension of capitalism: we study how space is not merely a backdrop but actively

	produced through processes of uneven development, globalisation, and territorial differentiation. Throughout the course, we will engage with both classical texts and contemporary applications, and reflect critically on the relevance of critical political economy approaches for understanding today's transformations. Students are encouraged to bring in their own interests and regional expertise, and to relate theoretical insights to empirical phenomena across scales.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• Gramsci, A., 2011. Prison notebooks. Vol. 1. Columbia Univ. Press. • Harvey, D., 2019. Spaces of Global Capitalism: A Theory of Uneven Geographical Development. Verso. • Massey, D.B., 1984. Spatial Divisions of Labour. Macmillan. • Moisio, S. (2018). Geopolitics of the knowledge-based economy. Routledge. • Sum, N.-L., & Jessop, B. (2013). Towards a cultural political economy: Putting culture in its place in political economy. Edward Elgar Pub. Ltd. • Vidal, M., Smith, T., Rotta, T., Prew, P. (Eds.), 2019. The Oxford Handbook of Karl Marx, 1st ed. Oxford University Press.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Präsentation: 15 min (50 %) • Hausarbeit: 6.000 Wörter (50 %)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	Not offered in the WS 2026/27 Module with limited number of participants - Registration two weeks prior to the commencement of lectures!
Module Components	• Seminar (2 SWS)
Components to be offered in the Current Semester	No assignment

Module 14726 Mathematical Optimization Techniques and Applications

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14726	Compulsory elective

Modul Title	**Mathematical Optimization Techniques and Applications** Mathematische Optimierungstechniken und Anwendungen
Department	Faculty 1 - Mathematics, Computer Science, Physics, Electrical Engineering and Information Technology
Responsible Staff Member	Prof. Dr. rer. nat. habil. Fügenschuh, Armin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Upon successful completion of the module, students will have acquired an understanding of core mathematical tools used in modern optimization. They will be able to identify optimization structures in real-world problems, formalize these problems in mathematical terms, and apply suitable algorithms to obtain and interpret solutions.
Contents	Foundations of optimization theory, global vs. local optimality, geometry of optimization, optimization for graph problems, fundamentals of linear programming, duality principles, advanced simplex methods, discrete optimization, interior point and ellipsoid methods, nonlinear optimization, applied modeling. Emphasis is placed both on theoretical insights and algorithmic implementation.
Recommended Prerequisites	Knowledge of subject matters of the modules • 11103: Analysis I • 11104: Analysis II • 11101: Lineare Algebra und analytische Geometrie I or of the modules • 11112: Mathematik IT-1 (Diskrete Mathematik) • 11113: Mathematik IT-2 (Lineare Algebra) • 11213: Mathematik IT-3 (Analysis)

Mandatory Prerequisites	• No successful participation in module 13862 Optimierung und Operations Research.
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	• V. Chvatal, Linear Programming, Bedford St Martins Pr 3PL, 2016 • R.J. Vanderbei: Linear Programming - Foundations and Extensions, 5th Edition, Springer, 2020
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• 4 intermediate tests of 30 minutes each, written during the lecture period. The best 3 count 1/3 each for the final grade.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• Study programme Angewandte Mathematik M.Sc.: Compulsory elective module in complex „Optimierung" • Study programme Mathematics M.Sc.: Compulsory elective module in complex „Optimization" • Study programme Mathematical Data Science M.Sc.: Compulsory elective module in complex „Advanced Mathematical Methods in Data Science" • Study programme Artificial Intelligence Science M.Sc.: Compulsory elective module in complex „Advanced Methods" • Study programme Künstliche Intelligenz Technologie M.Sc.: Compulsory elective module in complex „Software-basierte Systeme" • Study programme Physics M.Sc.: Compulsory elective module in complex „Minor Subject"
Module Components	• Lecture: Optimization and Operations Research • Accompanying exercise
Components to be offered in the Current Semester	**130710** Lecture Mathematical Optimization Techniques and Applications - 4 Hours per Term **130711** Exercise Mathematical Optimization Techniques and Applications - 2 Hours per Term

Module 14781 Biological Methods for Biomass and Waste Treatment

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14781	Compulsory elective

Modul Title	**Biological Methods for Biomass and Waste Treatment** Biologische Verfahren der Biomasse- und Abfallbehandlung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. habil. Abendroth, Christian
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	<p data-start="0" data-end="990">Students are introduced to ecologically and economically viable alternatives to conventional waste treatment, with integrated and system-oriented solutions at the core. Particular emphasis is placed on anaerobic microbiomes and their central role in biological conversion processes such as anaerobic digestion, composting, and other innovative approaches to residual waste valorization. Building on microbiological and biochemical fundamentals, functional principles, process dynamics, and efficiencies are analyzed and transferred to real-world applications. In addition to established technologies, current research approaches, international developments, and novel process combinations—including contributions from the instructor’s own research—are addressed. The aim is to develop an in-depth understanding of the material and energy recovery of residuals within the context of a sustainable circular economy, and to foster the ability to independently design system-oriented solutions. <p data-start="992" data-end="1542" data-is-last-node="" data-is-only-node="">An interactive teaching format forms the didactic core: during the sessions, students continuously work on tasks whose results contribute to the overall assessment. This supports an active learning process that promotes analytical thinking, applied competence, and scientific discussion.
Contents	<p data-start="0" data-end="361">The course provides a solid yet practice-oriented introduction to the biological utilization of residual materials within the context of a sustainable circular economy. Starting from the fundamentals of biology and photosynthesis, it first examines the ”food vs. fuel” debate in order to critically assess conflicts

between food production and bioenergetic use. <p data-start="363" data-end="906">Subsequently, key processes of biological waste treatment are covered, including composting, biogas production, and dark fermentation. These processes are considered not only from a technological perspective, but particularly from the viewpoint of anaerobic microbiomes, which are understood as the driving force behind material transformations. An introduction to microbiomes and their analysis—from taxonomic profiling to functional approaches such as proteomics—enables a deeper understanding of microbial communities and their performance. <p data-start="908" data-end="1251">Building on this, central metabolic processes such as fermentation and methanogenesis are examined in detail and placed in the context of technical applications. In addition, innovative and less established approaches—such as the use of insects, bioleaching, remediation strategies, and novel materials and systems (e.g., SLMs)—are introduced. <p data-start="1253" data-end="1504" data-is-last-node="" data-is-only-node="">The course combines current research with application-oriented knowledge and offers an interdisciplinary perspective on biological transformation processes, with the aim of developing sustainable and creative solutions for future resource utilization.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 4 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

Kranert M. Einführung in die Kreislaufwirtschaft, Springer Vieweg Wiesbaden, 2017, https://doi.org/10.1007/978-3-8348-2257-4
Bischofsberger, Dichtl, Rosenwinkel, Seyfried, Böhnke. Anaerobtechnik. Springer-Verlag Berlin Heidelberg 2005, ISBN: 3-540-06850-3
Further literature will be announced during the course
<p data-start="0" data-end="129">

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

<div id="meta-origin" data-coolorigin="https%3A%2F%2Fwww.b-tu.de%2Forgcloud%2Fapps%2Frichdocumentscode%2Fproxy.php%3Freq%3D%2Fcool%2Fclipboard%3FWOPISrc%3Dhttps%253A%252F%252Fwww.b-tu.de%252Forgcloud%252Findex.php%252Fapps%252Frichdocuments%252Fwopi%252Ffiles%252F11244624_ochtzup9yafk%26ServerId%3DF84FA4B4%26ViewId%3D7%26Tag%3D58C29858B529DFEC"> Assessment in this module follows a continuous, dialogue-based oral approach. Students are asked to demonstrate their understanding of the course content by answering subject-specific questions and by formulating questions for their peers. The assessment takes place regularly throughout the semester and aims to evaluate subject-specific knowledge, understanding, and the ability to engage in academic discussion. <p> oral assessment generally after every second lecture approximately 15–20 minutes per assessment session 1–2 questions per student approximately every two weeks approximately 10 assessed questions per student

	over the semester 1 point for each successfully completed question assessment of answers based on subject-specific correctness and demonstrated understanding assessment of student-formulated questions based on scientific relevance, clarity, and appropriateness All assessed questions/tasks are weighted equally. The overall assessment result is calculated based on the proportion of points achieved out of the total number of points available (100%). comparable number and level of assessment opportunities for all students
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	238117 Lecture / Seminar: Biological Processes in Biomass and Waste Treatment <p><br data-start="84" data-end="87" />
Components to be offered in the Current Semester	**238117** Lecture/Seminar Biologische Verfahren der Biomasse und Abfallbehandlung - 4 Hours per Term

Module 14872 Design Science in Entrepreneurship and Management

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14872	Compulsory elective

Modul Title	**Design Science in Entrepreneurship and Management** Designwissenschaft in Unternehmertum und Management
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Scheidgen, Katharina
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Successfully completing this course means, students will be able to apply design science in both scientific and practical projects. They will understand how design science differs from traditional explanatory research and know how to develop practical, research-based solutions to pressing challenges. Students will be able to identify design problems worth solving and use qualitative methods such as interviews to understand real-world problems. Based on this, they will be able to derive design requirements and create useful solutions, such as tools, processes, or frameworks. They will be competent in how to co-design these solutions with relevant stakeholders as well as how to evaluate these solutions.
Contents	The course *Design Science in Entrepreneurship and Management* introduces students to an innovative, impact-oriented approach that bridges academic theorizing with real-world problem solving. Design science is a problem-solving and scientific research approach that focuses on designing and evaluating solutions to pressing, complex problems. Unlike traditional academic research, which typically aims to understand and explain phenomena (“how and why” things happen), design science aims to shape and improve reality, answering “how can” and “how should things be” questions. The students will work in small teams and engage with a real-world problem. This problem will be introduced through a design brief, which outlines the problem they are asked to solve. Each team will plan and conduct their own design science mini-project. They will derive design requirements, that are, insights into what a solution must achieve in order to be useful. Based on these design requirements,

they will co-create artifacts and evaluate them. Drawing on both their artifact evaluation and academic literature, students will formulate design principles, that are, prescriptive knowledge that explains how to change an existing situation into a preferred one. Throughout their project, students will engage with relevant stakeholders to collect data, for example to understand the problem better or evaluate their solutions.The results of the project will be presented in two formats: a written report and an oral presentation.
By completing their own mini design science projects, students will gain hands-on experience in planning and conducting such projects. They will also learn how to communicate with relevant stakeholders, both in written reports and in oral presentations.

Recommended Prerequisites

- Experience in reading and engaging with academic literature as well as
- an interest in problem-solving are advantageous.
- Basic knowledge of qualitative approaches such as case studies are helpful.

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Seminar - 4 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Denyer, D., Tranfield, D., & Van Aken, J. E. (2008). Developing design propositions through research synthesis. Organization studies, 29(3), 393-413.
- Gregor, S., Chandra Kruse, L., & Seidel, S. (2020). Research perspectives: the anatomy of a design principle. Journal of the Association for Information Systems, 21(6), 2.
- Opdenakker, R., & Cuijpers, C. (2025). Design Science Methodology for the Management Sciences. Springer Texts in Business and Economics.
- Seckler, C., Mauer, R., & vom Brocke, J. (2021). Design science in entrepreneurship: Conceptual foundations and guiding principles. Journal of Business Venturing Design, 1(1-2), 100004.
- Thuan, N. H., Drechsler, A., & Antunes, P. (2019). Construction of design science research questions. Communications of the Association for Information Systems, 44(1), 20.
- Romme, A. G. L., & Holmström, J. (2023). From theories to tools: calling for research on technological innovation informed by design science. Technovation, 121, 102692.
- Romme, A. G. L., & Reymen, I. M. (2018). Entrepreneurship at the interface of design and science: Toward an inclusive framework. Journal of Business Venturing Insights, 10, e00094.
- Venable, J., Pries-Heje, J., & Baskerville, R. (2016). FEDS: a framework for evaluation in design science research. European Journal of Information Systems, 25(1), 77-89.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Presentation including discussion, max. 10 minutes, group-based (40 %)
- Term paper, 15 pages, group-based (40 %)

	• Reflections on sessions, individual (20%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	30
Remarks	***Module with limited number of participants - Registration two weeks prior to the commencement of lectures!***
Module Components	• Seminar 530505
Components to be offered in the Current Semester	**530505** Seminar Design Science in Entrepreneurship and Management - 4 Hours per Term

Module 41404 Strategic Environmental Assessment and Environmental Impact Assessment

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41404	Compulsory elective

Modul Title	**Strategic Environmental Assessment and Environmental Impact Assessment** Strategische Umweltprüfung und Umweltverträglichkeitsprüfung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Palekhov, Dmitry
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	**Environmental Impact Assessment (EIA)** After completing the module, the students will be able: • to compare the origins and development of EIA in the USA, Europe and worldwide; • to critically review the EIA process, explaining its various steps; • to select appropriate impact identification and prediction methods for the use within the EIA process. **Strategic Environmental Assessment (SEA)** After completing the module, the students will be able: • to understand the key principles, procedure and application of SEA; • to discuss SEA as a policy instrument and a way to improve strategic actions; • to explore benefits and barriers to a successful SEA; • to highlight the links and differences between SEA and Project EIA; • to understand the importance of strategic objectives and their alternatives at SEA level.
Contents	The contents of lectures will be discussed in more detail and applied to different case studies during seminars. While the lecture provides theoretical background, the seminars utilise a more practice-oriented approach. Students will apply various methods explained during the lectures with the help of relevant case studies. **Environmental Impact Assessment (EIA)**

- The history and development of EIA in the USA and the European Union
- The legal context of EIA (NEPA and the European Union EIA Directive)
- EIA system in Germany
- The EIA process – screening, scoping, environmental baseline, impact assessment, environmental impact statement (EIS) and its review, public participation, decision making and monitoring
- Methods used for identification of impacts and assessing their significance (checklists, matrices, networks, map overlays etc.)

Strategic Environmental Assessment (SEA)

- Basic concept and understanding of SEA, its benefits and importance for transition towards sustainability
- The objectives and implementation of the EC's SEA Directive 2001/42/EC
- The differences and similarities between EIA and SEA
- The SEA procedure and its integration into the process of planning

Recommended Prerequisites

None

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 2 hours per week per semester
Seminar - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

Lecture notes and presentations shown during seminars will be available for downloading from the BTU Moodle learning portal. For students interested in more in-depth study of lecture topics, optional advanced readings will be regularly uploaded to the BTU elearning portal Moodle.
Recommended Journals:

- Environmental Impact Assessment Review published by Elsevier
- Impact Assessment and Project Appraisal published by the International Association for Impact Assessment (IAIA)

Both journals are electronically available to all BTU students at the following web pages:

- http://www.sciencedirect.com/science/journal/01959255
- https://www.tandfonline.com/loi/tiap20

N.B.: to get full access for articles, these web pages have to be accessed from within BTU network or with the help of a VPN-Client.
Environmental Impact Assessment – recommended readings:

- Glasson J and Therivel R (2019) Introduction to environmental impact assessment: 5th Edition. Routledge, London

- Noble BF (2021) Introduction to Environmental Assessment: A Guide to Principles and Practice, 4th Edition.Oxford University Press, Toronto
- Morris P, Therivel R (eds.) (2001) Methods of Environmental Impact Assessment (2nd edition). Spon Press, London
- Petts J (ed.) (1999) Handbook of Environmental Impact Assessment. Volume 1. Environmental Impact Assessment: Process, Methods and Potential. Volume 2. Environmental Impact Assessment in Practice: Impact and Limitations. Blackwell Science Ltd., Oxford.
- Schmidt M et al. (Eds.) (2008) Standards and Thresholds for Impact Assessment. Environmental Protection in the European Union, Volume 3. Springer, Heidelberg.
- Wood C (2003) Environmental Impact Assessment. A Comparative Review: Second Edition. Pearson Education Limited, Harlow.

Strategic Environmental Assessment - recommended readings:

- Dalal-Clayton B, Sadler B (2005) Strategic environmental assessment: A sourcebook and reference guide to international experience. Earthscan, London.
- Fischer TB (2002) Strategic Environmental Assessment in Transport and Land Use Planning. Earthscan, London.
- Fischer TB (2007) Theory and Practice of Strategic Environmental Assessment: Towards a More Systematic Approach. Earthscan, London.
- Gühnemann A (2000) Methods for Strategic Environmental Assessment of Transport Infrastructure Plans. Nomos Verlagsgesellschaft, Baden-Baden.
- Jones C et al. (eds) Strategic Environmental Assessment and Land Use Planning – an international evaluation. Earthscan, London.
- Marsden S (2008) Strategic Environmental Assessment in International and European Law: A Practitioner's Guide. Earthscan, London.
- Partidario MR and Clark R (Eds.) (2000) Perspectives on Strategic Environmental Assessment. Lewis Publishers, Boca Raton.
- Schmidt M, João E and Albrecht E (Eds.) (2005) Implementing Strategic Environmental Assessment. Environmental Protection in the European Union, Volume 2. Springer, Heidelberg.
- Therivel R (2004) Strategic Environmental Assessment in Action. Earthscan, London.
- Therivel R, Partidario MR (eds.) (1996) The Practice of Strategic Environmental Assessment, Earthscan, London.
- Therivel R, Wilson E, Thompson S, Heaney D and Pritchard D (1992) Strategic Environmental Assessment. Earthscan, London.

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Oral performance verification (duration 10 minutes, maximum 15 points)
- Presentation (duration 10 minutes, maximum 15 points)

To pass the module students need to gain a minimum of 12 points (the sum of points for the above mentioned module components).

Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Registering for Examination of the module SEA/EIA is mandatory! No registration means no final grade in the end.
Module Components	• 2403121 LE Environmental Impact Assessment and Strategic Environmental Assessment • 2403122 SE Environmental Impact Assessment and Strategic Environmental Assessment
Components to be offered in the Current Semester	**240334** Lecture Strategic Environmental Assessment and Environmental Impact Assessment - 2 Hours per Term **240335** Seminar Strategic Environmental Assessment and Environmental Impact Assessment - 2 Hours per Term

Module 41405 Cost-Benefit Analysis in Environmental Evaluation

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41405	Compulsory elective

Modul Title	**Cost-Benefit Analysis in Environmental Evaluation** Kosten-Nutzen-Analyse in der umweltökonomischen Bewertung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. pol. Wätzold, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	To be able to apply economic thinking to solve environmental and resource management problems with a focus on cost-benefit analysis (CBA) and on cost-effective management and policy solutions.
Contents	• Economic principles (for non-economists) • Why does market failure exist in the case of environmental goods? • Methodology of CBA • Theory of CBA • Cost Assessment • Theory and methods of benefit valuation • Risk and uncertainty in CBA
Recommended Prerequisites	None
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Boardman, A.E. (2011), Cost-benefit analysis: concepts and practice (The Pearson series in economics) • announced in class
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	

	• written examination, 80 minutes (50%) • presentation, 15 min. and discussion (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240905 LE Cost Benefit Analysis in Environmental Evaluation • 240901 Examination Cost Benefit Analysis in Environmental Evaluation • 240902 Examination Cost Benefit Analysis in Environmental Evaluation
Components to be offered in the Current Semester	**240905** Lecture/Seminar Cost Benefit Analysis in Environmental Evaluation - 4 Hours per Term **240901** Examination Cost Benefit Analysis in Environmental Evaluation **240902** Examination Cost Benefit Analysis in Environmental Evaluation

Module 41422 Measuring Sustainability

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41422	Compulsory elective

Modul Title	**Measuring Sustainability** Nachhaltigkeit messen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Beckmann, Michael
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	**Lecture and Seminar on Measuring Sustainability** In the lecture fundamental knowledge regarding tools and approaches to measuring sustainability will be gained. **Learning outcome:** • Familiarisation with the concept of sustainable development. • Familiarisation with consequences of global challenges as threats to achieving sustainable development goals. • Understanding indicator systems for sustainable development. • Understanding voluntary sustainability standards (VSS). • Understanding various methods and tools for sustainability assessment.
Contents	• Historic development and current understanding of sustainable development; • International legal framework and policies for sustainable development; • Goals and targets for sustainable development; • Indicator systems for sustainable development; • Voluntary sustainability standards (VSS) as an instrument of sustainable development; • Tools and methods for assessing sustainability; • Sustainability in supply and value chains.
Recommended Prerequisites	none
Mandatory Prerequisites	none

Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Research paper/essay - 30 hours Self organised studies - 90 hours
Teaching Materials and Literature	Literature will be recommended at the beginning of the course. All presentations will be made available to students.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Series of MCQs during the lecture period (total duration 60minutes, 10points) • A final written examination (duration 90 minutes, 20 points) • To pass the module students need to gain a minimum of 12 points (the sum of points for the above mentioned module components).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	70
Remarks	Registering for examination of the module “Measuring Sustainability” is mandatory! No registration means no final grade in the end.
Module Components	• Lecture Measuring Sustainability • Seminar Measuring Sustainability
Components to be offered in the Current Semester	**240336** Lecture Measuring Sustainability - 2 Hours per Term **240337** Seminar Measuring Sustainability - 2 Hours per Term

Module 41427 Economics of Land Use and Biodiversity Conservation

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	41427	Compulsory elective

Modul Title	**Economics of Land Use and Biodiversity Conservation** Ökonomische Analyse der Landnutzung und des Schutzes der biologischen Vielfalt
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. pol. Wätzold, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	• acquire knowledge about the economic analysis of sustainable land use and biodiversity conservation • get acquainted with an economic analysis of related policy instruments • be able to discuss related issues on a scientific level • be able to read scientific papers and discuss them critically
Contents	• optimal spatial allocation of land use • policy instruments for sustainable land use (PES, conservation banking) • institutions and governance structures, common pool resources • REDD (reducing emissions from deforestation and degradation)
Recommended Prerequisites	Basic economic knowledge.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Excursion - 8 hours Self organised studies - 112 hours
Teaching Materials and Literature	To be announced in class.
Module Examination	Continuous Assessment (MCA)

Assessment Mode for Module Examination	• written examination, 70 minutes (50%) • oral presentation 15 min and hand-out (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Complementary module ERM Master 2006. *to Excursion - 8 hours (if possible) depending on the COVID-19 situation, the course may be offered online or in presence.
Module Components	• 240907 Lecture/Seminar Economics of land and biodiversity conservation management incl. excursion • 240912 Examination Economics of land and biodiversity conservation management • 240958 Examination Economics of land and biodiversity conservation management
Components to be offered in the Current Semester	**240907** Lecture/Seminar Economics of land and biodiversity conservation management - 4 Hours per Term **240912** Examination Economics of land and biodiversity conservation management **240958** Examination Economics of land and biodiversity conservation management

Module 42417 Methods of Water Resources Management

assign to: Modules with the Focus on Environmental Economics, Planning and Law
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	42417	Compulsory elective

Modul Title	**Methods of Water Resources Management** Methoden der Wasserbewirtschaftung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Kästner, Karl
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	At the end of the module the student are able to apply methods to assess and to balance the components of the water cylce and to derive properties of surface and subsurface catchments with respect to runoff generation and water yield. They can simulate hydrological responses of the water balance components to different inputs.
Contents	Elements of the water balance as a function of space and time; determination of available surface and groundwater resources; management practices for surface and groundwater resources: application of statistic, stochastic and deterministic methods in the fields of watershed modeling, system hydrology, reservoir management, flood prediction and integrative resources management, isotopic hydrology
Recommended Prerequisites	None
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Handouts and reading list • Manual and tutorial of the modeling programme
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Assessment report, max. 3 pages text without figures and tables - 40%

	• Exam, 80 minutes - 60%
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module will not be offered in the summer semester of 2026.
Module Components	**Summer semester:** • 240630 Lecture Methods of Water Resources Management - Lecture part • 240631 Seminar/Exercise Methods of Water Resources Management - Practical part
Components to be offered in the Current Semester	**240669** Examination Methods of Water Resources Management

Module 11225 Numerical Simulation: Free Surface and Groundwater Modelling

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11225	Compulsory elective

Modul Title	**Numerical Simulation: Free Surface and Groundwater Modelling** Numerische Simulation: Gewässer- und Grundwassermodellierung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. PD Dr.-Ing. habil. Molkenthin, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Understanding of numerical simulation methods for free-surface and groundwater flow and related processes.
Contents	• Hydrological and hydrodynamic modelling of free surface flow in rivers, lakes and coastal waters and related numerical schemes (FD, FV, FE) • Numerical and computational aspects for FD, FE and FV schemes • Setup, calibration, validation and application of models • Simulation result analysis • Exercises in 1D/2D model comparsion and 2D river modelling including flooding • Academic and real case studies from river modelling • Description of groundwater flow processes • Numerical modelling of groundwater flow in 1D, 2D and 3D and realted numerical schemes (FD, FE, FV) • Finite element and differences schemes for groundwater flow pollution transport, boundary conditions in 2D/3D • Exercise: 1D/2D/3D groundwater modelling project • Project presentation and journal paper writing
Recommended Prerequisites	• Successful participation in module Hydroloy & Hydraulics (11510 or 41414) with good result (ERM Module 11510 mark ≤2.3) • Advanced understanding of numerical methods, hydrological and hydrodynamic processes, computational hydraulics

	• Advanced data management and analysis skills (e.g. spatial data, time series) using GIS and data analysis software / modelling environments (R, Python, Matlab, SQL, ...).
Mandatory Prerequisites	No successful participation in associated phase-out module *41505 Coupling Free-Surface and Groundwater Modelling*.
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Practical training - 4 hours per week per semester Self organised studies - 60 hours
Teaching Materials and Literature	none
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• two assignments (each 15%) • poster presentation and discussion (10%) • journal paper and discussion (10%) • final written (120 min) or oral (30-45 min) examination (50%) The form in which the examinations will be carried out will be announced at the beginning of the course.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240636 Lecture/Exercise 2D Hydrodynamic numerical modelling • 240637 Lecture/Exercise Groundwater modelling
Components to be offered in the Current Semester	**240636** Lecture/Exercise 2D Hydrodynamic numerical modelling - 2 Hours per Term **240637** Lecture/Exercise Groundwater modelling - 2 Hours per Term

Module 11228 Modelling Process in Hydroengineering Projects

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11228	Compulsory elective

Modul Title	**Modelling Process in Hydroengineering Projects** Computergestützter Modellierungsprozess in Ingenieurprojekten des Wasserwesens
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. PD Dr.-Ing. habil. Molkenthin, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Understanding of modelling and information management methods in hydroengineering projects using simulation and data analysis tools.
Contents	Modelling Process • Modelling using hydroinformatics systems in hydroengineering projects • Physical understanding, data preparation • Model set-up, scenario definition, sensitivity analysis, result analysis • Application examples for real case studies (in combination with Module 11225)
Recommended Prerequisites	• Successful participation in module Hydroloy & Hydraulics (11510 or 41414) with good result (ERM Module 11510 mark ≤2.3) • Advanced understanding of computer based water related modelling techniques (data and processes), numerical methods (FDM, FEM, FVM), GIS and time series analysis. • Experiences in use of numerical simulation tools (esp. for 1D and 2D hydraulic modelling) • Hydroengineering knowlegde and skills
Mandatory Prerequisites	No successful participation in associated phase-out modules:

	• *41506 Modelling Business Processes, Workflow and Information Management* **OR** • *41507 Geometric Modelling and Presentation Methods*.
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Seminar - 4 hours per week per semester Practical training - 1 hours per week per semester Self organised studies - 60 hours
Teaching Materials and Literature	The current teaching materials including literature references are made available to students via the respective current websites (e.g. Moodle, Google site, HydroEurope server) for the current courses.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Assignments (30%) • Project reports (30%) • Seminar presentations and discussions (40%) The details and weighting of the different assessment elements are determined in the first lectures.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240640 Seminar Flood management • 240641 Seminar Groundwater management • 240639 Lecture/Practical training Modelling in Hydroengineering
Components to be offered in the Current Semester	**240640** Seminar Flood management - 1 Hours per Term **240641** Seminar Groundwater management - 1 Hours per Term **240639** Lecture/Practical training Modelling in Hydroengineering - 2 Hours per Term **248234** Lecture/Seminar Hydrogeology of large catchments

Module 11229 Information Management in Hydroinformatics Systems

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11229	Compulsory elective

Modul Title	**Information Management in Hydroinformatics Systems** Informationsmanagement in Systemen der Hydroinformatik
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. PD Dr.-Ing. habil. Molkenthin, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	Skills and abilities for Hydroinformatics system design and development; Understanding of information management, data analysis and Web-technology in hydroinformatics systems
Contents	information modelling techniques, components of numerical models, numerical model design for hydrodynamic simulation, interfaces to software modules, implementation and application examples, information analysis and mining, Web-Technologies for hydroinformatics systems,application of Web-Technologies in hydroinformatics systems, application of R /Python/... in hydroinformatics
Recommended Prerequisites	• Successful participation in module Hydroloy & Hydraulics (11510 or 41414) with good result (ERM Module 11510 mark ≤2.3) • Advanced programming and software development skills • Understanding of data bases, numerical methods, data analysis and visualisation, GIS • Experiences in Web-technology, XML-Schemes and software interfacing for water related applications
Mandatory Prerequisites	No successful participation in associated phase-out module *41508 Monitoring, Data Acquisition and Documentation*.
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 90 hours

Teaching Materials and Literature	none
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Exercises/assignments (50%) • Written (120 min) or oral (30-45 min) examination (50%) The details and weighting of the different assessment elements are determined in the first lectures.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• 240638 Lecture Hydroinformatics Systems design and development • 240643 Exercise Information handling (field, laboratory, simulation) • 240645 Practical training Web-based hydroinformatics systems
Components to be offered in the Current Semester	**240638** Lecture Hydroinformatics Systems design and development - 2 Hours per Term **240643** Exercise Information handling (field, laboratory, simulation) - 2 Hours per Term **240645** Practical training Web-based hydroinformatics systems - 2 Hours per Term

Module 11510 Hydrology & Hydraulics

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	11510	Compulsory elective

Modul Title	**Hydrology & Hydraulics** Hydrologie & Hydraulik
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. PD Dr.-Ing. habil. Molkenthin, Frank
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Understanding the typical modelling processes in hydrology & hydraulics such as GIS based catchment analysis, rainfall/runoff analysis, open channel hydraulics and hydrodynamic analysis of rivers. Practical experiences in application of related software tools. Basic ability to evaluate and present modelling results in respect to theoretical background, model assumptions and limits as well as uncertainties in data.
Contents	The module has four main parts. **First part** deals with the DEM based topographic analysis of a catchment as pre-processing for a hydrological analysis including catchment delinieation, rainfall interpolation, land-use and soil data analysis using GIS for a given case study. **Second part** deals with the hydrological rainfall/runoff analysis using different analysis methods. The lectures present the theoretical background of the analysis methods and their application in projects. Students will perform a EXCEL/Hec-HMS/Shetran based assignment for a given case study**.** **Third part** of the module deals with open channel hydraulics. The lecture presents the theoretical background including engineering assumptions and simplifications. Application examples with manual calculations in comparison to computer-based simulations are introduced and used for training. **Fourth part** of the module covers computer-based hydrodynamic simulation of river networks for flood management. The lectures present the theoretical background of the hydrodynamic simulation methods (basic differential equations, numerical methods, physical parameters,

	handling of structures such as weirs, calibration, validation, simulation scenarios …) and their application in projects. Students will perform a software-based assignment for a given case study. All assignments deal with the same case study data set and demonstrate the integrated application of different software tools within a project. Finally, the lectures will give an outlook for 2D flood modelling and related flood risk management.
Recommended Prerequisites	Advanced knowledge in mathematics/numerics, physics, fluid mechanics, GIS, ICT and water resource management on master level, experiences in computer based modelling, data management and data analysis
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Practical training - 3 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	Teaching material and a list of recommended literature will be published on the Web page / in Moodle, links will be provided to the participants during the lectures.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	1) Four assignments during the semester (each 10% -> four assignments 40%) 2) Written exam (60%) The written exam will be offered two times during the semester (e.g. last week of lecture period and mid of September). Participants can participate in both written exams, in this case the mean value of the two results will be considered as written result for the final mark. To pass the module, participants needs at least 50% summing up the results from the assignments (max. 40%) and from the written exam(s) (max. 60%).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	This module is for ERM Master study programme.
Module Components	• 240608 Lecture Hydrology & Hydraulics • 240610 Practical training Hydrology & Hydraulics • 240621 Examination Hydrology & Hydraulics (1st written exam) • 240654 Examination Hydrology & Hydraulics (2nd written exam)
Components to be offered in the Current Semester	**240621** Examination Hydrology & Hydraulics

Modul 11591 Numerik in der Geotechnik

zugeordnet zu: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Studiengang Environmental and Resource Management

Akademischer Grad	Modulnummer	Modulform
	11591	Wahlpflicht

Modultitel	**Numerik in der Geotechnik** Numerics in Geotechnics
Einrichtung	Fakultät 6 - Architektur, Bauingenieurwesen und Stadtplanung
Verantwortlich	Prof. Dr.-Ing. Grandas Tavera, Carlos
Lehr- und Prüfungssprache	Deutsch
Dauer	1 Semester
Angebotsturnus	jedes Sommersemester
Leistungspunkte	6
Lernziele	Nach Abschluss des Moduls kennen die Studierenden numerische Methoden zur Lösung der typischen Differentialgleichungen in der Geotechnik. Sie sind in der Lage, die Modellierung üblicher geomechanischen Randwertprobleme mit der Methode der Finiten Differenzen und der Methode der Finiten Elementen nachzuvollziehen und ihre Lösung kritisch zu bewerten. Sie können geeignete Stoffgesetze für die numerische Berechnung begründet auswählen und ihren Einfluss auf die Ergebnisse einschätzen.
Inhalte	Nachfolgende Inhalte werden themenbezogen vermittelt: • Anfangs- und Randwertprobleme in der Bodenmechanik • Finite Differenzen: Zeitintegration, numerische Stabilität, Beispiele • Einführung in die zeitliche Integration von Stoffgesetze: Return-Mapping, explizite und semi-explizite Methode • Finite Elemente: schwache Form, Diskretisierung, Randbedingungen, numerische Lösung • Locking, reduzierte Integration, Hour-Glass-Modes • Einführung in die Diskrete Elemente Methode
Empfohlene Voraussetzungen	Grundkenntnisse in Mechanik, Grundbau und Bodenmechanik.
Zwingende Voraussetzungen	keine
Lehrformen und Arbeitsumfang	Vorlesung - 2 SWS Übung - 2 SWS Selbststudium - 120 Stunden

Unterrichtsmaterialien und Literaturhinweise	• Witt, K.J.: Grundbau-Taschenbuch Teil 1 bis 3, 8. Aufl., Ernst & Sohn, Berlin, 2016. • Deutsche Gesellschaft für Geotechnik e.V.: Empfehlungen des Arbeitskreises Baugruben EAB, 5. Aufl., Ernst & Sohn, Berlin, 2012. • Presss, W., e.a., Numerical Recipies, Cambridge Univ. Press, 1992. • Zienkewicz O.C. et.al.: The Finite Element Method, Vol. 1, Wiley, 2005. • Strang, G.: Wissenschaftliches Rechnen, Springer, 2007.
Modulprüfung	Modulabschlussprüfung (MAP)
Prüfungsleistung/en für Modulprüfung	• Mündliche Prüfung, 20 min
Bewertung der Modulprüfung	Prüfungsleistung - benotet
Teilnehmerbeschränkung	keine
Bemerkungen	Für den Fall, dass das Modul nicht gemäß der vorliegenden Beschreibung gelehrt bzw. geprüft werden kann (z.B. aus Gründen des Infektionsschutzes), gelten die auf einschlägigen Plattformen (z.B. Homepage bzw. Moodle) kommunizierten Alternativen.
Veranstaltungen zum Modul	• 630350 Vorlesung Numerik in der Geotechnik • 630351 Übung Numerik in der Geotechnik • 630355 Prüfung Numerik in der Geotechnik
Veranstaltungen im aktuellen Semester	**630355** Prüfung Numerik in der Geotechnik

Module 12165 Renewable Energy Technologies for Power Supply

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12165	Compulsory elective

Modul Title	**Renewable Energy Technologies for Power Supply** Energieerzeugung auf Basis erneuerbarer Energien
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr. rer. nat. Röntzsch, Lars
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	The participants of the module acquire advanced knowledge in the design, operation, and application of renewable energy systems, including solar energy (solar thermal and photovoltaics), wind energy, hydroelectric power, geothermal energy (both near-surface and deep), biomass, and energy storage technologies, with a focus on hydrogen technology. They can analyze and reflect on the interactions between these subfields, considering their technical and ecological implications, and are capable of making scientifically grounded judgments within the discipline. The participants of the module develop the ability to formulate their own research questions and address them using appropriate scientific methods. They can effectively engage in domain-specific and interdisciplinary discussions, presenting complex topics clearly and persuasively to diverse audiences. Additionally, they demonstrate the ability to independently acquire new knowledge and apply it to solve and critically evaluate application- or research-oriented challenges.
Contents	Design, operation and use of: • Solar energy (photovoltaics, solar thermal) • Wind energy • Geothermal energy (deep and near-surface) • Biomass • Hydroelectric power • Energy storage inclusive hydrogen technology
Recommended Prerequisites	<div class="" data-turn-id-container="request-WEB:a3431c09-7954-4939-889f-9a2bd9d2dbf2-3" data-is-

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Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The course documents are provided in the learning management system Moodle.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Final written exam (120 min)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	60
Remarks	none
Module Components	Lectures, exam

Components to be offered in the Current Semester	**320461** Lecture Renewable Energy Technologies for Power Supply - 4 Hours per Term **320483** Examination Renewable Energy Technologies for Power Supply

Module 12989 Process System Technology II

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	12989	Compulsory elective

Modul Title	**Process System Technology II** Prozesssystemtechnik II
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Arellano-Garcia, Harvey
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	The students are able to describe dynamic and locally distributed systems of process engineering with the help of mathematical models. For this purpose, you can make suitable assumptions and neglects for the derivation of a model from the context of a task, then compile them on the basis of material, momentum, energy and property balances and complete them with kinetic approaches, thermodynamic equations of state and suitable boundary and initial conditions , In addition, students are able to apply systematic methods for model reduction, in particular for the reduction of spatial coordinates, for the introduction of quasi-stationarity assumptions and equilibrium assumptions. The students can use the finite-volume method to transform spatially distributed process models into systems of ordinary differential equations, to implement and solve them in a numerical simulation environment.
Contents	1. Modeling strategy: relevant scales, inputs / outputs, assumptions 2. Balancing: partial mass balances, total mass balances, momentum balance, energy balances. Substantive and local formulations 3. Entropy Balance: Source terms, drivers and rivers 4. Balancing of multiphase systems 5. Constitutive equations: Overview of kinetics (reaction, mass and heat transport, impulse transport), thermodynamic equations of state. Stefan Maxwell kinetics of mass transport. 6. Boundary and initial conditions: species, bad and well-posed problems 7. finite volume method 8. method of characteristics

	9. Model reduction: quasi stationarity, balance, integration 10. Differential Algebra Systems: Differential Index, Index Reduction, Solution Methods
Recommended Prerequisites	44303 Prozesssystemtechnik
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 3 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• M. Jischa, Konvektiver Impuls-, Wärme- und Stoffaustausch, Vieweg, 1982. • R. Taylor, R. Krishna, Multicomponent Mass Transfer, Wiley, 1993. • B. Bird, et al., Transport Phenomena, Wiley, 2002. • S. I. Sandler, Chemical, Biochemical and Engineering Thermodynamics, Wiley, 2006. • S. V. Patankar, Numerical Heat Transfer and Fluid Flow, McGraw-Hill, 1980. • A. Varma et al., Mathematical Methods in Chemical Engineering, Oxford U. Press, 1997.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	Examination 120 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	**Summer semester:** • Lesson/Exercise Process System Technology II • Examination Process System Technology II
Components to be offered in the Current Semester	**360381** Examination Process System Technology II

Module 13234 Communication of Science and Technology

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13234	Compulsory elective

Modul Title	**Communication of Science and Technology** Wissenschafts- und Technikkommunikation
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Students will know about different techniques, tools and formats for communication of science & technology. They will develop skills to break down complex issues at the nexus of science, technology and society to communicate science/technical information in a clear, understandable and engaging way to different stakeholders. On completion of the module, students will be able to: • Articulate the key issues and challenges in communicating about science & technology; • Understand the nature of different audiences for better stakeholder engagement; • Demonstrate awareness of and ability to use a variety of different techniques and media for targeted audience; • Improve their skills in communication of scientific/technical information in both written and oral forms; • work as part of a team to develop effective measures for communication of science & technology; • Provide constructive feedback to other students on their communication skills.
Contents	Course coverage: • Key issues in communication of science & technology; • Identify and knowing your audiences (mental models, risk perception, heuristics and biases, …); • Getting your audience's attention (Types of framing); • Communicating risk and uncertainty; • Formats for communication of science & technology.

	Students will also be given opportunities to receive feedback and improve their own written and oral skills. They will also work in small teams on team projects to further their skills for communicating about sustainability issues. These projects will focus on communicating about a given scientific topic to a particular audience using spoken, visual, written or web-based communication.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Center for Research on Environmental Decisions (CRED). 2009. *The Psychology of Climate Change Communication: A guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public.* New York. • Nisbet, M.C., Scheufele, D.A. 2009. What's next for science communication? Promising directions and lingering distractions. *American Journal of Botany*, 96(10): 1767-1778. • Bubela, T., Nisbet, M., Borchelt, R. *et al.* 2009. Science communication reconsidered. Nature Biotechnology, 27, 514–518. • Nelkin, D. 1989. Communicating technological risk: The social construction of risk perception. *Annual Review Public Health*, 10, 95-113. • Tversky, A., Kahneman, D. 1974. Judgment under Uncertainty: Heuristics and Biases. Science, New Series, 185(4157), 1124-1131. Further material (including lecture slides and additional materials including videos, readings etc.) might be announced during the first class meeting.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Individual E-Assessment – 60 min (40%) • Group project - Part 1: Science Communication Material e.g., poster, video, etc. (30%) • Group project - Part 2: Group presentation– 15min oral presentation (30%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	• Lecture / Seminar
Components to be offered in the Current Semester	**510601** Lecture/Seminar Communication of Science & Technology - 4 Hours per Term

Module 13249 Introduction to Gas Dynamics

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13249	Compulsory elective

Modul Title	**Introduction to Gas Dynamics** Einführung in die Gasdynamik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After successful participation the students are able to distinguish the physical properties of compressible and incompressible fluid flows. They have understood the governing equations, relevant phenomena, and control parameters, and they are able to perform a quantitative analysis of simple problems. In the exercise the students apply theoretical concepts to sample problems in order to develop analytical and numerical problem-solving skills.
Contents	• Conserved quantities and conservation laws • Nondimensional numbers • Sound speed and propagation • Flow regimes • Basics of aerostatics • Isentropic, barotropic, and polytropic flows • State change with entropy change • Steady compressible flows • Unsteady compressible flows • Stationary and propagating shocks
Recommended Prerequisites	Basic knowledge of continuum mechanics, fluid dynamics, and thermodynamics is an asset.
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Liepmann & Roshko. Elements of Gas Dynamics. Dover, 2002. • Babu. Fundamentals of Gas Dynamics. Springer, 2011. • Achterberg. Gas Dynamics: An Introduction with Examples from Astrophysics and Geophysics. Atlantis, 2016. • Oswatitsch. Grundlagen der Gasdynamik. Springer, 1976.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• oral examination, approx. 40 minutes
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module aims at Bachelor students from all disciplines with interest in but no or little knowledge of gas and fluid flows.
Module Components	VL/ÜB/PRÜ Introduction to gas dynamics
Components to be offered in the Current Semester	**350472** Examination Introduction to gas dynamics

Module 13251 Introduction to Computational Thinking and Programming for CFD

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13251	Compulsory elective

Modul Title	**Introduction to Computational Thinking and Programming for CFD** Einführung in das rechnergestützte Denken und Programmieren für CFD
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Students learn to use the higher programming language Python for numerical problem solving, data analysis, and visualization with links to computational fluid dynamics (CFD). After successful completion of the course, participants are able to develop algorithms and computer programs for simple problems on their own. On this basis, students will be put in the position to understand and work themselves into more complex problems. This module provides basic programming experience, which is recommended, but not mandatory, for the sequence of CFD courses (CFD 1, 2, and 3) that is offered by the department.
Contents	• Fundamentals of Scientific Computing • Data types, conversions, input, and output • Branching and iteration • Root finding, maximization, and minimization • Numerical differentiation and integration • Numerical errors and their quantification • Random sampling, distribution functions, and statistical moments • Computational efficiency • Functional programming and recursion • Object-oriented programming • Plotting and visualization
Recommended Prerequisites	Interest in computer simulations and/or numerical methods.

Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Kong, Siauw & Bayen. Python Programming and Numerical Methods: A Guide for Engineers and Scientists. Academic Press, 2020. URL: https://pythonnumericalmethods.berkeley.edu/notebooks/Index.html • Guttag. Introduction to Computation and Programming Using Python: With Application to Understanding Data. Second Edition. MIT Press, 2016. ISBN: 9780262529624. URL (code): https://github.com/guttag/Intro-to-Computation-and-Programming • Chapra & Clough. Applied Numerical Methods with Python for Engineers and Scientists. McGraw-Hill Education, 2021. • Theis. Einstieg in Python, Galileo Press, 2011.
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	The exam can be in written form or as an oral exam. • For a written examination: 90 minutes duration • For an oral exam: 30 min duration Until the end of the first three weeks of lectures it will be announced, if the examination will be offered in written or oral form.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	The module aims at students, primarily on the Bachelor level, from all disciplines with no or little programming experience.
Module Components	Lecture/Exercise
Components to be offered in the Current Semester	**350406** Lecture/Exercise Introduction to computational thinking and programming for CFD - 4 Hours per Term **350476** Examination Introduction to computational thinking and programming for CFD

Module 13515 Advanced Methods in Process, Energy and Systems Engineering

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13515	Compulsory elective

Modul Title	**Advanced Methods in Process, Energy and Systems Engineering** Erweiterte Methoden zur Prozessmodellierung und Optimierung in der Energie- und Verfahrenstechnik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Arellano-Garcia, Harvey
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	The module requires a basic background in calculus and linear algebra, thus allowing easy understanding of mathematical reasoning. In addition, numerous examples in process, energy, environmental and systems engineering will demonstrate key concepts and algorithms. The practical exercises will involve theoretical derivations and small-size numerical problems in modelling systems like matlab, python, octave, GAMS thus putting knowledge into practice. As part of the block course, students also gain an insight into German technical and everyday language, as well as into German culture.
Contents	This module will teach approaches to modelling and optimization frameworks to address the complex process and energy problems, which arise in design and operation of process and energy systems in an integrated way. Moreover, the presented theoretical and methodological concepts are joined conceptionally with optimal designed experiments to adjust the fundamental mathematical models and to validate the developed process concepts. The taught methods are of generic character, and thus, producing optimal design and operational plans for process and energy systems ranging from microscale to mega-scale stages over operative time horizons from milliseconds to years. The approaches to be discussed will mainly be around superstructure-based modelling, mixed-integer linear and nonlinear programming, multiobjective optimization, optimization under

	uncertainty, and life-cycle assessment. The presented case studies will be around advanced process systems for renewable energy conversion, separation and reaction systems as well as biotechnological production systems.
Recommended Prerequisites	• Basic backround in process engineering • calculus and linear algebra
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 90 hours
Teaching Materials and Literature	• Script zur Vorlesung • Advanced Optimization for Process Systems Engineering. Ignacio E. Grossmann, Cambridge University Press • Optimization for Chemical and Biochemical Engineering: Theory, Algorithms, Modeling and Applications. Vassilios S. Vassiliadis, Walter Kähm, Ehecatl Antonio del Rio Chanona, Cambridge University Press • Systematic Methods of Chemical Process Design. Lorenz T. Biegler, Ignacio E. Grossmann, Arthur W. Westerberg, Prentince Hall • Nonlinear Programming: Concepts, Algorithms, and Applications to Chemical Processes. Lorenz T. Biegler, SIAM, 2010
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written Examination 90 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	• The module takes place as a block course • The appointment will be announced in the current semester
Module Components	• VL Advance Methods in Process, Energy and systems Engineering • Ü Advance Methods in Process, Energy and systems Engineering • P Advance Methods in Process, Energy and systems Engineering
Components to be offered in the Current Semester	**360352** Seminar Advanced Methods in Process, Energy and Systems Engineering - 2 Hours per Term **360351** Lecture/Exercise Advanced Methods in Process, Energy and systems Engineering - 4 Hours per Term **360390** Examination Advanced Methods in Process, Energy and systems Engineering

Module 13517 CFD Seminar

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13517	Compulsory elective

Modul Title	**CFD Seminar** CFD-Seminar
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Schmidt, Heiko
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	After successful participation the students are able to evaluate distinguished fluid mechanical problems from a numerical point of view.
Contents	The numerically evaluated topics are: • Laminar, turbulent, compressible and incompressible flows in technical flows, geophysics, meteorology and reactive flows.
Recommended Prerequisites	• Basics of numeric and fluid mechanics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 2 hours per week per semester Self organised studies - 150 hours
Teaching Materials and Literature	• Stephen B. Pope, Turbulent Flows, 2000 • Joel H. Ferziger, Numerische Strömungsmechanik, 2007
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Presentation; 20 min (1/3 of grade for the quality of the preparation and 1/3 oral presentation) and • written report; 10 pages (1/3 of grade).
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none

Module Components	• SEM CFD Seminar
Components to be offered in the Current Semester	**350411** Seminar CFD Seminar - 2 Hours per Term

Module 13657 How to Talk about Nature?

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13657	Compulsory elective

Modul Title	**How to Talk about Nature?** Wie über Natur sprechen?
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. nat. phil. habil. Schwarz, Astrid
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After passing the module, students understand main philosophical theories of “nature”, interrogate the concept of “nature” and expose its numerous ideological and cultural manifestations. They identify the main ethical dimensions of “nature”, and its crosscultural and political dimensions. Additionally they understand the power of narratives and storytelling to shape our environmental present and future by insight into reading, writing, and visual practices about “nature”.
Contents	“How to talk about nature?” is closely linked to the question of what “nature” is, how it is construed and in which way we act with, in or against it. It is a question that is ontological and epistemological at the same time, it is about how we imagine nature “to be” and how we conceive knowledge about nature. The ideas about this entwinement are manifold over time and in space, different cultures have developed different ways of thinking and also practices of how to deal with a culture/nature distinction. Another important conceptual issue is how nature and technology are related, in contemporary debates for instance, "nature" is often identified with "environment" and as such inescapably entangled with its cultural, political, and technological context. Is the use of technology in “nature” then a threat or an opportunity to build a genuinely sustainable world? This module seeks to answer these and other questions, by approaching “nature” with variously grounded historical and contemporary theoretical approaches. For example, the concept of “nature” was differently interpreted in ancient times, compared to modern contemporary cultures. We will probe the different usage, the scope of historical and cross-cultural depth, the semantics, the images/

	imaginaries, and finally, the logical coherence of “nature” concepts. This variety of topics means that the assigned readings will draw from a wide range of sources. With respect to handle current ecological and technocultural problems, a conscious reflection about “nature” seems to be required. Thus, the module should be also seen, in part, as a way to gain insight into contemporary reading, writing, and visual practices about “nature”. Participation in the accompanying excursion is encouraged.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Literature and learning materials are given in the course description.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• One short essay, max 1500 words (25%) • Two reviews, each max. 2000 words (each 30%) • 2 oral (group) presentations, about 15 min **OR** weekly submitted written answers to one short question per week on the topical readings to be determined by the instructor (15%) The oral part of the examination can be done digitally or as a virtual meeting if the conditions for an examination in presence are not given.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	60
Remarks	none
Module Components	• Seminar, lecture - 4 hours per week per semester
Components to be offered in the Current Semester	**510112** Lecture/Seminar How to talk about "Nature"? / Ethik und Handeln / Philosophy of Technology and Nature / Natur und Technik / Wissenschaftstheorie, Logik und Naturphilosophie - 4 Hours per Term

Module 13664 Soil Reclamation and Landscape Restoration

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13664	Compulsory elective

Modul Title	**Soil Reclamation and Landscape Restoration** Bodensanierung und Landschaftsrenaturierung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. rer. nat. Badorreck, Annika
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After completing this course the student will be able to understand - the social need for management and protection of soils and ecosystems - prevention stragies of soil degradation and its crucial role in global food security - basic definitions and principles of sustainable and climate-smart agriculture, forestry and land management fundamental features and measures of soil reclamation and landscape restoration - deduction of restored soils functions, ecosystem functions and ecosystem services.
Contents	Scientific content: This course examines principles and strategies for soil reclamation and landscape restoration in tropical and subtropical regions of the Global South. It introduces climate-smart agriculture, forestry and livestock management. Emphasizing sustainable soil and land management, it explains how these practices can mitigate and adapt to climate change. The course also covers Sustainable Land Management (SLM) practices contributing to global goals, particularly SDG target 15.3 on achieving land degradation neutrality. It discusses urban forestry, its ecosystem benefits, and the challenges involved. Additionally, the course addresses soil salinization, proposing strategies for managing its effects on agriculture. Teaching concept: eLearning packages containing thematic lessons were provided to the students in order to engaging students through active self-paced learning. Four online certification tests within these packages account for in total 40% of the modul grade. Seminar: A

	scientific paper covering a topic of the modul is assigned to students. The content of the paper will then be presented as an oral presentation in the seminar at the end of the module by a group of students or as individual followed by a discussion (60% of modul grade).
Recommended Prerequisites	Knowledge of geology, soil science and renaturation
Mandatory Prerequisites	Module 13663 Environmental Soil Science and Plant Nutrition
Forms of Teaching and Proportion	Exercise - 2 hours per week per semester Seminar - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The class is organized as seminar complemented by discussions and individual contributions. Online packages containing lesson materials were provided via moodle. All seminar topics and material is provided prior the seminar via moodle. Self-organized work, in particular independent acquisition of relevant information, is required.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	• Seminar: One oral presentation, 15 min including discussion (60%) • Excercise as "Flipped-classroom/eLearning": Four online certification tests (4 x 10%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	*Exercise (as eLearning) Soil Reclamation and Landscape Restoration* *Seminar Soil Reclamation and Landscape Restoration*
Components to be offered in the Current Semester	No assignment

Module 13831 Process Simulation in Chemical and Process Engineering

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13831	Compulsory elective

Modul Title	**Process Simulation in Chemical and Process Engineering** Prozesssimulation in der Chemie- und Verfahrenstechnik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Arellano-Garcia, Harvey
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After completing the module, students will be able to analyse physical and chemical phenomena involved in different processes, develop mathematical models and use different process simulation approaches using ASPEN PLUS.
Contents	• Fundamentals: Continuity equations, energy conservation, momentum conservation and state equations; Transport properties; Equilibrium and chemical kinetics; Thermodynamic correlations for estimating physical properties. • Use and scope of mathematical modelling; principles of model formulation; principles of steady-state and dynamic simulation; simulation of models; sequential modular approach; Equation-based approach; analysis of simulation data. • Introduction and use of process simulation software for flowchart simulation • Modelling and simulation of specific systems: e.g., heat conduction in a rod; laminar flow of Newtonian fluid in a pipe; heat exchanger; gravity tank, Power Engineering
Recommended Prerequisites	Physics, Mathematics, Thermodynamics
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 120 hours

Teaching Materials and Literature	• Handouts and reading list • Manual and tutorial of the modelling programs
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination (90 min)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	none
Components to be offered in the Current Semester	**360351** Lecture/Exercise Prozesssimulation/Process Simulation - 4 Hours per Term **360385** Examination Process Simulation in Chemical and Process Engineering

Module 13832 Optimisation in Process and Energy Systems Engineering

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	13832	Compulsory elective

Modul Title	**Optimisation in Process and Energy Systems Engineering** Optimierung in der Verfahrens- und Energiesystemtechnik
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Arellano-Garcia, Harvey
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	After participating in this module, the students master the basic knowledge, in terms of mathematical optimization methods and tools. Relevant examples from Energy and Process Engineering are used to enhance the understanding of the various tools and methods taught. The focus is on the formulation of the problems and the approaches for their mathematical solution. The methods covered are applied in accompanying calculation exercises.
Contents	• Introduction: Definition, problem formulation, applications • Linear programming • Non-linear programming • Mixed integer non-linear programming • Dynamic optimization • Stochastic optimization
Recommended Prerequisites	• Chemical Engineering • Thermodynamics • Process Systems Engineering
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester Self organised studies - 135 hours

Teaching Materials and Literature	• T. F. Edgar, D. M. Himmelblau, Optimization of Chemical Processes, McGraw-Hill, New York, 2001 • L. T. Biegler, I. E. Grossmann, A. W. Westerberg, Systematic Methods of Chemical Process Design, Prentice Hall, New Jersey, 1997 • C. A. Floudas, Nonlinear and Mixed-Integer Optimization, Oxford University Press, 1995 • J. Nocedal, S. J. Wright, Numerical Optimization, Springer, 2006 • R. Baldick, Applied Optimization, Formulation and Algorithms for Engineering Systems, Cambridge University Press, 2006
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	• Written examination (90 min)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	VL + Ü + Prü Optimization in Process and Energy Systems Engineerin
Components to be offered in the Current Semester	**360331** Lecture/Exercise Optimierung in der Energie- und Verfahrenstechnik/Optimization in Process and Energy Systems Engineering - 3 Hours per Term **360386** Examination Optimization in Process and Energy Systems Engineering

Module 14069 Biomass and Bioenergy

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14069	Compulsory elective

Modul Title	**Biomass and Bioenergy** Biomasse und Bioenergie
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. phil. Hirschl, Bernd
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Students are able to understand the multifunctionality of biomass and know the various pathways of biomass conversion into energy. They are prepared to have critical knowledge regarding biomass cultivation for energy generation by discussing social and environmental concerns, like land use or the competition with food chains. After attending the module, students have expertise in interpreting and presenting scientific texts.
Contents	Sustainable energy generation is seen as one of the largest present challenges of our society. The module “Biomass and Bioenergy” will discuss climate neutral energy systems, where biomass is a sustainable carbon neutral source of energy. This module is highly interdisciplinary. Topics will include: • Overview on biomass production (agriculture and forestry) • Biomass residual waste • Energy conversion technologies • Social and ecological aspects of biomass use • Current bioenergy policies
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Seminar - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	The following literature can be used for preparation:

	• Book: Kaltschmitt, M., ed. (2018) Energy from Organic Materials (Biomass). A Volume in the Encyclopedia of Sustainability Science and Technology, 1439 p. Springer DOI:https://doi.org/10.1007/978-1-4939-7813-7 • Book: Srivastava, N., Verma, B. & Mishra, P.K., eds. 2023. Agroindustrial Waste for Green Fuel Application. Springer DOI:https://doi.org/10.1007/978-981-19-6230-1 • Journal “Biomass and Bioenergy” (Elsevier) • Journal “Sustainable Energy Technologies and Assessments” (Elsevier)
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Presentation (15 minutes + discussion) **Final Module Examination:** • Written exam, 120 min
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	Not offered in **summer semester 2026**.
Module Components	• Seminar: Biomass and Bioenergy • Examination: Biomass and Bioenergy
Components to be offered in the Current Semester	No assignment

Module 14132 Multidimensional Approaches for Technology Assessment

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14132	Compulsory elective

Modul Title	**Multidimensional Approaches for Technology Assessment** Multidimensionale Ansätze für Technikfolgenabschätzung
Department	Faculty 5 - Business, Law and Social Sciences
Responsible Staff Member	Prof. Dr. rer. pol. habil. Lee, Roh Pin
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	Students know about a range of technology assessment approaches, methodologies and tools to facilitate the evaluation of decarbonization & sustainability transformation options along socio-technological-economical-ecological-political (*STEEP*) dimensions. On completion of the module, students are able to: • Demonstrate a deep understanding of the multidimensional aspects and systemic interactions in the transformation of energy- and carbon-intensive industries; • Gain familiarity with a range of qualitative and quantitative methodologies in conducting technology assessment; • Design and conduct studies to analyze the opportunities and challenges which will be associated with the transformation of energy- and carbon-intensive industries along multiple dimensions; • Identify, assess and evaluate appropriate sources of information and critically reflect on the methodologies commonly implemented for technology assessment and their usefulness/weaknesses.
Contents	Course coverage: • Relevance and development of technology assessment; • Common methodological approaches and their usefulness/weakness; • Data and approaches for assessment (e.g., primary vs. secondary; qualitative vs. quantitative); • Methodologies for socio-political evaluations, techno-economic evaluations and ecological evaluations;

- Application on a case study to assess multidimensional opportunities and challenges associated with the transformation of a specific sector and derive implications along the *STEEP* dimensions based on assessment results.

Recommended Prerequisites

none

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 1 hours per week per semester
Exercise - 1 hours per week per semester
Study project - 2 hours per week per semester
Self organised studies - 120 hours

Teaching Materials and Literature

- Lee, R.P., Meyer, B., Huang, Q.L, Voss, R. 2020. Sustainable waste management for zero waste cities in China: potential, challenges and opportunities. *Clean Energy*, 4(3): 169 – 201.
- Lee, R.P. 2019. Alternative carbon feedstock for the chemical industry? – Assessing the challenges posed by the human dimension in the carbon transition, *Journal of Cleaner Production*, 219: 786-796.
- Lee, R. P., Tschoepe, M., Voss, R. 2021. Perception of chemical recycling and its role in the transition towards a circular carbon economy: A case study in Germany. *Waste Management*, 125: 280-292.
- Voss, R., Lee, R.P., Seidl, L., Keller, F., Fröhling, M. 2021. Global warming potential and economic performance of gasification-based chemical recycling and incineration pathways for residual municipal solid waste treatment in Germany. *Waste Management*, 134: 206 – 219.
- Keller, F., Lee, R.P., Meyer, B. 2020. Life cycle assessment of global warming potential, resource depletion and acidification potential of fossil, renewable and secondary feedstock for olefin production in Germany. *Journal of Cleaner Production*, 250: 119484.
- Lee, R.P., Scheibe, A. 2020. The politics of a carbon transition: An analysis of political indicators for a transformation in the German chemical industry*, Journal of Cleaner Production*, 244: 118629.

Further materials are provided via Moodle (including lecture slides and additional materials including videos, readings etc.)

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Individual component (E-assessment), 60-90 min - 50%
- Group Project - Part 1: Create a scientific poster (Analysis of e.g., a scientific article, industry report, case study, ...) - 25%
- Group Project - Part 2: Presentation, 15min - 25%

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

- Lectures & Exercises
- Projects

Components to be offered in the Current Semester	No assignment

Module 14462 Lightweight and Active Structures

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14462	Compulsory elective

Modul Title	**Lightweight and Active Structures** Leichte und Aktive Tragwerke
Department	Faculty 6 - Architecture, Civil Engineering and Urban Planning
Responsible Staff Member	Prof. Dr.-Ing. Bleicher, Achim
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	On special announcement
Credits	6
Learning Outcome	Knowledge / Skills: Bringing together theories, methods and tools from different fields for the optimal design of lightweight and active structures. Competencies: After successful participation in the module, students are able to design, model, optimate and simulate simple lightweight and active structures. The contents of the module are applied by working with the simulation software Sofistik and Matlab/ Simulink.
Contents	• Lightweight design principles • Concepts and Mechanisms for moveable and active structures • Optimization of lightweight structures • Systems for vibration control • Modeling and simulation of simple active structures as a basis for the design of adaptronic systems • Design of adaptronic systems (sensors, actuators, control)
Recommended Prerequisites	Vorgespannte Tragwerke (11694) Schwingungsanfällige Tragwerke (23503)
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 1 hours per week per semester Seminar - 1 hours per week per semester Consultation - 1 hours per week per semester Self organised studies - 135 hours
Teaching Materials and Literature	Otto, F., 1972. IL 5 Wandelbare Dächer Convertible Roofs. Karl Krämer,

	Wittenborn and Company, Stuttgart / Bern, New York. Wiedemann, J., 2007, 1996. Leichtbau I und II. Springer-Verlag Isermann, R., 2008. Mechatronische Systeme. Springer Berlin Heidelberg, Berlin, Heidelberg. Housner, Bergman, Caughey, Chassiakos, Claus, Masri, 1997. Structural Control: Past, Present and Future. Journal of Engineering Mechanics Vol. 123, 897–971. Janocha, H., 2007. Adaptronics and Smart Structures. Springer Berlin Heidelberg, Berlin, Heidelberg. Preumont, A., 2011. Vibration Control of Active Structures: An Introduction, Edition: 3rd. 2011. Springer, Berlin.
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Preparation of a written project report (ca. 20000 signs) (70%) Presentation of the project results (15 Min.) (15%) Oral examination (15 Min.) (15%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	Lecture / Seminar Lightweight and Active Structures
Components to be offered in the Current Semester	No assignment

Module 14496 Applied Biostatistics for Environmental Data

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14496	Compulsory elective

Modul Title	**Applied Biostatistics for Environmental Data** Angewandte Biostatistik für Umweltdaten
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Djoudi, El Aziz
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	This module will provides a theoretical introduction to data analysis and results interpretation, statistical methods and tools for environmental and biological sciences, as well as applied tools with a particular focus on R programming (R software).
Contents	Part 1. Introduction to experimental design Design principles Random sampling, block design, nested design, split-plot… Replication and Pseudoreplication Part 2. Introduction to R Introduction to the essentials of R Basics: Syntax, packages, writing codes & functions Data handling, analysis and visualisation (graphs and tables) Exercises Part 3. Distributions, Parameters and Estimators Data classification & distribution Measures of central tendency: mean, median … Measures of variability: variance and standard deviation Likelihood and Akaike Information Criterion Exercises Part 4. Univariate analysis T-test and ANOVA (Analysis of variance) Correlation and regression analysis Non parametric analysis (Wilcoxon, Mann-Witney-U, Kruskal-Wallis) linear models & introduction to mixed models Exercises

	Part 5. Multivariate analysis Principal component analysis (PCA) Non-metric multidimensional scaling (NMDS) Redundancy analysis (RDA) & Canonical correspondence analysis (CCA) Exercises
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Zuur, A. F., Ieno, E. N. & Smith, G. M. 2007 Analysing ecological data. New York Gotelli, N. J. & Ellison A. M. 2013 A primer of ecological statistics. Sunderland Dormann, C. 2020 Environmental Data Analysis: An Introduction with Examples in R. Cham Lakicevic, M., Povak, N. & Reynolds, K. M. 2020 Introduction to R for terrestrial ecology: basics of numerical analysis, mapping, statistical tests and advanced application of R, Cham Wilke C.O. 2019 Fundamentals of Data Visualization, O'Reilly Wickham H& Grolemund G, 2017 R for Data Science, O'Reilly
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	- 10 Exercises during the courses (50%)) - Individual project presentation, 15 min. (50%)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	25
Remarks	Please bring your laptop!
Module Components	240740 Lecture/Exercise: Applied Biostatistics for environmental data
Components to be offered in the Current Semester	**240740** Lecture/Exercise Applied Biostatistics for environmental data - 4 Hours per Term

Module 14506 Advanced Geophysical Methods in Natural Resource Investigation (ANRI)

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14506	Compulsory elective

Modul Title	**Advanced Geophysical Methods in Natural Resource Investigation (ANRI)** Fortgeschrittene geophysikalische Methoden zur Erkundung natürlicher Ressourcen
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Bordon, Pablo
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every semester
Credits	6
Learning Outcome	Understand advanced geophysical methods for subsurface exploration. Gain practical skills in applying geophysical methods in real fieldwork scenarios, including magnetometry, ground-penetrating radar (GPR), electrical resistivity tomography (ERT), and electromagnetics for data acquisition and interpretation Learn to process and interpret geophysical data including airborne data. Develop expertise in using specialized software. Evaluate the efficiency of different geophysical methods in various field conditions. Analyze and mitigate common issues encountered during geophysical surveys.
Contents	**Lecture:** The lecture component of this course will provide an overview of advanced geophysical investigation methods used in subsurface exploration. It will cover the principles of magnetometry, ground-penetrating radar (GPR), geoelectrics and electromagnetic methods, along with an introduction to radiometry and its applications in natural resource exploration. Students will learn about data acquisition techniques for both ground and airborne geophysical surveys, and explore the challenges associated with data interpretation. Additionally, the lecture will address typical workflows used in the processing of geophysical data to ensure accurate results.

	Practical Training: The practical training component will focus on providing hands-on experience in fieldwork, utilizing magnetometry, GPR, geoelectric, electromagnetic instruments. Students will actively participate in data acquisition and analysis using specialized software. They will gain experience in processing, and learn how to apply these methods effectively in real exploration scenarios. Practical training will also include the development of field reports and presentations based on data collected during field activities, helping students to refine their skills in communicating technical results.
Recommended Prerequisites	none
Mandatory Prerequisites	Successful completion of the NRI module 42421 – Natural Resource Investigation
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Practical training - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	Material provided by the Chair
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	Exam for the lecture (60 minutes) Presentation (15 minutes) and report for the practical training (10-15 pages)
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	15
Remarks	none
Module Components	Lecture Practical training Exam
Components to be offered in the Current Semester	**240813** Lecture Advanced Geophysical Methods in Natural Resource Investigation (ANRI) - 2 Hours per Term **240814** Practical training Advanced Geophysical Methods in Natural Resource Investigation (ANRI) - 2 Hours per Term **240815** Examination Advanced Geophysical Methods in Natural Resource Investigation (ANRI)

Module 14781 Biological Methods for Biomass and Waste Treatment

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	14781	Compulsory elective

Modul Title	**Biological Methods for Biomass and Waste Treatment** Biologische Verfahren der Biomasse- und Abfallbehandlung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. habil. Abendroth, Christian
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	<p data-start="0" data-end="990">Students are introduced to ecologically and economically viable alternatives to conventional waste treatment, with integrated and system-oriented solutions at the core. Particular emphasis is placed on anaerobic microbiomes and their central role in biological conversion processes such as anaerobic digestion, composting, and other innovative approaches to residual waste valorization. Building on microbiological and biochemical fundamentals, functional principles, process dynamics, and efficiencies are analyzed and transferred to real-world applications. In addition to established technologies, current research approaches, international developments, and novel process combinations—including contributions from the instructor’s own research—are addressed. The aim is to develop an in-depth understanding of the material and energy recovery of residuals within the context of a sustainable circular economy, and to foster the ability to independently design system-oriented solutions. <p data-start="992" data-end="1542" data-is-last-node="" data-is-only-node="">An interactive teaching format forms the didactic core: during the sessions, students continuously work on tasks whose results contribute to the overall assessment. This supports an active learning process that promotes analytical thinking, applied competence, and scientific discussion.
Contents	<p data-start="0" data-end="361">The course provides a solid yet practice-oriented introduction to the biological utilization of residual materials within the context of a sustainable circular economy. Starting from the fundamentals of biology and photosynthesis, it first examines the ”food vs. fuel” debate in order to critically assess conflicts

	between food production and bioenergetic use. <p data-start="363" data-end="906">Subsequently, key processes of biological waste treatment are covered, including composting, biogas production, and dark fermentation. These processes are considered not only from a technological perspective, but particularly from the viewpoint of anaerobic microbiomes, which are understood as the driving force behind material transformations. An introduction to microbiomes and their analysis—from taxonomic profiling to functional approaches such as proteomics—enables a deeper understanding of microbial communities and their performance. <p data-start="908" data-end="1251">Building on this, central metabolic processes such as fermentation and methanogenesis are examined in detail and placed in the context of technical applications. In addition, innovative and less established approaches—such as the use of insects, bioleaching, remediation strategies, and novel materials and systems (e.g., SLMs)—are introduced. <p data-start="1253" data-end="1504" data-is-last-node="" data-is-only-node="">The course combines current research with application-oriented knowledge and offers an interdisciplinary perspective on biological transformation processes, with the aim of developing sustainable and creative solutions for future resource utilization.
Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 4 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	- Kranert M. Einführung in die Kreislaufwirtschaft, Springer Vieweg Wiesbaden, 2017, https://doi.org/10.1007/978-3-8348-2257-4 - Bischofsberger, Dichtl, Rosenwinkel, Seyfried, Böhnke. Anaerobtechnik. Springer-Verlag Berlin Heidelberg 2005, ISBN: 3-540-06850-3 - Further literature will be announced during the course <p data-start="0" data-end="129">>
Module Examination	Continuous Assessment (MCA)
Assessment Mode for Module Examination	<div id="meta-origin" data-coolorigin="https%3A%2F%2Fwww.b-tu.de%2Forgcloud%2Fapps%2Frichdocumentscode%2Fproxy.php%3Freq%3D%2Fcool%2Fclipboard%3FWOPISrc%3Dhttps%253A%252F%252Fwww.b-tu.de%252Forgcloud%252Findex.php%252Fapps%252Frichdocuments%252Fwopi%252Ffiles%252F11244624_ochtzup9yafk%26ServerId%3DF84FA4B4%26ViewId%3D7%26Tag%3D58C29858B529DFEC"> Assessment in this module follows a continuous, dialogue-based oral approach. Students are asked to demonstrate their understanding of the course content by answering subject-specific questions and by formulating questions for their peers. The assessment takes place regularly throughout the semester and aims to evaluate subject-specific knowledge, understanding, and the ability to engage in academic discussion. <p> oral assessment generally after every second lecture approximately 15–20 minutes per assessment session 1–2 questions per student approximately every two weeks approximately 10 assessed questions per student

	over the semester 1 point for each successfully completed question assessment of answers based on subject-specific correctness and demonstrated understanding assessment of student-formulated questions based on scientific relevance, clarity, and appropriateness All assessed questions/tasks are weighted equally. The overall assessment result is calculated based on the proportion of points achieved out of the total number of points available (100%). comparable number and level of assessment opportunities for all students
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	20
Remarks	none
Module Components	238117 Lecture / Seminar: Biological Processes in Biomass and Waste Treatment <p><br data-start="84" data-end="87" />
Components to be offered in the Current Semester	**238117** Lecture/Seminar Biologische Verfahren der Biomasse und Abfallbehandlung - 4 Hours per Term

Module 42421 Natural Resource Investigation

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	42421	Compulsory elective

Modul Title	**Natural Resource Investigation** Rohstofferkundung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Prof. Dr. rer. nat. Herd, Rainer
Language of Teaching / Examination	English
Duration	2 semesters
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	• Get to know geological processes and to understand the role of these processes for the formation of natural resources • Become acquainted to the processes leading to the genesis of different raw materials • Study methods and techniques for investigation of natural resources • Use these investigation methods in the field and in the lab • Be able to present working results in an oral presentation and to defend them in an open discussion • Get an insight in the work of a professional exploration company during an excursion
Contents	**Lecture Prospection and Exploration of Natural Resources** The lectures provides an overview about the geological processes which are responsible for the formation of different natural resources including energy resources, metals, industrial minerals and ground water. Methods for the prospection and exploration of these resources are presented using geological, geophysical, geochemical and remote sensing techniques. Advantages and disadvantages of the methods are discussed. **Practical training Prospection and Exploration of Natural Resources** The focus of this course is the practical training of the prospection and exploration methods in the field and in the lab. Geological, geophysical and remote sensing techniques are used in order to detect e.g. raw material deposits. **Lecture/exercise Introduction to Coal Petrology** Lecture and practical training at the microscope.

The lecture provides an overview about the genesis of coal seams and about the microscopic constituents of coal. The maceral concept is introduced. It is shown that coal is also a source of environmental information. The student will do a reconstruction of the paleoenvironment by using microscopic maceral analyses.
Excursion Prospex
Field trip to an active exploration site. Topics: Geological setting, exploration technology, efficiency and costs.

Recommended Prerequisites

- General high school knowledge in physics
- Basics in geology

Mandatory Prerequisites

none

Forms of Teaching and Proportion

Lecture - 3 hours per week per semester
Exercise - 1 hours per week per semester
Excursion - 8 hours
Practical training - 3 hours per week per semester
Self organised studies - 67 hours

Teaching Materials and Literature

Material provided by the Chair

Module Examination

Continuous Assessment (MCA)

Assessment Mode for Module Examination

- Written examination, 80 min. (50%)
- Written essay, 8-10 pages (30%)
- Short report about results of the microscopic analyses (20%)

Excursion participation is mandatory.

Evaluation of Module Examination

Performance Verification – graded

Limited Number of Participants

none

Remarks

none

Module Components

Winter semester:

- 240809 Lecture Prospection and Exploration of Natural Resources
- 240808 Excursion Raw Material Exploration
- 240804 Lecture/Exercise Introduction to coal petrology
- 240869 Examination Prospection and Exploration of Natural Resources

Summer semester:

- 420830 PR Prospection and Exploration of Natural Resources
- 842090 Examination Prospection and Exploration of Natural Resources

Components to be offered in the Current Semester

240809 Lecture
Prospection and Exploration of Natural Resources (Modul 42421) - 2 Hours per Term
240808 Excursion
Raw Material Exploration (Modul 42421)
240804 Lecture/Exercise
Introduction to coal petrology (Modul 42-4-21) - 2 Hours per Term

240869 Examination
Prospection and Exploration of Natural Resources (Modul 42421)

Module 44107 Safety- and Risk-Analysis for Process Plants

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	44107	Compulsory elective

Modul Title	**Safety- and Risk-Analysis for Process Plants** Sicherheits- und Risikoanalyse für Prozessanlagen
Department	Faculty 3 - Mechanical Engineering, Electrical and Energy Systems
Responsible Staff Member	Prof. Dr.-Ing. Arellano-Garcia, Harvey
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every summer semester
Credits	6
Learning Outcome	After completing the module, students will be able to apply basic methods for performing and evaluating safety-related aspects for industrial plants. They learn methodical basics for the evaluation of probabilities of occurrence and the derivation of the resulting consequences. Using the methods taught for qualitative and quantitative risk assessment, students are able to independently develop sustainable concepts and solutions. They also have basic knowledge of safety-related plant optimization and can communicate this to plant operators, authorities, etc.
Contents	• Hazard identification methods (e.g. Checklists, FMEA, HAZOP) • Frequency evaluation methods (event tree, fault tree) • Consequence evaluation methods (e.g. one- and two phase flow (critical, sub-critical), dispersion of neutral and dense gas, fire, explosion and toxic hazards) • Qualitative and quantitative risk assessment methods • Safety related plant optimization Exercise: • Realization of safety and risk studies (method, case study)
Recommended Prerequisites	None
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Exercise - 1 hours per week per semester

	Practical training - 1 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Lecture notes • Lees,F.P.: Loss prevention in the process industries, Butterworth 1996, Oxford • Guidelines for chemical process quantitative risk analysis AICHE,1989, New York • Guidelines for hazard evaluation procedures AICHE , 1992, New York • W.F.Kenney: Process risk management systems, VCH 1993, New York • D. A. Crowl;J. F. Louvar: Chemical process safety, Prentice Hall, Inc., 2002, New Jersey
Module Examination	Prerequisite + Final Module Examination (MAP)
Assessment Mode for Module Examination	**Prerequisite:** • Successful completion of the exercises within the practical training **Final module examination:** • Written examination, 90 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	None
Module Components	• 238227 Lecture Safety and risk analysis • 238231 Examination Safety- and risk-analysis
Components to be offered in the Current Semester	**360375** Examination Safety- and Risk-Analysis for Process Plants

Module 44419 Wastewater and Sludge Treatment

assign to: Modules with the Focus on Environmental Engineering
Studienrichtung / Vertiefung:Universidad Tecnologica de Pereira

Study programme Environmental and Resource Management

Degree	Module Number	Module Form
	44419	Compulsory elective

Modul Title	**Wastewater and Sludge Treatment** Abwasser- und Schlammbehandlung
Department	Faculty 2 - Environment and Natural Sciences
Responsible Staff Member	Dr. Riedel, Ramona
Language of Teaching / Examination	English
Duration	1 semester
Frequency of Offer	Every winter semester
Credits	6
Learning Outcome	At the end of the module the student are able to understand the basic processes of process engineering in waste water sludge treatment.
Contents	**Anthropogenic pollutants:** • Pollutants - kinds, environmental an health effects, pollutants transport/natural degradation **Sewage treatment:** • History of sewage treatment **Methods in sewage treatment:** • Sedimentation, flotation, sieving and filtration, chemical treatment (neutralization, flocculation and precipitation, oxidation and reduction processes, electrochemical processes), biological processes (aerobic and anaerobic biodegradation, biological nitrogen and phosphorus elimination) **Technologies in sewage treatment:** • Coarse cleaning by screens and rakes, micro-sieving, sedimentation processes: Grid chamber, preliminary sedimentation and secondary settling, flotation processes: Oil and fat trapping, light density material collector, flocculation filtration, biological sewage treatment: The activated sludge process, fixed bed reactors, treatment plant design, combined technologies in industrial water treatment, • Sewage sludge treatment, thickener, sludge conditioning, sludge dewatering, sludge recycling, land application, composting, innovative technologies for sludge reuse

Recommended Prerequisites	none
Mandatory Prerequisites	none
Forms of Teaching and Proportion	Lecture - 2 hours per week per semester Tutorial - 2 hours per week per semester Self organised studies - 120 hours
Teaching Materials and Literature	• Wastewater Treatment. Biological and Chemical Process: Biological and Chemical Processes (Environmental Engineering), Mogens Henze (Autor), Poul Harremoes (Autor), Jes LaCour Jansen (Autor), Springer Verlag 2002 • Biological Wastewater Treatment, Second Edition, Revised and Expanded, C. P. Leslie, JR. Grady, Glen T. Daigger, und Henry C., Marcel Dekker Ltd , 1999
Module Examination	Final Module Examination (MAP)
Assessment Mode for Module Examination	Written examination, 120 min.
Evaluation of Module Examination	Performance Verification – graded
Limited Number of Participants	none
Remarks	none
Module Components	**Winter semester:** • 230506 Lecture Waste water and sludge treatment • 230500 Examination Waste water and sludge treatment • 230544 Examination Waste water and sludge treatment **Summer semester:** • 230544 Examination Waste water and sludge treatment
Components to be offered in the Current Semester	**230506** Lecture Waste water and sludge treatment - 4 Hours per Term **230500** Examination Waste water and sludge treatment **230544** Examination Waste water and sludge treatment

Erläuterungen

Das Modulhandbuch bildet als Teil der Prüfungsordnung die Rechtsgrundlage für ein ordnungsgemäßes Studium. Darüber hinaus soll es jedoch auch Orientierung bei der Gestaltung des Studiums geben.

Dieses Modulhandbuch wurde am 21. September 2026 automatisch für den Master (universitär) - Doppelabschluss-Studiengang Environmental and Resource Management (universitäres Profil), PO-Version 2021, aus dem Prüfungsverwaltungssystem auf Basis der Prüfungsordnung generiert. Es enthält alle zugeordneten Module einschließlich der ausführlichen Modulbeschreibungen mit Stand vom 21. September 2026. Neben der Zusammensetzung aller Veranstaltungen zu einem Modul wird zusätzlich das Veranstaltungsangebot für das jeweils aktuelle Semester gemäß dem Veranstaltungsverzeichnis der BTU ausgegeben.

The module catalogue is part of the examination regulation and as such establishes the legal basis for studies according to the rules. Furthermore, it should also give orientation for the organisation of the studies.

This module catalogue was generated automatically by the examination administration system on the base of the examination regulation on the 21 September 2026, for the Master (universitär) - Doppelabschluss of Environmental and Resource Management (research-oriented profile). The examination version is the 2021, Catalogue contains all allocated modules including the detailed module descriptions from 21 September 2026. Apart from the composition of all components of a module, the list of lectures, seminars and events for the current semester according to the catalogue of lectures of the BTU is displayed.